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Beyond Surface Knowledge: An Exploration of How Empathic Design Techniques Enhances Engineers Understanding of Users' Needs*

DIANA BAIRAKTAROVA
Engineering Education, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA. E-mail:dibairak@vt.edu

WILLIAM Z. BERNSTEIN
School of Mechanical Engineering, Purdue University, West Lafayette, Indiana, 47907, USA. E-mail: wbernste@purdue.edu

TAHIRA REID
School of Mechanical Engineering, Purdue University, West Lafayette, Indiana, 47907, USA. E-mail: tahira@purdue.edu

KARTHIK RAMANI
School of Mechanical Engineering and School of Electrical and Computer Engineering (by courtesy), Purdue University, West Lafayette, Indiana, 47907, USA. Email: ramani@purdue.edu

This study explores the role of empathic design techniques on solving design problems in a developing world context. In our study, over 100 graduate students were asked to individually conceptualize and design an extremely affordable washing machine to be used in developing countries. All participating students, many of whom had significant industry experience, were enrolled in a graduate-level product design course. This course is as much about design thinking and learning as it is about design innovation, creativity and doing design. The design of an artifact is addressed from a multidisciplinary perspective that includes determination through inspiration, ideation, and implementation using a design thinking framework. Student submissions were categorized based on (1) design methods such as concept generation, product definition, prototyping and design verification, and (2) student demographic information. The application of the design methods on the project influenced the further development of class-based exercises that infuse empathy into design. The study presented here also provides a framework for engaging distance-learning students within hands-on empathic-design exercises. The results show that techniques such as interviews of focus groups and immersive practices help students to better understand user needs in developing world contexts, leading to more feasible design solutions. Visual thinking was also linked as an effective means to engage students in empathic design without the use of physical materials.

Keywords: empathic design; engineering education; distance learning

1. Introduction

Practically every engineering firm has a code of conduct for its employees. Within these organizations, engineers are expected to factor in social considerations into everyday decisions. Top-down approaches, such as programs from management, to incorporate social considerations within design rarely reach junior engineers due to complex and deep organizational hierarchies. Targeting the skill-sets of young engineers, engineering curricula-based educational models have been instituted in order to infuse social responsibility into existing engineering programs [1–3]. However, current engineering curricula are already filled with traditional (and irreplaceable) courses, e.g. heat transfer and thermodynamics, where few address social responsibility. The advantages of soft engineering skills, e.g. leadership, environmental sustainability, and management, for success in industry have widespread support [4]. Furthermore, concepts and principles associated with empathic design share parallels with sustainability, specifically in a social context, presenting further motivation for helping students learn empathic design. However, there still remains a significant gap in the research community to infuse empathic design into the curriculum without disrupting traditional engineering pedagogy, and for ways to impart this to distance education students.

This paper presents an effort within a graduate product design course at Purdue University, in which the authors explored a new perspective to disseminate empathic design thinking within a design assignment. This course is part of the distance-learning program and about two thirds of the students enrolled are taking it from a distance. Each student was provided the task of designing a human-powered washing machine to be used in developing countries. In the context of this work, developing countries were identified as low-income countries with rural, non-industrialized areas, and limited resources. The students were encouraged to use various tools that were presented throughout

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the course, including empathic design frameworks and visual thinking techniques.

Results of this exploratory study suggest that there is potential in cultivating user-centered design skills for distance learning students through the introduction of empathic design thinking in design. The design module presented here can serve as a step towards conducting empathic design problems in a distance learning setting, where physical resources are often limited and rely on materials found in a student's home. Additionally, the process of globalization in the context of design presents diverse user contexts that lead to unique product requirements. As an example, portable washing machines designed in the US cannot be adopted in India due to various factors, such as a lack of clean water, affordability/the need to make products at extreme low cost, local materials use and repairability, need for manual operation, as well as hygiene-related concerns. It is our hope that those who participate are motivated to adopt relevant design techniques into their everyday engineering practices.

The rest of this paper is divided as follows: Section 2 and 3 continues with the Motivation and Related Work; Section 4 discusses the Methodology; Section 5 presents results; Sections 6 and 7 discusses the results and conclusions.

2. Motivation

In order to remain an accredited engineering program, ABET requires specific student outcomes related to social responsibility, including "an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability", pg.1 [5]. The importance of this notion was reaffirmed with a 2006 report by researchers at Penn State University detailing the outcomes of ABET's EC2000 program pushing towards more inclusion of social consciousness within engineering programs [6]. The study compared the then-current student performance in key accreditation areas with respect to 1994 data. Therein, the authors showed that awareness of societal and global issues that can affect engineering decisions as well as awareness of issues relating to professionalism was among the top 5 improved areas judged directly by student outcomes.

Within design tasks, however, students have difficulty in connecting social consciousness with user needs. Often, when students are responsible for identifying customer needs, their efforts are limited to the results of surveys and focus groups, in which relevant data is collected early in the design process often without subsequent iterations. Students typically treat the customer as a list of requirements that serve as an input to the design process. Within this context, interventions are needed to help students better think through details beyond survey results striving towards socially conscious levels of understanding. Designers need both domain-specific knowledge and situation-relevant strategies to design effectively [7]. As an example, costumer observation through videos present preference-related knowledge that are difficult to procure at focus groups and interviews. Leonard & Rayport (1997) report the elicitation of intangible attributes of products through video, e.g. the smell of detergent products evoking feelings of nostalgia [8].

It is apparent that students need to know how customer information influences the design of products and systems even when the human-centered details are not explicit. This thinking can be enabled through an increased level of social consciousness, or an awareness of the impact that design decisions could have on the cultural, social, and emotional aspects of the end-users. The commitment and empathic design levels [9] as well as elements of compassionate design [10] foster this type of thinking. It should be noted that socially conscious design thinking is not limited to problems related to developing countries and users with disabilities but also encompasses everyday "first-world" design contexts. However, in situations where the designers lack exposure to end-users, the mapping between user needs and product attributes is non-trivial and challenging for students.

Our goal here is to introduce a non-intrusive learning module in an existing design class that elicits user-centered design thinking. In our previous work, a product design course was supplemented with a critique module in order to illustrate that concepts related to sustainability can be effectively infused into an existing course framework while maintaining original learning objectives [11]. Here, we employ a similar technique by using an individual design assignment to explore the effectiveness of teaching social consciousness along with salient sustainability and empathy trends to a group of geographically distributed students. The impact associated with disseminating empathic design thinking within a distance class is significant, since many students have positions in industry in leading engineering firms, e.g. Boeing, Whirlpool, and General Electric. If students acquire adequate empathic design thinking skills, they will be more likely to incorporate related principles within their professional work. Within this context, it is critical to use a design activity that can be distributed to distance learning students, whose resources may be limited.

3. Related work

In this section, we review existing efforts for incorporating socially conscious thinking into both engineering practice and curricula. Schinzinger et al. contend that engineering work should be viewed as social experimentation [12]. Although ABET requires US engineering programs to demonstrate that their graduates have an understanding of social responsibility [13], very few courses provide formal training or opportunity for these skills to be developed. Most often such training is found in elective courses and are not part of the required core curriculum. We believe that incorporating empathic design techniques in engineering design courses is an appropriate pedagogical approach considering that the inclusion of empathic design thinking can influence a broad range of design projects, including products that lack an explicit connection to the developing world, e.g. high performance washing machines.

3.1 Understanding users through empathic design

Understanding user needs and customer preferences is critical to the design process [14–16]. Although it is well known that designers often rely on intuition and experience in the design process [17, 18], there are some contexts in which it is unrealistic for designers to rely upon their own experience and knowledge when designing for others [19]. Thus researchers from the engineering design community have developed methods and models for quantifying customer needs and preferences in various design contexts [20–23]. However, these studies focus primarily on customer's choices for actual products, and do not lend themselves well to empathic understanding in designers.

In general, empathic design frameworks can be related to ethical and socially conscious thinking. These methods have been developed to help designers build a general intuition and understanding of these latent customer needs by providing a platform in which designers experientially gain insights about their target customers [24] through targeted experiences [25]. Kouprie and Visser (2009) argue that in order to truly perform empathic design, four engagement phases by the designer are necessary: Discovery, Immersion, Connection, and Detachment. The process is centered around the designer approaching the user with a heightened sense of curiosity (Discovery), wandering around in the user's world (Immersion), recalling their own memories that match aspects of the users world (Connection) and leaving the users world in order to design from afar (Detachment) [26].

Service-based learning and immersive experiences have been noted as one of the best approaches for enhancing students' sensitivity to stakeholder needs [27]. This approach has been used in the context of students designing medical devices for individuals in third world countries [28] as well as designing playground equipment for children with disabilities at summer camp [29]. In other disciplines, nursing students developed cultural competencies through immersive experiences [30]. One of the challenges with service-based learning and immersive experiences is the cost and time associated with them [28]. Implementing these practices in large lecture size classes as well as distance learning environment would be difficult to manage.

Another framework, the Empathic Experience Design (EED) Method [31, 32], was tested with a group of senior-level student volunteers. Their task was to improve the design of existing alarm clocks and litter collectors with the goal of generating innovative concepts that met the addressed needs of their target users. A unique contribution of this work is that they provided a formal method that could be used during the conceptual design phase of the design process, whereas others focused more on the problem definition phase. However, this method was conducted in a laboratory context and focused primarily on re-design tasks. To the best of our knowledge, there has not been any efforts for disseminating instruction with respect to empathic design within a geographically distributed class, specifically relevant to the concept design phase.

3.2 Educational models

As stated above, there have been a number of efforts for incorporating existing design frameworks within the classroom. Here, we present additional educational models, including curricula and program reform. Zoltowski et al. present their extensive efforts through the EPICS program that focuses on human centered design [9]. Mehalik et al. (2008) presented a new course that focused on "Product Realization for Global Opportunities" to infuse sustainability and product realization into undergraduate curriculum [34]. Nieusma and Riley present several case studies of universities near developmental opportunities, e.g. Sri Lanka and Nicaragua, partnering with US universities targeted at engineering for development. This further motivates the importance of social sustainability [35]. Viswanathan et al. present their efforts at the College of Business in the University of Illinois at Champaign as a product innovation course targeted at the bottom of the pyramid. They develop the context mainly focused on subsistence and sustainability [36].

The connection between sustainability and empathic design becomes evident when considering additional efforts. These studies range from curri-

culum reform, pedagogy of eco-design, embedding sustainability-related principles into existing courses [12] and beyond. Green et al. presented a framework for understanding ''frontier design'' in high human-need projects, essentially connecting social sustainability with empathic design [37]. Boks et al. present the overhauled TU Delft curriculum that offers entire courses targeted at eco-design as well as modifications of existing courses to include relevant principles [38]. Therein, the authors suggest that the principle of corporate social responsibility (CSR) is vital in order to encompass a holistic sustainability perspective. Furthermore, Hutchins et al. suggest that CSR has a direct influence with ethical behavior of engineers, further motivating its inclusion in the classroom [39].

Matching similar studies to the related issues of social consciousness and empathy seems to not be as prevalent. In the specific context of extreme affordability, the connection between user-centered design and sustainability is rather concrete based on the literature presented above. One of the aims of this paper is to link user-experience design and sustainability with an appropriate educational framework. Within this study, we aim to use the design context of developing countries to engage students within complex empathic design thinking.

4. Methodology

We present a general framework for implementing empathic design thinking into the engineering classroom, particularly applicable for situations with large enrollment and a geographically distributed student population. Here, we describe the existing course's structure and the student assignment distributed.

4.1 Case study: product design course

This study was conducted within an existing graduate-level product design course at Purdue University. It should be noted that undergraduate students also take the course as a technical senior elective. This course serves as a staple in the distance learning program, in which non-traditional students earn masters degrees in engineering from afar, typically while working in industry. The course comprises a project that contributes to over 50% of students' final grades and a month-long individual design assignment representing 30% of the students' final grades. In the Spring semester, each student was provided the task of designing a human-powered washing machine to be used in developing countries. The students were encouraged to use various tools that were presented throughout the course, e.g. design thinking [14], business models [40], sketching techniques [41], and thinking related to the bottom of the pyramid [42].

4.2 Participants

Graduate and undergraduate engineering students from Purdue University (N = 103) completed an online study survey as part of an on-line mass-testing session at the middle of a fall semester. The on-line survey consisted of demographic questions, including information regarding gender, work experience, and global experiences. The median age of participants was 26 years (range: 18–44), the majority of whom were taking the course from afar and were practicing engineers (75%). Twenty-three (23%) percent of the sample was Female and 60% were White.

4.3 Judging criteria

Each submission was judged by two different experts, in various areas related to product design, e.g. design thinking, eco-design, kinematics, and engineering education, in order to ensure inter-rater reliability. The final scores were calculated by shifting means of each individual grader to a mean representative of the course. It should be noted that the distribution types of each grader were similar. Each grader's assessments were representative of a normal distribution. The success of a project was measure based on 6 main criteria:

1. Ability to recognize user needs and product requirements using appropriate methods and frameworks.
2. Ability to identify, inspire, and ideate potential concepts.
3. Effectiveness in using methods related to visual thinking throughout your design process, e.g. sketching, visual maps, storyboarding, etc.
4. Effectiveness in communicating your ideas, concepts, strategies, etc.
5. Feasibility of your final design in terms of manufacturability, deployment and use.
6. Effectiveness in presenting and organizing the final report.

The experts tagged submissions based on their subjective assessment of submissions based on empathic design criteria. These tags were used to trace specific design exercises to student outcomes. The judges were given a standard set of criteria and were coached before assessing the submissions. For example, if the ''student recognized and articulated the importance of social and environmental responsibility as an essential component of socially consciousness reasoning,'' the submission would be tagged as one that exhibited some form of empathic design reasoning.

4.4 Predictions from the study

We expected that those that used empathic design techniques would submit better solutions in this specific design context. We also expected that culture and life experience would significantly impact solutions in the context of projects for extreme affordability. For example, students with global experiences were expected to perform better in identifying user needs in a developing world context.

4.5 Research questions

Since this study was mainly an exploratory one, we present several research questions below and attempt to both quantitatively and qualitatively assess our general hypotheses.

Q1: Which empathic design techniques lead to better solutions in the context of projects for extreme affordability?
Q2: Does ethnicity, nationality, gender and/or work or personal travel experiences significantly impact solutions in the context of projects for extreme affordability?
Q3: Is it feasible to use a supplemental assignment in order to infuse empathic design thinking into an existing course?

In the next section, we focus on discussing salient observations through submissions in the context of these research questions and their connection towards future work in this effort.

5. Findings

Findings from this study are fundamental to our understanding of embedding empathic design techniques seamlessly into a product design class. Within this section, we explore the takeaways associated with the study. In general, we can categorize our significant takeaways into three topics: context, empathic design, and visual thinking. The instructors have little control over exactly how these graduate-level engineers solve problems. Only through lectures and minimal communication, e.g. e-mail, can we promote certain activities. Hence, it was interesting to assess how students use particular aspects and material from a product innovation course. It turns out that there were a wide variety of design techniques used to solve the given design task.

It should be noted that there was no significant correlation between students' demographic background, gender, and life/work experience and the outcome of the projects (total project score). Our observed results are rather counter intuitive. We expected that those who were labeled as having more global and life experiences would have exhibited much clearer empathic design thinking in the assignment. Based on the existing literature and the essence of the task, we also expected that female students would better identify user needs and develop better project by incorporating empathic design techniques. Instead, we saw little relationship between students' demographic background, gender, and life/work experience and their solutions in this specific design context. These results may suggest that regardless of past experiences and background, student performance and understanding of user needs can be learned through targeted exercises. Here we present observations based on this assignment.

5.1 Context

It is apparent through observations of students work that the context associated with a given design problem is crucial for eliciting empathic design thinking within engineering students. Here, we employ an extreme affordability context for the design of alternatively powered washing machine. In this design problem, students have little-to-no experience within the target user experience, i.e. washing clothes by hand with little access to water. In order to gain insight into the set context, several methods by students were observed, including empathic design and visual thinking paradigms. In this section, we discuss the various outcomes in order to steer a larger more comprehensive educational model towards socially conscious, empathy-driven thinking.

5.2 Empathic design

From a qualitative perspective, it is evident that students who used empathic design approaches developed more meaningful and feasible designs. In effect, students developed separate mental models that distanced their own environment from the problem. In other words, students implemented various techniques to "walk in the shoes" of rural-based people in developing countries. Examples of students' use of empathy include: (1) text-based testimonies, (2) observation through videos or photographs, (3) empathy maps, (4) interviews and focus groups, and (5) immersive practices. Each are described below.

5.2.1 Text-based testimonies

The most common form of empathy employed was simply using free writing in a diary-like format about the hardships of hand washing clothes with little access to water and electricity. Some common insights within these testimonies include hand, back, and neck pain with the washers, and allotted time associated with such practices. It is possible

that students who wrote textual testimonies were inspired by photographs or videos found outside the class, but they chose not to include them in their submissions. Examples of textual testimonies from student submissions can be found below:

> "Parita is a mother of 4 children living in an underdeveloped part of India. She scrubs each article of clothing individually on a Rocky River bank in order to get her lightly soiled clothing clean. She then has to ring out her clothing by hand and carry it back to her house to hang on a clothing line to dry. These wet clothes, even after being rung out to get rid of the excess water, are heavy and hard to carry back to her clothes line."

> "Plunging clothes in and out of piping water causes strain on your fingers as you twist and turn the fabric to ensure they get detergent on them, and the heat causes the skin on your fingers to become dehydrated, soft and likely to tear more easily."

These testimonies were influenced from course instruction. Within the product design course, we encouraged students to develop use-case scenarios of "to-be" products in order to anchor their constraints with hypothetical users. There was no correlation with the use of this technique and success within the design project. This may suggest that this technique is superficial and dependent on previous experiences.

5.2.2 Observation through videos or photographs

Other students chose to inform their empathic thinking through the presentation of videos and photographs found online. Common to these submissions is the notion that it was infeasible to travel to an environment that would be fully immersive. Submissions here were very often followed by textual testimonies. One submission showed multiple photographs from different parts of the world in order to make the point that there exist similarities across multiple user environments. Students reflected on the photographs with their own assertions, as seen below:

> "The use environment would be wet, and contain harsh detergents by the nature of the product opportunity. If being used outside of the home the user would encounter elements of weather, dirt, rough terrain. Inside the home the user would have the advantage of privacy, but they might be concerned with noise, limited space, and fragile decor and/or construction materials."

> "Collecting water with this method . . . causes strain on the arms, shoulder, neck and wrist. The washer is often required to work in awkward positions. In [the] picture, the lady is [scrubbing] the clothes with [a] bar [of] soap on a flat, hard surface."

Coupled with photographs and videos, textual testimonies allowed the students to better map user context with specific user needs.

5.2.3 Empathy map technique

Since the empathy map was covered within the course itself, some students used the technique to organize their thoughts surrounding the users, themselves. Fig. 1 illustrates the use of the empathy map in this context. The idea is to categorize user feelings by what the user feels, does, says, sees, thinks and hears. One student, seen in Fig. 1a couples the technique with some visual thinking to help center on the specific target user and environment.

5.2.4 Interviews or focus groups

Some students had access to people who had experienced hand-washing clothes in developing countries. The methods of interviewing and holding focus groups allow the designer to live vicariously through their peers. The nationalities of those interviewed included Puerto Rico, Ghana and India. Students that engaged in focus groups and user interviews performed better in the overall design, based on expert ratings. This falls in line with the concepts related to empathic design and the idea better understanding of the users themselves.

5.2.5 Immersive practices

It can be argued that the best technique to engage in empathic design is through immersive practices. This includes prototyping some process that is common to the users for which the expert is designing a product. In a total of 98 submissions, there were only two students who actually conducted their own physical exercises to understand the target users' plight. In this case, the students were engaged in immersive practices and washed clothes by hand in a limited amount of water. The students, who conducted a hands-on empathic design exercises, submitted photographs within each assignment submission.

5.3 Visual thinking

Aside from performing physical empathic design exercises, students also used visual thinking tools to inform their own designs. Many ideas were spawned from Bill Buxton's Sketching User Experiences point of view [41]. It should be noted this design course has within it a heavy focus on visual thinking, sketching, and diagramming. From our perspective, we consider visual thinking as an essential practice to engage in empathic design. Within Fig. 2, we provide several examples of concept sketches, in which students describe the feasibility of their washing devices through various visual artifacts. Within the project, many students chose to reflect on the user interaction of the proposed design through storyboarding, adding an additional reflection step

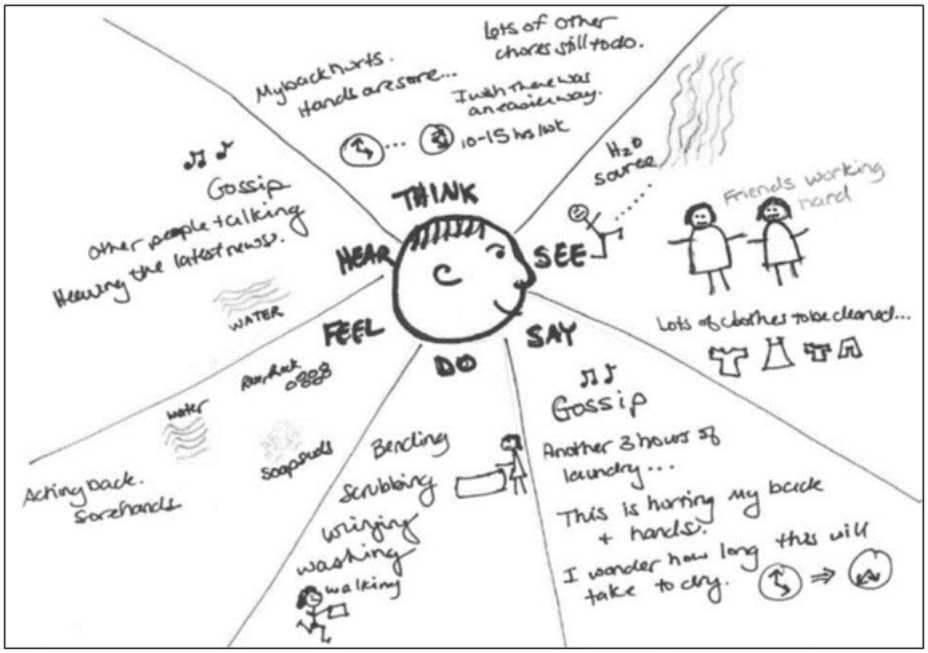

Fig. 1a Example of the use of the X-PLANE technique in order to understand customer needs.

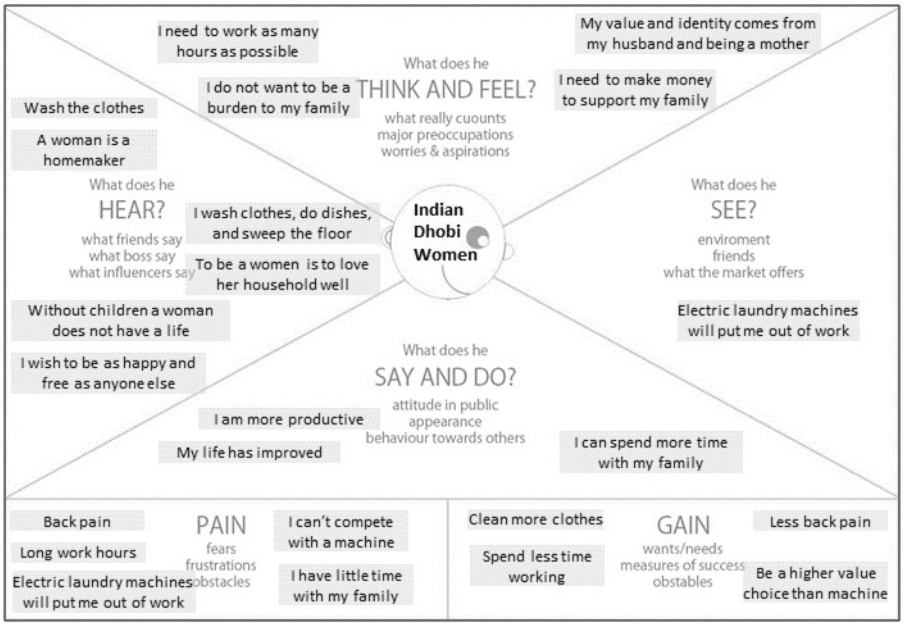

Fig. 1b Example of the use of the X-PLANE technique in order to understand customer needs.

to the ideation process and way in which they can tell the user's story.

Figure 3 provides two examples of the use of storyboards within student submissions. One student (Fig. 3a) used the method to further understand the user's daily life, while the other student (Fig. 3b) explored the intended use and environment of their product and the role of the user. Similar to the top storyboard depicted in the figure, a number of students provided a timeline of the user's daily clothes washing activities. Some students then connected their designs to match the daily activities in the context of the power requirements of their device. For example, some drum-based designs used the time of the user's walk from home to the water source as time for the washing drum to rotate in order to save time, as seen in Fig. 3b example. Here, the use of visual thinking demonstrates the product's feasibility in its targeted context. In general, we noticed visual thinking to be an effective means to engage students in empathic design without the use of physical materials.

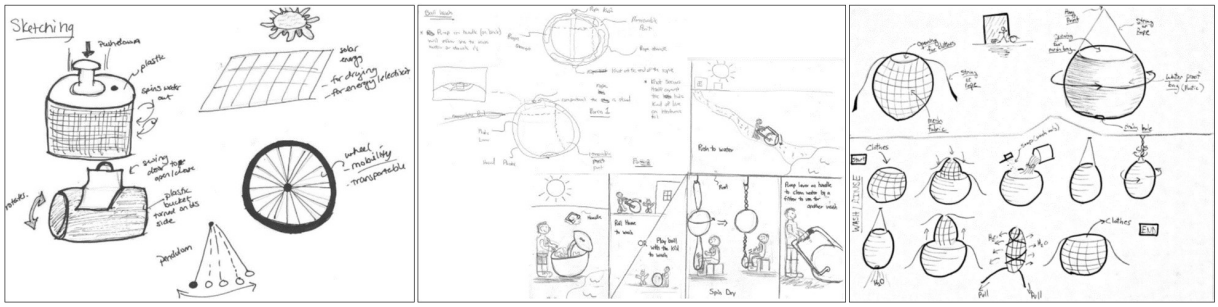

Fig. 2a. Examples of Ideation provided in students submissions that employed visual thinking.

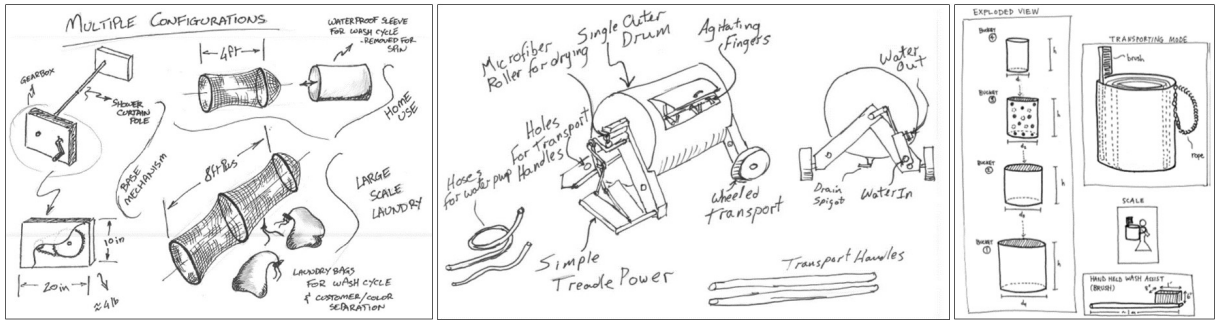

Fig. 2b. Examples of Multiple Configurations and Design Feasibility.

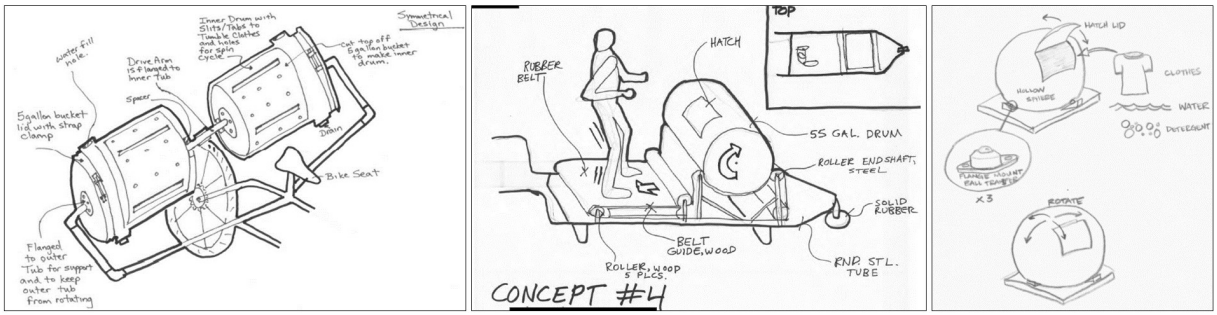

Fig. 2c. Examples of Concept Generation.

6. Discussion and future work

One of the goals of this study was to create a platform for which educators can incorporate empathic design exercises in the design classroom, specifically for distance learning situations. We presented the following problem statement to each student for their consideration: The objective of this project was to develop a device that can perform textile washing and if possible the drying function to the greatest extent possible. It was required that the developed concept includes the following features and considerations:

1. Extremely low cost
2. Durability
3. Limited usage of water
4. Minimal operator effort
5. Address the impact of the device on social issues
6. Portability
7. Operator safety and device reliability

We encouraged the students to use design frameworks presented through the course, including storyboarding, empathic design, and functional decomposition. However, there were no set requirements with regards to these techniques and exercises for the submissions. The use of these design tools was left to the discretion of the student.

Through observations, we can state that those students who interviewed people with experience hand- washing clothes or practiced hand washing themselves generally performed better in the assignment. This might simply mean that those students who completed a more comprehensive job towards understanding the user achieved more feasible designs as judged by experts. On the other hand, it might point to the importance of immersive prac-

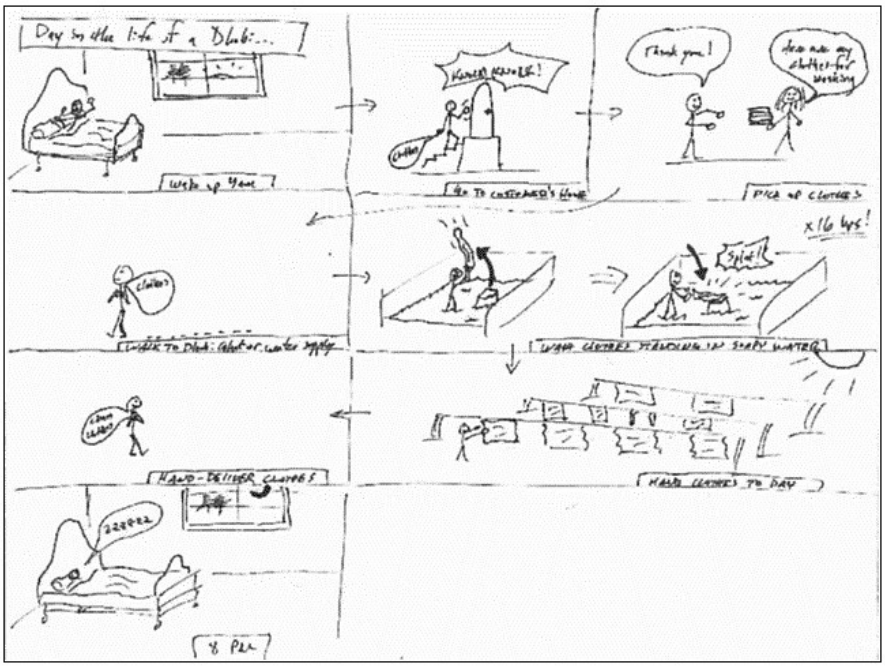

Fig. 3a. Storyboard to understand the user's daily life.

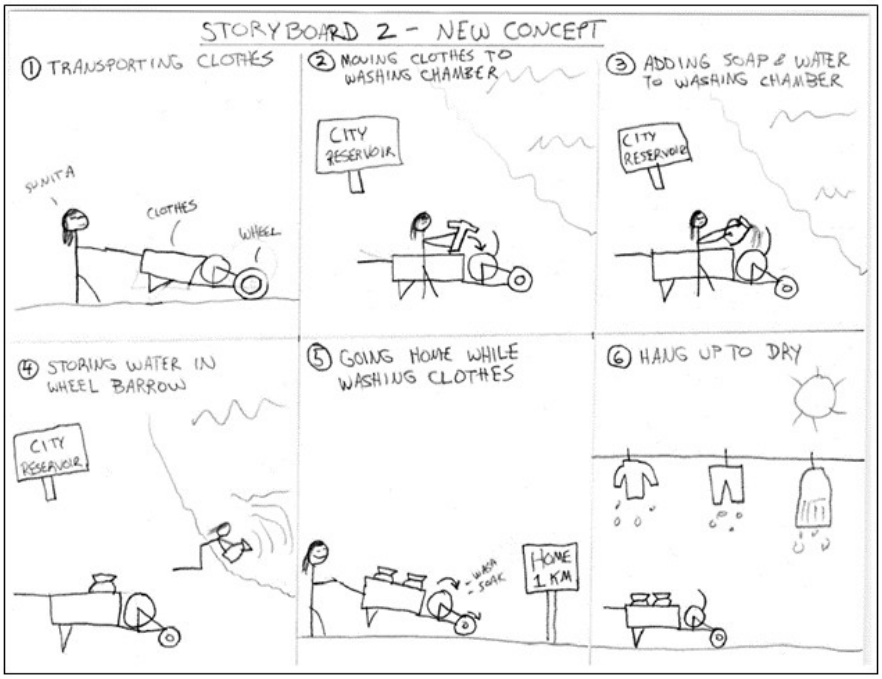

Fig. 3b. Storyboard to explore the use and environment of the intended product and the role of the user.

tices in expressing user needs. It is impractical to have an entire class to travel to developing countries for students to investigate use environments. However, allowing access to users through a virtual medium is much more feasible. In the future, we plan to connect distance learning students to lead users with experiences in developing world contexts through online video interviews. We also plan to release additional design assignments that relate to everyday problems as experienced by people in different contexts, similar to what was done here (e.g. washing clothes in the developing world). This provides an opportunity for students to perform immersive design exercises by simply using material found around their homes. We hope that encouraging non-traditional distance learning students to complete hand-on activities will increase student engagement and inclusion.

In this exploratory study we observed whether students respond with appropriate design practices when engaged in empathic design thinking. These observations motivate several modifications to the design problem as future directions.

One recurring issue in student submission is the lack of performance feasibility in achieving appropriate agitation of the clothing. Many students submitted rotating drums as ideas, however, without a long washing cycle and expensive detergent, this will simply not properly clean the clothes. For the next run, we will not allow rotating drums, alone, as an acceptable solution. Secondly, it is our general feeling that student fixated on existing solutions that we provided as benchmarks. Many students simply enhanced an existing design with several new features and submitted it as their own design. It is difficult to track engagement and learning in this situation, where design intent is quite difficult to extract. In the next run, we plan to write the problem statement in a way that simply instructs students based on customer requirements and feasibility constraints. If the students choose to investigate existing designs, mapping their thinking to design features that exist in the market will become possible.

In general, we view this effort essential for all students engaging in engineering design. Once engineering students become engineering professionals, understanding user needs through empathic design techniques in all related projects is vital not only for their success but for the financial sustainability of their employers and especially the end users. Furthermore, this study can be used as a framework for the inclusion of immersive empathic design exercises within a geographically distributed learning scenario, or a MOOC environment.

7. Concluding remarks

This paper presented a platform for engaging students in empathic design thinking through a problem based approach in a product design course. Therein, we asked the students to design a washing machine applicable in the developing world, focusing on clothing agitation, extreme low cost and minimal human effort. Several empathic design techniques led to better solutions in the context of projects for extreme affordability, such as text-based testimonies, observations through videos or photographs, empathy map technique, interviews of focus groups, and immersive practices. The utilization of the last two techniques was linked to more feasible designs. Visual thinking was also linked as an effective means to engage students in empathic design without the use of physical materials.

Demographic background, gender, and life/work experience did not significantly impact solutions in the context of projects for extreme affordability. Results of this exploratory study suggest that it is feasible to use a supplemental assignment in order to infuse empathic design thinking into an existing course. Our findings suggest that there is potential in cultivating user-centered design skills for distance learning students through the introduction of empathic design thinking in design.

The design assignment presented here can serve as a step towards conducting empathic design problems in a distance learning setting, where physical resources are often limited. This study offers substantial lessons learned from qualitatively assessing the students' project submissions. It is our hope that engineering design educators will adopt a similar platform to motivate engineering students to apply relevant design techniques into their engineering practices.

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Diana Bairaktarova, MBA, PhD, is an Assistant Professor in the Department of Engineering Education at Virginia Polytechnic Institute and State University. Diana completed her Ph.D. in Engineering Education from Purdue University and she also holds BS and MS degrees in Mechanical Engineering from Technical University in Sofia, Bulgaria and an MBA degree from the Hamline School of Business, St. Paul, Minnesota. Diana has over a decade of experience working as a Design Engineer. Her research focuses on human learning and engineering, i.e. understanding how individual differences and aptitudes affect interaction with mechanical objects in engineering education instruction and how engineering students' personality traits influence decision-making process in engineering design.

William Z. Bernstein, PhD, is a Mechanical Engineer in the Life Cycle Engineering (LCE) Group of the Systems Integration Division of the Engineering Laboratory (EL) at the National Institute of Standards and Technology (NIST). Dr. Bernstein's research at NIST primarily contributes to two programs: (1) Performance Assurance for Smart Manufacturing Systems and (2) Enabling the Digital Thread for Smart Manufacturing. Prior to joining NIST, Dr. Bernstein was a member of the C-Design Lab at Purdue University. His research at Purdue was focused on establishing frameworks and methods to enable environmentally conscious product redesign activities. Central to this work was the idea of infusing principles from the fields of Information Visualization and Visual Analytics into Sustainable Design. Dr. Bernstein's current research interests include Sustainable Design, Data-Driven Manufacturing, Product Lifecycle Management, Visual Analytics, and Information Visualization.

Tahira Reid is an Assistant Professor in the School of Mechanical Engineering at Purdue University and is the director of the Research in Engineering and Interdisciplinary Design (REID) Laboratory. Her research interests include developing methods that help engineers think critically about non-technical issues and their impact on engineered design solutions. Prior to arriving at Purdue in 2012, she completed a postdoctoral fellowship in the Mechanical Engineering department at Iowa State working in the Interdisciplinary Research in Sustainable (IRIS) Design Laboratory under the mentorship of Erin MacDonald. In 2010, she received her PhD from the University of Michigan in Design Science, with Mechanical Engineering and Psychology as her focus areas. Dr. Reid received both her BS and MS degrees in Mechanical Engineering from Rensselaer Polytechnic Institute in 2000 and 2004, respectively.

Karthik Ramani is the Donald W. Feddersen Professor in the School of Mechanical Engineering at Purdue University. He earned his B.Tech from the Indian Institute of Technology, Madras, in 1985, an MS from The Ohio State University, in 1987, and a Ph.D. from Stanford University, in 1991, all in Mechanical Engineering. He serves on the editorial board of the Elsevier Journal of Computer-Aided Design and the ASME Journal of Mechanical Design. His research lies at the intersection of mechanical engineering, and information science and technology. His research areas encompass design and manufacturing, new kernels for shape understanding using machine learning, geometric computing and human-computer natural user interaction and interfaces with shapes and sketches. A major area of emphasis in his group is computer support for early design, shape searching, sketch-based design, cyber and design learning, sustainable design, and natural user interfaces for shape modeling. He is also currently serving on the NSF Advisory Committee for the SBIR/STTR program of the Industrial Innovation and Partnerships program. In 2006 and 2007, he won the Most Cited Journal Paper award from Computer-Aided Design and the Research Excellence award in the College of Engineering at Purdue University. In 2009, he won the Outstanding Commercialization award from Purdue University and the ASME Best Paper Award from technical committees twice at the IDETC. In 2012 his labs paper won the all-conference best paper award from ASME-CIE. He has published over 200 peer-reviewed papers, over 90 Journal publications; over 70 invited presentations, and granted 10 patents.