NOVICE ENGINEERS' PREDISPOSITION TO COMPASSIONATE DESIGN

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Abstract

The objective of this research paper is to study the ways in which engineering students naturally apply elements of compassionate design thinking to design tasks. We hypothesize that engineers will engage in compassionate design ways of thinking only when explicit information is provided and/or if they have had prior experience with the design context. The goal here was to understand whether or not engineers are able to intuit the need for compassionate design thinking and if their experience guides their approach. A mixed methods approach was used to study novice engineers in design contexts that warrant the need for compassionate design thinking. A 'Think Aloud protocol' was used and a coding scheme was developed to analyze the documented video/audio recordings. The results show that participants with experience invest more thought in framing the problem as compared to those without experience. Observations showed that factors like 'dignity' were less discussed and need more probes to be included in the design process. These results will provide information that will lead to the development of a tool, such as Design for Compassion or DfC for compassionate design thinking.

Keywords: Design for X (DfX), Design cognition, Design methodology, Compassion, Novice

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Please cite this paper as:
Surnames, Initials: *Title of paper*. In: Proceedings of the 20th International Conference on Engineering Design (ICED15), Vol. nn: Title of Volume, Milan, Italy, 27.-30.07.2015

1 INTRODUCTION

Compassionate design thinking is the ability to think through, identify, and potentially implement compassion factors in the design process (Seshadri et al., 2014). It is intended to sensitize engineers and designers to familiar and unfamiliar contexts, in which the user has a high level of emotional involvement with product interactions (Seshadri et al., 2014). Compassion factors can be defined as the physical or psychological design interventions that affect the interaction of the user with an artifact.

Compassionate design is intended to aim at similar results as would be elicited by natural 'compassion' for the user, which is a subjective criterion and depends on the personal experience of the designer. It is not realistic for every designer to have experience in every area that they are working on. But, to enable everyone to use compassionate design, a metric called Design for Compassion (DfC) is being developed, so that an engineer or designer could use compassion elements even if they do not have natural compassion for a certain user.

There are a number of design thinking methods and philosophies that have been developed over the years. Some of them include emotional design (Norman, 2007), user-centered design (Norman et al., 1995, Preece et al., 2002, Abras et al., 2004, Hassenzahl and Tractinsky, 2006 and Baek et al., 2008), human-centered design (Krippendorff, 1989, Gasson, 2003 and Giacomin, 2012, Zoltowski et al., 2012), empathic design (Leonard and Rayport, 1997 and Lin and Seepersad, 2007), and Kansei engineering (Nagamachi, 1995, Nagamachi, 2002). Across most design methods, the ultimate goal is to provide value to the customer. However, there are certain contexts of use that require a greater level of sensitivity on the part of the designer due to the high level of emotional involvement of the user within that context – for example, medical treatment contexts or distressing situations. These factors are not always explicitly addressed by existing design methods. A detailed review of the existing methods and how compassionate design fits in this space is explained by Seshadri et al.2014).

As seen in Figure 1 (Seshadri et al., 2014), compassionate design is driven by the motivation of compassion for the user and affects those needs of the user that can be identified with the following categories:

- Dignity
- Health
- Empowerment
- Safety
- Happiness

Some of the case studies in that work show that the big difference in the way the design problem was handled was in the motivation or the overarching need that the designers/ engineers tried to address; it was the difference between "What can I do to save the women from violence?" versus "Let us make a fuel efficient cook-stove" (Darfur stove case study from Seshadri et al., 2014). Compassionate design starts with the motivation of compassion and targets contexts that have a high level of emotional involvement of the user. In this process, aspects of DfC can act as probes that help in the identification of needs that affect the user's sense of dignity, empowerment, safety, happiness/satisfaction and health/hygiene while using the potential design solution.

This design philosophy is intended to be complementary to the other design philosophies and ideally, would be able to guide the designer even in situations when there is no direct access to the user.

Problem scoping or framing is an important phase (Cross, 2001) where the designer/ engineer decides the needs that they want to address and the context for it (Schön, 83). The use of DfC is applicable in this phase as it is intended to serve as prompts or probes to address unarticulated needs. The role of experience in learning has been widely studied and as mentioned by Collin (2004), "various kinds of know-how and gut feelings may be acquired, accumulated and later applied in new situations". The experiences shape the learning of a person (Watkins and Marsick, 1992) and these might play a role in the problem-framing phase. In Cross' (2002) studies of exceptional designers, there are many references to designers, who drew on their personal experience.

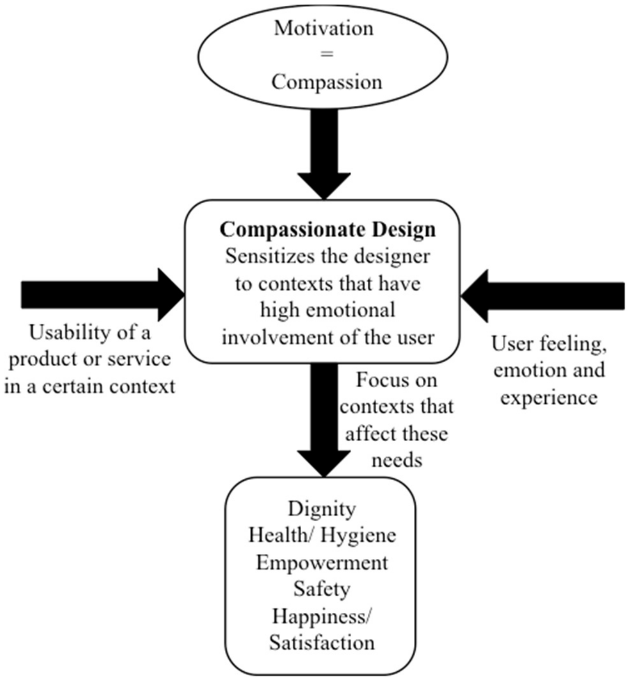

Figure 1: Framework for Compassionate Design

This work aims at studying the following: 1) how experienced and non-experienced novice engineers tackle a relatively open-ended design problem, and 2) analyze the language used by the designers during the design process to identify evidence of compassionate design. This is the first step to establish if there is a need for DfC and to see if a lack of experience makes designers/ engineers neglect some aspects (like dignity) of the user experience.

2 METHODOLOGY

In order to conduct this study, we used an explanatory mixed methods approach (Creswell, 2011) where an experiment was used to conduct the study, and the data were analyzed using qualitative methods.

Experiment Design: A between-subjects study was conducted to examine the effect of prior experience with the problem context on students' ability to generate design solutions. All participants were divided into two groups: Group A represents those with no personal experience with the context; Group B included those who have had experience with the context. In this experiment, a design task was given to the subjects and they were asked to talk as they were thinking and completing the design task (an aspect of 'Think Aloud Protocol'). The design task given to the subjects was the following: *"The design task is to come up with design solutions that can improve the life a person while her/ his hand(s) and/ or leg(s) are in a cast or a sling"*. This was chosen as a design task as this was considered to be personal but non-stigmatizing and something that can be commonly observed on campus. A pilot study was conducted prior to the actual experiment, which helped in refining details of the experiment including language for the actual design task and the initial structure.

Participants: The participants were undergraduate mechanical engineering students. A total of ten subjects (seven male, three female) participated in the experiment out of which five have had personal experiences with bone fracture sometime in the past, while five did not have any personal experience with bone fracture. The subjects were pre-screened to identify this information.

Procedure: To make the participants comfortable with talking, thinking and drawing at the same time, a short exercise was performed before starting the actual design task. They were asked to draw the path from their room to the parking lot or main road and to simultaneously explain everything they saw on their way. This also gave them an idea of how they were supposed to go through the design task. Once the task was completed, the participants then had to complete two surveys: one survey allowed participants to provide feedback on the overall experience and the other was used as a self report about the compassionate nature of the person in accordance with questions from (Hwang et al., 2008). These data are outside of the scope of this paper and are not reported here.

Videos of each session were recorded, and also notes were taken. The data were analyzed qualitatively using a coding scheme, which was developed and includes included the proposed framework for compassionate design and other relevant criteria. The coding scheme along with the data for one participant is given in Figure 3. The coding scheme was based on verbal references that participants made as they were designing. The explanation for each criterion is given below:

- *Awareness around*: Any references made to personal observations of individuals who have had the experience (e.g., family-members, roommates, friends, people on campus, etc.).
- *Think about own experience*: Any references made to their own personal experience (i.e. when they themselves had the fracture).
- *Dignity*: Any references to instances that could affect a user's sense of self-respect or self-worth.
- *Health/Hygiene*: Any references to instances that could affect the health or hygiene of the user.
- *Happiness/ Satisfaction*: Any references to instances that could affect the user's happiness or satisfaction with the current or proposed solution.
- *Safety*: Any references to instances that could affect the perception of safety of the user.
- *Empowerment (less/ more)*: Any references to instances that could make the user feel less or more empowered about self or perception of the same for others.
- *Helplessness (self/ others)*: Any references to instances that were perceived by the user as a state of helplessness, either for self or others.
- *Imagining (activities through the day)*: Any references to instances that were identified by the user by imagining the daily routine of a person and how a cast could create a hindrance for carrying out those activities.
- *Technical Details/ working*: Any references to instances when the participant started talking about the size, working methodology or material of the proposed design.
- *(Dis) Comfort/ (In) Convenience*: Any references to instances, problems or situations that were perceived by the user as (un) comfortable or (in) convenient, either to self or others.
- *Others*: Any references to instances that were not relevant to any of the above criteria were included in this. A few examples include 'cost-effective' and 'not efficient'.

The criteria can be broadly divided into three categories:

- *'How' was the problem identified?*
  - Awareness around
  - Think about own experience
  - Imagining (activities through the day)
- *'Which' aspect of the user-experience does it influence?*
  - Dignity
  - Health/ Hygiene
  - Happiness/Satisfaction
  - Safety
  - Empowerment (less/ more)
  - Helplessness (self/ others)
  - (Dis) Comfort/(In) Convenience
- *'What' are some solutions?*
  - Technical Details/ working

Each session lasted for approximately 30-45 minutes. The whole session was divided into three-minute intervals for ease of coding and a ✓was used anytime a participant made reference to one of the criteria in the coding scheme. The ✓ s were counted and ranged from zero references to a maximum of four references per three-minute intervals. These data were then plotted and will be discussed further.

3 RESULTS AND DISCUSSION

3.1 Differences in Problem Identification

It was observed that participants from Group A (no experience with fracture) identified relatively more obvious problems and fewer unique problems as compared to those in Group B (experience with fracture) (see Table 1). However, Group B identified significantly more unique problems than Group A. Some examples of unique problems from Group B include: difficulty stabilizing things with one hand like tearing paper towels, applying soap and washing the other hand, and sore armpits due to crutches interfering with the straps of the backpack. An exhaustive list of all the problems identified by both groups is given in Table 1.

Participants from Group A identified problems mainly through observations around campus and with friends while participants from Group B more frequently referred to their experiences for identification of problems.

All participants unanimously agreed that having the experience would provide more insight into identifying problems and designing solutions for patients experiencing a fracture. Participants from Group B expressed that not having these experiences would have limited their ability to identify unique problems and they would have been able to identify only obvious problems. These experiences allowed them to identify inconspicuous inconveniences in everyday life. Statements from participants in Group A show that experience would have helped them to relate better to the task and identify more problems, for example: *"…can't even imagine this solution...", "This would have been easier had I had a cast", " sorry that I am having trouble coming up with ideas"*. This highlights the importance of using empathic design, where the designer/ engineer role-plays the user (Lin and Seepersad, 2007) in order to gain a better understanding of the problem.

3.2 Emphasis on Variations in Criteria

Figure 2 shows some interesting patterns that were observed in the responses of the participants. More references about one's own experience were made for problem identification by participants from Group B as compared to participants from Group A, which was expected. Group A had more references to identifying problems by imagining the daily routine or by recollecting information from the time they had seen others with a similar experience, as compared to Group B. Owing to their first-hand experience, Group B referred to more problems related to 'health/hygiene' and 'happiness/satisfaction' in comparison to Group A. This difference between the two groups is most notable for three criteria: 'empowerment', 'helplessness' and 'comfort/convenience'. As they had experience with fracture, participants from Group A were able to remember how helpless they were in some situations and were able to articulate more problems; for example, one of the participants referred to the situation he faced as "collateral damage". He said that even though only one small part of the bone was fractured, the whole hand was constrained and he couldn't use it for getting any work done. Differences in references to 'safety' and 'dignity' between the two groups were not obvious. It was interesting that more references were made to technical aspects and working method of the potential design solution by participants from Group A as compared to Group B. Group A participants seemed to focus more on the conceptual design phase and quickly moved to this phase from the problem framing phase (where they were identifying what need should be targeted).

3.3 Other observations

Some other observations, which have not yet been studied in detail, are enumerated here:

- The graph for some of the criteria show that the first five minutes of the experiments witnessed fewer references to the criteria compared to the rest of the time. For instance, fewer participants made references to the criterion '(Dis) Comfort/(In) Convenience' during the first three to six minutes and then more references were made as the experiment progressed.
- There were elements of reflection in design that could be seen in these experiments, although these were more of a reflection on the experience and using that to inform the design problem than reflection on the design itself.
- Co-evolution of problem and solution space (Maher et al., 1996, Dorst and Cross, 2001) could be seen, as some participants would start to talk about potential solutions but then go back to defining more details about the problem.

- Some of them showed more qualities of a novice engineer (Atman et al., 2007) than others, as they were following the design process they had learned in class. One participant reached to a point of doing decision matrices and then she was told that she need not complete the entire design process but could focus on generating concepts and identifying problems.
- Analogical reasoning (Daugherty and Mentzer, 2008 and Daly et al., 2012) was used in some cases as can be seen from the data of one participant presented in Figure 3. Use of such phrases as "like a pair of scissors" or "like a pair of backward tongs" indicates that the design concept was being explained by using analogical reasoning.

Table 1: List of problem identified by people who have and have not experienced fracture

	Group A (no fracture experience)	Group B (experience with fracture)
Obvious Problems	1. Low speed of walking 2. Difficulty in bathing 3. Inability to wear shoes/ socks 4. Difficulty in typing 5. Difficulty in carrying things around 6. Low mobility 7. Using the toilet 8. Sitting in lecture hall 9. Inability to clean or wash inside the cast 10. Difficulty in doing everyday tasks, brush, shower, cook, eat 11. Difficult in lifting things 12. Difficulty in eating 13. Difficult to wear backpack (if both hands are in a cast) 14. Difficult to exercise 15. Inability to swim 16. Difficult to sleep 17. Difficulty in gripping/ grasping 18. Pain on colliding with objects around 19. Difficulty in getting into and out of bed 20. Difficult to ride bike	1. Difficulty in bathing 2. Uncomfortable to sleep 3. Less flexibility of the cast material 4. Difficulty wearing clothes 5. Difficulty in using the whole limb even if only one part is fractured (wrist in cast when thumb is fractured, leg in cast when ankle is fractured) 6. Difficulty in going upstairs and downstairs 7. Difficulty in supporting body while bathing with a leg cast 8. Difficulty in writing 9. Difficulty in eating 10. Difficulty in driving 11. Low mobility- cannot play or exercise 12. Difficulty to hold silverware 13. Difficulty in sitting in some chairs 14. Difficulty in standing 15. Difficulty in using chair-desk joined together 16. Difficult to wear only one kind of shoe throughout the time the cast is there 17. Difficulty in gripping things
Unique Problems	1. Itchy inside the cast 2. Difficulty in opening door knob 3. Difficulty in holding a book (if both hands are in a cast) 4. Lopsided arm (due to lack of exercise) and loss of hair on the arm when the cast is removed 5. Difficulty in using both pockets of the jeans 6. Difficulty in cutting food 7. Difficulty in maintaining balance 8. Difficulty in keeping crutches with oneself while sitting or travelling 9. Difficulty in holding-brushing teeth, shaving and holding the razor	1. Itchy inside the cast 2. Difficult to grip door knob 3. Soar armpits due to crutches interfering with the straps of the backpack 4. Leg was twisted and crooked after cast was removed 5. Pain in hips after walking with cast 6. Difficulty in breaking eggs 7. Difficulty in lifting heavy pans for cooking 8. Difficulty in opening or uncorking a bottle 9. Difficulty in supporting guitar 10. Different color of the skin when the cast is removed 11. Increase in gap between cast and leg as muscle mass reduces over time 12. Keeping the cast dry from inside (could get wet due to sweat) 13. Holding both crutches in one hand while going up or down the staircase 14. Difficulty in use of the crutches on carpeted floors and staircases 15. Sore armpits due to crutches 16. Inability to tie shoe-laces with hand cast 17. Difficulty in stabilizing things, like tearing paper towels with one hand 18. Difficult to climb ladder to a loft bed 19. Washing the other hand (not in cast) by itself with soap- cannot rub hands together 20. Difficult to use tape (with only one hand) to cover the casted hand in plastic to keep it dry
Total number of obvious problems identified	20	17
Total number of unique problems identified	9	20

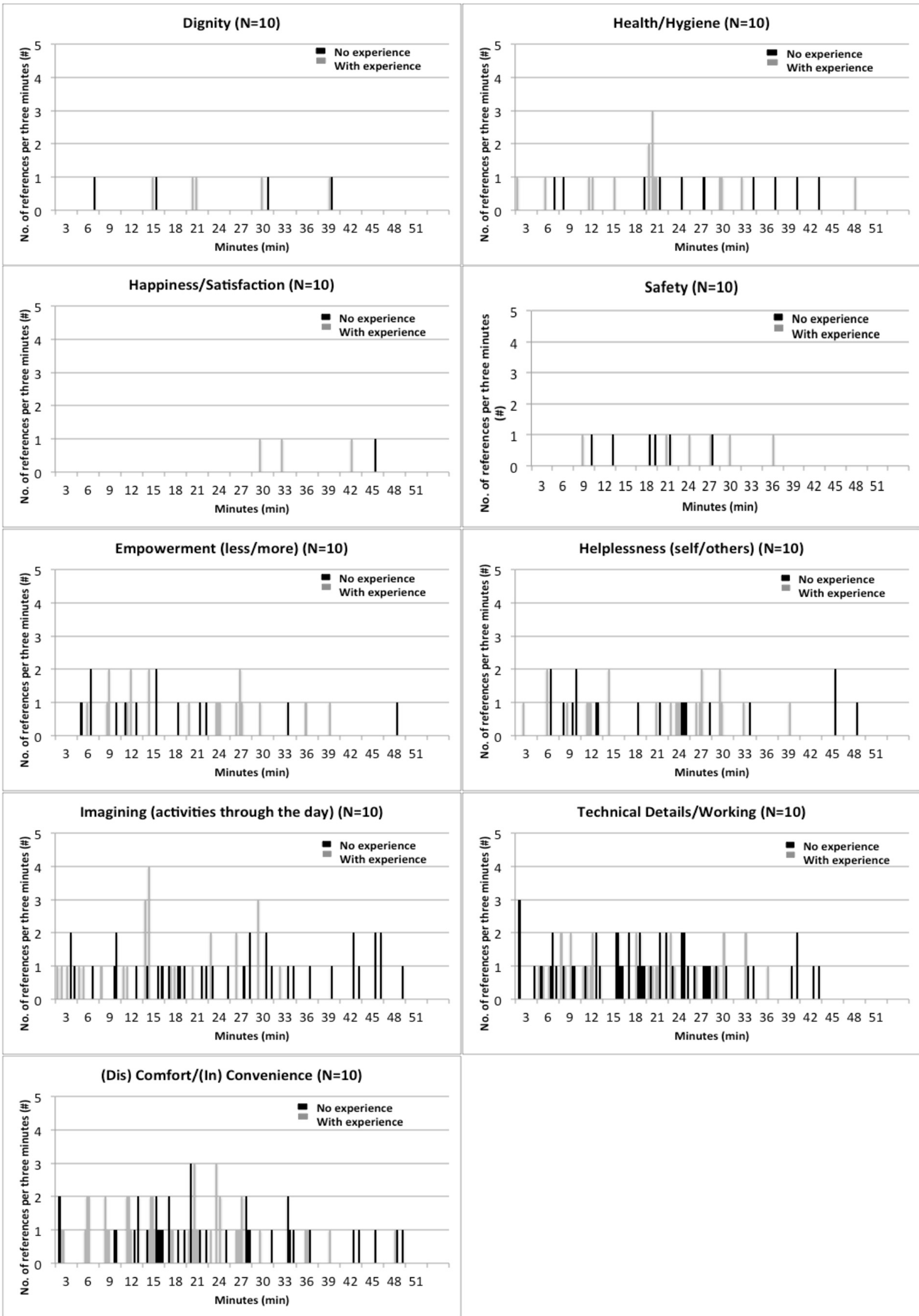

Figure 2: References to problems in various criteria by participants (Grey- Group A with no experience, Black- Group B with experience)

3.4 Summary

This experiment gives a glimpse of the role of experience in the problem framing or scoping phase. Participants with experience were able to identify more problems, especially those that were unique as compared to those without experience. 'Experience' provided more insight for problem identification. This result seems obvious. However, what was not so obvious was the fact that inexperienced participants were more inclined to begin developing technical solutions. This is consistent with work by Crismond and Adams (2012), which indicates beginning designers tend to converge to design solutions rather than spend more time framing the problem.

The results also indicate that there are some criteria (like 'dignity') that are overlooked or need more probes. It would be interesting to see how participants would think through some of these criteria if prompted to consider them while framing the problem (i.e. "Consider how your solution affects the dignity of the user."). This would be one of the key functions of DfC when it is developed. It would enable designers/ engineers to target the not-so-obvious facets of the problem and solution space that affect the unarticulated needs of the user.

Insight and motivation driven by compassion would define compassionate design. When the designer/ engineer frames the problem with a motivation driven by compassion for the user and also uses insight, then compassionate design can happen. For instance, in the 'Jaipur foot' case study identified by Seshadri et al., 2014, a different prosthetic limb was developed for amputees and it was successful as it was relatively inexpensive and 'looked like a foot'. The developers of this product were motivated to understand the reason behind the low rate of acceptance of a regular prosthetic limb and did not decide to 'just improve' the prosthetic limb. One of the aspects that they addressed was that the 'foot looked like a foot'. This is related to the 'dignity' of the user who wants to feel accepted as a part of the society. In this example, the motivation was compassion for the user, and the designer was powered by insight and technical knowledge, thus leading to a product that represents compassionate design.

4 CONCLUSIONS AND FUTURE WORK

The essence of the study with the various participants shows that some participants had a lot more insight into framing the design problem and identifying potential areas of improvement as compared to others. The participants who had more insight did not find it extremely difficult to come up with problems and identified some unique problems. They seemed to relate more to the context and thought about solutions that might have helped them when they were in the situation. They were drawing upon ideas based on their experience. Their experience helped them consider the task in a different light and motivated them to show more compassion towards the context. Participants who have never had the experience were able to identify some problems, but comparatively, they were finding it difficult to perform the task. A few unique problems were identified by these participants after thinking for a long time. They seemed to focus more on the technical or working aspects of the problem. They said that most of their work was based on imagination and what they have seen or heard from other people.

This study demonstrates the use of experience by novice engineers in the problem scoping or framing phase. This study shows that a novice engineer's natural disposition to compassionate design is limited by her/ his prior experience with the context. It was observed that lack of experience leads to difficulty in holistically approaching the design task. It should be noted that prior experience could also bias the way an engineer/ designer approaches design and cause some fixations as far as the problems identified are concerned.

If compassionate design is thought to lie at the intersection of compassion and insight, then the role of DfC will be in augmenting the understanding of the problem, in the absence of insight. If there is no motivation, then the use of various priming methods might help to induce motivation for the cause. If there is no insight and access to the user is not possible, DfC is envisioned to be useful and help in prompting thoughts to unlock some latent needs of the user. Other design approaches like empathic design and human-centered design might also help the same.

Future work will include conducting studies with different types of familiar and unfamiliar contexts and also using prompts from the compassionate design framework to verify the hypothesis. The group of participants will also be varied to include students from industrial design, graduate students and professional engineers from the industry. Development of a DfC metric is intended to bridge the gap between the scenarios already discussed and empower engineers and designers to use the same insight and compassion in designing solutions, regardless of their experience and access to the user.

Mark a tickmark for each time reference is made to a criterion, in intervals of 3 minutes.

Participant#

Experience? Yes

Minutes in the video	3	6	9	12	15	18	21	24	27	30	33	36	39	42	45	48	51
Criteria																	
Awareness around						✓				✓		✓			✓		
Think about own experience	✓✓✓		✓✓	✓	✓	✓✓		✓	✓	✓		✓	✓	✓		✓	✓
Dignity					✓								✓				
Health/ Hygiene							✓	✓	✓								
Happiness/ Satisfaction															✓		
Safety						✓	✓		✓								
Empowerment (less/ more)		✓✓			✓✓	✓	✓				✓					✓	
Helplessness (self/ others)		✓✓	✓			✓	✓	✓							✓✓	✓	
Imagining (activities through the day)						✓			✓	✓✓	✓	✓	✓	✓✓	✓✓		
Technical Details/ working		✓	✓		✓✓	✓	✓✓	✓✓	✓	✓	✓		✓	✓			
(Dis) Comfort/ (In) Convenience				✓	✓✓	✓	✓				✓✓	✓		✓	✓	✓	
Others																	
Not efficient											✓						
Paraphrased excerpts from the conversation	Couldn't tie shoes, velcro shoes, backpacks difficult, messenger bags	Parents helped, was in first grade, big cast compared to first grader;s arm, trouble tearing things	Tearing paper towel difficult, device like a pair of scissors, backward pair of tongs possible, started sketching	All first graders recognized her quite well, ~5 months in cast, gross to look at pins in hand	Something to grip soft material would help, "Being the kid who had to take tongs to the bathroom seemed weird to me."	Climbing ladder, imagining if broke hand now, lofted bed- so stabilizing is difficult, "Let's see" for decribing others with leg cast, stairs are a problem but there are many things for it, parents taped plastic grocery bags around hands	Drawing arms and hand etc., bags have to be different size for different people,would want the grip in hand, want texture at the end of the bag, washing hands was a problem	Difficult to wash one hand with soap, some kind of brush to wash hand, may be something that went over the faucet, sketching	Advice-not to club other kids with it, design such that cast is independent of the limb that has broken bones so that not get hurt, brush to clean hands is attached to faucet	Deal with the fact that you are carrying a dirty brush around, something to help people with leg in cast	The scooter used by people with leg fracture- if the shelf of that cart be at an angle and something attached to hand rails could help, time added to go in between classes if use the special doors	Wore oversized sweatshirt, now- a lot more self-conscious about appearance	Since in school, didn't have to carry books around, so backpack was not a problem, now would use a messenger bag	Listed these problem partially because those were the ones that could be remembered, accessing now wheelchair accessible doors might be helpful	Frusttration if it took longer time to go to class, trying to find what would be more frustrating, looking at people	Assumption that fingers can move a little bit	More aware of gripping problem due to personal reasons, washing hands- we do it and don't even think about it- do it on auto-pilot

Figure 3: Data set for one participant who had a fracture experience

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