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Implications of Contextual Empathic Design for Engineering Education

Mr. Benedikt von Unold, Stanford University

Benedikt studied Medical Engineering and Mechanical Engineering at the Technical University of Munich (TUM). In 2017, he joined the Designing Education Lab at Stanford University to learn more about the integration of user backgrounds in design. He was involved in various entrepreneurial activities and worked as a student in small, medium and large companies. The creation of innovation was both an essential part in his studies as it was in his jobs.

Ms. Annette Isabel Böhmer, Laboratory for Product Development and Lightweight Design

Annette Böhmer studied Mechanical Engineering at Technical University of Munich (TUM). Currently she is about to finish her PhD in Agile Innovation of Mechatronic Systems. She co-founded Think.Make.Start., which is a lecture at TUM, that already created ~10 startups (eg. Hawa Dawa, Kewazo, Solos mirrors). This so-called Makeathon format was evaluated at BMW Group with ~250 employees that convinced top management with their working prototypes, created in just 5 days. Besides she benefit of a scholarship "Manage&More" at UnternehmerTUM, the Center for Innovation and Business Creation at TUM.

Dr. Tua A. Björklund, Aalto University Design Factory

Tua Björklund is one of the co-founders and the head of research at Aalto University Design Factory. She conducts and leads research, teaches product design, and facilitates development at the Design Factory. Tua has a DSc degree in industrial engineering and management and a MA degree in cognitive science.

Mr. Nicolas Ledl, Stanford University

Nicolas first studied mechanical engineering and then management at the Technical University of Munich (TUM). In 2018, he joined the Design Education Lab at Stanford University to continue Benedikt von Unold's work on Contextual Empathic Design. He gathered his core competencies in product development in the Rapid Prototyping Laboratory of BMW, in the Nanotech-Startup tilibit where he developed application scenarios for future products and during his master studies which he focused on innovation and entrepreneurship.

Prof. Udo Lindemann, Laboratory for Product Development and Lightweight Design

Udo Lindemann started 1968 to study Mechanical Engineering at the University of Hannover with a main focus on thermal process engineering. After graduation, he continued at the university as a research associate of Prof. Klaus Ehrlenspiel. The research focuses were cost driven product development and systems engineering. He finalised his dissertation in 1979 at the Technical University Munich.

In the years to follow, he held leading positions at Renk AG, Augsburg, in divisions such as mechanical engineering design and product development. Within Renk he was involved in the business of gears boxes, transmissions and test equipment. In 1992 he became CEO of MAN Miller Druckmaschinen GmbH and was responsible for production, logistics, quality, services, personal and factory planning. He also was responsible for a certain product range of the parent company MAN Roland AG.

Prof. Dr.-Ing. U. Lindemann succeeded Professor Ehrlenspiel in 1995 as head of the Institute of Product Development at the Technical University of Munich. Within the time since 1995 until today he served as Dean for Study Affairs and as Dean of the Faculty Mechanical Engineering. Today he is a member of the Academic Senate of the Technical University Munich.

He is co-publishers of the German journal "Konstruktion" and co-editor of several international journals. Since the initiation of the Design Society, he has been an active member, from 2007 to 2010 he served as its President. In addition he is an active member of a number of scientific societies and other organisations. 2008 he became a member of the German Academy of Science and Engineering.

Dr. George Toye, Stanford University

George Toye has been professional engineer, designer, researcher, consultant, entrepreneur, manager, and executive. Having worked on a diverse range of projects ranging from nuclear power plant control systems to digital libraries, he is a self-professed technology junkie — a perpetual misfit who enjoys mixing it up. In mechanical engineering circles, he is often labeled the "information technology" guy; amongst computer science folks, he is the "computer hardware" person; or to electrical engineers, he is the "mechanical" person. More often than not, he is simply one with a holistic systems perspective.

At Stanford, George has been senior research associate, associate director at Stanford Center for Design Research, and associate director of technology at Stanford Learning Lab.

Dr. Sheri Sheppard, Stanford University

Sheri D. Sheppard, Ph.D., P.E., is professor of Mechanical Engineering at Stanford University. Besides teaching both undergraduate and graduate design and education related classes at Stanford University, she conducts research on engineering education and work-practices, and applied finite element analysis. From 1999-2008 she served as a Senior Scholar at the Carnegie Foundation for the Advancement of Teaching, leading the Foundation's engineering study (as reported in *Educating Engineers: Designing for the Future of the Field*). In addition, in 2011 Dr. Sheppard was named as co-PI of a national NSF innovation center (Epicenter), and leads an NSF program at Stanford on summer research experiences for high school teachers. Her industry experiences includes engineering positions at Detroit's "Big Three:" Ford Motor Company, General Motors Corporation, and Chrysler Corporation.

At Stanford she has served a chair of the faculty senate, and recently served as Associate Vice Provost for Graduate Education.

Implications of Contextual Empathic Design for Engineering Education

Abstract

This research paper describes the results of a study exploring how **user backgrounds** can systematically be considered in **design activities** and how this can be used to enhance engineering design courses.

In human-centered engineering design, understanding what users desire and need is key for creating innovative solutions [1]. Uncovering insights of users is needed as a backbone to provide the best possible solution for real customer needs. In this process, it is important to consider the background of users such as their culture, gender, education, or socio-economic class. Many project-based engineering design courses have been developed over the years to explicitly address user needs. However, little is known on how influential these exercises are on the subsequent design decisions. In order to move towards evidence-based education, we need to be able to understand the impact of these exercises to improve students' ability to consider user backgrounds.

This study is based on a multiple case study of eleven student projects sampled within the past four years of the three-quarter master's level engineering design course ME310 at Stanford University. First, mid- and end-of project reports ranging from 50 to 250 pages were coded from seven projects, chosen after a teaching team session in which the projects were ranked. Four high-performing and three low-performing projects, in which people were seen highly pertinent to the design brief, were chosen for the analysis. A systematic comparison of the methods and strategies reported in each project was performed. Second, four ongoing projects from 2016 were chosen for further study in which people played a large part in the design brief. Students from these four projects were interviewed mid-course on how and why they considered user backgrounds. The interviews were audio recorded and transcribed for analysis, coding each interview for the reported problems and influences for considerations regarding user backgrounds.

The analysis revealed that challenges in considering user backgrounds occur on **three different levels**: First, teams are not **aware** of the background of the user as they do not consciously think about it (lack of awareness). Second, they do not **understand** the user background, even if they are aware of it (lack of empathy). Third, some teams are aware of the background and understand it but do not **integrate** the knowledge into the design (lack of integration). Especially methods with direct user contact and ones, in which designers immerse themselves in the user perspective are effective as hereby designers rely less on stereotypes and the empathic process is facilitated.

We develop a set of methods called "Contextual Empathic Design (CED)" based on the identified successful patterns of the student design projects to counteract problems occurred in user considerations. These guidelines enhance the education of engineers by improving their needfinding capabilities leading to an advanced overall ability to innovate. Further, this paper marks a novel way of supporting human centered design and provides recommendations on how CED can be translated into modern engineering education.

1.0 Introduction

In industry and science, huge efforts are made to create innovations since they are the basis for economic growth and determine the success of companies, communities, and nations [2], [3], [4]. However, the ability to innovate is a complex issue and has to be understood and managed properly. An important aspect in the creation of innovations is to understand what users desire and need [1]. Therefore, an essential part at the beginning of each development is to uncover insights of users to provide the best possible solution for real customer needs. In this process, it is important to consider the background of users such as their culture, gender, education, or socio-economic class. This background, and the set of involved life experiences, influences people's patterns of thinking and hence how people behave, how they perceive their world, and eventually what they desire [5]. Thus, understanding the background of users is important to understand their needs. Analyzing different contextual influences enhances a multi-perspective understanding of user problems and leads to more innovative ideas [1], [6]. However, design teams often do not pay sufficient attention to it. There are many examples where an incomplete understanding of the user background led to unsuccessful projects, and hence missed market opportunities or higher costs (see [7], [8], [9]).

In order to improve this situation, we have to provide a framework for engineers that guides them in their development (and consideration of background characteristics) and to teach them how to apply it. By doing this, we want to give engineers the ability to be aware of the range of people, who are affected by a product or service as related to their background characteristics. We coined this consideration and empathy towards users' backgrounds and characteristics as "peopleness" (see definition in Appendix).

2.0 Research Approach

We adopted a theory-building case study approach as suggested by Eisenhardt [10] to investigate (I) why design teams include peopleness or not in their projects and (II) how they achieve more peopleness in their projects.

2.1 Case Study Design

Cases were selected from the projects of the master's level engineering design course ME310 – a three-quarter course at Stanford University where student teams develop an innovative solution for a real-world problem and use a Design Thinking approach, each team working with a unique design brief. After each quarter every team writes an up to 250-page report describing the whole design process. The course provided cases with uniform structure (length, schedule, deliverables), ideal for comparisons on peopleness. To gain different perspectives on the design process, we considered both current projects from the batch of 2017 and projects from previous years (2013 - 2016). Interviews and observations were used to collect data from the 2017-projects, which could be studied in real time and therefore enabled a perspective on the messy process of product development with all influences and problems involved. Hence, these projects were especially valuable to reveal why design teams included peopleness. Here, problems that hindered the integration and influences that fostered the integration were extracted.

From past projects, the design reports were analyzed. As these projects were already completed, their results could be assessed and enabled conclusions on the efficacy of used practices. These practices, divided into methods and strategies, provide a glimpse in how the designers achieved more peopleness. Polar cases – successful and less successful cases – were

selected from the past projects as recommended by Eisenhardt [10] and Yin [11] to draw conclusions and build theory from success and failure.

2.2 Case Selection

Cases were chosen based on the extent of peopleness and for past projects, their success in addressing peopleness. The selection of the four current projects was based on results from a workshop with design experts that ranked the projects on peopleness based on the project prompts (design briefs). For the selection of people-centered projects from 2013 to 2016, a two-phased selection process was used. First, a natural language algorithm was developed and used to rank the design reports of all 39 conducted projects in terms of their peopleness by calculating the word vector distance between the text and a defined list of background characteristics (the algorithm is described in [12]; see Appendix for the list of characteristics). Word vectors are mathematical representations of the meanings of words. The algorithm in the program searched for the closest words to the target word and calculated the average distance between the vectors.

In the second step, the 11 past projects that were calculated as the most people-centered, were assessed in a workshop by the course professors (Larry Leifer, Mark Cutkosky, and George Toye), who are established experts in design and well familiar with all cases. The workshop was conducted to evaluate how well the team considered people and their background (peopleness performance, see Figure 1, below).

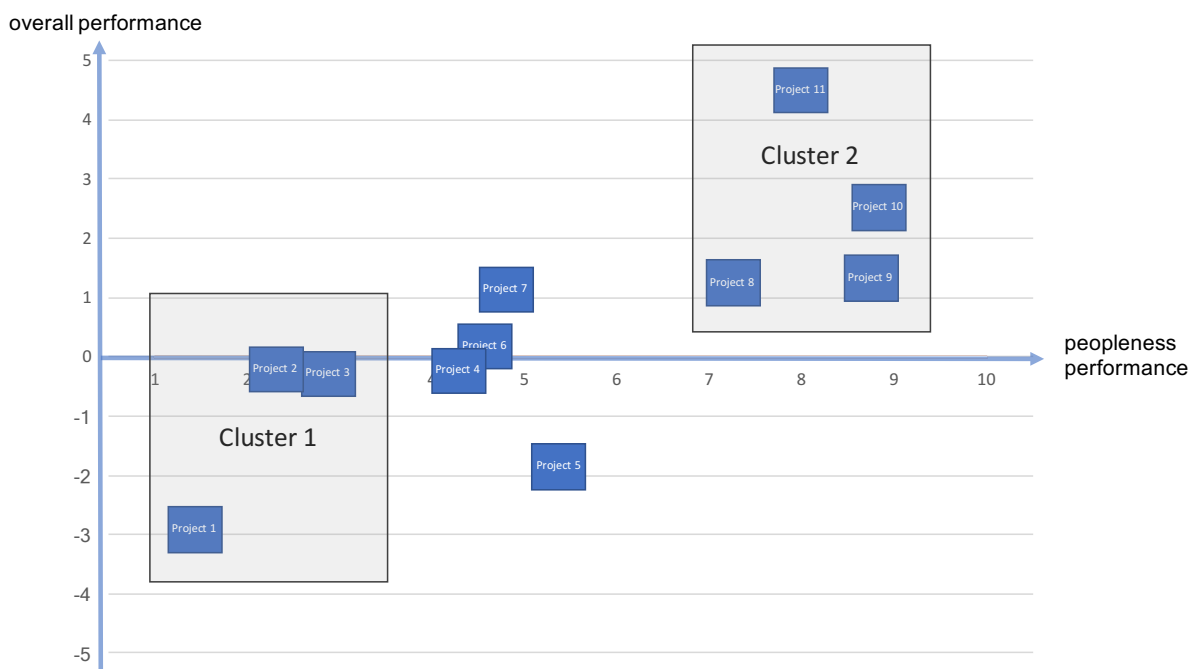


Figure 1: The eleven people-centered projects from 2013 - 2016 ranked on two axes

From the 11 projects, we could detect four projects that were more successful in terms of peopleness and three less successful ones. These were chosen for the cases of the current study (see also Figure 2). The axis “overall performance” emerged as suggestion from the workshop participants. However, it did not play a role in the case selection process. Further, the projects were not ranked on an absolute scale but relatively to one another. This procedure was used since the professors experienced that they are highly convergent on rank orders rather than absolute numbers such as grades.

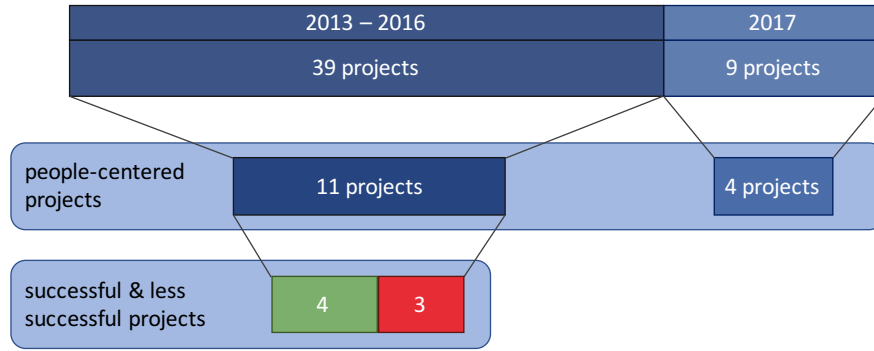


Figure 2: Selection process of past and current projects

2.3 Data Collection and Analysis

In the 7 cases from past projects (2013 – 2016), the final/quarterly reports (totaling at over 17,000 pages) were used as data. In the four cases of current projects (2017), three sources of data were used: 16 hours of interviews, 20 hours of observation, and the project reports (over 1600 pages).

The reports and transcripts of the interviews were analyzed in a qualitative text analysis as suggested by Kuckartz [13]. Three coding rounds were done. In the first round, everything related to peopleness was coded, i.e. any text mentioning user descriptions together with background characteristics. This step served as filter, to extract all relevant parts of the text.

Next, the texts were - deduced from the research questions - coded for “methods”, “strategies”, “problems”, and “influences”. This coding round was done in the program Dedoose and resulted in 751 code applications. The distribution of the code applications to these main-categories is shown in Table 1. The primary data source for the identification of methods and strategies were the reports, but triangulation was done with the interview data. Similarly, the interviews were used as the primary data source for identifying influences and problems, but the report data were used as a triangulation.

Table 1: Code applications in the second coding round

data type code	interview transcripts	reports	total
method	87	158	245
strategy	48	167	215
problem	75	14	89
influence	87	115	202
total	297	454	751

From here, sub-categories were developed inductively based on thematic similarities of the content [14]. The reports were used to create sub-categories for methods and strategies – the interview transcripts were used for the identification of problems and influences. We started with an unsystematic list of methods, strategies, problems, and influences and successively structured and concentrated them. At a point of saturation, the list was fixed and resulted in the coding scheme for the last coding round.

Afterwards, the sub-categories were clustered. The clustering of the methods was done deductively, whereas the strategies, problems, and influences were clustered inductively. The development and structure of the coding scheme is visualized in Figure 3.

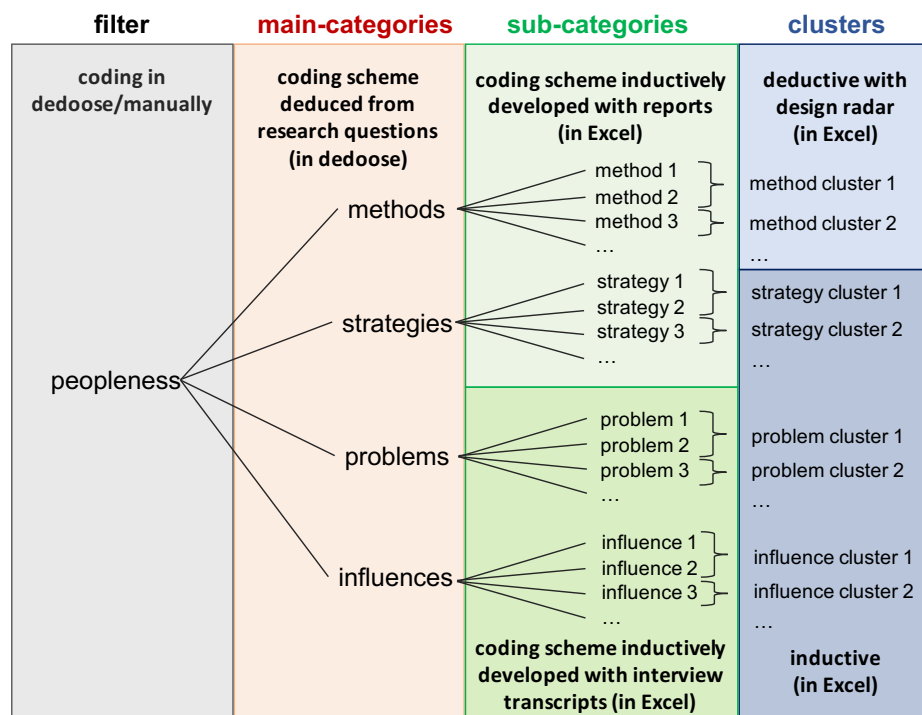


Figure 3: Coding scheme

3.0 Findings

This section presents the findings in the qualitative text analysis.

3.1 Practices

In total 24 methods and 21 strategies were found. It is important to note that the results do not reflect all applied methods or strategies in the projects, but only those which were used by teams to bring more peopleness into design.

Methods behind Peopleness

The 21 methods found in the analysis were clustered deductively along the fields of the “design radar” [15]. This radar categorizes design methods along two axes (see Figure 4).

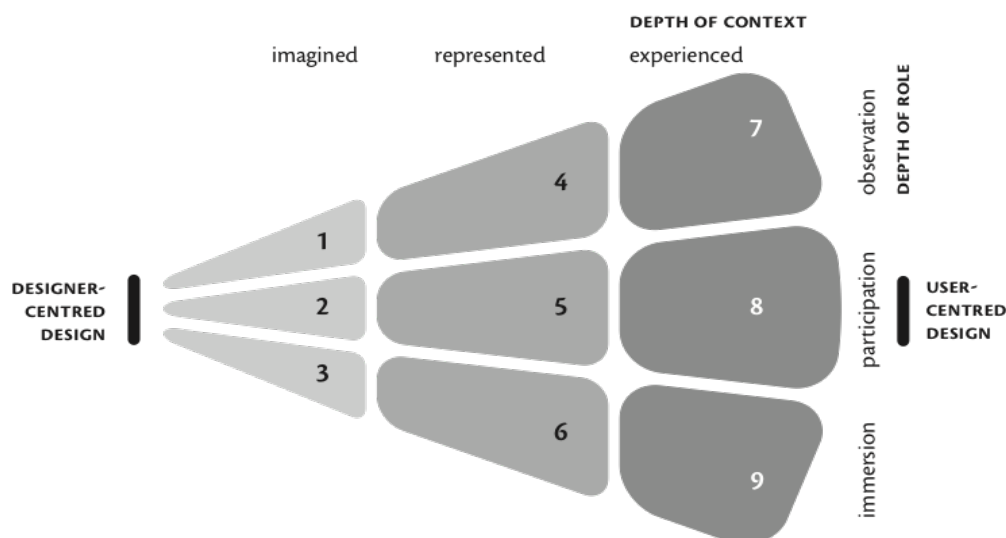


Figure 4: The radar of design research methods, from Koskinen [15]

The abscissa represents the depth of context. On the left are methods like brainstorming which are based on the imagination of the designer (cells 1-3). Methods that rely on secondary data are in the represented sections of the radar (cells 4-6). Here, documents and statistics are used. User research methods that enable a direct contact with users are located on the right of the design radar (cells 7-9).

On the ordinate, the depth of role of the designer is expressed. As opposed to participatory methods, observational methods are the ones where designers observe the users as bystanders and do not participate in the life of the users. In the *immersion*-fields, the designer enters the world of the users to see it from their perspective.

Besides the nine cells of the radar, “structure” was added as another cluster for two methods that did not fit into the design radar cells. Structuring-methods provide structure to the design process and guide the integration of peopleness throughout the development. Table 2 shows which methods were found and how they were clustered.

Table 2: Results of the report-analysis (numbers in the matrix indicate how often a method was mentioned)

design radar clustering			less peopleness - group 1				good peopleness - group 2				
			Project 1	Project 2	Project 3	total	Project 8	Project 9	Project 10	Project 11	total
observation	imagined	scenario building			2	x					
observation	imagined	brainstorm			1	x					
observation	imagined/represented	persona	3	3	4	x	1	3	5	3	x
observation	represented	online survey					1				x
observation	represented	secondary research	3	1	2	x	3	2	2	1	x
observation	experienced	interview with people from field	2			x		2			x
observation	experienced	user interview	3		4	x	13	5	5	11	x
observation	experienced	expert interview	4	1	2	x	1	11	5	2	x
participation	experienced	questionnaire with diary								1	x
participation	experienced	co-creation workshop						1		3	x
participation	experienced	emotion-timetable								1	x
participation	experienced	brain picture								1	x
participation	experienced	field visit	4			x	2	1	1	4	x
participation	experienced	user testing		1	2	x	3	1	4	5	x
immersion	imagined	role playing						1			x
immersion	represented	4-dimensional persona								1	x
immersion	experienced	real scale prototype					2				x
immersion	experienced	experience prototyping					2				x
immersion	experienced	age-man suit								1	x
	structure	mindmap for culture						1			x
	structure	mindmap to structure needfinding					1	1		2	x
total number of different methods			6	4	7	9	10	11	6	13	19
total number of mentioned methods			19	6	17	42	29	29	22	36	158

Whereas the projects with “less peopleness” (group 1) used nine different methods, the projects with “good peopleness” (group 2) used 19. Figure 5 reveals that group 2 used eleven more methods in the clusters participation, immersion, and structure – the numbers in the cluster observation differ by one.

group 1 – less peopleness

	imagined	represented	experienced
observation	3	1	3
participation			2
immersion			
structure			

group 2 – good peopleness

	imagined	represented	experienced
observation	1	2	3
participation			6
immersion	1	1	3
structure	2		

Figure 5: Comparison of the design radar of the two groups (numbers indicate number of different methods)

The method “questionnaire combined with a diary” exemplifies how teams can delve into the users’ routines and hence participate in their lives. As shown in the excerpt, this method was explicitly used to better understand cultural contexts and to go beyond the reach of observational methods, because “[...] they have limited reach regarding detailed information such as their daily life. [...] We wanted to understand more about their cultural context [...]]. The format of the first probe was a questionnaire combined with a diary section. The

questions revolved around best running experiences [...]. The diary section was designed to be filled over two days and it would detail the activities on those two days.”

With methods from the immersion-fields, teams can go even one step closer. One example is the age-man suit. This method is about designing and simulating the sensations elderly people experience. Thereby, the actual senses are impaired in a way that designers are able to see, hear, and feel like elderly do. The team recognized the limited reach of traditional methods and used the age-man suit to immerse into the life of elderly: *“Observation and interviews only get you so far. In order to really step into the shoes of the elderly we needed to feel the effects of growing old ourselves.”* To enhance the authenticity of this experiment, the team designed an everyday obstacle course. This course included *“[...] basic actions you do during the day, including getting out of the bed, putting on shoes, and going up and down the stairs.”* Also methods that structure findings and help to systematically consider background characteristics could be detected in the projects of group 2. One team created a context map where they specifically looked at the culture, socio-economic class, religion, age, and gender of their users. They also combined all their learnings about culture from interviews in a short but dense text – a written “mindmap about the user’s culture”: *“About culture: People are relaxed, but timetables aren’t kept. Don’t worry about the future. Everything is based on social relationships, work comes after that. Christianity is very prevalent. Education isn’t related to real life, but still very appreciated. [...] It gets dark by 7; don’t go alone (or with 2, or 3). Father is the head of the house, relatives come and go.”*

The analysis of the interview transcripts strengthened the findings from the reports. Seven methods were found in this analysis that were already found in the reports. Furthermore, three new methods (videos & pictures from field, what-if, asking about biases), forming a new cluster (“inspiration”), were found from the interviews. Methods from this cluster were designed to evoke insights regarding peopleness. In the method “asking about biases” a coach asked the design teams to think about the biases which they brought to a prototype. The designers were forced to think about their perspective and how this perspective might differ from the user’s perspective. In this way, they were made aware of the difference – and how this biased perspective eventually shaped the prototype: *“And one of the things [name - course coach] frequently did [...] when we prototyped an experience, he would ask us to identify what biases we brought to that prototype. And that was very, very, very, very helpful. [...] Being a man, I don’t think about safety the way a mother with two little kids [user] thinks about safety. And, definitely, young, 23-year-old [name - University] graduate students don’t think about safety in those terms.”*

Table 3 consolidates all methods from the report- and interview-analysis segmented into the structure of the design radar [15].

Table 3: All discovered methods from the reports and interviews

inspiration:	what-if		asking about biases		
	imagined		represented	experienced	
observation	brainstorm	per sona	videos & pictures from field	interview with people from field	user interview
	scenario building		secondary research	expert interview	
participation				questionnaire with diary	brain picture
				co-creation workshop	field visit
immersion				emotion-timetable	user testing
	role playing		4-dimensional persona	real scale prototype	experience prototyping
structure:	mindmap for culture		mindmap to structure needfinding		

Strategies for Peopleness

The report analysis yielded 21 strategies, classified into seven clusters. This clustering was done inductively based on thematic similarities. Table 4 provides an overview of the analysis.

Table 4: Results from the strategy-analysis with the reports (numbers indicate number of applied codes)

cluster	strategy	less peopleness - group 1				good peopleness - group 2				
		Project 1	Project 2	Project 3	applied in group 1	Project 8	Project 9	Project 10	Project 11	applied in group 2
awareness	conscious exploration of culture and context				0%		1		3	50%
	awareness of bias				0%	2	3		2	75%
broad perspective	holistic view - consider diverse stakeholder and perspectives	1			33%	1	3	6	8	100%
	universal/inclusive design		2	1	67%	6	2	5	8	100%
design reasons	design for biggest need				0%	1	1		3	75%
	broaden findings from field with secondary research				0%	1		2		50%
	design for biggest impact	1			33%					0%
	rely on imagined or secondary research	2	2		67%			1		25%
field work	go to user environment	4			33%	1	6	5	1	50%
	participatory design				0%		3		3	50%
	partnership for regularly field visits & user testing				0%			1	1	50%
integration	integration of needfinding results in persona	1			33%		4	2	3	75%
	integration of needfinding results in requirements	1			33%		1	2		50%
	peopleness in requirements	4		1	67%	3	4	3	4	100%
	continuously work with persona and complement				0%		1	1		50%
structure	integration of needfinding results in product				0%	1	1	5	1	100%
	structure findings and control mechanism				0%	9	4	1	2	100%
	persona framework				0%		2	2		50%
design principles	knowledge transfer				0%		2			25%
	root-cause-analysis				0%			1	2	50%
	question centered design				0%	2	1	1	2	100%

Awareness strategies: A pattern was found that most good projects explore background characteristics consciously and are aware of their bias. For one team of “group 2” a good understanding of the user’s context was important. They were aware of cultural differences and therefore analyzed it consciously. The “*socio-economic conditions, lifestyles, environment, etc.*” were critical for the team “*to be able to conceive empathetic solutions that would be accepted and effective.*”

Three out of four projects with good peopleness reported being aware of their own bias. They were aware that they make assumptions which come from their perspective, but need to understand the perspective of their users who often have other background characteristics: “*It is important to note that many of these observations stem from issues due to western cultural practices when it comes to using the restroom (such as the preference for sitting toilets over squat toilets, and the need for privacy). These issues must be further investigated: both from the standpoint of the target country, and among potential users who are more familiar with these cultural conventions.*”

Broad Perspective strategies: It was discovered that all group 2 teams tried to gain a broad perspective. They achieved a holistic view on the problem space by considering many different stakeholder and by approaching problems from various perspectives. They also intuitively applied universal and inclusive design approaches which counteract the exclusion of potential user groups: “*A lot of seniors use wheelchairs or scooter and not making the product accessible to them would eliminate a lot of users in the facility that would incorporate the product.*”

Design Reasons strategies: It was discovered that teams from group 2 tend to design for the user with the biggest need and then use secondary research to broaden the findings from

needfinding. In contrast, group 1 chose their user based on the biggest impact and used imagined or secondary data to justify their selection.

Field Work strategies: The successful design teams used several strategies where getting in the field and the interaction with users were the focus. They let users participate in their development process, desired experiences in user experiences, and build partnerships with institutions that enabled regularly field visits and user testings. One team, for example, developed a partnership with nursing homes to conduct weekly user tests and interviews: *“To gain access to the elderly, we made a deal with a senior house in Helsinki [...] that allowed us to visit them weekly. This weekly visit [...] became a centerpiece of the week for us. We would prepare our prototypes before Wednesday, take them out for testing and user interviews on Wednesday, and process the results after Wednesday and start preparing for the next iteration.”*

Integration strategies: Especially in group 2, strategies were found where design teams integrated peopleness in every step of the design process. They used needfindings results for the definition of their persona and their requirements, they used the persona throughout the design process, and they eventually integrated peopleness-insights into their product: *“Mahogany was chosen for the base material for its attractiveness to the older population, indicated by observations of antiques and furniture style.”*

Structure strategies: A strong pattern was found in the cluster structure. This was applied by all projects in group 2, but from none in group 1. Here teams used either formal design methods or simple tools like lists to structure their results – for example from needfinding. One team used five themes, that they discovered in needfinding, throughout the whole development as a control mechanism by analyzing whether all themes are addressed - for example in prototypes or in the persona. Others used frameworks for their persona where fields for background characteristics had to be filled out.

Design Principles: Three other strategies were found (knowledge transfer, root-cause-analysis, and question-centered design). These are general principles of how the teams approached design problems and were solely found in group 2. One team gained peopleness-knowledge by analyzing already finished but similar projects that considered the culture of their target user group. It was also found that teams in group 2 not only found peopleness insights but scrutinized their causes and effects. This approach, and also question-centered design, helped the teams to better understand the design space in a divergent manner (see [16]): *“The definition of footwear may seem trivial at first glance, but in reality it is not. For example, cultures around the world have different uses for footwear. What is the significance of this? Are there cultural roots or themes behind these differences?”*

3.2 Reasons behind the Degree of Peopleness

Cited Influences

Both the designer's environment and methods influenced the projects to include peopleness in their design. The environment is defined as all stimuli that are surrounding the designer such as internal stakeholders or activities that happen in the class. Whereas the teaching team and the team members were significant influences in the environment, the user interview was the most frequently mentioned method (see Figure 6).

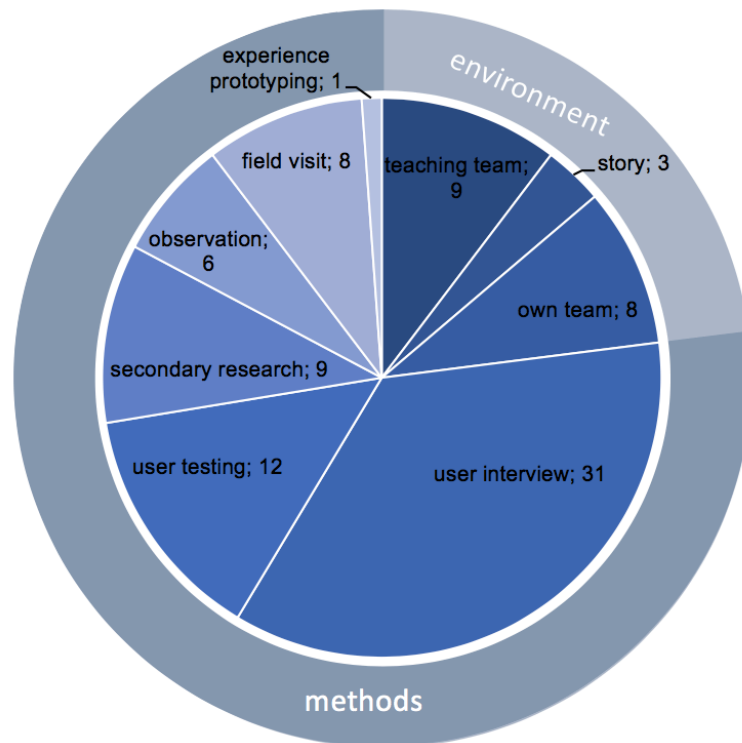


Figure 6: Influencing factors to include peopleness into design (numbers indicate number of applied codes)

People from the students' environment, such as the teaching team, were especially influencing when they told stories. In one project, a TA told the team stories about their children, which helped them to recognize the needs in this particular context and let them focus on said user group: *"So, because this idea first came from one of our TA, and she has two chaos children, and she also complained [...] We found it's a quite interesting topic."*

Furthermore, the team members themselves influenced their teams. In one team a Chinese team member helped the team to better understand the Chinese culture: *"And, particularly for probably the first three or four months, it was a big jump for me and [name –team member1] to actually understand a lot of the culture; whereas, [name –team member2] would just come in and go, "Yeah, that's just what Chinese people do." Whereas, for us, it was sort of, "Is it, really?" Like, we sort of had to have that validated; whereas, for him, it was sort of inherent that that is what Chinese culture is."*

Methods were found to be highly influencing for including peopleness in the case projects. Especially user interviews were often mentioned as influence. Although these were often not specifically designed to learn more about certain background characteristics and their implications, they provided unanticipated, yet important insights. In one project, two interviews influenced the team to look at gender differences and consequences for their design: *"So, actually, two interviewees told us about this before we thought about it. They told us that the problem of, like, being socially isolated after retirement was even more severe with males than females."*

The analysis of the reports repeated all influences from the interview transcript analysis except for the influence of the teaching team. In addition, some new influences in the environmental cluster were identified: personal experience, expert interview, age-man suit, and co-creation workshop.

Problems

In total, eleven problems were identified that are impediments to including peopleness. These problems were found on three different levels, which reflect different steps of the inclusion of background characteristics (both in terms of time and progress):

- lack of awareness
- lack of empathy/understanding
- lack of integration

Furthermore, a fourth cluster was deduced for problems that overarch the whole product development process (see results in Table 5).

Table 5: Result of the problem-analysis with the interviews (numbers indicate number of applied codes)

	project	project 1 (2017)	project 2 (2017)	project 3 (2017)	project 4 (2017)	total	total in cluster
lack of awareness	unconsciousness	6	13	8	7	34	40
	design for themselves	2	2	0	2	6	
lack of empathy/ understanding	acceptance of other perspective as truth	0	0	0	3	3	28
	hard to get users with certain background characteristic	0	0	1	2	3	
	hard to do needfinding with users from certain background characteristic	1	2	4	3	10	
	no clear user/persona	3	0	2	1	6	
lack of integration	peopleness insight, but no integration	0	1	1	0	2	5
	peopleness in requirements but not in product	0	0	2	0	2	
	persona without culture	0	0	0	1	1	
overarching themes	focus on technology	2	0	1	0	3	8
	lack of time	1	1	2	1	5	

Lack of Awareness: Every case mentioned that they had not included peopleness in the projects because it was not on their radar – they did not think about the background characteristics of their user. When asking the teams about background characteristics, they often gave answers like the following: *“I never thought about it, to be honest.”* Although their persona often had a gender, culture, age, or socio-economic class, they did not think about the implications and assigned those attributes only as a description: *“We’ve always kind of included them in our persona but more as a description of the persona and less as a distinctive characterization.”*

During the interview, however, they expressed interest towards considering peopleness: *“Now that you mention it, it might actually be important, because maybe some of them can afford to buy a smartphone but maybe some of them can’t.”* In some cases, the teams were not aware of peopleness or did not try to understand it because they designed for themselves: *“We didn’t have the cultural understanding, and, therefore, we probably didn’t use them because of that. Because they [personas] did quite end up just sounding [...] like us, which they shouldn’t.”*

Lack of Empathy/Understanding: The interviewees reported 28 times that they had problems to understand and empathize with the user. Reasons for this were the following:

- The teams had problems doing needfinding with people from certain backgrounds such as kids, elderly, and people from certain cultures: *“We’ve done some interviews for kids, but they [...] just start talking and inventing things [...] – it is difficult.”*
- They had trouble to accept a different cultural perspective as truth.
- They had problems getting in contact with users from certain backgrounds.
- It was difficult for the teams to understand the user when the persona is unspecific: *“We probably haven’t had a clear user from the start, which has probably not helped us. [...] So, now that we’re at the sort of pointy end, I think we’ve got a clearer user, which is helping.”*

Lack of Integration: Even with an awareness and understanding of the background of a user, the teams often did not integrate peopleness insights in the design process: *“In Germany, we spent a bit of time looking at the difference between female and male retirees, and we felt that the needs in male retirees were more pronounced because they tended to be even less socially active after retirement than females. But we didn’t really carry on that during the rest of the quarter.”*

Teams also did not integrate their insights in the persona and although one team had peopleness insights in their requirements they did not integrate this knowledge into their final solution.

Overarching Themes: Besides previously mentioned problems, the projects did not include peopleness because they focused on the technology or had no time. Often, these two problems were interrelated. The teams had to converge and build their prototypes because they had to deliver a solution and hence were not able to focus on the user anymore.

3.3 Development of Design Guidelines

In most cases, teams are not aware of the user background, or parts of it, because they do not think about it. But even when they are aware of it, some projects have problems in doing needfinding and understanding the user background. And sometimes, teams are aware of the background and understand it, but they fail to integrate the knowledge in their solution. Hence the integration requires both an awareness and understanding. Table 5 reveals that the numbers of code instances shrink from the lack of awareness to the integration of peopleness. An explanation for this phenomenon is that every step requires the existence of the previous step. The awareness lays the foundation and the integration eventually ensures that peopleness is considered in the product (see Figure 7).

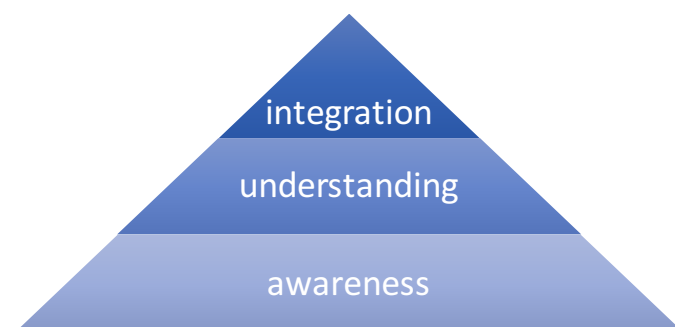


Figure 7: The peopleness pyramid

On the basis of the knowledge created in the case study the Contextual Empathic Design methodology was developed. This set of methods enables an empathic needfinding process and focuses on the user's context. They make use of background characteristics as a source of inspiration and foster the awareness, understanding, and integration of peopleness insights.

The methods are clustered in the three layers of the peopleness pyramid (see Figure 7):

1. *Methods of Discovery* (awareness)
2. *Methods of Enlightenment* (understanding)
3. *Methods of Integration* (integration)

Peopleness is achieved as an iterative implementation of all steps. Exposure creates awareness, awareness and empathy yield insights, and peopleness in the product is ensured by the integration of these insights. In total, Contextual Empathic Design contains 20 method cards. These include successful methods, counteract the identified problems, and summarize peopleness strategies which were found in the case study. Many cards are based on existing methods or are only the first formal descriptions of already used procedures. Some methods originate directly from the project teams or the teaching team. The framework for the methods is a structure proposed by Lindemann [17]. It consists of a description of the method and its application procedure, the purpose, the situation in which the method can be applied, and the effect. In Figure 8 an exemplary card is depicted.

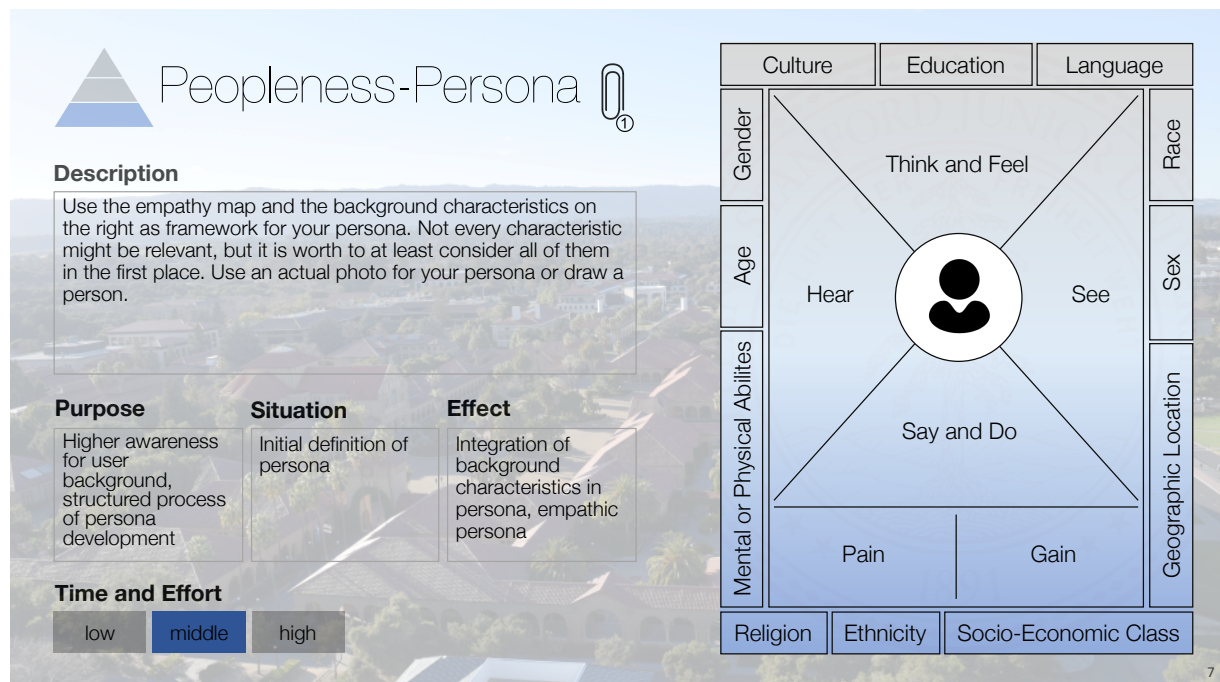


Figure 8: The method "Peopleness Persona"

4.0 Discussion

In this study it was not considered that different projects might require more or less peopleness. This could be achieved, for example, with a "light" or "advanced" set of cards. Furthermore, certain background characteristics might have a different importance in different projects. In projects that develop a product for a certain culture, culture is probably more important than for a project that is developing a product for the global market. Although there are specific methods which support cultural awareness and understanding, there is no support for the decision which background teams should prioritize – if they should prioritize any at

all. For the developed set of cards, it was defined as important that teams are at least aware of all characteristics initially and explore them consciously.

It is important to note that the cards represent only a first formal description of the patterns found in this study. They should be viewed as prototypes that have to be improved iteratively by testing them in real-life settings. Therefore, it would be valuable to conduct further applied research on how to integrate the cards into the design process and to measure their impact.

5.0 Outlook - Application in Practice

To extract knowledge about the integration of the cards, a first preliminary study was done. It should give a first impression of how teams empirically perceive and apply the design cards. The card-deck was provided during an intense two-week engineering course called Think.Make.Start (at TU Munich) that represents the process from idea to prototype within just 10 days in form of a Makeathon. The study goal was to explore the application of the CED-cards in a real-life context to observe general patterns across teams during application. The CED-cards were provided to the teams from day 3 after the first ideation phase. During the last day of the Makeathon, qualitative interview data were collected. The participating teams also wrote a reflection report about their experiences with Contextual Empathic Design. Three main reasons prevented observed teams from diving deeply into CED and seriously using the cards. Students reported the consistent lack of time and high pressure to keep their deadlines as main reason for not applying CED. Additionally, all participating teams consistently stated that CED-cards would have been more helpful when provided at the very beginning and during the initial ideation of their projects. Another key finding is the teams' desire for an instructor or a manual that facilitates the "right" situational application of a particular CED-method.

To start measuring the impact of the methods, a qualitative intervention study will follow. In a controlled quasi-experiment, a treatment group will be introduced to selected CED-methods whereas a control group will be provided with placebo design methods. Both groups will run a design task that is set up to be as relevant for peopleness considerations as possible. Each participant should complete the design task individually while thinking aloud. The transcribed data set will be coded with the purpose of "counting" peopleness relevant details. This consecutive study is intended to propose an experimental design that enables future research to investigate CED-methods and reveals the impact of specific CED-cards on students peopleness considerations during a design process.

6.0 Conclusion

A qualitative research design was used to build theory from case study research as suggested by Eisenhardt [10]. Innovation projects of the master's level engineering design course ME310 at Stanford University were analyzed and patterns of successful methods and strategies, to include user backgrounds in design, were extracted. Furthermore, the case study aimed to reveal where teams face problems that hinder the integration of user backgrounds as well as what influences them to integrate it. A qualitative text analysis of interview transcripts and design reports ensured a structured approach to identify methods, strategies, problems, and influences.

It was discovered that, besides the designers' environment, methods play an important role in including user backgrounds. Especially methods with direct user contact and methods where designers are put in the user's place are effective (immersion). For these methods, the designers rely less on stereotypes and the empathic process is facilitated. Problems occur on three different layers. First, teams are not aware of the background of the user because they do not think about it. Second, they do not understand the user background, even when they are aware of it. Third, some teams are aware of the background and understand it but do not integrate the knowledge into the design.

These layers were used as a structure for the development of method cards called "Contextual Empathic Design". "Methods of Discovery" help to create an awareness for user backgrounds. "Methods of Enlightenment" support the process of understanding the backgrounds and "Methods of Integration" help designers to integrate their insights in the solution. The methods created in this research are empirically connected to successful patterns in real design projects and address the most frequent, empirically identified impediments for including peopleness in design. They should enable an advanced human-centered design process that increases the desirability of products by harnessing the potential of background characteristics to better understand users, inform design decisions, and hence foster innovations.

References

- [1] D. Kelley and T. Kelley, *Creative confidence : unleashing the creative potential within us all*. New York: Crown Business, 2013.
- [2] T. Friedman, "The world is flat: A brief history of the globalized world in the 21st century," *London: Allen Lane*, 2005.
- [3] R. Berger, "Innovation als Grundlage des Wachstums von Wirtschaft, Beschäftigung und Wohlstand," in *Wertorientiertes Management*, N. Schweickart and A. Töpfer, Eds. Berlin: Springer, 2006, pp. 139-156.
- [4] P. Skogstad and L. Leifer, "A unified innovation process model for engineering designers and managers," in *Design Thinking Understand - Improve - Apply*, H. Plattner, C. Meinel, and L. Leifer, Eds. Heidelberg: Springer, 2011, pp. 19-43.
- [5] G. Hofstede, *Cultures and organizations. Software of the mind*. London: Mc Iraw-Hill, 1991.
- [6] T. Lindberg, R. Gumienny, B. Jobst, and C. Meinel, "Is there a need for a Design thinking Process?," in *DTRS8 - Proceedings of the 8th Design Thinking Research Symposium* Sydney, 2010, Sydney.
- [7] T. Brown and J. Wyatt, "Design thinking for social innovation," *Development Outreach*, vol. 12, no. 1, pp. 29-43, 2010.
- [8] L. Schiebinger, I. Klinge, I. Sánchez de Madariaga, H. Y. Paik, M. Schraudner, and M. Stefanick. (2017). Gendered Innovations in Science, Health & Medicine, Engineering and Environment [Online]. Available: <http://genderedinnovations.stanford.edu/>
- [9] S. Waller, J. Goodman-Deane, M. Bradley, I. Hosking, P. Langdon, and J. Clarkson. (2017). Inclusive Design Toolkit [Online]. Available: <http://www.inclusivedesigntoolkit.com/>
- [10] K. M. Eisenhardt, "Building theories from case study research," *Academy of management review*, vol. 14, no. 4, pp. 532-550, 1989.
- [11] R. K. Yin, *Case study research: Design and methods*. Thousands Oaks: Sage publications, 2003.

- [12] C. R. Wiggins, S. D. Sheppard, S. K. Gilmartin, T. Björklund, M. Arruza, and B. von Unold, "Coding for Culture, Diversity, Gender, and Identity in Engineering Education Papers," presented at the ASEE, Salt Lake City, June 24-27, 2018, 2018 (submitted).
- [13] U. Kuckartz, *Qualitative Inhaltsanalyse Methoden, Praxis, Computerunterstützung* (Grundlagentexte Methoden). Weinheim: Beltz Juventa, 2014.
- [14] V. Braun and V. Clarke, "Using thematic analysis in psychology," *Qualitative research in psychology*, vol. 3, no. 2, pp. 77-101, 2006.
- [15] I. Koskinen, K. Battarbee, and T. Mattelmäki, *Empathic Design*. Helsinki: IT Press, 2003.
- [16] J.P. Guilford, *The nature of human intelligence*. New York: McGraw-Hill, 1967.
- [17] U. Lindemann, *Methodische Entwicklung technischer Produkte: Methoden flexibel und situationsgerecht anwenden*. Dordrecht: Springer, 2006.
- [18] M. Loden and J. B. Rosener, *Workforce America!: Managing employee diversity as a vital resource*. Illinois: Business One Irwin, 1991.
- [19] K. V. T. Bui, "First-generation college students at a four-year university: Background characteristics, reasons for pursuing higher education, and first-year experiences," *College Student Journal*, vol. 36, no. 1, pp. 3-12, 2002.
- [20] S. R. Jones and M. K. McEwen, "A conceptual model of multiple dimensions of identity," *Journal of college student development*, vol. 41, no. 4, pp. 405-414, 2000.
- [21] M. D.-A. García, *The archaeology of identity: Approaches to gender, age, status, ethnicity and religion*. Taylor & Francis, 2005.
- [22] C. A. O'Reilly, K. Y. Williams, and S. Barsade, "Group demography and innovation: Does diversity help?," in *Research on Managing Groups and Teams*, D.H. Gruenfeld, Ed. St. Louis: Elsevier, 1998, pp. 193-207.

Appendix

Definition of Peopleness

Peopleness is awareness and empathy of the range of people, who are affected by a product or service as related to their background characteristics.

On the basis of Loden and Rosener [18] as well as Bui [19], Jones and McEwen [20], García [21], and O'Reilly, et al. [22] the following set of background characteristics is defined:

- culture
- gender
- sex
- education
- race
- ethnicity
- age
- religion
- mental or physical abilities
- geographic location
- socio-economic class
- language