AC 2010-822: EXTREME EXPERIENCE INTERVIEWS FOR INNOVATIVE DESIGNS: CLASSROOM ASSESSMENT OF A NEW NEEDS-GATHERING METHOD

Matthew Green, LeTourneau University

Dr. Matthew G. Green is an assistant professor of Mechanical Engineering at LeTourneau University, Longview. His objective is to practice and promote engineering as a serving profession, with special interest in improving the quality of life in developing countries. Focus areas include remote power generation, design methods for frontier environments, and assistive devices for persons with disabilities. Contact: MatthewGreen@letu.edu.

Carolyn Conner Seepersad, University of Texas, Austin

Dr. Carolyn C. Seepersad is an assisstant professor of Mechanical Engineering at the University of Texas, Austin.

Katja Holtta-Otto, University of Massachusetts Dartmouth

Dr. Katja Holtta-Otto is an assistant professor of Mechanical Engineering at the University of Massachusetts, Dartmouth.

Extreme Experience Interviews for Innovative Designs: Classroom Assessment of a New Needs-Gathering Method

Abstract

A recently published "Extreme Experience Design[1]" method places interviewees in simulations that parallel physical disabilities (such as wearing dark glasses to simulate low vision) in order to elicit normally-hidden product needs. This new needs-gathering technique equips students with awareness and skills to design for persons with disabilities, as well as an interview method leading to breakthrough design innovations through uncovering latent (hidden) needs. Traditionally-taught needs gathering interviews typically lead to parametric needs and thus incremental design changes; however, the latent needs uncovered with extreme experience interviews are often non-parametric and offer greater potential for breakthrough innovations.

We implemented the new extreme experience interview technique in 1st year Cornerstones Design and 3rd year Design Methods courses through a slide-based lecture and a live demonstration of the interview method. We then surveyed ~100 students from both classes across two semesters in order to assess student learning and the effectiveness of the interview method for uncovering user needs. We also analyzed a subset of 26 design team interview transcripts for new information elicited by extreme experience interviews following a "benchmark" articulated use interview.

Building upon previously reported work[2], results include a summary of student surveys, analysis of customer needs before and after extreme experience interviews, and a qualitative review of re-design ideas generated. The surveys show students understand and like both the "normal" benchmark articulated-use interviews and the extreme experience interview technique and would like to re-use them on future projects. Surveys also indicate strong agreement that extreme experience interviews "*inspired ideas that are better for average users as well*." An examination of interview transcripts shows the extreme experience interviews are valuable not only for uncovering a much more comprehensive set of customer needs, especially with respect to product-user interactions, but also for obtaining innovative redesign suggestions from customers themselves. The results collectively show extreme experience interviews are an effective and valuable addition to the design process in these courses, with additional room for improvement in teaching technique.

1 Introduction

In the last decade the engineering design community has shown tremendous interest in design for such "frontier contexts" as persons with disabilities and rural villagers. Recent design research not only acknowledges the importance of accounting for persons with disabilities in the design process, but further suggests the resulting insights may benefit the larger community and lead to breakthrough innovations. A new "Extreme Experience Design" method at the forefront of this exciting theme places interviewees in simulations that parallel physical disabilities (such as wearing dark glasses to simulate low vision), in order to elicit ideas and needs that are normally hidden and known as "latent needs."

The power of this method is partially based on the belief that niche innovations for special populations can add value for larger segments of the user population. Table 1 lists examples gleaned from everyday experience of technologies with broader impacts than the target audience. The table is divided into "trickle-down" effects in which high-dollar development efforts eventually lead to more affordable products versus the less common "trickle-up" effect in which less lucrative niche markets resulted in broader impacts. The latter phenomenon is believed to be at work in the Extreme Experience Design methodology.

Table 1: Examination of Broader Impacts: Trickle-Up and Trickle-Down[2]

"TRICKLE-DOWN"		
Technology	**Target Beneficiaries**	**Wider Beneficiaries**
Tang	Astronauts	Kids
Photovoltaic cells	Space program	Remote individuals
Anti-glare coatings	Astronauts	Glasses wearers
Anti-lock brakes	Luxury car or Volvo drivers	Normal car drivers
Crumple zones	Luxury car or Volvo drivers	Normal car drivers
Britax car seats	Affluent families	Middle-class families
RV refrigerators	RV vacationers	Individuals "off grid"

"TRICKLE-UP"		
Technology	**Target Beneficiaries**	**Wider Beneficiaries**
Curb cutouts	Wheelchair users	Bicyclists, skaters, cane users, cart/stroller pushers
Easy doorknobs	Motion-impaired	All users, especially load carrying
Closed captioning	Deaf or hard of hearing	Noisy or multi-TV environments
Freeplay Wind-up Radio	Rural African villagers	Survivalists, Gadget lovers
Screen readers	Visually impaired	Users preferring audio

The greatest engineering challenges of the 21st century, such as clean water and energy for all, call for a generation of engineers inspired and equipped to tackle *frontier-design*[3,4] needs *outside their experience and expertise*. Prototypical frontier-design needs include persons with disabilities, rural areas of developing countries, and space exploration. Circumstances often call on engineers to design for such *frontier-design contexts* outside their experience and expertise. This occurs by default because engineers are a subset of society and design products to be used by children, remote villagers, illiterate individuals, and other groups typically not represented among design engineers. Additionally, the importance multi-national companies place on positioning products in a global marketplace requires design for customers in other countries, cultures, and economies. Although most design engineering is performed in *developed* countries, 86% of the world lives in a developing country[5]. Approximately 1 in 5 US residents (18.1 %) have a disability, and for the 65+ age group that number is 50%[6].

In view of these needs, many universities seek to foster a global-service mindset with an experiential learning curriculum. Partly for these reasons, extreme experience interviews are being piloted in 1st year Cornerstones Design and 3rd year Design Methods courses at the first author's institution, which offers a B.S. and M.S. in engineering with concentrations including biomedical, computer, electrical, mechanical, civil, and materials joining.

2 The "Extreme Experience" Design Method for Customer Needs Elicitation

Effective design hinges upon obtaining high-quality customer requirements; however, many current engineering design texts give little guidance on *how* to acquire this important data. Some progressive texts suggest either a verbal interview or an articulated-use interview, in which a volunteer actively uses the product to be re-designed during the interview[8,9]. Lead-user interviews and empathic design techniques have also generated recent interest in the design community. It has been shown[10] that persons with disabilities qualify as lead-users since they often identify novel and important needs which many customers value, but few articulate. For example, many pedestrians and bicyclists appreciate curb cutouts, yet only wheelchair users would normally articulate this need.

Figure 1: Simulating visual and fine motor disability[7]

Building on these findings, *empathic lead-user analysis* simulates a disability (such as dark glasses simulating visual impairment) while a test subject experiences the product of interest during an interview. This disability-simulation approach greatly broadens the availability of "lead-users," and enables every engineer on the team to experience the product as a lead-user. Not surprisingly, research on the empathic lead-user technique indicates vastly improved customer needs elicitation over currently taught methods, *showing a 500% increase in latent needs collection* over articulated-use techniques and a *25-fold increase* over verbal-only approaches[1]. Seepersad and Holtta-Otto continue to build on their empathic lead-user research with the development of the "extreme experience design" method for needs elicitation.

These recent findings hold exciting implications for teaching and learning design methods. Our experimentation with frontier-design suggests that students may learn problem-definition techniques most effectively when nudged outside of their comfort zone into a frontier-design need. The extreme experience approach allows every student to experience a product from the point of view of a person with disabilities, as well as to conduct a number of disability-simulation interviews on classmates.

3 Piloting "Extreme Experience" Design Interviews in 1st and 3rd Year Design Courses

3.1 Course Background: 1st Year Cornerstones Design

The 1st year Cornerstones Design course (ENGR 1812 "Fundamentals of Engineering Design") introduces the engineering design process to ~130 students each year from all engineering disciplines. Project work includes interdisciplinary teams adapting everyday products to accommodate persons with disabilities, such as a digital camera interface accommodating fine motor disabilities. Experiential, project-based teaching stimulates learning of teaming skills, design process, written and oral communication, and basic robotics and programming skills. Interdisciplinary teams use a machine language trainer and the LEGO™ NXT robotics kits programmed with LabVIEW™ as electro-mechanical "breadboards."

In the final project, teams re-design and prototype everyday products adapted to accommodate persons with disabilities. Examples include an automated pill dispenser accommodating visual, dexterity, and cognitive disabilities (Figure 2); an alarm clock accommodating dexterity disabilities, a digital camera interface accommodating fine motor disabilities, and a mixer-blender accommodating one-handed use with fine motor disabilities. This frontier-design project is one of the most popular among students, and the only project to-date with unsolicited comments from students after class such as "*thank you for doing this [assistive] project*."

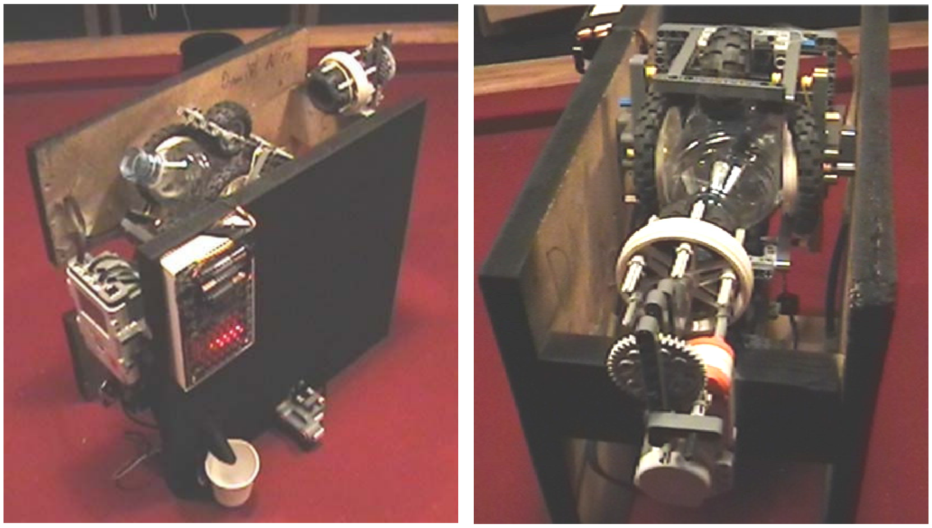

Figure 2: Automated Pill Dispenser Prototype, Accommodating Multiple Disabilities
(Functional prototype and photo by "Team #18": B. Ludwig, N. Bryant, and C. Schults)

3.2 Course Background: 3rd Year Design Methods

The 3rd year Design Methods course strengthens and extends the foundational concepts introduced in 1st year Cornerstones Design for all engineering and engineering technology majors, excluding materials joining and civil engineering (60-90 students per year.) Students explore a variety of engineering design methods through a semester-long reverse-engineering re-design team project. Example topics include: planning the design process, stakeholder analysis, design specifications, functional analysis and concept generation, feasibility estimation, prototyping, and design-for-manufacturing. (This course is an interdisciplinary adaptation of a course developed by Kristin Wood[11] in collaboration with Kevin Otto and others.)

Many projects in the 3rd year Design Methods course involve re-designing an existing product for a frontier-design environment such as for a person with disabilities or rural areas of developing countries. Student teams identify an opportune product to measure, dissect, reverse-engineer, re-design, physically modify, and evaluate. For example, students could re-design an electric food dryer for use in a remote area (without electricity) by a person with dexterity limitations. As part of the reverse-engineering process, the student teams first dissect and measure an existing food dryer to provide a benchmark and a basis for re-design work.

3.3 Classroom Implementation of Extreme Experience Customer Interviews

Appendix A shows the most recent "Extreme Experience" design project assignment from 1st year Cornerstones Design (ENGR 1812 "Fundamentals of Engineering Design.") The design scenario includes individuals who need an accessible mixer-blender suitable for one-handed use or severe fine-motor impairment. Table 2 outlines the design process involving: (1) need definition (including simulation interviews), (2) concept development and selection, and (3) prototyping and demonstration.

Table 2: Design Process Steps for the "Extreme Experience" Project in 1st Year Design (*Underlined Steps are Project Deliverables.)

Phase I: Clarify the Task
- ► Background Research – review handout, ask questions, web, experiments
- ► *Planning Project (AIM) – "Team To-do List" or "Action Item Matrix (AIM)"
- ► *Customer Needs Interviews – ask people what they need
- ► Requirements List – list what the final design must do & be

Phase II: Develop Concepts (& Select)
- ► *Functional Outline – divide problem into functions to solve
- ► Brainstorming – verbal &/or graphical
- ► *Solutions Grid – list as many ideas as possible (per function)
- ► *Concept Choices – define concepts to choose among
- ► Concept Selection - pick the best solution to move forward with

Phase III: Embody (Implement) Concept
- ► Flowcharting & Programming
- ► *Prototyping (Building) – NXT kits, online reference guides
- ► Test Requirements List – refine design as needed, trouble-shooting
- ► *Communicate Results - class demonstration, memo, video, web

Table 3 shows the interview procedure demonstrated live in class. The instructor interviews a student volunteer and types notes into the template (Figure 3) projected overhead. The interview method combines three needs elicitation techniques; an *articulated use* interview finishes with *like/dislike* questions, and then is repeated under an *"extreme experience"* simulation of disability. Throughout the interview customer comments are recorded in the template and actions or interviewee questions are shown in brackets as shown in Table 4. In step #2 the "voice of the customer" interview notes are translated into positive, solution-independent need statements such as "easy to use with limited motor control" and given an importance rating such as "must" or "nice." In step #3 each team distills their interview data into a needs summary list similar to that shown in Table 5. The list shown in Table 5 is actually a "uniform customer needs list" distilled from the entire class's data by the instructor and distributed as a common grading basis across all teams.

Table 3: Interview Procedure

1. Interview 3+ people
    a. Record <u>normal usage</u> interview transcript (two hands used normally)
    b. Repeat Q's#2-5 with <u>*Extreme Experience*</u> usage (one-handed with an oven mitt or equivalent) *Important*: clearly separate parts a & b in transcript
2. Add translated needs & weights to transcripts
3. Compile a separate needs summary list (~5-15) (Add any additional needs the team has discovered)

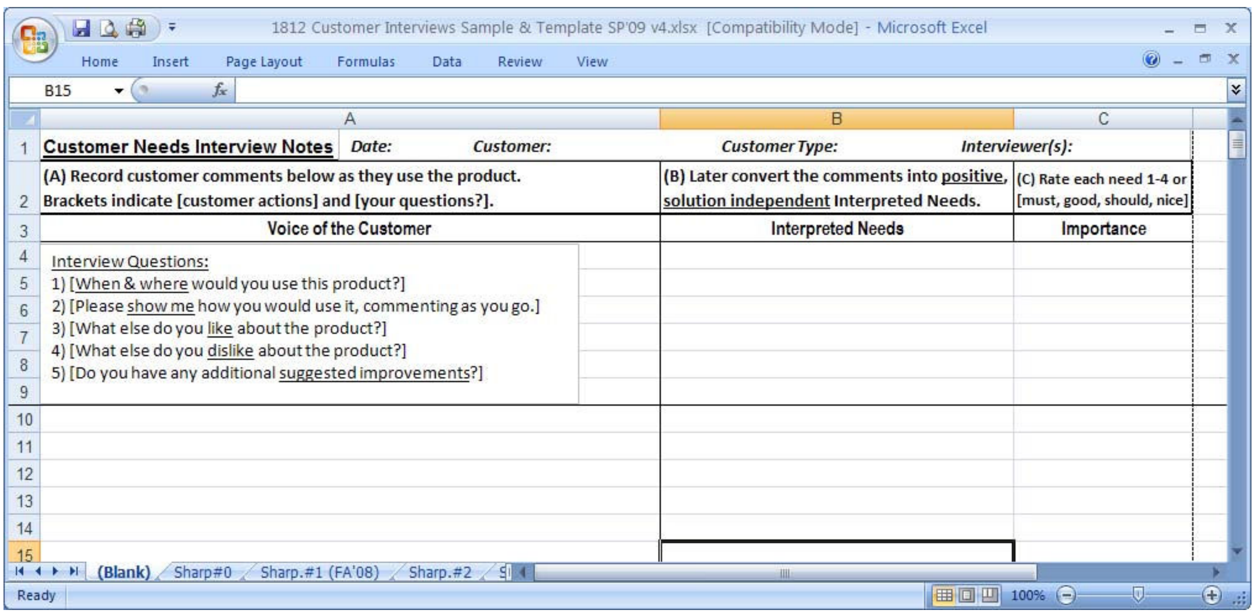

Figure 3: Customer Needs Interview Template Provided to Students

Table 4: Sample Interview Transcript with Interpretation and Importance
(Adapted from Team #34, SP'09)

Voice of the Customer	Interpreted Need	Importance
Q1: <u>When & where</u> would you use this product?		
I would use it in a kitchen	Suitable for countertop	4
to make something to drink or quickly chop food	Can mix or blend food/liquid	4
Q2: Please <u>show me</u> how you would use it ...		
[first takes off lid]		
[insert ingredients]	Place to insert ingredients	4
[pushes button]		
likes this	Easy to operate	2
Q3: What else do you <u>like</u> about the product?		
it looks really cool	Stylish/Attractive	1
It's very lightweight	Portable	1
*****EXTREME EXPERIENCE (One hand & oven mitt)**		
Q1: <u>When & where</u> would you use this product?		
Q2: Please <u>show me</u> how you would use it ...		
[shakes violently]	Easy to remove lid	3
[container falls to the table]	Container stays attached to unit	3
[uses "thumb" holder]	Easy to pickup	3
...		

Table 5: Uniform Customer Needs List (Adapted from Class Needs Lists, Fall'08)

Customer Need	Weight (5=Must)
1. Functionality	
1.1. Mixes contents well	5
1.2. Cup held stationary	5
1.3. Variable speed	1
1.4. Works with different cups	1
2. User Interface	
2.1. Easy to operate w/ limited hand usage	5
2.2. Simple/easy to understand controls	4
2.3. Little strength and grip required to move	3
2.4. Auto-reset	1
3. Cleanable	
3.1. Easily cleanable parts	4
3.2. Dirty parts detach	3
3.3. Non-stick surface	1
4. Stability	
4.1. Stays upright and in place when used	5
5. Aesthetics and Size	
5.1. Compact for easy storage	3
5.2. Aesthetically pleasing	2

4 Results

4.1 Student Survey Results

Students rated agreement on a 1-5 scale for the survey prompts in Appendix B. Response rates for 1st year Cornerstones Design range from 21 to 25 (in sections with ~30 students.) The response rate for 3rd year Design Methods is 11 out of 11. The total sample size is 103.

Students in 1st year Cornerstones Design completed the survey after the mixer-blender "extreme experience" design project, and students in 3rd year Design Methods completed the survey after the semester-long reverse-engineering re-design project. Appendix C presents average survey scores for each course section and Table 6 provides the average of all five sections.

Table 6, Section (A) summarizes student's background. Questions A1 and A2 on prior design experience and experience with special needs receive almost neutral cumulative average responses. The average score of question A3=2.7 (lower is better) is a concern indicating clearer teaching is needed on the distinctions between the benchmark "normal" articulated-use interviews and the extreme experience interviews. This survey response agrees with the fact that some of the customer interview data submitted did not distinguish between extreme experience interviews and the benchmark interviews. The improvement in this score from FA'08 to SP'09 is likely due to improved classroom teaching, and the surveys indicate additional improvement is needed. The score of question A4=3.4 indicates students enjoyed the design-for-disability theme of the project.

Table 6, Section (B) responses refer to the benchmark "normal" articulated-use customer interviews (using both hands normally), and indicate students understand and like the technique and would like to re-use it on future projects. Responses also indicate the interviews enhance understanding of customer needs and in some cases lead to good design ideas.

Table 6, Section (C) responses refer to the extreme experience interviews (e.g. one-handed with oven mitts). Similar to the "normal" interviews, the surveys also indicate students understand and like the extreme experience interview technique and would like to re-use it on future projects, with agreement ranging from 3.8 to 4.0. Question C6=3.1 "… made me more interested in an engineering career" suggests the interviews did not increase or decrease interest in engineering careers on average. One of the most significant responses is C7=4.0 indicating students believe the extreme experience interviews "*inspired ideas that are better for average users as well*." The extreme experience interviews occurred immediately after the normal customer interviews, and therefore student ratings are based to some extent on the *additional value* added by the extreme interviews.

Table 6: Student Survey Results (FA'08 and SP'09 Cumulative; n=103)
Scale: 1) Strongly disagree, 3) Neutral, 5) Strongly agree.

(A)	General		Cumulative Average
1	I have done very little design before this class.		2.7
2	I have experience with people with special needs such as physical disabilities.		2.9
3	The three interviews (normal, one-hand, over mitts) all blurred together into one.		2.7
4	I enjoyed designing for people with special-needs such as arthritis or a newborn.		3.4
(B)	**Normal Customer Interview (both hands, normal)**		
1	I understand customer interviews well enough to use them in a future project.		4.0
2	I like the customer interview technique for finding design needs.		3.9
3	I would like to do customer interviews next time I am designing for a customer.		3.9
4	Customer interviews helped me better understand customer needs.		4.2
5	Customer interviews gave me good design ideas.		3.8
6	Customer interviews made me more interested in an engineering career.		3.1
(C)	**Extreme Experience Interview (e.g. one-hand, oven mitts)**		
1	I understand extreme interviews well enough to use them in a future project.		4.0
2	I like the extreme interview technique for finding design needs.		3.8
3	I would like to do extreme interviews next time I am designing for a customer.		3.8
4	Extreme interviews helped me better understand customer needs.		4.0
5	Extreme interviews gave me good design ideas.		3.9
6	Extreme interviews made me more interested in an engineering career.		3.1
7	Extreme interviews inspired ideas that are better for average users as well.		4.0

Table 6 shows that cumulative survey scores for the benchmark articulated-use interviews (section B) are almost identical to survey scores for the extreme experience interviews (section C). A review of the per-section data in Appendix C shows that this pattern is broken only in one section of 3rd year Design Methods (DZ.1) in Spring of 2009, which is summarized in Table 7. In that specific semester the extreme experience interviews receive lower ratings than any other semester, and the benchmark articulated-use interviews receive higher ratings than any other semester, thus giving a ~0.5 point difference on most items. More data is needed to draw strong conclusions since this relatively small (n=11) data set is the only one from 3rd year students.

Table 7: Student Survey Results (SP'09 3rd Year Design Methods; n=11)
Δ (C-B) = (Extreme Experience Interview Scores – Benchmark "Normal" Interview Scores)

		DZ.1 SP'09	
(C)	**Extreme Experience Interview (e.g. one-hand, oven mitts)**	**AVG**	**Δ (C-B)**
1	I understand extreme interviews well enough to use them in a future project.	3.8	-0.4
2	I like the extreme interview technique for finding design needs.	3.6	-0.5
3	I would like to do extreme interviews next time I am designing for a customer.	3.6	-0.4
4	Extreme interviews helped me better understand customer needs.	3.9	-0.5
5	Extreme interviews gave me good design ideas.	3.7	-0.5
6	Extreme interviews made me more interested in an engineering career.	3.0	-0.2
7	Extreme interviews inspired ideas that are better for average users as well.	3.8	n/a

Three students in 1st year Cornerstones Design and 6 students in 3rd year Design Methods wrote survey comments. The first-year design students mentioned a slight disconnect between interviewing with an off-the-shelf blender and yet designing a different product, a "mixer." The 3rd year Design Methods students described the extreme experience interview simulations performed including: using a *camping stove in the dark* (highlighting the need for simplicity and night visibility of controls and food), using a *car air compressor in the dark with bulky gloves*, and using a *closed fist to feed a paper shredder*. One comment noted that blindfolded users seemed unaffected if they were "technical" but "had lots of difficulty" if they were non-technical.

4.2 Comparison of Customer Needs Analysis with and without Extreme Experience Interviews

Customer interview data was gathered from 26 design teams, each of which followed the procedure described in Section 3 to gather customer needs for a countertop mixer-blender. The mixer-blender is intended for use by one-handed users and users (e.g. mothers with a baby in one arm) and users with dexterity disabilities. Significant differences were observed between the results of the "normal" benchmark articulated-use interviews and extreme experience interviews. The benchmark interviews elicited the types of customer needs that one would expect to find for a countertop mixer-blender. A representative sample of benchmark customer needs is documented in Table 8.

Table 8: A Representative Set of Customer Needs Data from the Benchmark Interviews

- Quiet operation
- Easy to clean
- High quality blending
- Easy to assemble
- Durable (and structurally sound)
- Simple and easy to use
- Portable (easy to store, long extension cord, lightweight)
- Attractive (color, style)
- Satisfactory number of speeds
- Ease of viewing and measuring contents
- Ease of pouring
- Ergonomic (ease of using buttons, locks, etc.)
- Safe (protection from sharp blades and overheating)
- Adequate size

While the benchmark interviews elicited a broad set of customer needs, the results of the extreme experience interviews focused almost exclusively on aspects of product-user interaction. A representative set of customer comments from the extreme experience interviews are documented in Table 9. As reflected in the table, customer needs were often expressed in much more detail in the extreme experience interviews; for example, customers often commented on the spacing of buttons and the size and location of handles rather than simply summarizing their thoughts with comments on good or poor ergonomics. Also, it was apparent that many of the customer needs were linked specifically to the impairments (oven mitts and one-handed operation). These impairments made it very difficult to remove a jar/bowl from its base, remove/replace the lid, disassemble components for cleaning, and sometimes perform even basic operations such as switching the unit on or off and selecting speeds.

Table 9: Representative Customer Comments from Extreme Experience Interviews

- The unit is difficult to disassemble and clean. (It was often extremely difficult to remove blades or clean the device with one hand, for example.)
- The base and/or cup needs to be stabilized.
- It is difficult to pick up the machine and move/store it. (Many blenders have no handles and easily separate into pieces if grasped with one hand.)
- The unit is too heavy (for one-handed transport and operation).
- The buttons are too small and spaced too closely together. It is difficult to determine whether a button is pressed and, if so, which button is pressed.
- It is difficult to remove/replace the lid. It is difficult to twist and lock a lid with one hand. Also, when the lid is on, it is impossible to secure it and operate the buttons at the same time with only one hand.
- It is difficult to plug/unplug the unit for customers with arthritic hands and limited dexterity.
- It is difficult to grab the jar/cup/bowl and stabilize it on the counter.

One of the most interesting aspects of the extreme interview results was the frequency with which customers offered redesign options for fixing the perceived negative aspects of the product. In fact, *customers made approximately twice as many redesign suggestions during extreme experience interviews* relative to benchmark interviews. This increase occurred despite the fact that the extreme experience interviews always followed regular interviews, which presumably exhausted some of each customer's redesign ideas before the extreme experience interview began. Table 10 documents some of the redesign suggestions obtained during the extreme experience interviews.

Table 10: Redesign Suggestions Obtained during Extreme Experience Interviews

- Add bigger tabs on the lid for ease of removal. Alternatively, use a push (spring-loaded) opener to make it easier to remove a lid.
- Use raised edges and/or depth to make it easier to retrieve lids from a surface.
- Space out the buttons, make them larger, and make them protrude more prominently from the surface of the unit. Alternatively, replace the buttons with dials that are easier for arthritic hands to operate. Voice-activated controls were also suggested.
- Add automatic shutoff features and/or timing features to prevent the need for continuous pressing of a button. Alternatively, add buttons to the top of the unit to enable users to depress buttons and the lid simultaneously.
- Provide a stand or holder for supporting the cup/jar/mixer and preventing spills. For some portable handheld mixers that are inserted into cups, customers suggested attaching the mixer to a fixed base and moving the cup rather than the mixer. A swing arm was suggested for moving the mixer rather than the cup.
- For ease of cleaning, customers suggested auto wash cycles with water.
- Dispense liquid from the bottom of a jar/cup with a spout to make it easier to pour liquids.

These preliminary results provide evidence that extreme experience interviews are helpful not only for uncovering a much more comprehensive set of customer needs, especially with respect to product-user interactions, but also for obtaining innovative redesign suggestions from customers themselves.

5 Conclusions and Future Plans

Exposing students to frontier design scenarios beyond their experience and expertise, such as persons with disabilities, can serve as rigorous design training comparable to strengthening grammar through foreign language learning. Including design for disability projects in the curriculum potentially has multiple long-term benefits including increasing awareness of the needs of disabled persons and better-trained engineering designers able to deal with frontier environments. In addition to possible long-term benefits, this paper suggests that design for such niche "frontier" needs may have an immediate impact – better designs for everyone.

Results include a summary of student surveys, analysis of customer needs before and after extreme experience interviews and a qualitative review of re-design ideas generated. The surveys show students understand and like both the "normal" benchmark articulated-use interviews and the extreme experience interview technique and would like to re-use them on future projects. Surveys also indicate strong agreement that extreme experience interviews "*inspired ideas that are better for average users as well*." An examination of interview transcripts shows the extreme experience interviews are valuable not only for uncovering a much more comprehensive set of customer needs, especially with respect to product-user interactions, but also for obtaining innovative redesign suggestions from customers themselves. The results collectively show extreme experience interviews are an effective and valuable addition to the design process in these courses, with additional room for improvement in teaching technique.

The case study here ends at the proof-of-concept prototyping stage. Carrying the work further into courses which result in a more refined product that may be delivered to a customer for long-term testing is a next step. Additionally, reviewers have suggested the intermediate step of having the additional needs generated through extreme experience interviews validated by a person with the disability in consideration. Using Kano diagrams to help students visualize latent needs was also suggested. Future work may also include extending the disability simulation into other realms such as economic scarcity simulation.

References

---

[1] Lin, J. and C.C. Seepersad, 2007, "Empathic Lead Users: The Effects of Extraordinary User Experiences on Customer Needs Analysis and Product Redesign," ASME IDETC/CIE *Design Theory and Methodology Conference*, Las Vegas, NV. Paper Number: DETC2007-35302.

[2] Green, M.G., "Is Design for the Disenfranchised a Vehicle for Reciprocal Blessing?," Proceedings of the 2009 Christian Engineering Education Conference, Waco, TX.

[3] Green, M.G., 2005, "Enabling Design in Frontier Contexts: A Contextual Needs Assessment Method with Humanitarian Applications," *PhD Dissertation,* Mechanical Engineering, University of Texas, Austin.

[4] Green, M.G., J.S. Linsey, C.C. Seepersad, K. Schmidt and K.L. Wood, 2006, "Design for Frontier Environments: A Novel Methodology and Results of Classroom Integration," *ASEE Annual Conference*, 1125: Design for Community and Environment of the Design in Engineering Education Division, Chicago, IL.

[5] Mahajan, V. and K. Banga, 2005, *The 86 Percent Solution: How to Succeed in the Biggest Market Opportunity of the Next 50 Years*, Wharton School Publishing.

[6] www.census.gov

[7] Rehabilitation Engineering Research Center for Wireless Technologies, http://www.wirelessrerc.org/, (Accessed May 19, 2008).

[8] Otto, K.N. and K.L. Wood, 2001, *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, Upper Saddle River, NJ.

[9] Ulrich, K. and S. Eppinger, 1995, *Product Design and Development*, McGraw-Hill.

[10] Hannukainen, P. and K. Holtta-Otto, 2006, "Identifying Customer Needs -- Disabled Persons as Lead Users," *ASME IDETC Design Theory and Methodology Conference*, Philadelphia, PA, Paper Number: DETC2006-99043.

[11] Otto, K.N. and K.L. Wood, 2001, *Product Design: Techniques in Reverse Engineering and New Product Development*, Prentice Hall, Upper Saddle River, NJ.

Appendix A: Extreme Experience Design Project Assignment (ENGR 1812, LeTourneau U.)
(***This and related documents are freely available from the author in electronic form.***)

DESIGN PROJECT #4: Accessible Mixer-Blender

PROJECT STATMENT: Apply the three-phase design process to design and prototype a mixer-blender for one-handed users and users with dexterity disabilities. Prototype the device using your class-issued LEGO® Mindstorms kit along with up to $10 in pre-approved non-LEGO passive hardware (such as bolts, custom wood or metal parts, string, springs, etc). A proposed parts list must be pre-approved by the course instructor with normal retail prices.

CUSTOMER PROFILE: Mr. Jones is an independent-minded senior-citizen who loves to prepare health shakes. Unfortunately his severe arthritis makes thorough mixing difficult, and conventional blenders are large, awkward, and difficult to keep clean. Mr. Jones lives with his daughter who is a new mother. His daughter Emily often finds herself with the two-month-old baby in one arm, and needing to puree fresh vegetables into baby food with the other. For such small amounts of food, Emily also considers a counter-top blender large, awkward, and difficult to keep clean. Mr. Jones and Emily are convinced there is a market for their needs, and have asked a group of engineering students to design and prototype a device to help them safely and conveniently mix and puree small quantities of drink or food.

CUSTOMER INTERVIEWS: Your team will conduct customer interviews and develop a detailed needs list for the mixer-blender. Each team will either quickly construct a simple NXT prototype, or (optionally) obtain a blender to use in your interviews. The people you interview will simulate Emily's child-care needs and Mr. Jones' arthritis by using only one hand with an oven mitt on. The interviews must include both mixing and cleaning. After all teams have collected customer needs, results from the entire class will be combined into a standardized needs list to guide final design work.

FINAL DEMONSTRATION: Each team will demonstrate a final prototype for the class. A functional test will involve thoroughly mixing 50 mL (10 tsp) of powdered oatmeal with 50 mL of water in a standard size Styrofoam cup. After 5 seconds the mixing must be complete (defined as a mixture such that no water may be poured off and no dry mix remains.) Cleaning should be demonstrated or explained by the team. The class instructor will also test the prototype against the standardized customer needs list, including one-handed use with simulated arthritis (wearing an oven mitt.)

GRADED COMPONENTS: The project includes the following graded components:
1. **Design Process Checkpoints (150pts) –** These checkpoint items will be due as indicated on the schedule: (1) Action Item Matrix, (2) Customer interview data (transcripts, compiled needs list), and (3) a Solutions Grid.

2. **Design Memo (200pts)** - Describe your design approach and results according to the guidance given below. Attachments will include a device photo, customer interviews with a needs summary, function outline, solutions grid, and the first and last AIM's.

3. **Final Demonstration (200pts)** – Demonstrate the full capability of your prototype. Grading will be based on the fulfillment of minimum design requirements in addition to customer design requirements in the instructor's judgment.

DESIGN MEMO: Describe your design approach following the three phases of design: (1) Task Clarification, (2) Concept Generation and Selection, and (3) Embodiment. Explain how the team determined what should be designed (e.g. customer interviews). Identify how concepts were generated functionally, and any unusually insights or experiences. When discussing embodiment, highlight key hardware and software capabilities integrated into your device in response to the customer needs. In the text be sure to reference all of the attachment items listed below, and describe if appropriate.

- Include the following attachments, numbered as indicated:
    1. A clear, high-quality photo of your final device
    2. Customer interview transcripts (3 "normal usage" combined with 3 "EE" transcripts)
    3. Customer needs summary list
    4. Function outline
    5. Solutions grid (with chosen solutions indicated)
    6. Printout of any LabVIEW program(s) used (print using *File>Print>VI Documentation*)
    7. AIM's - initial and final

- Use a memo format consistent with those recommended in the course textbook. Memo fields should include a minimum of the: instructor's name, author's names (with signed initials), due date, assignment name, and "ENGR 1812, Team #__".
- The text should be a maximum of 2 pages in length (printed on one side only), 1.5 spaced, with an 11-point font or greater and one inch margins all around. This does not include attachments. Use paragraph and section headings as appropriate.

SCHEDULE (Tentative):

L#	MW	TTh	Assignments Due	Class Topics/Activities/Assignments
20	3/23	3/24		**P4: Final Design Project (Customer-Driven)** Lec: AIM & Customer interviews
21	3/25	3/26	AIM P4 #1	P4 Q&A Example FO, SG, & Concepts
22	3/30	3/31	P4 HW: 3*2 interview transcripts w/ translations P4 HW: Needs summary list (submit both assignments by printout + **email**)	
23	4/1	4/2	P4 HW: function outline, solutions grid	[LV Quiz Prep.]
24	4/6	4/7	[Quiz5: LabVIEW]	TBA
25	4/8	4/9		TBA
26	4/13	4/14	Demo: P4 Final Prototype Memo: P4 Design Memo w/ final AIM	←
27	4/15	4/16	Check in MLT + Kit w/ Inventory (signature req.)	

Appendix B: Extreme Experience Design Project - Student Post-Survey

This survey is **anonymous and voluntary**. Only the average results of all surveys will be shared. No individual results will be reported. Do not sign your name. The results of this survey will help improve design courses. Thank you for taking a moment to complete this – *your response is appreciated!*

0. How many total LETU semester hours did you have when this semester began?
(a) 0 hours (b) 1-30 (c) 31-60(d) 61-90 (e) 90+ hours

1. Please circle your gender (optional): Male / Female.

2. What is your current *first choice* of a degree concentration (circle one)?
(a) ME (b) MET (c) BME (d) EE
(e) EET (f) CE (g) MJE (h) MJET
(i) Other: ____________ (j) Undecided

Please indicate whether you agree or disagree with each statement by placing a √ in the appropriate column to the right.

		1) Strongly disagree.	2) Disagree.	3) Neutral.	4) Agree.	5) Strongly agree.
		××	×	😐	✓	✓✓
1	I have done very little design before this class.					
2	I have experience with people with special needs such as physical disabilities.					
3	The three interviews (normal, one-hand, over mitts) all blurred together into one.					
4	I enjoyed designing for people with special-needs such as arthritis or a newborn.					
These question are for the normal customer interview (both hands used normally)						
1	I understand customer interviews well enough to use them in a future project.					
2	I like the customer interview technique for finding design needs.					
3	I would like to do customer interviews next time I am designing for a customer.					
4	Customer interviews helped me better understand customer needs.					
5	Customer interviews gave me good design ideas.					
6	Customer interviews made me more interested in an engineering career.					
These question are for the extreme experience interview (one-hand, oven mitts)						
1	I understand extreme interviews well enough to use them in a future project. 					
2	I like the extreme interview technique for finding design needs.					
3	I would like to do extreme interviews next time I am designing for a customer.					
4	Extreme interviews helped me better understand customer needs.					
5	Extreme interviews gave me good design ideas.					
6	Extreme interviews made me more interested in an engineering career.					
8	Extreme interviews inspired ideas that are better for average users as well.					

Please write any additional comments or suggestions on the back of this page. ➔

Appendix C: Student Survey Data: FA'08 and SP'09

		CUMM.		FD.1 FA'08		FD.1 SP'09		FD.2 SP'09		FD.3 SP'09		DZ.1 SP'09	
SCALE: 1) Strongly disagree. 3) Neutral. 5) Strongly agree.	Sample size (n):	103		22		25		21		24		11	
#	Prompt	AVG	Δ	AVG	Δ	AVG	Δ	AVG	Δ	AVG	Δ	AVG	Δ
(A)	**General**												
1	I have done very little design before this class.	2.7		2.7		3.1		2.9		2.8		2.1	
2	I have experience with people with special needs such as physical disabilities.	2.9		3.1		2.8		3.1		2.8		2.8	
3	The three interviews (normal, one-hand, over mitts) all blurred together into one.	2.7		3.0		2.7		2.7		2.7		2.6	
4	I enjoyed designing for people with special-needs such as arthritis or a newborn.	3.4		3.7		3.3		3.2		3.5		3.3	
(B)	**Normal Customer Interview (both hands, normal)**												
1	I understand customer interviews well enough to use them in a future project.	4.0		3.9		4.1		4.0		3.9		4.2	
2	I like the customer interview technique for finding design needs.	3.9		4.0		3.6		3.8		4.2		4.1	
3	I would like to do customer interviews next time I am designing for a customer.	3.9		3.9		3.6		3.8		4.1		4.0	
4	Customer interviews helped me better understand customer needs.	4.2		4.0		4.2		3.9		4.3		4.4	
5	Customer interviews gave me good design ideas.	3.8		3.5		3.9		3.6		4.1		4.2	
6	Customer interviews made me more interested in an engineering career.	3.1		3.1		3.0		3.1		3.2		3.2	
(C)	**Extreme Experience Interview (one-hand, oven mitts)**		C-B		C-B		C-B		C-B		C-B		C-B
1	I understand extreme interviews well enough to use them in a future project.	4.0	-0.1	3.9	-0.0	4.1	+0.0	4.2	+0.2	3.8	-0.1	3.8	-0.4
2	I like the extreme interview technique for finding design needs.	3.8	-0.1	3.7	-0.3	3.9	+0.2	3.9	+0.1	4.2	+0.0	3.6	-0.5
3	I would like to do extreme interviews next time I am designing for a customer.	3.8	-0.1	3.7	-0.2	3.7	+0.1	3.8	-0.0	3.9	-0.2	3.6	-0.4
4	Extreme interviews helped me better understand customer needs.	4.0	-0.1	4.0	-0.0	4.0	-0.2	4.0	+0.1	4.3	-0.0	3.9	-0.5
5	Extreme interviews gave me good design ideas.	3.9	+0.0	3.6	+0.2	4.0	+0.1	3.8	+0.2	4.3	+0.2	3.7	-0.5
6	Extreme interviews made me more interested in an engineering career.	3.1	-0.0	3.1	+0.0	3.1	+0.0	3.1	+0.0	3.3	+0.0	3.0	-0.2
8	Extreme interviews inspired ideas that are better for average users as well.	4.0	n/a	4.0	n/a	3.8	n/a	4.0	n/a	4.2	n/a	3.8	n/a