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An analysis of designer empathy in the early phases of design projects

Antti Surma-aho[1], Tua Björklund[1], Katja Hölttä-Otto[1]

[1]Aalto University Design Factory
antti.surma-aho@aalto.fi, tua.bjorklund@aalto.fi, katja.holtta-otto@aalto.fi

Abstract

User-centered design attempts to create innovation by understanding and answering the needs of users, a process in which the importance of empathy is increasingly highlighted. To formalize the concept of empathizing with users in design, recent research has uncovered various empathic techniques that designers employ throughout their projects, including not only early needfinding activities, but also the empathic formulation of design criteria and concepts. By observing the design review sessions of 4 novice design teams throughout 9-month design projects, this study attempted to show the prevalence and development of empathy in the user-centered design process. The work of the teams was divided into three phases: concept development, system-level design, and detail design. A thematic analysis of 20 design review sessions revealed distinct ways in which the novice designers considered the perspectives of their end-users in these phases, primarily including goals for interacting with users, descriptions of the users and their actions, making generalizations based on those descriptions, and finally transferring them into design requirements and features. The number of excerpts tagged in each of the three project phases showed that, quantitatively, empathy was more prominent during concept development and system-level design than in detail design. However, during detail design the novice designers focused more on referencing earlier user interactions and insights as well as realizing the final concept prototype. These results extend the current understanding of empathy in real-life design projects by showing differences in its use in user-centered design projects. More research with larger amounts of data and triangulated methods is required to produce generalizable conclusions.

Keywords: Empathy, user-centered design, novice designers

1 Introduction

Many established user-centered design guides, such as those created by Stanford d.School (Both & Baggereor, 2009) and IDEO (Kelley, 2015), highlight the importance of empathizing with the end-users of designs. However, while guides and methods exist for empathic design practices (such as those described by Johnson et al., 2014; Kouprie & Visser, 2009; Raviselvam, Hölttä-Otto, & Wood, 2016), there is scarce understanding of how empathy is utilized in design projects in a real-world context. A recent study by Hess and Fila (2016) takes initial steps towards filling this research gap by describing the empathic techniques utilized by novice

designers while designing for people with disabilities. However, these techniques have not previously been connected to the processes of neither user-centered design nor empathizing.

The purpose of this study is to describe the processes designers use to empathize with their potential end-users, within the context of design projects. This translates into two research questions:

1. How do designers show that they empathize with end-users during design projects?
2. How do designers' ways of empathizing change throughout design projects?

2 Background

2.1 Design processes

The process of early-phase design can be defined in numerous ways. Iterative design processes, involving user needfinding, concept generation, and testing, are commonly defined by both academics (such as Liedtka, 2015) and practitioners (such as Brown, 2009). Also, several studies look at design from the perspective of specific mindsets and activities, such as problem framing (Kirjavainen, Björklund, & Laakso, 2016), self-efficacy (Jerkku, Taajamaa, & Kirjavainen, 2016), and needfinding (Hölttä-otto & Raviselvam, 2016). However, in established mechanical engineering literature, the design process is often visualized as a progression of steps, depicting concept exploration and requirement definition at the beginning and detailed design and realization at the end. While we are aware that design is not a linear process, in this study we utilize the somewhat straight-forward model of Ulrich and Eppinger (2015) to define distinct phases in design projects.

2.2 Empathy in psychology and design

In psychology, empathy is often depicted as a multidimensional personal trait, consisting of affective and cognitive reactions to the observed experiences of others (Davis, 1983). The cognitive reactions are called perspective taking, and comprise attempts to make sense of the experiences, thoughts, and feelings of others (Gerace, Day, Casey, & Mohr, 2013; Gerdes, Segal, & Lietz, 2010). In an exploratory interview study, Gerace et al. (2013) found that acts of everyday perspective taking are motivated by a desire to understand the other, such as finding reasons for specific behavior, and that the process tends to result in increased understanding as well as changes in behavior. In other research, perspective taking has been shown to induce positive outcomes in various human-centered fields, including reduced psychologist stress (Gerdes, 2011), feelings of being understood at the doctor's office (Halpern, 2001), and enhanced creativity in team problem solving (Hoever, van Knippenberg, van Ginkel, & Barkema, 2012). Thus, perspective taking is an interesting construct to explore also for user-centered designers.

The role of empathy in user-centered engineering design has recently received increasing attention in academic research. Existing research has focused on three aspects of empathy: practitioner's perceptions of it (Hess, Strobel, & Pan, 2016; Hess, Strobel, Pan, & Wachter Morris, 2016), methodologies that enhance it (Johnson et al., 2014; Kouprie & Visser, 2009; Walther, Miller, Sochacka, & Brewer, 2016), and defining how it is used in design projects (Hess & Fila, 2016). While indications exist that practitioners value empathy (Hess, Strobel, Pan, et al., 2016) and that immersive techniques can enhance it (Zoltowski, Oakes, & Cardella, 2012), understanding of its use in real projects is largely based on one study by Hess and Fila (2016) where three novice design teams were observed for 9 weeks. The observations resulted in the definition of various empathic techniques that were present throughout the design

process, such as interacting with users, synthesizing information about them, generating concepts that match the synthesized information, and testing those concepts with users. With our research, we aim to build upon the current understanding of how empathy is used in real-life design projects, partially by repeating a similar observatory study as that of Hess and Fila (2016).

3 Methodology

3.1 Study participants

This study observed novice designers during the review sessions of a multidisciplinary project-based design course at Aalto University. During the 9-month course, students worked in multinational teams of three to four people on broadly-defined design briefs provided by industry liaisons. The course is paced by roughly two-week-long prototyping assignments, where students iteratively create a design concept, test it, and modify it based on the tests. These assignments are evaluated in design review sessions, where the design teams present their work, receive feedback from course staff, and discuss the next steps of their project. Furthermore, the course curriculum includes lectures and workshops on human-centered design methods and principles roughly once per week, while otherwise allowing students to manage their own work. Overall, the course emphasizes user-centered design, while not highlighting empathy *per se*.

The dataset of this study was collected from a total of 20 design review sessions held throughout spring 2017, comprising the project work of four novice design teams. In general, design review sessions have widely been studied in academic literature (e.g., Adams & Siddiqui, 2015). The included review sessions covered five prototyping assignments, each of whom was associated with a design process phase as described in Table 1. Each team included students from multiple disciplines and national backgrounds, with all of them studying at the graduate level and most equipped with working experience from part-time jobs and summer internships. The review sessions lasted 41 minutes on average, resulting in a total of 13 hours and 38 minutes of observations.

Table 1. The prototyping assignments in the studied course.

Assignment description	Associated process phase (Ulrich & Eppinger, 2015)
Prototype and test a high-risk, high-reward, "outside the box" solution.	Concept development
Prototype and test a first approximation of a final solution, i.e. a low-fidelity, system-level concept.	System-level design
Prototype and test a system-level concept, whose most important functionalities are usable as they would be in a proof-of-concept prototype.	System-level design
Build and test one part of the system-level concept, so that it can be integrated into the final prototype once other parts are finished.	Detail design
Build and test a functional pre-production prototype, so that if your final, polished prototype fails, you can use the penultimate prototype instead.	Detail design

3.2 Qualitative data collection and analysis

Qualitative data was collected by recording the audio and video of the included design review sessions. Within the data, categories were created for the ways in which students showed consideration of their end-users' perspectives. This thematic analysis procedure followed the guidelines of Braun and Clarke (2006) through the following steps:

1. Familiarization with literature on empathy and perspective taking, and the creation of "top-down" categories.
2. Recording review sessions while observing them in-situ and transcribing the data afterwards. Through this, the first author familiarized himself with the data.
3. Inductively, "bottom-up", generating initial codes based on the data.
4. Coding a total of 12 review session transcripts from different teams and project phases.
5. Reviewing the coded excerpts by category, thus assuring the coherence of each category.
6. Producing the final code descriptions along with example excerpts.
7. Coding the remaining transcripts.

Finally, the project-level developments in empathy and perspective taking were sought by qualitatively comparing the content in each theme between project phases. Also, the prevalence of empathy and perspective taking was evaluated through comparisons of the average number of coded excerpts in the review sessions of each project phase.

4 Results

4.1 Content themes

A total of 1144 excerpts from the review session transcripts were coded as depicting the process of end-user perspective taking. The thematic analysis procedure yielded seven exclusive categories to describe the designers' consideration of their end-users' perspectives: *Goals of user interaction*, *Concept background*, *Concept walkthrough*, *User interaction methodology*, *User information*, *User reactions and experience*, *Impact*.

4.1.1 Goals of user interaction

The *Goals of user interaction* category comprises the reasons teams cited for involving users in their project work, thus capturing aspects preceding perspective taking. Only 31 of the 1144 coded excerpts (3 %) were tagged in this category, making it the smallest content theme in size. In 15 of 31 instances, the design teams expressed a desire to learn about their end-users' opinions about and behavior with a concept prototype. In the example below, a designer demonstrates a desire to learn about user behavior, namely whether they would notice an information sign and act according to its instructions:

> *The idea was to… whether people would notice if there is a sign like that, the photo on the thing. Whether people would notice it and even if they notice it whether they would participate, as in scan the QR code, send the SMS, or notify us.*

Other cited aims were less specific. Thirteen of 31 coded excerpts described generic desires to find the needs of users, to interact with users, to progress the project, and to learn whether a concept helps users or not. Such reasoning is exemplified by the following quote:

> […] *we wanna have the interviews so we can find out what they* [the end-users] *actually want from the thing that we need to focus on.*

4.1.2 Concept background

The *Concept background* theme (147 coded excerpts, 13 %) includes descriptions of developed design concepts and their relation to the needs, activities, and desires of potential end-users. The theme displays an explicit connection between considering the perspectives of users and designing solutions for them. A designer highlighted this behavior by reasoning the existence

of a feature with a specific example through the eyes of an end-user (a person owning a household goods business):

> […] *this is part of the functionality* […] *that it's not just about competitors but also your synergies. So, I know that I'm in the household article space, but also people who sell curtains tend to be really synergistic with me, like the curtain company right next door, like we help bring customers into each other's businesses, so...*

Several teams, especially late in the project, considered options for technical implementation together with the users' experience. An example of this integration between technology and the user is shown below, though a designer's comparison between using the camera lens built-in to smartphones and incorporating external lenses:

> […] *in Android, the operating system knows the camera parameters, it's like written down there, so we can get those. But if you* [as an end-user] *use an external lens, then you need to either calibrate it* […]

4.1.3 Concept walkthrough

This theme, representing 4 % of all coded excerpts, includes descriptions of design concepts in a stepwise manner, mimicking the steps a user would take during use, thus requiring a degree of perspective taking. Below a designer demonstrates a walkthrough with a description of search and filter tools in an online application prototype:

> *So, these are the topics that might interest you* [the end-user]*, but you wanna search something else. It gives you your latest search. You start typing and you want that one. These are the topics that you find with those keywords. Uh, the green thingy here, the top one, are the farmers that are in your filters. So,* […] *you know that in these topics a farmer that is like you in the certain ways you have filtered, they have commented on two of these. So you wanna go to the first one. Someone has posted a question that was kind of summer wheat you wanna grow* […]

4.1.4 User interaction methodology

The *User interaction methodology* theme (154 coded excerpts, 13 %) encompasses descriptions of how end-users were interacted with, thus highlighting the activities that helped the designers form an accurate understanding of their users' perspectives. The design teams specified whether they had interviewed or observed users, conducted desktop research, asked users to interact with concept prototypes, requested feedback, or collected information from secondary stakeholders. A distinct difference was observed between asking users for feedback and for action, as demonstrated by the two quotes below. In the first quote, the designers express explaining a concept before asking for feedback on it, whereas in the second quote the designers describe a more realistic use scenario with little hand-holding.

> Asking for feedback: *We went to businesses, and first we explained shortly about the project and then we* […] *told the idea and asked general comments on it, like how do they feel, would they be interested in being featured in this window and having advertisement there.*

> Asking for action: *So, we basically handed them the application and the sensor, and said: "you have now been given these. You are at a citizen*

science group day, and maybe you missed the whole presentation of how it's supposed to be used, you know. Go and measure this water quality. Go."

4.1.5 User information

User information (272 coded excerpts, 24 %) includes the designers' descriptions of the potential end-users of their concepts, namely the users' demographics, thoughts, activities, and the environment around them. As an example, a designer briefly outlined *User information* about their potential end-users, farmers, without explicitly connecting it to their current concept design:

> *The problem in Finland is that farmers, they know their neighbor farmers but they don't know the farmers in other parts of Finland.*

4.1.6 User reactions and experience

User reactions and experience was the category with most coded excerpts (352 of 1144, 31 %). It includes the designers' descriptions of the users' feedback on design concepts, thus depicting a more concept-focused user perspective than the *User information* category. These descriptions originated from verbal discourse with end-users and observing them interact with concept prototypes. The end-users' reactions were split into three sub-categories: confirming, critical, and neutral towards the concept design. Confirming reactions were shown through positive statements ("They liked it", "Users said they would use it") and praise towards specific aspects of a design, such as its layout or the relevance of presented information. Below are examples of the three types of end-user reactions.

> Confirming: *People liked the, well, temperature a lot,* […] *understand all variables that are shown: the fishing, drinking, swimming. People in general like to have those.*

> Critical: *That was also said that, you know, it's 2017, it's sort of stupid to have a screen and then a screen and you are the person who has to match these numbers.*

> Neutral: […] *people didn't say that it was that big the difference, like doesn't really matter if it's one-fifty or two…*

4.1.7 Impact

The *Impact* theme (133 coded excerpts, 12 %) describes the designers' key takeaways as a result of considering their end-users' perspectives. Within the category, designers described changing some of the elements in their design, performing new types of tests on their existing design, generating ideas for improving their concept, and generally better understanding their end-users – all with an explicit connection to their interactions with end-users. A key difference observed between review sessions was that some focused on describing their learnings of the users, while others connected their learnings more clearly to concept development. These two types of *Impact* are exemplified below, where the designers in two different teams were asked to describe their key outcomes at the end of one prototyping challenge.

> Understanding users: *The idea of free advertising for them* [users]… *it's fantastic. They don't really care where it comes from, I guess.*

> Developing a concept: *In terms of the live aspect,* […] *as being a person who checks water quality* [with the designed application]*, yes. But asking*

them [users] *to go and do a measurement, that really drastically cuts down the interest.*

4.2 Variance in empathy between project phases

Each of the three major phases of the design projects saw distinct types of perspective taking activity, both in qualitative and quantitative terms. Quantitatively, Figure 1 shows the difference in the average number of coded excerpts per project phase. This illustrates a slight growing trend of end-user perspective taking from concept development to system-level design, along with a significant drop in its prominence during concept realization. At an aggregate level, these developments are supported by the content of each project phase (as described by Ulrich & Eppinger, 2015): during concept design the designers generate understanding of their end-users and test low-fidelity mockups, during system-level design more holistic concepts are tested and validated, and during concept realization the designs are built based on the requirements defined in prior phases.

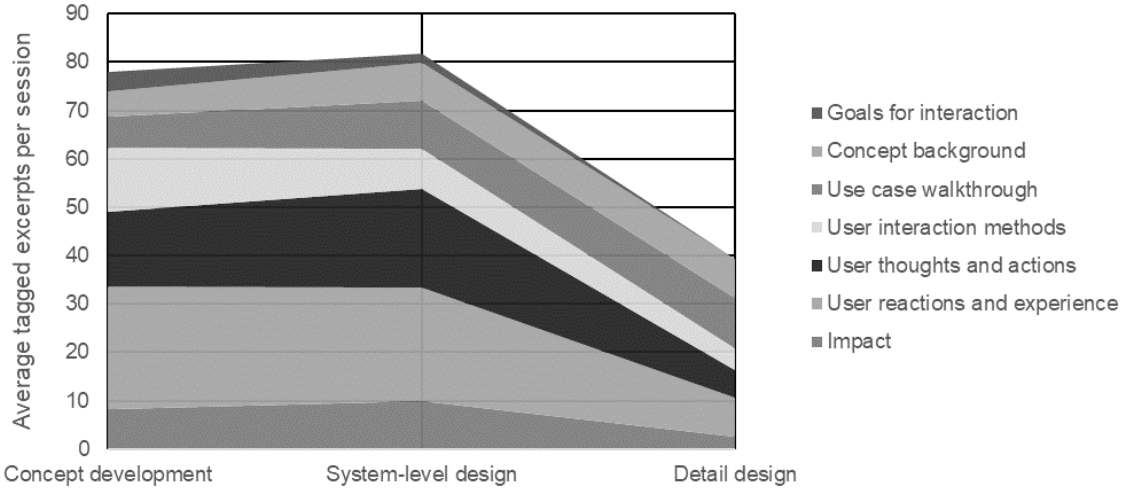

Figure 1. The quantitative development of empathic perspective taking through the three design phases.

Qualitatively, various content categories show interesting differences between phases of the project, as summarized in Table 2. During concept development, the novice designers explicitly stated their *Goals for user interaction*: to understand the users better, and to progress the project. At this early stage, the *Concept background* of their design concepts was somewhat rudimentary, largely based on the designers' best guesses of user value and needs, with little thought on the feasibility of implementation. Despite this, the designers had subjected their concepts to scrutiny from potential end-users with *User interaction methodology*, but some with lacking techniques, such as only interviewing the users without allowing them to simulate use of the concept, or only asking users to use a prototype and not asking for their opinions afterwards. For the most part, this resulted in generic *User reactions and experience* statements of the value users perceived in the solution, as well as the designers learning general *User information* of the users' context. In this phase, the designers' mentioned *Impact* was either an increased understanding of their users or purely process-related insights, such as plans for improved testing methods.

In system-level design, the designers' focus had shifted from understanding users towards developing a concept that both is feasible to implement and produces value for its end-users. Their prior interactions with end-users enabled them to describe *Concept background* with relation to the end-users' context and needs. The *User information* and *User reactions and*

experiences gathered were more specific and mature than in the prior phase, with designers discussing multiple different user archetypes, the differences in their needs and preferences, and often focusing on a specific aspect of the end-users' context, such as their planning or communication habits. The *Impact* mentioned explicit implementations of user insights into concept developments, including added and removed features, modified means of inputting information, and new ideas for delivering a physical product directly to the users.

Table 2. The qualitative characteristics of empathic perspective taking displayed in three project phases.

Theme	Concept development	System-level design	Detail design
Goals of user interaction	Desire for understanding the user, or desire for progressing the project	Desire for understanding the user and developing a valid concept	Not mentioned
Concept background	Based on assumptions of user behavior and value	Based on information gathered about the user	Referencing prior user interactions and tests, considering technical aspects
Concept walkthrough	Brief and superficial	Detailed descriptions, sometimes considering multiple stakeholder groups	Detailed, with user, stakeholder, and technical implementation perspectives
User interaction methodology	Contextual inquiry, or either interview or observation alone	Contextual inquiry, desktop research, sometimes involving secondary stakeholders	Contextual inquiry, sometimes involving secondary stakeholders
User information	General knowledge about the users and their context	Understanding on specific aspects of the users' lives, multiple groups of users	Referencing prior user interactions and tests
User reactions and experience	Mostly general feedback on the value of the solution	A mix of feedback on specific aspects and general value of the solution	Focused on specific aspects
Impact	User understanding and non-user-centered learning	User understanding and concept implications	Concept validation and limitations

Lastly, the detail design phase highlighted a need to manufacture a working prototype and validating its design. Here, the *Concept background* and *Concept walkthrough* themes saw increased mentions of the technical implementation of the concept, with the designers balancing between the limitations of technology and the needs of the end-users. Much of the *User information* was references to earlier interactions, while *User reactions and experience* were focused on detailed aspects of the concepts, such as the placement of individual buttons and their descriptive texts. With *Impact*, the designers summarized both the strengths and limitations of their concepts, such as user groups it did and did not serve well, and features that would still require additional development and testing to be fully operational.

5 Discussion

5.1 The prevalence and uses of empathy in design projects

This study thematically analyzed 20 design review sessions in a user-centered design project course to better understand how novice designers adopt the perspectives of their end-users into their work. As a result, 7 distinct categories for considering end-users in design projects were developed, and their prevalence across concept development, system-level design, and detail design phases was compared both quantitatively and qualitatively. It was found that empathic perspective taking was most prominent in the first two phases, where the designers first learned of the general context of their users and developed rudimentary concepts based on it, and then

focused their work on more specific aspects of the users, while more explicitly connecting their user interactions to concept development. In the detail design phase, the novice designers balanced between the requirements posed by technology and users, referenced prior interactions, and summarized both the pros and cons of their concepts regarding various user groups.

The content themes developed in this study extend the work of Gerace et al. (2013) as well as Hess and Fila (2016). The observed goals of perspective taking centered on a desire to understand others in both the everyday interpersonal situations discussed by Gerace et al. and the novice designers in this study. Similarly, the outcomes of perspective taking included an increased understanding of the other's actions. However, the novice designers displayed a focus on concept development in multiple review sessions, and explicitly connected user actions to their design decisions. This is an important distinction between perspective taking in the two contexts: for designers, it is not enough to merely understand the other as they must also develop solutions to observed problems. This finding matches previous research on design processes, stating that designers must both understand users and develop solutions (Dorst & Cross, 2001; Zoltowski et al., 2012).

Compared to the study of Hess and Fila (2016), this study discovered both similarities and differences in the empathy of novice designers. The novice designers in both studies developed empathic understanding through methods such as observations and direct interaction, summarized their empathic knowledge and designed concepts based on it, as well as finally assured the fit of the concepts by checking with the users themselves. However, all the novice design teams observed in this study checked concepts with users in all project phases, whereas those observed by Hess and Fila only did so at the end or did not do it at all. This difference is likely due to the project observed in this study being more than twice the length of that observed by Hess and Fila, providing the novice designers more time to arrange meetings with users and establish a longer-lasting connection with them. Also, it is likely that the course context, including encouragement by course staff and the teaching curriculum, were different between the two studies, thus potentially influencing the actions of the teams. A more detailed comparison of the two courses might yield interesting implications for enhancing the empathy of novice designers.

Similarly to Hess and Fila (2016), this study demonstrates that empathy is utilized throughout the design process, but adds the notion of its quantitative development. While the designers eagerly interacted with their end-users in all phases, the number of coded excerpts was halved in the detail design phase. This is a natural development, as the novice designers had to focus on fabricating components, coding interfaces, and otherwise creating a solution that matches the user-centered criteria they had previously defined.

5.2 Limitations

This study is primarily limited by the small number of participants, its focus on review sessions instead of more hands-on project work, and the lack of validity assessments for its qualitative analysis. However, the dataset of four teams is similar in size to that explored by Hess and Fila (2016), and this study extends the period of observation from 9 weeks to 20 weeks. Nevertheless, the course context in which this study was performed should be carefully considered when generalizing the outcomes. Further, observing review sessions is an established method in design research, and it can be argued that also professional design teams need to present their progress and outcomes to review boards, be they internal managers or

external client companies. Validity analyses, such as inter-rater reliability, are left for future work.

6 Conclusions

This study supports existing indications of empathy being present throughout the user-centered design process. This study further showed that the nature of empathy varies across the early development process. Future research should focus on validating these results and triangulating the methodologies of this study. Also, there is still a need to explicitly connect empathic activities and techniques to other measures of design work, including design outcomes, mindsets, and project success.

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References

Adams, R. S., & Siddiqui, J. A. (2015). *Analyzing design review conversations*. Purdue University Press.

Both, T., & Baggereor, D. (2009). Bootcamp Bootleg. *Stanford d.School*. Retrieved from https://dschool.stanford.edu/resources/the-bootcamp-bootleg

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101.

Brown, T. (2009). *Change by Design*. HarperCollins.

Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. *Journal of Personality and Social Psychology*, *44*(1), 113–126.

Dorst, K., & Cross, N. (2001). Creativity in the design process: Co-evolution of problem-solution. *Design Studies*, *22*(5), 425–437.

Gerace, A., Day, A., Casey, S., & Mohr, P. (2013). An Exploratory Investigation of the Process of Perspective Taking in Interpersonal Situations. *Journal of Relationships Research*, *4*, e6.

Gerdes, K. E. (2011). Empathy, Sympathy, and Pity: 21st-Century Definitions and Implications for Practice and Research. *Journal of Social Service Research*, *37*(3), 230–241.

Gerdes, K. E., Segal, E. A., & Lietz, C. A. (2010). Conceptualising and measuring empathy. *British Journal of Social Work*, *40*(7), 2326–2343.

Halpern, J. (2001). *From Detached Concern to Empathy: Humanizing Medical Practice*. Oxford University Press.

Hess, J. L., & Fila, N. D. (2016). The manifestation of empathy within design: findings from a service-learning course. *CoDesign*, *12*(1–2), 93–111.

Hess, J. L., Strobel, J., & Pan, R. (Celia). (2016). Voices from the workplace: practitioners' perspectives on the role of empathy and care within engineering. *Engineering Studies*, *8*(3), 212–242.

Hess, J. L., Strobel, J., Pan, R. (Celia), & Wachter Morris, C. A. (2016). Insights from industry: a quantitative analysis of engineers' perceptions of empathy and care within their practice. *European Journal of Engineering Education*, 1–26.

Hoever, I. J., van Knippenberg, D., van Ginkel, W. P., & Barkema, H. G. (2012). Fostering team creativity: Perspective taking as key to unlocking diversity's potential. *Journal of Applied Psychology*, *97*(5), 982–996.

Hölttä-otto, K., & Raviselvam, S. (2016). Guidelines for Finding Lead User Like Behavior for Latent Need Discovery. In *Proceedings of NordDesign 2016* (pp. 339–348).

Jerkku, M., Taajamaa, V., & Kirjavainen, S. (2016). Self-efficacy in product development

student teams - What shapes students' perceived self-efficacy. In *Proceedings of NordDesign 2016* (Vol. 2).

Johnson, D. G., Genco, N., Saunders, M. N., Williams, P., Seepersad, C. C., & Hölttä-Otto, K. (2014). An Experimental Investigation of the Effectiveness of Empathic Experience Design for Innovative Concept Generation. *Journal of Mechanical Design*, *136*(5), 051009.

Kelley, D. (2015). The Field Guide to Human-Centered Design. *IDEO.Org*. Retrieved from http://www.designkit.org/resources/1

Kirjavainen, S., Björklund, T., & Laakso, M. (2016). Framing activities and the co-evolvement of products and operations in new ventures. In *Proceedings of NordDesign 2016* (Vol. 2).

Kouprie, M., & Visser, F. S. (2009). A framework for empathy in design: Stepping into and out of the user's life. *Journal of Engineering Design*, *20*(5), 437–448.

Liedtka, J. (2015). Perspective: Linking Design Thinking with Innovation Outcomes through Cognitive Bias Reduction. *Journal of Product Innovation Management*, *32*(6), 925–938.

Raviselvam, S., Hölttä-Otto, K., & Wood, K. L. (2016). User Extreme Conditions to Enhance Designer Empathy and Creativity: Applications Using Visual Impairment. In *ASME 2016 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference* (pp. 1–9). Charlotte, North Carolina, USA.

Ulrich, K. T., & Eppinger, S. D. (2015). *Product Design and Development* (Vol. 6). McGraw-Hill.

Walther, J., Miller, S. E., Sochacka, N. W., & Brewer, M. A. (2016). Fostering empathy in an undergraduate mechanical engineering course. In *ASEE Annual Conference and Exposition*.

Zoltowski, C. B., Oakes, C., & Cardella, M. E. (2012). Students' Ways of Experiencing Human-Centered Design. *Journal of Engineering Education*, *101*(1), 28–59.