AN ABSTRACT OF THE THESIS OF

Christopher Mendez for the degree of Master of Science in Computer Science presented on March 2, 2020.

Title: The InclusiveMag Method: A Start Towards More Inclusive Software for Diverse Populations

Abstract approved:

_____

Margaret M. Burnett

How can software practitioners assess whether their software supports diverse users? Although there are empirical processes that can be used to find "inclusivity bugs" piecemeal, what is often needed is a systematic inspection method to assess software's support for diverse populations. To help fill this gap, this thesis introduces InclusiveMag, a generalization of GenderMag that can be used to generate systematic inclusiveness methods for a particular dimension of diversity. We then present 1) a multicase study covering eight diversity dimensions, of eight teams' experiences applying InclusiveMag to eight under-served populations and their "mainstream"

counterparts and 2) the start of the application of InclusiveMag to making software more inclusive to individuals of low socioeconomic status, through means of a systematic mapping study.

The InclusiveMag Method: A Start Towards More Inclusive Software for Diverse Populations

by

Christopher Mendez

A THESIS

submitted to

Oregon State University

in partial fulfillment of
the requirements for the
degree of

Master of Science

Presented March 2, 2020

Commencement June 2020

Master of Science thesis of Christopher Mendez presented on March 2, 2020

APPROVED:

Major Professor, representing Computer Science

Head of the School of Electrical Engineering and Computer Science

---

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Christopher Mendez, Author

ACKNOWLEDGEMENTS

I would like to thank Dr. Margaret Burnett for all her help in developing my skills as a researcher and critical thinker. This work would not be possible without her. I would also like to thank my other co-authors who have helped with this work. Specifically, material in this thesis about InclusiveMag was co-authored with Larissa Letaw, Simone Stumpf, Anita Sarma and Claudia Hilderbrand and the material about the systematic mapping study was co-authored with Christopher Perdriau and Catherine Hu

Thank you as well to Jill Woelfer and Nizar Saqqar for mentoring me through internships and showing me how to apply what I've learned in school to product research.

I am very grateful to have been surrounded by many fantastic graduate and undergraduates throughout my time and while they didn't directly contribute to this thesis they impacted me along the way. Thank you, Will Jernigan, Charles Hill, Susmita Padala, Alannah Oleson, Amber Horvath, Andrew Anderson, Zoe Steine-Hanson, Jill Emard, Shannon Ernst, and Rupika Dikkala.

Lastly, I am immensely thankful to my family, friends and loved ones who have supported my journey. Thank you especially to Alyssa Saito, for embarking on our journey through grad school together and to my mom for maintaining a loving presence in my life from afar.

TABLE OF CONTENTS

Page

LIST OF FIGURES

Figure Page

LIST OF TABLES

LIST OF APPENDICES

Chapter 1: Introduction

Designing software so that it works for diverse populations matters—to software companies' profitability, to equity in the workplace and at home, and to anyone in a situation that changes the way they think, such as when under deadline pressure. Unfortunately, most software does not support diversity well (Borkin et al., 2013; Fernandez et al., 2013; Hassell, 2015; Subrahmaniyah et al., 2008; Tan et al., 2003; Williams, 2014).

Inclusive design aims to address this problem by considering diverse users throughout the software design process (Clarkson et al., 2013). There are many ways to bring diverse users into the conversation when designing software. For example, in co-design diverse users can be invited into design sessions to directly collaborate with software designers and one another in a small group setting (Bourazeri and Stumpf, 2018; Neate et al., 2019). Another example is user testing, which can give diverse users an opportunity to provide input about an existing software design, leading to a more inclusive design (Petri and Bevan, 2009).

However, working with diverse users directly is costly, both in terms of money and time, so methods that do not directly require users to be present are also needed. Toward that end, there has been a move to develop inclusive design guidelines and analytic methods but, except for a few well-researched user groups (Web Content Accessibility Guidelines, 2019), this work is still in its infancy. Moreover, few of these methods are usable by *software practitioners* in their every-day practice, but instead rely on experts to apply these guidelines and analytic methods.

Much of the software we use today has been written by software developers who are well-educated and well-paid individuals. As such, they are a relatively privileged group of individuals. Yet, as use of software has become more and more pervasive, software is expected to be usable by people with widely varied backgrounds and demographics—the old and the young, the educated and the uneducated, the fluent English speaker and the barely literate, the rich and the poor. As Microsoft's CEO put

it in 2015, Microsoft's vision is for their software to "empower every person and every organization on the planet" (Statt, 2016).

How can software professionals design software to fit people so diverse, many of whose lives are so different from most of their own experiences? Human Computer Interaction (HCI) researchers' ability to help address this question is hampered by the wide range of diversity in the populations affected by this situation. In fact, some of the populations affected have been barely studied at all. However, there are promising starts to research for some of the populations that have been rarely studied in past HCI research.

In this thesis, we introduce InclusiveMag (Inclusiveness Magnifier), a (meta-)method to generate inclusiveness methods. We built InclusiveMag inductively, by generalizing upon the principles and processes used in creating GenderMag (Burnett et al., 2016). Our inductive process is similar to one defined by Sjøberg et al. (2008) on how theories (and methods) can be inductively defined from concrete practice to more generalized forms. We additionally begin the application of InclusiveMag to making software more inclusive to individuals of low socioeconomic status, through means of a systematic mapping study.

The InclusiveMag method allows *inclusivity researchers* to set up a systematic inclusiveness inspection method, for *software practitioners* to then apply to their own software to systematically evaluate how it supports (or doesn't) diverse populations. The contributions of this thesis are:

- The InclusiveMag methodology, a systematic meta-method for *inclusivity researchers* to generate inclusive design methods for under-served software users;
- A methodology for *software practitioners* to *use* these generated methods to evaluate and re-design their software to increase its inclusivity;
- An early multi-case study of eight teams generating and using the InclusiveMag methodology.

- A start, in the form of a systematic mapping, to the application of InclusiveMag to making software more inclusive to individuals of low socioeconomic status.

Chapter 2: Background

2.1 GenderMag and Inclusive Design

Although InclusiveMag has not been described in the literature, we have been developing it for several years; in its first iteration, we used it to generate GenderMag.

GenderMag, short for "Gender Inclusiveness Magnifier" (Burnett et al., 2016), integrates a specialized cognitive walkthrough (CW) with research-based personas that capture individual differences in how people problem solve and use software features—differences that statistically cluster by gender. GenderMag has been used to detect gender biases in several commercial and open source software products (e.g., Burnett et al., 2010; Burnett et al., 2016; Cunningham et al., 2016; Hill et al., 2016; Mendez et al., 2018; Shekhar and Marsden, 2018).

The GenderMag method rests on five problem-solving facets, which it brings to life with three multi-personas—"Abi", "Pat(ricia)/Pat(rick)", and "Tim". They are multi-personas in that their backgrounds, photos, job titles, etc., are customizable. The facets, however, are fixed. Abi's facet values (Figure 1) are more frequently seen in women than other genders, and Tim's facet values are more frequently seen in men than other genders. The Pats' (identical) facet values emphasize that differences relevant to inclusiveness lie not in a person's gender identity, but in the facet values themselves (Hill et al., 2017). GenderMag's personas and facets are integrated into a specialized CW (Wharton et al., 1994).

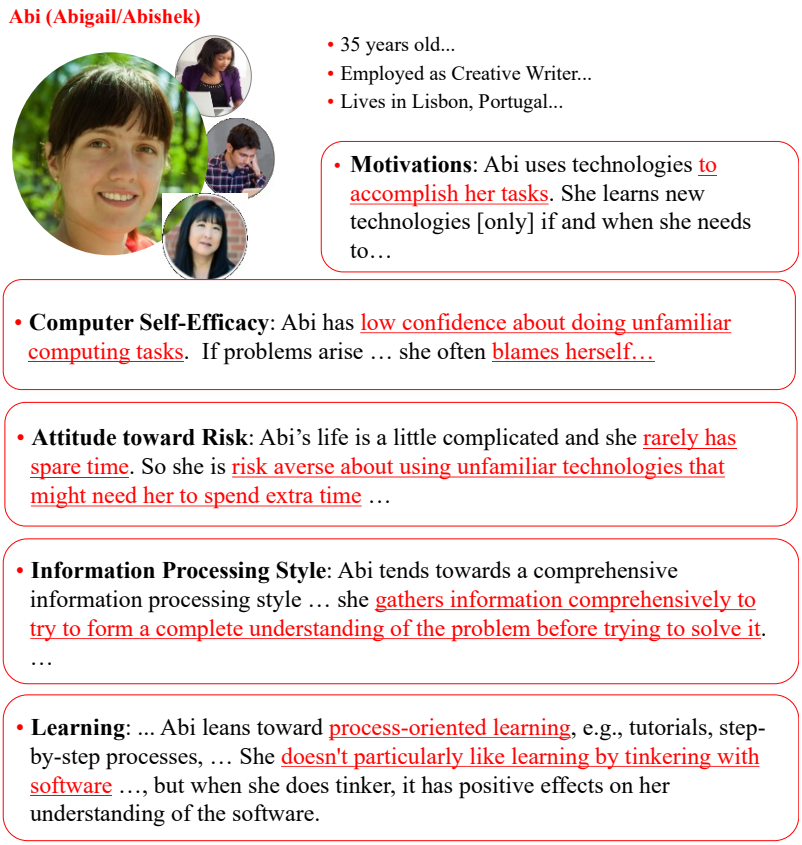


Figure 1. Abi's background, age, job, ethnicity, pictures, etc. (excerpted at top) are customizable, but her thinking is defined by the facets (red roundtangles).

2.2 Systematic Mapping

A systematic mapping study analyzes existing research in order to map the landscape of a research area (Petersen et al., 2015; Petersen et al., 2008). Although systematic mapping studies are common in some areas, such as social sciences, software engineering, and medicine, they are less common in HCI. In essence, a systematic mapping study is a breadth study, analogous to a highway map. It is used to study areas with diverse research. Like a highway map, its goal is to show the "locations" (subtopics) of research activity across the research space, to give an idea of the relative size of each, to show connections among them, and to identify gaps.

Systematic mapping studies use a selection methodology, similar to that of a systematic literature review; both are structured ways of identifying and evaluating literature relevant to a particular research question. The main difference is that a systematic literature review aims at depth coverage, whereas a systematic mapping study aims at breadth (a map of the landscape) to cover more papers in a high-level overview (Kitchenham, 2014).

Chapter 3: The InclusiveMag Method

InclusiveMag is a (meta-)method to enable inclusivity researchers to generate new inclusive design methods. The methods they generate are then intended for use by software practitioners to evaluate the software they are producing, with the goal of making the software more inclusive to an under-served population, while simultaneously making the software more usable to a mainstream population. As Figure 2 shows, InclusiveMag has three steps—(1) Scope, (2) Derive, and (3) Apply. Inclusivity researchers perform Steps 1 and 2, and software practitioners perform Step 3.

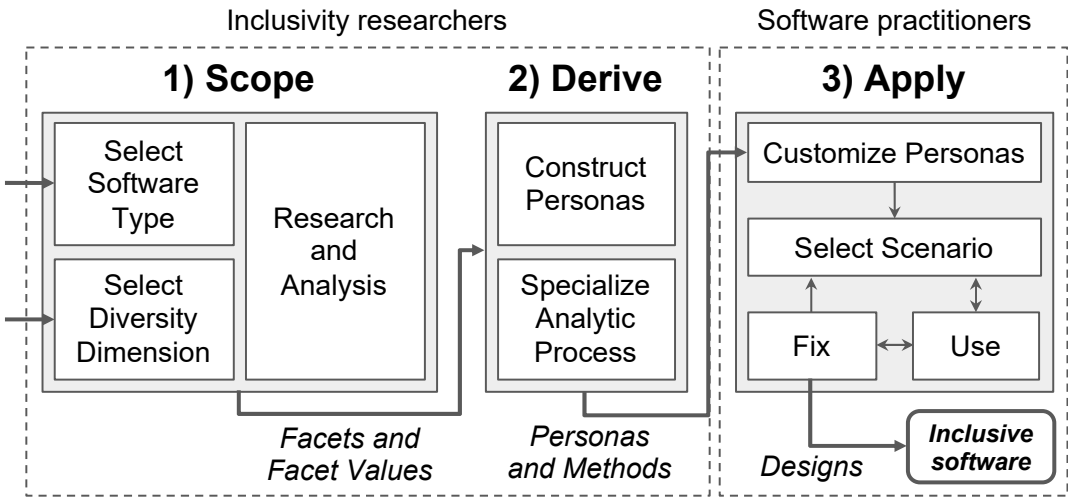


Figure 2. The InclusiveMag process has three steps, each of which has multiple components. Inclusivity researchers perform Steps 1 and 2, and software practitioners perform Step 3.

Step 1: Inclusivity Researchers Set the Scope

In Step 1, inclusivity researchers scope the inclusiveness method. They select a software type, select a diversity dimension, and perform research on what might affect how populations along the diversity dimension use the software type. The components of this step are iterative and often intertwined: the software type and diversity dimension inform the facets, and vice versa. Step 1 results in a set of facet categories (termed "facets" in this thesis), which are relevant to both the under-served and mainstream populations, and facet values, which differ between the under-served and

mainstream populations. The facets form the core of the InclusiveMag-generated method.

Step 1's research component is labor-intensive, but the resulting facets depend on its quality. The goal is to produce well-established facets in which individual differences (i.e., the facet values) tend to cluster into the under-served population differently than from the mainstream population, and that are relevant to the chosen type of software. It may include a systematic literature review (Kitchenham et al., 2009), interviews with experts in the software types and members of the under-served population, lab or field studies, etc. For example, the GenderMag research component included reading theories and empirical work in other disciplines to understand gender differences in cognitive styles and attitudes affecting cognition (Beckwith and Burnett, 2004), such as in information processing theory (Arcand and Nantel, 2012; Meyers-Levy and Loken, 2015; Meyers-Levy and Maheswaran, 1991; O'Donnell and Johnson, 2001; Riedl et al., 2010) and self-efficacy theory (Beckwith et al., 2005; Burnett et al., 2010; Huffman et al., 2013; PiazzaBlog, 2018; Singh et al., 2013). It also included empirical studies (e.g., Beckwith et al., 2005; Beckwith et al., 2006).

The output of this step is a "small enough" number of facets to keep the method feasible for use by software practitioners. GenderMag, for example, has five facets Shown in section 4.1 of Burnett et al. (2016) these facets were selected from the larger set of individual difference research results (Beckwith et al., 2005; Beckwith and Burnett, 2004; Beckwith et al., 2006) using three criteria. First, (1) the facet needed to have direct implications for software usage. (2) Second, the facet and/or facets' ties with software usage needed to be backed by extensive prior research. (3) Third, the facets needed to be usable by ordinary software developers or user experience (UX) practitioners who had no prior background in gender research or in psychology (Burnett et al., 2016).

Step 2: Inclusivity Researchers Derive the Method

In Step 2, inclusivity researchers use the facets produced in Step 1 to derive customizable personas and an analytic process specialized to their selected diversity dimension. Step 2 begins with projecting (flattening) the values of each facet (category) onto a linear scale for that facet. These scales provide the positioning for the facet values: one value at each "endpoint" of each facet, and one somewhere within, to make clear that the facet values are on a continuum, not binary (yes/no) values. For each facet, the inclusivity researchers assign to the under-served persona facet values that represent the endpoint of the under-served population, and to the mainstream persona the opposite end-point, selecting endpoints that are reasonably common among those populations, not extreme outliers.

The facet values of the middle persona depend on what the data "tell" the inclusivity researcher to do. Sometimes there are interesting points between the two endpoints. For example, GenderMag learning styles had three distinct styles observed: learning by process, learning by tinkering, and learning by mindful tinkering. There being a third unique or interesting point between the endpoints is not always the case, so sometimes the middle persona is assigned one of the endpoints.

For example, consider GenderMag's risk facet as flattened onto a linear scale. Abi's facet value (risk averse) is at one endpoint, Tim's facet value (risk tolerant) is at the other endpoint and Pat (moderately risk averse) is in the middle. As Figure 3 shows, all of these facet values are fairly common among the population of users shown. Table 1 shows the assignments of all five GenderMag facets' values.

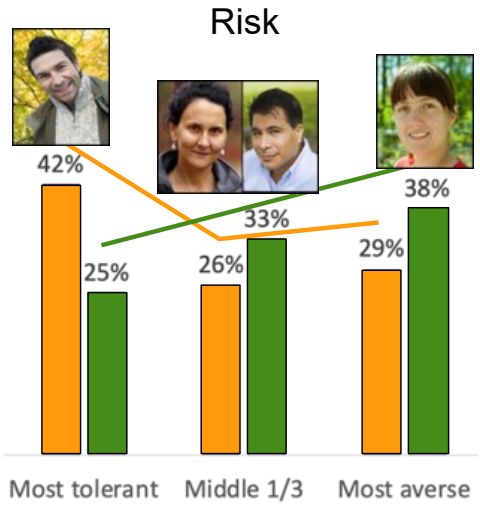


Figure 3. A population of users' self-reported attitude toward risk in technology. Tim represents users on the risk tolerant side of the data, Abi represents users on the risk-averse side, and Pat represents those in the middle. These data had two genders: Orange: men; Dark green: women.

Table 1. A summary of the facet values for each persona.

Facet (category)	**Abi facet value (Figure 1)**	**Pat facet value**	**Tim facet value**
Motivations for using technology	Wants what the technology can accomplish.	Wants what the technology can accomplish.	Technology is a source of fun.
Computer Self-Efficacy (confidence) in using unfamiliar technology	Low compared to peer group.	Medium.	High compared to peer group.
Attitude towards Risk when using technology	Risk-averse.	Risk-averse.	Risk-tolerant.
Information Processing Styles for gathering information to solve problems	Comprehensive.	Comprehensive.	Selective.
Learning Styles for learning new technology	Process-oriented learner.	Learns by tinkering; tinkers reflectively.	Learns by tinkering (sometimes to excess).

The inclusivity researcher then embeds the facets in the different personas, but leaves most of the background section customizable (e.g., Figure 1) to allow software practitioners to customize the persona in Step 3 to fit their target demographics. For

example, in GenderMag, personas' ages, education, job title, familiarity with particular technologies, ethnicity, etc., are customizable, but not the facet values.

For specializing the analytic process, GenderMag specialized a CW, and their procedure generalizes, so we describe it here. (We briefly consider other analytic processes in later sections.)

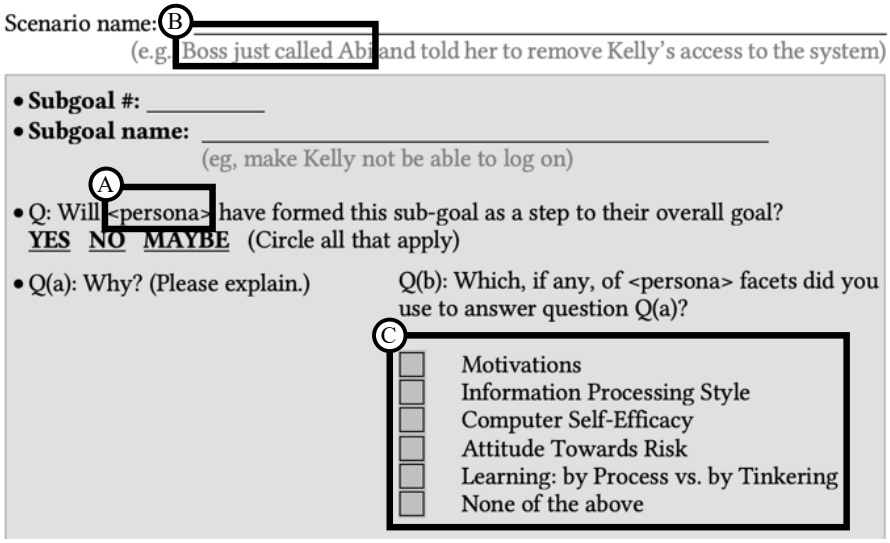


Figure 4. GenderMag's specialization of a CW form (see text).

To specialize a CW, an inclusivity researcher can point explicitly to the selected persona and to relevant facets for each question. For example, as Figure 4 shows, GenderMag researchers specialized in three ways to help software practitioners maintain engagement with the persona (Hill et al., 2017; Mendez et al., 2018). First, the form refers to the persona by name in the questions (Figure 4 (A)). Second, it provides example text to encourage practitioners to express goals/scenarios from the persona's perspective (Figure 4 (B)). Third, it scaffolds "Why/which" responses with a list of the personas' facets (Figure 4 (C)).

An InclusiveMag CW *itself* needs to be inclusive—collecting a *union* of evaluations, not arguing toward a consensus. To help make this explicit in GenderMag, the forms include a "maybe" option (Figure 4, just below Box "A") to encourage everyone to

voice their views along with their explanations of why. Although a potential concern could have been that including all views would encourage false positives (including issues that do not actually arise) GenderMag's empirical false positive rate has been very low, ranging from 0%-4% (Burnett et al., 2016; Vorvoreanu et al., 2019).

Step 3: Software Practitioners Apply the Method

The outcome of Step 2 is a generated method built upon the facets selected in Step 1. In Step 3, a team of one or more software practitioners applies it to their software.

Software practitioners begin Step 3 by customizing the persona(s) they want to use to the appropriate background/demographics/skills for the software they will evaluate (recall Figure 1). The skills, experience, and education/training dictate what a persona would reasonably be expected to already know and expect to accomplish in the new software features if they haven't used them before. For example, if software practitioners in Portugal wanted to evaluate a new word processing application using GenderMag, they might make Abi a 35-year old Portuguese novelist who lives in Lisbon and has a degree in creative writing, with experience using other word processing applications.

The software team chooses one of the personas they just customized. (One persona is used at a time.) They then choose a scenario to analyze for their software, from the perspective of that persona. For example, a software team using GenderMag might choose Abi for their first session (Burnett et al., 2016). In the word processing example, a scenario might be "Abi wants to edit Chapter 2's story line to include foreshadowing of an upcoming kidnapping plot. She has already typed in Chapter 2, but hasn't used many of the application's editing features before." Using the persona and the scenario, the team then performs the analysis, producing a list of specific issues that some users like the persona could encounter.

The session's output is a list of issues to fix. Some of these issues found will be general usability issues (e.g., the font is too small), whereas others will be

inclusiveness issues (e.g., risk-averse users would struggle with this step). For the inclusiveness issues, inclusive fixes can be driven by the facets that revealed the issue (e.g., risk). For example, in one GenderMag study, generating fixes to a facet's full range of values (e.g., risk averse and risk tolerant users) resulted in the software improving for everyone, and a previous gender gap in using it entirely disappearing (Vorvoreanu et al., 2019). As this process of fixing the issues suggests, the success of the generated method depends heavily on facet quality, which in turn depends on the researchers' abilities to obtain or produce enough high-quality evidence from which to derive such facets. The following case study sheds some light on this.

Chapter 4: Multi-Case Study

4.1 Multi-Case Study: Method

How generalizable is InclusiveMag? Can inclusivity researchers (other than the original inventors) use InclusiveMag to generate methods analogous to GenderMag, for other diversity dimensions? To find out, we conducted a multi-case study of eight teams using InclusiveMag, who derived eight different InclusiveMag-generated methods.

The setting was an Inclusive Design class[1] for Computer Science juniors, seniors, and graduate students, a population aiming to become the software practitioners at whom the InclusiveMag method aims. About half the students had Human Computer Interaction (HCI) experience, and some also had professional software development experience. Students formed eight teams of 3-4 people each. All teams included someone with research experience.

Each team worked for 10 weeks. Their goals were: (1) to use InclusiveMag to generate (scope and derive) their method for a software type and a diverse population of their choice along some diversity dimension, and (2) to apply that method in an effort to make software prototypes that were inclusive to their under-served as well as a mainstream population.

This empirical set-up involved an empirical trade-off. The disadvantage was that the teams had a relatively concrete focus: to generate a method that would help a single software product's inclusiveness. As Chapter 3 shows, the cost of building the method is high enough that many inclusivity researchers would be likely to want a reusable method that could be used on many software products, as with the GenderMag

---

[1] The class materials (shorturl.at/lUY23) entirely define the study environment and the methodological guidance available to the participants.

method. However, the empirical advantage to this approach was that it included coverage of how teams went about the third InclusiveMag step, *applying* the generated method to a software product. (It also provided an education advantage: a feedback loop that enabled teams to gain insights into how the method they generated would play out in practice when they had to apply it.)

The eight teams selected a variety of populations and software, such as making email more inclusive for older (and younger) adults; self-driving cars that would work for people with dementia and for people without it; and university websites that would work for people with low socioeconomic status and for people with higher socioeconomic statuses. Table 2 details the 8 teams' populations and application types.

4.2 Multi-Case Study: Results

4.2.1 Step 1: The Teams Set the Scope

4.2.1.1 Scoping the Software Type and Population

All eight teams tended toward a narrow scope for their *software* type (see Table 2). This contrasts with GenderMag, for which the software type scope is any "problem-solving software". Had the teams extended their work past 10 weeks, they may have found the narrowness of their software type scope limiting. For example, Team ADHD might want to know how their under-represented persona would fare with Team Autism's math learning app—but since Team ADHD created their persona facets with finance management in mind, the team might have to do the entire InclusiveMag process again, rather than re-using the method they had just generated.

Table 2 The eight teams present in the multi-case study, along with some information on their projects. Team names used in this Thesis are Underlined.

Populations considered	**Diversity dimension**	**Software type**	**Facets from research**
ADHD, ≠ADHD	Cognitive	Managing finances	Focus, Organization, Impulsivity,

			Memory, Financial responsibility
Autism kids, ≠Autism kids	Cognitive	Math learning	Comprehension ability, Ability to follow instruction, Concentration level
Dementia, ≠Dementia	Cognitive	Self-driving car	Motivations, Memory, Problem-solv. & learning ability, Self-sufficiency/independence, Attention
Diabetic retinopathy, Good vision	Vision	Chore robot	Physical/visual ability, Technology preferences, Emotional state & well-being, Financial stability & status, Social interactions
Low literacy, Med/High literacy	Education	Language learning	Confidence in using tech, Reading skills, Learning style, Motivations/frustrations with tech. Susceptibility/sensitivity to tech requiring reading
Low socio-economic status (SES), Med/high SES	Socio-economic status	University's website	Home life, School experience, Psychological health, Career aspirations
Older Adults, ≠Older Adults	Age	Email	Tech. comfortable with, Attitude toward tech, Physical difficulties
Pre-schoolers, Adults	Age	Media player	Motivations, Approach to learning, Attitude to recovery, Interaction style, Approach to tech.

In contrast to narrow software type scopes, some teams scoped their *populations* broadly. For example, Team SES chose people with low socio-economic status for their under-served population. This population is very large and diverse, which could have made it difficult for Team SES to choose a set of facets that was both small enough and sufficiently representative of their under-served population. Even so, because they had chosen a narrow *software* type scope (one section of a university website), they focused most of their research pertinent to students using that university's site, such as basic literacy and digital search skills.

Other teams chose a narrow population slice. For example, Team Retinopathy chose, as their under-served population, a visual impairment resulting from diabetic

retinopathy (Figure 11). Diabetic retinopathy is a specific disease that affects, at least to some degree, millions of people (about one-third of the estimated 285 million people in the world with diabetes mellitus) (Lee et al., 2015). However, the millions with the disease of diabetic retinopathy are but a small fraction of the approximately 1.3 billion people who have some form of vision impairment (World Health Organization, 2018). Even more people encounter forms of vision impairment situationally, such as when wearing sunglasses (Microsoft, 2019).

Despite narrowness's detriment to later reusability of the method they would generate, narrowness had some advantages. For example, during their research into their under-served population, Team Retinopathy identified facets specifically applicable to their population—but not necessarily to other vision impairments—such as emotional well-being (Figure 5). Indeed, in Step 3, this facet did impact the team's design of their prototype:

> Team Retinopathy (excerpt from final report, on design decisions due to facet "emotional well-being"): All of these features will help make Suzie less stressed out as she interacts with the prototype.

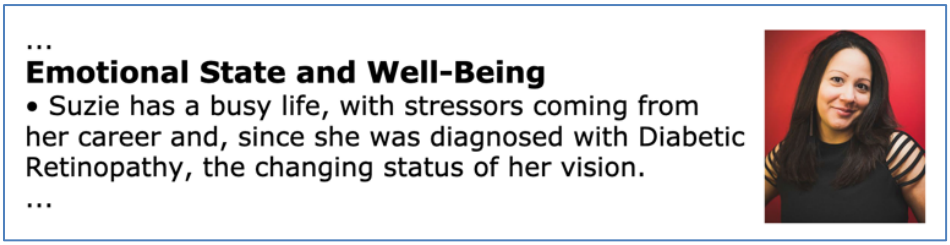


Figure 5. An excerpt from Team Retinopathy's foundation document for Suzie, their under-served persona.

4.2.1.2 Researching the Populations and Facets

To research their populations, especially the under-served members of it, teams gathered data through literature reviews and, in some cases, directly from individuals in their under-served population. For example, Figure 6 shows an excerpt from Team

Older's literature-based research about older adults, and Figure 7 shows summary data gathered by Team SES from individuals in their under-served population.

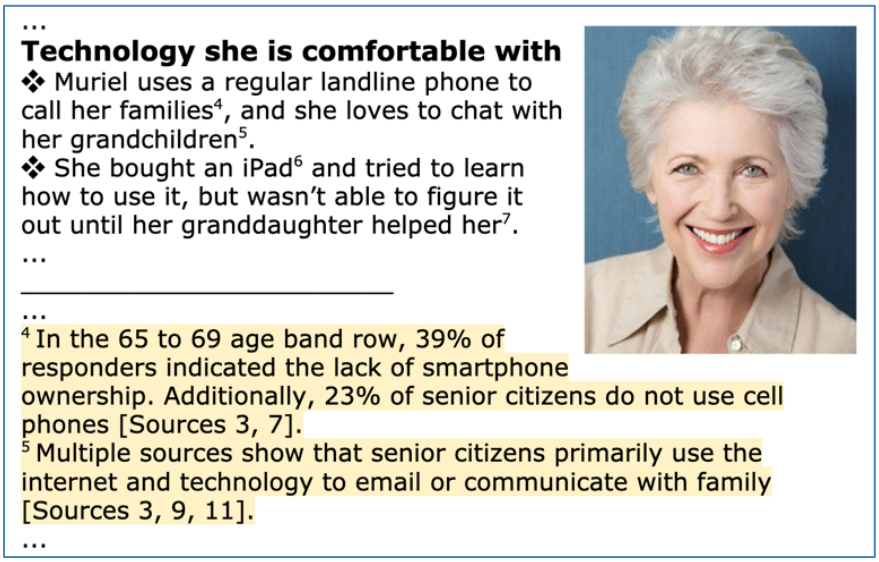


Figure 6. An excerpt from Team Older's persona foundation document with data (highlighted) sourced from literature about their under-served population.

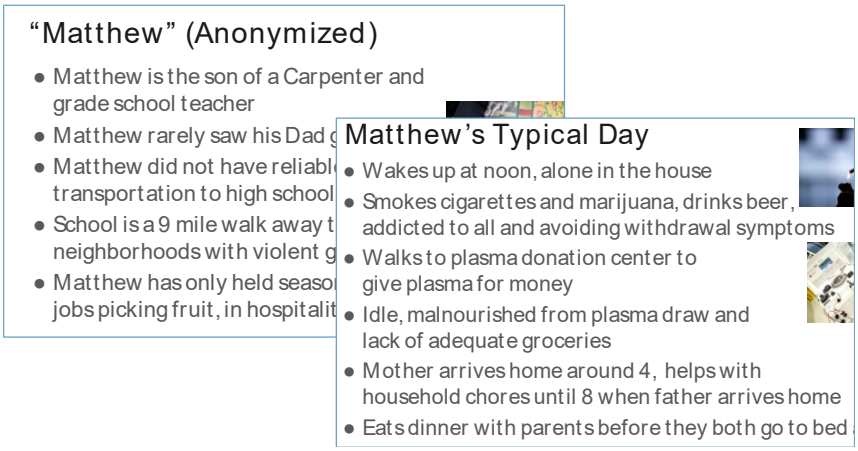


Figure 7. Excerpts from Team SES qualitative experiences with low-SES people.

The teams followed a qualitative affinity diagramming process as described in (Adlin and Pruitt, 2010) to organize their data "factoids" (short facts) into facets (categories) whose values distinguished their mainstream vs. their under-served populations. (In

contrast, the GenderMag creators had tended toward quantitative techniques to identify relevant data that clustered by gender, as per Figure 3.)

The facets captured what the teams saw as the most critical attributes of their under-served populations vs. their mainstreamers for their software type scope—thus defining the non-customizable portions of the personas. All eight teams documented the foundations they used to develop the facets via persona foundation documents, which they presented in styles modeled after the GenderMag foundation documents [gendermag.org] or the sample foundation documents in (Adlin and Pruitt, 2010).

4.2.1.3 Which Facets?

When inclusivity researchers choose how many facets to give personas, they are deciding on behalf of software practitioners, who will need to keep these facets in mind. The GenderMag researchers settled on five facets (Burnett et al., 2016), and the teams loosely patterned their notions on how many facets to choose after that example. Five teams chose five facets, one settled on three facets, and two used four facets.

Team Dementia finessed their five facets by adding 14 sub-facets. For example, Figure 8 shows three subfacets within Team Dementia's "Self-sufficiency" facet. An advantage of this level of detail is a rich and informative representation, but a potential disadvantage is the difficulty of keeping 14 subfacets in mind when evaluating a software product. However, Team Dementia's final evaluation explicitly used 11 of their 14 subfacets, and seems to have implicitly used the remaining 3 subfacets.

...

Self-sufficiency/Independence

- Driving Ability: Lillian's driving privileges were taken away due to the progress of her Alzheimer's so she needs to rely on her family and friends to take her places such as the grocery story, appointments, etc. [sources]
- Living Ability: Lillian has lived alone for about 3 years and since she is a very social person it makes her depressed. [sources]
- Physical Ability: She can only walk short distances and feels unsafe using public transportation. [sources] ...

Figure 8. An excerpt from Team Dementia's foundation document for their under-served persona, showing the multiple subfacets of "Self-sufficiency"

One reason Team Dementia had so many subfacets may have been because intersectionality was hard for them to avoid. People suffering from dementia are also likely to be older, and both of these situations come with side effects. Team Dementia wanted their facets to be general enough to be reusable but still realistic. Since people with dementia are older, should they also have a motor impairment facet? Since many people with dementia suffer other mental issues as well, such as depression, should depression be a facet?

Teams addressed their intersectionality dilemmas in three ways. Some teams, like Team Dementia, incorporated depression as part of an existing facet value (see the "Living Ability" subfacet in Figure 8). Some teams, when the side effect was not directly associated with the diversity dimension (e.g., an explicit motor impairment), excluded it for generality reasons. Some teams made facets to address physical or mental issues that affect their population, without labeling them with specific disorders. For example, Team Older used the facet "Physical Difficulties" and Team SES used "Emotional Volatility". (We will return to intersectionality in Section 4.3.2.)

All GenderMag facets are cognition-based, but some of the teams' facets weren't. For example, Team SES had "Home life" and "School experience" (Table 2) and Teams Retinopathy and Older included pertinent physical/physiological attributes.

However, Team Older may have gone too far in the direction of concreteness with their "technology she is comfortable with" facet choice (Figure 6). Including specific technology preferences like the ones in the Figure 6 seems likely to give the generated method itself a short 'expiration date'. Such concreteness is common in *personas* for use in a specific *product* line, the traditional use of personas (Adlin and Pruitt, 2010). However, for a *facet* used within a generated *method*, a higher level of abstraction may be called for. For example, "Attitude toward getting the latest technology" might be a more generalizable facet, with the specifics of that technology enumerated only during customization of the background section, which occurs just-in-time when a software team is ready to apply the method to a specific product (Step 3).

4.2.2 Step 2: The Teams Derive Their Method

Using the results from Step 1, each team then derived two personas from the facets—an under-served persona and a mainstreamer—and selected an analytical process to use with these personas and facets.

Deriving two personas from the facets included deciding upon facet *values* to assign to each persona. This challenged some of the teams, because not all facets reduced well to a linear scale. For example, for Team Autism, the "Nick" (Autistic) persona has difficulty when there are multiple attentional demands, whereas "Jane" (the mainstreamer) becomes bored when there is just one task to concentrate on, and this did not reduce well to "low" vs. "high" concentration abilities. Instead, each persona concentrates best under different circumstances. They settled on making the scale instead be *circumstances* under which each concentrate best (Figure 9).

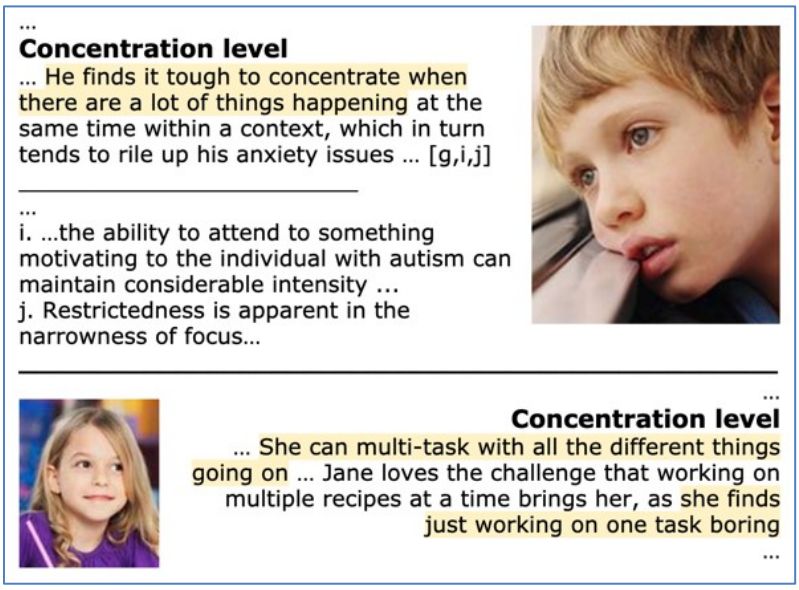


Figure 9. An excerpt from Team Autism's under-served (top) and mainstream (bottom) persona foundation documents.

To choose the (analytic) process they would specialize to "drive" their generated method, all eight teams began with a "Studio Analysis" process. With this process, teams set up at tables around the room and a group (here, the members of the other teams) stopped by for informal descriptions (walkthroughs) through the prototype use-cases, with the persona nearby, and provided feedback on problems or opportunities they saw. This process took place twice in class meetings, with about a month between them.

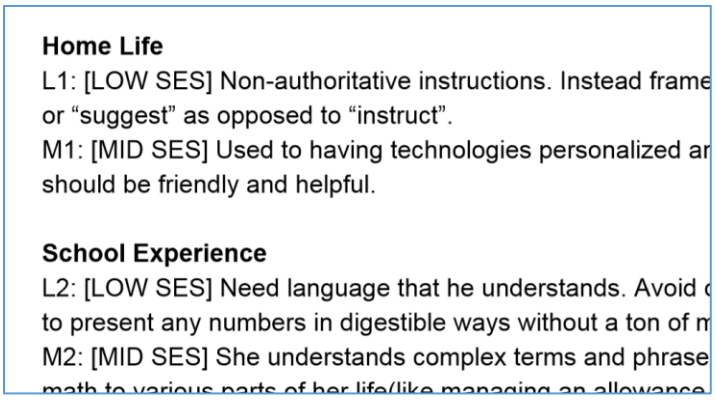


Figure 10. An excerpt from Team SES's HE process

In addition to using Studio Analyses, two teams also specialized another analytic process. Team Literacy specialized a CW during a class meeting (illustrated in Step 3), and Team SES made their facets into heuristics (Figure 10).

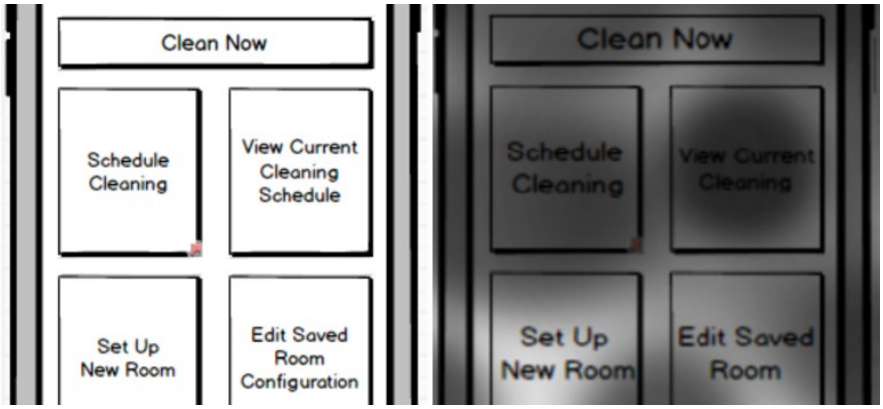


Figure 11. (Left): An early prototype from Team Retinopathy. (Right): An updated version (larger font) as it could appear to people with diabetic retinopathy, as per the University of Cambridge Impairment Simulator (University of Cambridge, 2019).

In addition, Team Retinopathy used a visual impairment simulator (Figure 11) to visually consider what their prototype would look like from the perspective of someone with diabetic retinopathy. Using an impairment simulator could be a way to specialize any of the analytic processes in Table 3.

Table 3. Analytic processes used by case study teams

Teams	**Used the analytic process…**	**Which had the components…**	**And received feedback on…**
(All)	Studio Analysis	Use cases + one or more personas + software prototype	Everything
Literacy	Cognitive Walkthrough	Scenario + one persona + software prototype + forms	Prototype
SES	Heuristic Evaluation	Scenario + heuristics + software prototype	Prototype

There are different advantages to highly structured processes like the CW or Heuristic Evaluation (HE), vs. the more informal Studio Analysis sessions (Table 3). Structured processes' systematicness produces a thoroughness hard to match in more informal

processes. But an advantage of the Studio Analysis sessions was that teams got feedback not just on the prototype, but on *all* parts of their method; for example:

> **Persona** feedback for Team ADHD: I would avoid using "known" persona pictures to avoid people … overlaying attributes you don't intend for them to have.
>
> **Use Case** feedback for Team Dementia: For use case 2, it seems like making Noah mentally fatigued and tired after work makes your mainstreamer too much like your underserved persona.
>
> **Prototype** feedback for Team Pre-schoolers: children … still easily get lost because of their relatively low comprehension skill. Therefore, if there is a progress bar to indicate their progress toward a specific task, it would be helpful to prevent them from becoming lost.

The above examples suggest that the teams were able to engage with the methods being generated enough to provide feedback on the other teams' emerging methods (facets, personas), methods' application (use cases), and prototypes.

4.2.3 Step 3: The Teams Apply Their Methods

What kinds of inclusivity issues did the teams find with these methods, and how did they fix them? Here we briefly consider three examples: one from a Studio Analysis-based method (Team Retinopathy), one from a HE-based method (Team SES), and one from a CW-based method (Team Literacy).

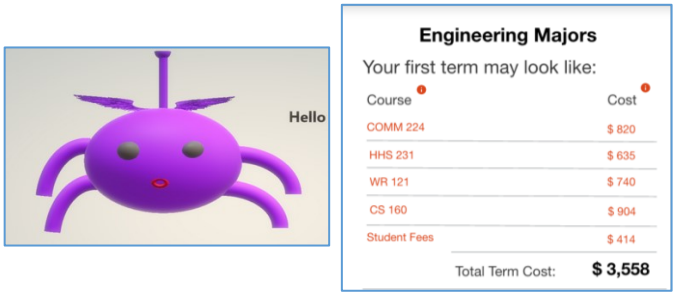


Figure 12. (Left) An image from Team Retinopathy's final design of spiderbot (Right) Part of Team SES's prototype that underwent a wording change

From the Studio Analysis process, Team Retinopathy realized how the aesthetics of their robot might actually interfere with the robot's usability or adoption. Their fix, shown in Figure 12 (left), was based on the following (emphasis added to facet values):

> Team Retinopathy: Originally, we … had a claw arm on wheels ... Multiple of our peers pointed out that that design might … negatively impact Suzie's perception of the product, given her **Emotional & Mental Well-Being** facet … <We> changed the design of the robot to SpiderBot … a cute, talking animal-like bot … [Figure 12]

Team SES found changes to make based on all eight of their heuristics. For example, two of Team SES's heuristics (Figure 10) came from linguistic facets, which led to them making wording changes (Figure 12, right):

> Team SES: Wording: "Your first term may look like" is trying to **be friendly (M1)** and **Non-authoritative (L1)**.

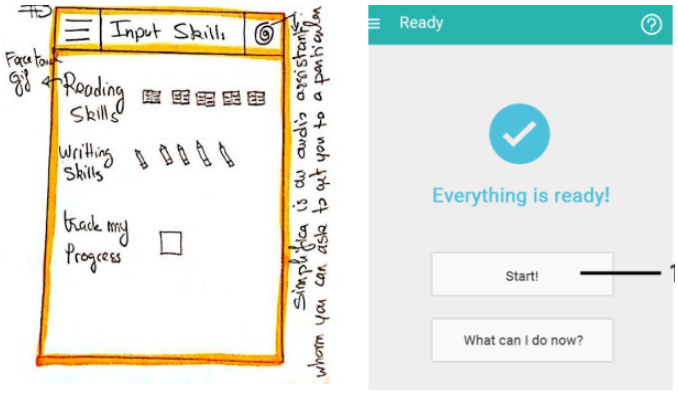


Figure 13. Screen at the end Team Literacy's use case of customizing the settings. (Left): Before using "Literacy-Mag". (Right): After.

Team Literacy's "Literacy-Mag" CW-based walkthrough occurred during a class meeting, with half the class using GenderMag's Abi persona and the other half using Team Literacy's under-served persona, Dave. Team Literacy used the results of their walkthrough to make changes to their prototype like the one in Figure 13:

> Team Literacy: … our underserved population … <lacks> **confidence in their ability to interact with technological interfaces**, … they often do not

> know if they … <completed> a task. This screen [Figure 13] offers a confidence boost … and … feedback that they have finished …

This variety of populations, software types, analytic processes used, and fixes generated, provides encouraging evidence of the generality of InclusiveMag, if care is taken with the facets (Step 1), deriving the new methods from them (Step 2) and attending to them (Step 3).

4.3 Multi-Case Study: Discussion - Open Questions

Table 4. Applying Sjøberg et al.'s evaluation criteria to InclusiveMag (Sjøberg et al., 2008). Here "Accuracy" combines parts of Sjøberg et al.'s "testability" and "explanatory power" that apply to a method

	"The degree to which..." (Sjøberg et al., 2008)	**Applicability to validating InclusiveMag**	**Validation evidence to date**
Accuracy, Empirical Support	... empirical refutation is possible. ... supported by empirical studies that confirm its validity. ... predicts all known observations within its scope	Test whether InclusiveMag-generated methods correctly evaluate software's inclusivity.	(1) The only InclusiveMag-generated method that has been tested for validity is GenderMag. Its "true positive" rate at evaluating software's inclusiveness has been reported at 75%-100% (Burnett et al., 2016; Vorvoreanu et al., 2019). (2) For generated versions using CWs: Errors of omission (false negatives) are common in cognitive walkthrough methods, with rates 30%-70%, depending on analysts' expertise (Mahatody et al., 2010).
Parsimony	...<has> a minimum of concepts ...	Investigate whether all steps/components of InclusiveMag are needed	
Generality	...breadth of the scope ... and independent of specific settings	Breadth of scope in (1) InclusiveMag usage, and in (2) InclusiveMag-*generated* methods' usage.	(1) The 8-team case study showed wide breadth of scope for InclusiveMag. (2) The resulting InclusiveMag-generated methods' scopes were explicitly defined (as narrow or broad) by teams generating them.
Utility	...supports the relevant areas of the software industry	Investigate whether software practitioners choose to use the generated methods	

4.3.1 Validating InclusiveMag

Although the case study data are encouraging, the question of whether InclusiveMag is useful for generating inclusiveness methods that really work is largely open. Indeed, InclusiveMag's journey is just beginning, and more research is also needed on the design decisions that define it. Still, we can begin to consider how the InclusiveMag method might be validated, by following the lead of Sjøberg et al. (2008).

Sjøberg et al.'s (2008) recommendations are about validating theories, not validating methods, but their validation criteria still provide useful insights into method validation. In Table 4, we consider how to apply these criteria to InclusiveMag, and the available evidence.

4.3.2 InclusiveMag in Practice

One open question is how the facets produced in Step 1 inform Step 2's choice of the analytic process to specialize GenderMag uses strictly cognitive facets, so fits well with including a specialized CW. However, some diversity dimensions like accessibility need physical facets (Neate et al., 2019), and Team SES had environmental facets (e.g., their "home life" facet). For methods using facets like these, the question in Step 2 of which analytic process to specialize arises. One possibility for some physical attributes may be analyzing with the help of a simulator, as Team Retinopathy did (Figure 11).

Since the facets are the core of InclusiveMag, it seems possible to embed the facets in any analytic process. However, Team SES's attempt to embed their facets in a set of heuristics raises questions as to whether all analytic processes really can support the selected facets well. Team SES's heuristics may have been too low level and overly specific—they focus mostly on language, ignoring other aspects that could also be non-inclusive like icon choices, workflow, etc.

Another question is *how* to actually build a persona into an analytic process other than a CW. Without the persona, the software practitioners lose "theory of mind" benefits

(i.e., empathy, or taking another kind of person's perspective), the psychological basis that personas leverage (Grudin, 2005).

Finally, could inclusivity researchers leverage personas they already have in InclusiveMag? For example, would they be able to start at Step 2 with their existing persona in hand? We believe that the existing persona might be blendable with the facets, but the facets would need to be thoroughly reconsidered, which may require a repeat in Step 1. Exactly *how* a researcher can decide whether to return to Step 1, and how exactly to go about it in these circumstances is an open question.

4.3.3 InclusiveMag and Intersectionality

Intersectionality considers specific insights and problems that arise at the *intersections* of two or more different diversity dimensions (Schlesinger et al., 2017). Intersectionality is a term originally coined to show how, through only considering race or gender, the experiences of black women were being ignored by anti-discrimination legislation (Crenshaw, 1989). From this origin, the idea has been adopted by other fields, including HCI (Schlesinger et al., 2017).

This raises the question of whether it would be possible for InclusiveMag to generate an *intersectional* inclusive design method. One possibility, similar to what we saw teams do in Section 4.2, is to simply use the scoping process (i.e., Step 1) to define any population of interest (e.g., low-SES women). This possibility may be viable when the under-served population of interest is large, but runs the risk of comparing a smaller of-interest group with "everyone else", which could be problematic (as well as some of the same problems of a narrow population scope seen in Section 4.2).

A more genuinely intersectional approach seems to require adding more diversity dimensions to InclusiveMag. It remains an open question whether it is possible to expand the number of dimensions, to how many, how to do so, and what the impacts on applying the generated method (Step 3) would be.

Chapter 5: Systematic Mapping Study

To start down the path of answering one of the open questions raised in Section 4.3, we will begin performing the research needed to build facets for a novel population. Specifically, we will perform an SES-HCI systematic mapping to establish research that can be used in the construction of SES-facets. The systematic mapping will also lay out the landscape for other researchers in the SES-HCI space as well as providing an example of research and analysis useful for Inclusivity Researchers creating inclusiveness methods.

Socioeconomic status (SES) is an examination of economic and sociological factors to understand what class an individual falls in relative to others in society (often categorized broadly as lower, middle and upper class). The American Psychological Associate (APA) defines socioeconomic status as the social standing or class of an individual or group, often measured as a combination of education, income and occupation (American Psychological Association, 2019). Low-SES individuals encompass a broad range of the population, from homeless populations in North America, to indigenous people in rural India.

Although studies regarding low SES are not yet common in the field of HCI, with many published papers overlooking socioeconomic status and class (Ames et al., 2011; Schlesinger et al., 2017), interest in "Socioeconomic HCI" (SES-HCI) is increasing, giving rise to a need to map the SES-HCI literature, to enable SES-HCI researchers to share foundations and build upon each others' work effectively. A systematic mapping study can provide this.

5.1 Systematic Mapping Study: Method

We framed our systematic mapping study around the following two main questions:

- What subpopulations and topics are covered by the SES-HCI research literature?
- What does the literature reveal about designing technology for individuals of different socioeconomic backgrounds?

To investigate these questions, our methodology consisted of six steps, which are shown in Figure 14. The first five steps ("main search") involved searching and filtering the ACM and IEEE databases with our specific search strings to try and get answers relating to our research questions (ACM and IEEE are associations which publish HCI papers as well papers from other computing-related fields such as Artificial Intelligence or Software Engineering). A strength of this strategy was the relevance of papers, but not including other databases, or errors during our text screening processes, could potentially cause missing important papers. To mitigate this threat, we added a second, broader search to generate a list of quasi-gold standard (QGS) papers, a method recommended by (Zhang and Babar, 2010) to validate a search procedure. The QGS being sought is the set of highly cited and relevant papers. We detail each of these steps next.

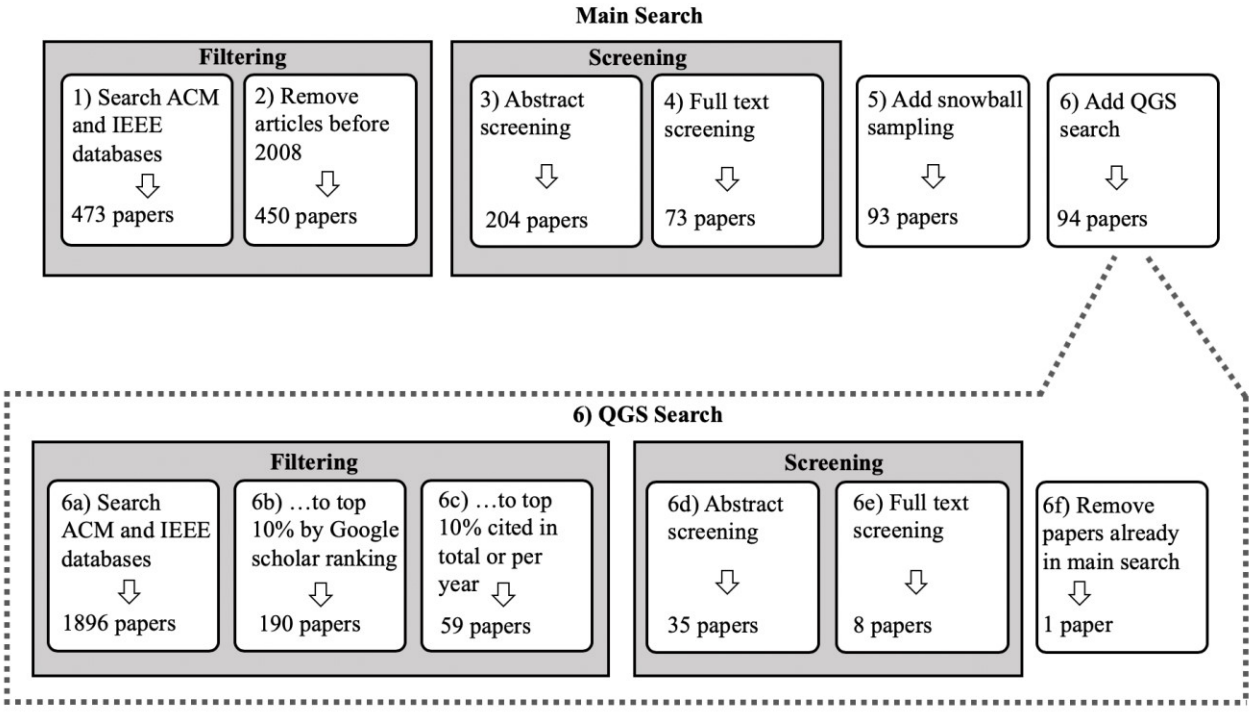


Figure 14: The steps we followed that resulted in the 94 papers in our sample. Showing both the steps taken for the main search and the QGS search.

5.1.1 Main Search

5.1.1.1 Steps 1 & 2: Filtering

To conduct the search, we generated search strings following Petersen's recommended method (Petersen et al., 2015) of Population Intervention Comparison Outcomes (PICO). PICO starts by listing our goals for P, I, C, and O:

- Population: We were interested in research on low-SES populations and differences that were observed from studying populations of varying degrees of socioeconomic status
- Intervention: We did not specifically seek to gather interventions, as our goal was not to reduce the study to the tools or methods that researchers employed.
- Comparison: Comparison is frequently used to consider alternative interventions. Since we did not particularly seek interventions, we did not use comparisons as a criterion.
- Outcomes: We were interested in anything relating to designing technology more inclusively for multiple SES levels and low-SES populations.

From our research questions and the above PICO, we then derived with the following search strings

- (Socioeconomic AND (inclusive design OR "technology design"))

We then used the software tool "Publish or Perish" to generate all the papers in the ACM and IEEE databases satisfying our search strings. These searches returned 473 unique papers, 450 of which were in our target time frame of 2008-2018.

5.1.1.2 Steps 3&4: Screening

One researcher read all 450 abstracts and selected the 204 that were relevant to SES-HCI. An abstract was deemed to be not relevant to SES-HCI, if it did not relate to technology usage by/for those populations, such as a paper interviewing low-SES populations about their beliefs on environmental sustainability. Petersen et al. (2008) and Budgen et al. (2007) also point out that abstracts can be unclear or missing information; we handled these by including papers with unclear abstracts at this stage, and then using our full-text screenings to eliminate them if warranted.

For the full-text screening, we divided the 204 papers from Step 3 between two researchers; these researchers read their assigned papers to determine relevance to low SES and technology design. The full-text screening process was to first read the abstract to get an idea of what the paper was about, then look through the methods section to answer the question of what the paper was investigating, and finally to read the results sections to find ties to SES and technology design.

We used that information to vote on which of the 204 papers were relevant to SES-HCI, which we would include in the final set. We included all 73 papers that received at least one vote.

5.1.1.3 Step 5: Snowball Sampling Through Factoid and Data Extraction

Three researchers then divided up these 73 papers and extracted from them the subpopulation, location, and research topics of each study. The location and subpopulation began to reveal the diversity of the low-SES population. For example, homeless youth in the United States are different than blind users of technology in rural India, but both of these subpopulations were classified as low-SES by the authors. Extracting each paper's research topic added depth and context. We strove to strike a balance between specificity and the ability to group. We defined subpopulation as a specific aspect that people had in common, such as being children or being minorities. Many papers did not cleanly fall into just one subpopulation category, so we allowed multiple subpopulations. For example, we classified a paper that studied Latino children as both minority group and children.

In parallel, we also extracted factoids from the results, discussion, and conclusion sections. We defined factoids as short (a few sentences at maximum) insights related to SES. The factoids were often direct quotes from the paper with our only additions being for context. We pulled one factoid per paragraph.

If factoids that we pulled from the main set of papers included citations to other papers, we gathered these citations and put them through a quick screening process.

Similar to our original screening process, we first screened the title and abstract including papers relevant to our research questions. We excluded duplicates of papers in our main search as well as non-peer reviewed literature like websites and books. After this initial screening, we did data and factoid extraction in the same way as in our main search, including 20 of the snowballed papers. This increased our paper total from 73 to 93. None of the snowball citation factoids included more citations so we didn't snowball further (likely because none of the snowballed papers were literature reviews).

5.1.2 Step 6: Quasi-Gold Standard Search

To ensure that our 93 papers were representative of the current research relating to SES-HCI, we followed the advice of Zhang and Babar (2010) and defined a set of quasi-gold standard (QGS) papers. In Zhang and Babar (2010), the authors recommended using a list of known papers, but the field of SES-HCI is too young to offer such a list uncontroversially, so instead we did the following.

5.1.2.1 Steps 6a, 6b, & 6c: Filtering

To cast a wide net for QGS possibilities, we used the search string "socioeconomic status" on the ACM and IEEE databases, producing 1896 papers. We then applied the following formula to determine quasi-gold standard papers:

QGS = Top 10% of google scholar rank AND (top 10% cited OR top 10% citation per year of the whole search)

To ensure that the threshold of 10% was not critical to our results, we also experimented with 5% and 15% thresholds, but with diminishing returns (e.g., increasing to 15% added only 1 more QGS paper). See Table B-1 (Appendix B) for the differences in results at each threshold level. This produced 59 candidate QGS papers.

5.1.2.2 Steps 6d & 6e: Screening

As with our main search we did a title and abstract screening followed by full text screening. Our inclusion and exclusion criteria were the same. The title and abstract screening narrowed our number of QGS papers from 59 to 35. We then did full text screening with voting as described earlier, resulting in a total of eight QGS papers.

5.1.2.3 Step 6f: Remove papers already in main search

Seven of the eight QGS papers were already in our main set of 93 papers so we added the one paper that was not in our main set making the final set of papers 94. All 94 papers from our search are shown in Table A-1 (Appendix A), with the eight QGS papers appearing in bold. Once we screened the papers, we followed the same process detailed in Section 5.1.1.3 to extract data and factoids from the paper we added.

5.2 Systematic Mapping Study: Results

5.2.1 Results OVERVIEW: Low-SES Populations and Topics represented in HCI research

The 94 SES-HCI papers in the final sample covered a diverse set of subpopulations from six of the seven continents (all but Antarctica). Figure 15 enumerates the subpopulations these papers investigated by continent, and Figure 16 enumerates the topics investigated by continent. This section provides an overview of some of the most common patterns in these data. Section 5.2.2 and Section 5.2.3 will then consider each subpopulation investigated in more depth.

	Living situation		Age groups					Communication grouping		Health situations			Societal assimilation		Totals
	Homeless	Low-SES location	Children	Teenager	College students	Parents	Older adults	Online communities	Families	Disability	Patients	Healthcare professionals	Low literacy	Minority	
Africa	1	5	4	2	0	0	0	3	2	1	0	0	2	3	23
Asia	0	6	3	3	1	0	0	4	0	3	0	1	2	8	31
Europe	1	4	2	1	1	0	0	1	0	1	1	1	1	2	16
N. America	2	7	7	2	5	3	1	6	4	0	3	1	3	10	54
Oceania	0	2	0	0	1	0	0	3	1	0	0	0	1	2	10
S. America	0	1	2	0	1	0	0	2	0	1	0	0	1	1	9
Total	4	25	18	8	9	3	1	19	7	6	4	3	10	26	143
Africa	4%	22%	17%	9%	0%	0%	0%	13%	9%	4%	0%	0%	9%	13%	100%
Asia	0%	19%	10%	10%	3%	0%	0%	13%	0%	10%	0%	3%	6%	26%	100%
Europe	6%	25%	13%	6%	6%	0%	0%	6%	0%	6%	6%	6%	6%	13%	100%
N. America	4%	13%	13%	4%	9%	6%	2%	11%	7%	0%	6%	2%	6%	19%	100%
Oceania	0%	20%	0%	0%	10%	0%	0%	30%	10%	0%	0%	0%	10%	20%	100%
S. America	0%	11%	22%	0%	11%	0%	0%	22%	0%	11%	0%	0%	11%	11%	100%
Average	2%	18%	12%	5%	7%	1%	0%	16%	4%	5%	2%	2%	8%	17%	

Figure 15: The subpopulation samples investigated in the 94 papers. Top half: heatmap of papers covering each subpopulation by raw counts. Bottom half: heatmap of papers covering each subpopulation as a percentage of papers about that continent's subpopulations. (Yellow depicts heatmap of totals. Papers sampling more than one subpopulation are counted more than once.) Note that most of the research has concentrated on only four subpopulations: Low-SES locations, low-SES children, low-SES online communities, and low-SES minority groups.

	Environmental factors		Personal situation						Built-in attributes		Totals
	Culture	Education	Health	Tech (access)	Tech (literacy)	Disability	Low Income	Unemploy-ment	Age	Race	
Africa	2	4	1	4	1	0	3	0	2	0	17
Asia	7	5	1	4	8	4	6	0	0	0	35
Europe	2	2	2	1	3	2	3	0	1	0	16
N. America	8	10	3	2	6	0	16	2	0	4	51
Oceania	2	2	0	1	3	0	2	0	0	0	10
S. America	2	2	0	2	2	2	1	0	1	0	12
Total	23	25	7	14	23	8	31	2	4	4	141
	Culture	Education	Health	Tech (access)	Tech (literacy)	Disability	Low Income	Unemploy-ment	Age	Race	
Africa	12%	24%	6%	24%	6%	0%	18%	0%	12%	0%	100%
Asia	20%	14%	3%	11%	23%	11%	17%	0%	0%	0%	100%
Europe	13%	13%	13%	6%	19%	13%	19%	0%	6%	0%	100%
N. America	16%	20%	6%	4%	12%	0%	31%	4%	0%	8%	100%
Oceania	20%	20%	0%	10%	30%	0%	20%	0%	0%	0%	100%
S. America	17%	17%	0%	17%	17%	17%	8%	0%	8%	0%	100%
Average	16%	18%	5%	12%	18%	7%	19%	1%	4%	1%	

Figure 16: The primary research topics (relative to SES and technology) of the 94 investigations. (Yellow depicts heatmap of totals. Papers sampling more than one subpopulation are counted more than once.) Note that most of the research has focused on only five SES-HCI topics for low-SES populations: cultural factors, educational factors, tech access, tech literacy factors, and how income itself relates to low-SES populations' technology experiences.

5.2.1.1 Patterns in subpopulations and topics (Independent variables)

In HCI evaluation and design, the subpopulations that researchers select for investigation/support often have a direct relationship to the hypotheses the researchers will investigate. For example, selecting a subpopulation based on age suggests that the researchers plan to investigate how low-SES people's age impacts their technology experiences. As Figure 15 shows, the 15 different low-SES subpopulations these researchers selected suggest the presence of five SES-HCI investigation patterns: investigations into low-SES subpopulations' technology experiences based on (1) their living situation, (2) their age group, (3) communication groupings, (4) their health situations and (5) their societal assimilation disadvantage. This list of five patterns is arguably not complete—for example, low-SES people's occupations might be another relevant subpopulation criterion. This lack of completeness suggests the possibility of research gaps in the *types* of SES-HCI hypotheses and investigations.

On the other hand, Figure 16's 10 research topics reside in three patterns that are arguably complete at the top level: (1) environmental factors, (2) personal situations that could be changed by an individual or event, and (3) personal attributes that cannot be changed by an individual or event. However, as the figure shows, the coverage within these categories is very uneven—about 1/3 of the research, about 2/3 of the research, and only about 5%, respectively. In fact, as Figure 16 shows, some topics were almost entirely ignored in relation to SES (e.g., the subpopulation's health status). suggesting the possibility of research gaps *within* some of these top-level categories.

Also, as the figures show, the SES-HCI subpopulations and topics that researchers investigated varied—often dramatically—with the locations of subpopulations being studied. For example, for African subpopulations, tech access was one of the two top factors investigated, with very little emphasis on tech literacy, but for European and Oceania subpopulations, the opposite was the case. Research on North American

subpopulations had 31% of the papers addressing the topic of low income, compared to lower percentages in other continents, especially South America. Another difference by continent is that research on North American populations were the *only* papers to focus on unemployment and race.

5.2.1.2 Cross-cutting Patterns of Trust and Willingness to Adopt Technology (Dependent Variables)

Investigating the subpopulations and topics discussed above produced certain cross-cutting results patterns. One of these was trust/distrust of using technology, which arose in at least four of the subpopulations investigated (low-SES locations, online communities, families, and minority groups). For example, Guberek et al. (2018) observed that when low-SES Latino migrant minorities were asked about their concerns and risks of using technology, the respondents voiced security concerns such as identity theft, online financial fraud, and unauthorized access to their Facebook accounts. This concern was echoed by low-income individuals in England, with some of the participants felt that technology was insecure and untrustworthy: *"I don't believe in Internet banking, because I believe once things get into the electronic mode, they're susceptible to attack (P6)"* (Vines et al., 2014). Research on urban sex workers in India produced similar results; as one worker put it, "Since the messages were about health and money, if it were a male voice or a film star's voice, then I will be really suspicious because the content is so sensitive." (Sambasivan et al., 2011).

Distrust of using technology can in turn reduce willingness to adopt new technologies, but for low-SES youth, any distrust they may have had did not seem to deter their willingness to adopt new technologies. In fact, even when youth's access to technology was low, low-SES youth demonstrated willingness and even eagerness to adopt technology. For example, in Kumar and Anderson's (2015) investigation of rural mothers in India, they observed that rural Indian children who did not have phones were still learning to use them, pointing out that: "For them, these phones owned by their family members are among few 'toys' that they have access to… ". At

the opposite end of the age spectrum, Awori et al. (2016) reported that indigenous elders in Kenya had a different opinion than the children. In one investigation into using technology to connect distributed cultural communities, "...elders found it troublesome to manage the device while carrying out the sessions". The age-related difference in low-SES subpopulations' willingness to adopt and use technology sometimes led to the youth and adults to collaboratively use technology. For example, in one case of refugee immigrants from Africa and Asia, the youth acted as information brokers, relaying information from technology to adults to assist the adults to get their questions answered (Fisher et al., 2014). Such collaborations may actually be facilitated due to the fact that low-SES populations' access to technology is often through shared/public devices, as we will see in Section 5.2.2.

5.2.1.3 Patterns of Education, Culture, and Empowerment (Relationships in Dependent and Independent Variables)

SES-HCI investigations with education and culture as independent variables were fairly common on all six continents, and also for multiple subpopulations. Education was a focus of investigation for nine subpopulations, culture for six, and these two topics often intersected with additional independent variables.

Many of the education papers considered barriers to education in low-SES subpopulations, especially barriers relating to literacy—language literacy and/or technology literacy. For example, Levy's (2009) investigation into how technologies used by non-native language learners impact major language skills recommended using mechanisms that matched low-SES subpopulations' potentially limited English and limited technologies: "vocabulary items can be presented through short definitions and examples that suit the screen dimensions and general handling capabilities of the mobile phone". For some low-SES subpopulations, language literacy is not just about being a non-native speaker, but even in an individual's native language. For example, research into how mobile-assisted language learning tools can help develop non-English speaking migrant and refugee women's language skills,

found that this subpopulation had minimal literacy in even their first language, let alone a second (Ahmad et al., 2013). Sometimes technical literacy issues came together with language literacy issues. For example, in a case study of indigenous rural villages in India, participants had both limited language literacy in English, Hindi, and Bengali and limited experience with computers (Dutta and Das, 2016). To accommodate the participants' limited literacy of both types, the investigators recommended using visual affordances, so that the users don't have to intuit textual or interface information.

In some contexts, education and culture came together in single investigations, and when they did, empowerment arose as either a motivation for the combination or an outcome. For example, Rader et al. (2011) developed a virtual tool to help African American students, raised in large urban areas between the ages of 8 and 10, learn to speak "school English". The tool aimed to allow students to obtain achievement in the classroom while staying connected to their traditional language usage and culture. Another example by Nacu et al. (2015) encouraged Latino students aged 11-14 to create their own reaction emojis on an online classroom community, to not only lower barriers to participation but also allow them to create content culturally relevant to them.

Empowerment also arose as a common pattern in other low-SES contexts. For example, Dillahunt et al. (2016) conducted research on whether massive open online course platforms support job employment. They reported that even though technical literacy was still a barrier for low-SES populations, one participant stated that *"<the course> will greatly increase my chances of employment because I have been a stay home mother for a long time. I can prove that I am a quick learner [as] programming is pretty difficult"*. Erete et al.'s (2014) investigation into how online communities affected the behavior of five low-income neighborhoods in Chicago reported that technology influenced and empowered people's abilities to protect themselves and their property. These examples alone show the range of empowerment arising in SES-

HCI investigations: empowering children in the classroom, empowering adult on-line learners to find jobs, and empowering people to better protect themselves and their communities.

5.2.2 Results: Low-SES populations' Goals and SES-HCI Barriers

The research in our sample produced rich detail about low-SES subpopulations' goals, their current usage contexts, and the barriers these subpopulations face to achieving their goals in those usage contexts. Table 5 summarizes.

A row-wise reading of Table 5 shows, for each subpopulation in Figure 15, how that subpopulation's goals come together with the technology access they have, and barriers the subpopulation may face in trying to accomplish those goals. For example, the "Children" row of the table shows that some low-SES children who wanted to use technology to play games didn't have access to the technology to do that (Rosner and Ames, 2014). Further, even when they did have access to technology, they can face further barriers. For example, in a study of low-income Latino, Asian, and African American children, the cultural norms behind Minecraft—largely the middle-class Euro-American norms of interaction established by Minecraft's earliest adopters—was often at odds with the cultures of the children in their camp (Ames and Burrell, 2017).

On the other hand, a column-wise reading of the table reveals similarities across subpopulations. For example, the tech access column shows a heavy dependence by many of these subpopulations on public or shared devices. There was sometimes a "power" differential embedded in their technology access as well as their "power access" to the device (owned, borrowed). For example, people who have access to only borrowed or public devices may not be able to install the software they need for their tasks. Their relationships with technology devices could also be shaped by different situations. For example, even if someone owns a device, circumstances might mean they can use it only in public: "Some families had laptops but no home broadband... The library was a central hub for computer access, wireless, and

entertainment" (Yardi and Bruckman, 2012). Yardi and Bruckman (2012) also showed the effect of not accounting for shared devices: "Our findings suggest that low SES families are more likely to share devices like computers and cell phones than high SES families. Low SES parents reported that sharing posed challenges for them, such as the logistics of trying to share computer time. Parents were annoyed when children downloaded software and that slowed down the machine or when they changed settings".

Table 5: Each subpopulation's technology goals, technology access and technology barriers.

Findings: Subpopulation's goals of tech usage	Findings: Subpopulation's tech access to achieve the goal(s)	Findings: Subpopulation's barriers to achieving the goal(s)
Research by living situations		
Homeless		
• To keep in touch with family, friends (Le Dantec and Edwards, 2008) : P17: *"You stay in that depressing state where you feel as though giving up... people I talk to on a daily basis... make me realize, you know, that it's going to be ok"* (Le Dantec and Edwards, 2008) • For safety (Woelfer et al., 2011): P27: *"It's one thing being homeless but it's another thing. . . disappear[ing] from the face of the earth. And that's the biggest danger for homeless people. That's the hardest thing to manage, is when you get disconnected."* (Le Dantec and Edwards, 2008)	• Public devices (Le Dantec and Edwards, 2008) • Didn't own (Le Dantec and Edwards, 2008) • Owned (Woelfer et al., 2011) • Older devices (Woelfer et al., 2011) • Desktop computers (Le Dantec and Edwards, 2008) • Mobile phones (Woelfer et al., 2011)	• Limited/unreliable access introduces difficulties getting/staying connected to family, friends, safety network (Le Dantec and Edwards, 2008; Woelfer et al., 2011)
Low-SES Location		

• Employment (Nacu et al., 2015) • Information (Erete, 2015) • Keep close control of their finances (Vines et al., 2014) • Transportation (Dillahunt et al., 2017)	• Public devices (Noll et al., 2018) • Owned Devices (Wadley et al., 2014) • Shared devices (Wadley et al., 2014)	• Difficulties affording transport: "*being able to afford public transport or run a car … meant planning travel very carefully (doing as much as possible in one visit to town)*" (Vines et al., 2014) • Lack of trust with technology and public ride sharing (Dillahunt et al., 2017)
Research by age groups		
Children		
• To play games (Ames and Burrell, 2017) • To expand vocabulary (Breazeal et al., 2016) • Repair laptops (Rosner and Ames, 2014)	• Shared Devices (Ames and Burrell, 2017) • Didn't own device (Ames and Burrell, 2017) • Home desktops (Ames and Burrell, 2017) • School provided iPads (Breazeal et al., 2016) • Laptop (Rosner and Ames, 2014)	• Game cultures (e.g., Minecraft) largely defined by middle-class Euro-American norms (Ames and Burrell, 2017) • Access to education (Breazeal et al., 2016) • Lacked money to repair devices (Rosner and Ames, 2014) • Difficulty solving technical problems forcing them to seek assistance (Rosner and Ames, 2014)
Teenagers		
• To help others (Fisher et al., 2014) • To play games (Yardi and Bruckman, 2012) • For work (Bajpai et al., 2013) • Feel comfortable enough to speak in front of the class (Nacu et al., 2015)	• Individual devices (Bajpai et al., 2013; Fisher et al., 2014; Yardi and Bruckman, 2012) • Shared devices (Bajpai et al., 2013; Fisher et al., 2014; Yardi and Bruckman, 2012) • Purchased own devices (Bajpai et al., 2013; Yardi and Bruckman, 2012) • Borrowed devices (Bajpai et al., 2013) • Mobile phones (Bajpai et al., 2013; Fisher et al., 2014; Yardi and Bruckman, 2012)	• Lack of access to formal employment, take on risky, physically demanding jobs, such as scrap collection. (Bajpai et al., 2013) • Social reservedness (Nacu et al., 2015) • Trouble engaging with interactive technologies (Fisher et al., 2014)
College students		

• To play games (Rahmati et al., 2012) • To do social media (Rahmati et al., 2012) • Access to information (Waycott et al., 2010) • Communication (Waycott et al., 2010)	• Individual devices (Rahmati et al., 2012) • Owned devices (Rahmati et al., 2012) • Mobile Phones (Rahmati et al., 2012)	• Access to technology (Waycott et al., 2010) • Usability issues (Waycott et al., 2010) • Difficulties learning technology (Waycott et al., 2010) • Missed communications (Waycott et al., 2010) • High dropout rate (Marcelino-Jesus et al., 2016)
Parents		
• To communicate with Family (esp. children or teachers) (Roshan et al., 2014; Yardi and Bruckman, 2012) • To monitor children's tech use (Yardi and Bruckman, 2012) • Busy don't care about frivolous features (want things to fit their schedule) (Roshan et al., 2014; Yardi and Bruckman, 2012)	• Shared Devices with family (Roshan et al., 2014; Yardi and Bruckman, 2012) • Public Devices (Roshan et al., 2014; Yardi and Bruckman, 2012) • Owned devices (Roshan et al., 2014; Yardi and Bruckman, 2012) • Mobile phones (Roshan et al., 2014; Yardi and Bruckman, 2012) • Desktop computers (Roshan et al., 2014; Yardi and Bruckman, 2012)	• Difficulty coordinating afterschool plans between parents and children (Yardi and Bruckman, 2012) • Limited time on the device which restricted their autonomy (Roshan et al., 2014; Yardi and Bruckman, 2012) • The parents were concerned that children might download viruses/malware on shared device (Roshan et al., 2014)
Older Adults		
• Display information to stay connected (Arreola et al., 2014)	• Remote sensing technologies (Arreola et al., 2014)	• Unreliable ways for people to contact remote caregivers (Arreola et al., 2014)
Research by communication grouping		
Online Communities		
• Education (Tang, 2015) • Employment (Nacu et al., 2015) • Consume online content (Kaur et al., 2012)	• Mobile Devices (Le Dantec and Edwards, 2008)	• A lack of overall technical literacy (e.g., difficult for some to leverage the platform) and the fact that taking these courses was not able to replace real-world experience. (Dillahunt et al., 2016) • Content isn't socially and culturally relevant (Kaur et al., 2012)
Families		
• To communicate with family (family coordination) (Ames et al., 2011; Oduor et al., 2014; Wyche and Murphy, 2012) • For economic support (Oduor et al., 2014) • To promote tech to not limit	• Individual devices (Khan et al., 2012; Wyche and Murphy, 2012) • Shared devices (Ames et al., 2011; Oduor et al., 2014; Wyche and Murphy, 2012)	• Prepaid phone created conflict between parents and children due to children's perception of stigma around prepaid phones (Yardi and Bruckman, 2012) • Low-cost Nokia phones have short battery lifespans, so families had to

children (Ames et al., 2011)	• Owned devices (Ames et al., 2011; Khan et al., 2012; Oduor et al., 2014; Wyche and Murphy, 2012) • Mobile phones (Ames et al., 2011; Khan et al., 2012; Oduor et al., 2014; Wyche and Murphy, 2012) • Knock off Phones (Wyche and Murphy, 2012) • Laptop (Ames et al., 2011) • Desktops (Ames et al., 2011; Khan et al., 2012) • Prepaid phones (Wyche and Murphy, 2012; Yardi and Bruckman, 2012) • Older devices (Ames et al., 2011; Wyche and Murphy, 2012) • Used devices (Wyche and Murphy, 2012) • TV (Ames et al., 2011) • DVD players (Ames et al., 2011)	buy new batteries or recharge dead batteries (Wyche and Murphy, 2012) • Varying values and practices around technology use (Ames et al., 2011)
research by health situations		
Disability		
• Device as a toy (Hebert et al., 2016) • For family (Pal et al., 2013) • For work (Hebert et al., 2016; Pal et al., 2013) • For school (Pal et al., 2013) • Communication (Vyas et al., 2015) • Accessing education content (Vashistha et al., 2014)	• Individual device (Chakraborty et al., 2017) • Owned Device (Chakraborty et al., 2017) • Accessed through institutions (Hebert et al., 2016; Pal et al., 2013) • Mobile phones (Hebert et al., 2016) • Assistive tech (Chakraborty et al., 2017; Pal et al., 2013)	• Acute shortage of accessible educational content (Vashistha et al., 2014) • Lacked access to diagnosis, treatment, and medication (Hebert et al., 2016) • Challenges using social media when blind (Vashistha et al., 2015)
Patients		
• For self-management (Barnes et al., 2013) • For communication (Barnes et al., 2013	• Individual device owned (Barnes et al., 2013) • Mobile phone (Barnes et al., 2013) • Desktop computer (Barnes et al., 2013)	• Difficulty understanding medical information (Maitland et al., 2009) • How comorbid diseases affect their health (Barnes et al., 2013) • Unable to order/buy prescriptions on online platforms due to lack of income. (Mathes et al., 2013)

		• Low income leads to less access to different medical resources (Mathes et al., 2013; Tang, 2015)
Healthcare Professional		
• For communication (Maitland et al., 2009) • For work (Maitland et al., 2009)	• Individual (Maitland et al., 2009) • Public devices (Maitland et al., 2009) • Owned and unowned (Maitland et al., 2009) • Desktop computers (Maitland et al., 2009) • Mobile phones (Maitland et al., 2009)	• Lacked financial, strategic, and social resources (Maitland et al., 2009)
research by societal assimilation disadvantage		
Low Literacy		
• To play games (Chaudhry et al., 2012; Chaundhry et al., 2016) • To browse internet (Chaudhry et al., 2012; Chaundhry et al., 2016) • For work (Chaudhry et al., 2012) • For self-management (Chaudhry et al., 2012) • Learn English (Ahmad et al., 2013) • Communicate within villages (Dutta and Das, 2016)	• Individual devices (Chaudhry et al., 2012; Chaundhry et al., 2016) • Public devices (Chaudhry et al., 2012) • Work devices (Chaudhry et al., 2012) • Owned Devices (Chaudhry et al., 2012; Chaundhry et al., 2016) • Didn't own devices (Chaudhry et al., 2012; Chaundhry et al., 2016) • Company provided (Chaudhry et al., 2012) • Desktop computer (Chaundhry et al., 2016) • Mobile device (Chaudhry et al., 2012)	• Secondary English language learners need more access to basic reading and writing technical tools and support (Ahmad et al., 2013) • Websites with too many options can lead to a loss of focus (Chaudhry et al., 2012) • Difficulty comprehending textual information (Dutta and Das, 2016)
Minorities		
• Device as a toy (Cain and Trauth, 2017) • To make calls (Kumar and Anderson, 2015; Sambasivan et al., 2011) • To listen to music (Kumar and Anderson, 2015) • To play videos (Dell and Kumar, 2016; Kumar and Anderson, 2015) • To communicate with friends (Guburek et al., 2018) • Communicate with family, community institutions	• Shared Devices (Dell and Kumar, 2016) • Individual devices (Cain and Trauth, 2017; Guburek et al., 2018; Kumar and Anderson, 2015) • Dual-sim or multiple devices (Kumar and Anderson, 2015; Sambasivan et al., 2011) • Owned devices (Cain and Trauth, 2017; Guburek et al., 2018; Kumar and	• Concerned about the security of device, identity theft, financial fraud, unauthorized social media access (Guburek et al., 2018) • *"Along with the increased sense of insecurity, almost half of our participants mentioned a growing sense of collective identity with other immigrant families over the past year. Technology is increasingly used to share information about the presence of immigration officers, news of raids, or any other immigration*

(Guburek et al., 2018) • Feel comfortable enough to speak in front of the class (Nacu et al., 2015) • Learn Second Language (Levy, 2009)	Anderson, 2015; Sambasivan et al., 2011) • Desktop (Cain and Trauth, 2017; Dell and Kumar, 2016; Guburek et al., 2018) • Tablets (Guburek et al., 2018) • Mobile phones (older ones) (Kumar and Anderson, 2015; Dell and Kumar, 2016; Sambasivan et al., 2011) • Smartphones (Dell and Kumar, 2016; Guburek et al., 2018)	*enforcement related activities"* (Guburek et al., 2018) • Cultural norms (Levy, 2009; Nacu et al., 2015)

	Living situation		Age groups					Communication grouping		Health situations			Societal assimilation		Total
	Homeless	Low-SES Location	Children	Teenager	College students	Parents	Older adults	Online communities	Families	Disability	Patients	Healthcare professionals	Low literacy	Minority	
Goals	2	4	3	4	2	2	1	3	3	4	1	1	4	7	41
Access	2	2	3	3	1	2	1	1	5	3	1	1	2	6	33
Barriers	2	2	3	3	2	2	1	2	3	3	4	1	3	3	34
Total	6	8	9	10	5	6	3	6	11	10	6	3	9	16	108

	Living situation		Age groups					Communication grouping		Health situations			Societal assimilation		Total
	Homeless	Low-SES Location	Children	Teenager	College students	Parents	Older adults	Online communities	Families	Disability	Patients	Healthcare professionals	Low literacy	Minority	
Goals	2	4	3	4	4	3	1	3	3	6	2	2	6	8	51
Access	6	3	5	5	3	5	1	1	12	5	3	5	8	8	70
Barriers	1	2	4	3	5	3	1	2	3	3	4	1	3	3	38
Total	9	9	12	12	12	11	3	6	18	14	9	8	17	19	159

Figure 17: (Top): Number of papers reporting on low-SES populations' goals, tech access, and barriers for each subpopulation. (Bottom): Number of research findings (bulleted items). By both measures, the researchers have focused on families, low-literacy populations, and minorities the most.

Two maps of the research space detailed in Table 5 are summarized in Figure 17. Because different papers have different length constraints and scopes, we measured the research both by counting papers and counting research findings. These maps of the data show concentrations and gaps in this body of research. The rows show that, for the most part, goals, tech access, and barriers have all received attention, although the lower heatmap may suggest an oversupply of research on tech access issues. The columns show that low-SES families, low-literacy subpopulations, and minority groups have received the most attention, and some subpopulations, especially low-

SES older adults, have been almost entirely overlooked. In essence, Figure 17 points out numerous research opportunities.

5.2.3 Results: From SES-HCI Barriers to SES-HCI Design Solutions

Researchers have also begun to work on solutions to some of the barriers in the previous section. Generally speaking, their research toward solutions is one of three types: (1) formative research suggesting proposed design solutions; (2) summative research that validates through evidence particular design solutions; and (3) observations of technology successes by the populations of interest from introducing a technological intervention, such as an application or a device.

Each row in Table 6 shows a subpopulation's barrier and any resulting solutions and successes. For example, in Low-SES Locations-Row1, Dillahunt et al. (2017) noted the barrier of trust for ride sharing apps falling in low income areas. Part of their study involved onboarding users from low income areas onto a ride sharing app (Dillahunt et al., 2017). From their experience they proposed design solutions to ride sharing app, including public kiosks, which notably has been adopted by Uber, albeit primarily aimed at drivers (Mckeon, 2019).

The columns of Table 6 can be read as a list of the researchers' approaches and the solutions and successes they revealed. This list perspective allows for comparing and contrasting approaches researchers took, as well as solutions and successes to see which are similar or different across subpopulations.

Table 6: For each subpopulation, the barriers (from Table 5) for which researchers have worked to address the barrier and/or successes they observed related to overcoming that barrier. The types of results in this table are color-coded to denote Proposed Design Solutions, *Validated Design Solutions*, and Subpopulation Successes.

Subpopulation and Barrier	What the researchers did	Resulting Design Solutions and Subpopulation Successes
Research by living situation		
Homeless		
Limited/unreliable access introduces difficulties getting/staying connected to family, friends, safety	Qualitative study with 43 homeless young people, service providers, police officers, and community	Proposed: Designs should account for the following attributes: *"(1) low cost; (2) outdoor resilience to drops, wet, and cold; (3) flexible*

network (Le Dantec and Edwards, 2008; Woelfer et al., 2011)	members (Woelfer et al., 2011)	*power decoupled from infrastructure (e.g., solar); (4) 24/7 reliability for emergency use; (5) separate communication channels protected from surveillance; (6) recovery options needed due to inattention or theft."* (Woelfer et al., 2011).
Limited/unreliable access introduces difficulties getting/staying connected to family, friends, safety network (Le Dantec and Edwards, 2008; Woelfer et al., 2011)	Qualitative study of homeless population to better understand effects of technology (Le Dantec and Edwards, 2008)	Proposed: App platform should be phones: Compared to other forms of computers, homeless individuals recognized utility and versatility of cell phones (Le Dantec and Edwards, 2008).
Low-SES Locations		
Lack of trust with technology and public ride sharing (Dillahunt et al., 2017)	Onboarded 13 low-income individuals to Uber as passengers. (Dillahunt et al., 2017)	Proposed: To address trust issues on ridesharing platforms, focus on visibility, and information collection transparency such as by removing them from people's phones. *"For example, installing public kiosks...through which people could call real-time ridesharing services would eliminate the need for smartphones"* (Dillahunt et al., 2017).
Research by age groups		
Children		
Game cultures (Minecraft) largely defined by middle-class Euro-American norms (Ames and Burrell, 2017)	40-hour Minecraft camp for 28 low-income and minority children (Ames and Burrell, 2017)	Success: Activities that didn't require culturally specific knowledge appealed more to low-SES children (i.e. a treasure hunt compared to a Harry Potter specific activity) (Ames and Burrell, 2017).
Access to education (Breazeal et al., 2016)	Introduced iPads to 40 school children aged 4 – 11 (Breazeal et al., 2016)	Success: Having access to the iPads in an education context led to increased literacy and vocabulary compared to peers without access. (Breazeal et al., 2016)
Teenagers		
Social reservedness (Nacu et al., 2015)	Case study of an online media tool for students to react to each other's assignments. (Nacu et al., 2015)	Success: Accommodated social reservedness by: *"offering a low barrier to participation… reactions allow for a relatively quick and easy way to respond to others to contribute encouragement and critique."* (Nacu et al., 2015)
College Students		

High dropout rate (Marcelino-Jesus et al., 2016)	An analysis of what factors influences higher education students to drop out (Marcelino-Jesus et al., 2016)	Success: Providing online and offline spaces to share knowledge and experience with fellow students addressed some of the dropout factors (Marcelino-Jesus et al., 2016)
Parents		
Limited time on the device which restricted their autonomy (Yardi and Bruckman, 2012; Roshan et al., 2014)	Qualitative study of parents to understand their access to technology (Roshan et al., 2014)	Proposed: Improve parents' search efficiency by scaffolding their search keywords and allowing them to specify context (e.g., looking for learning materials in an educational dataset) (Roshan et al., 2014).
Older Adults		
Unreliable ways for people to contact remote caregivers (Arreola et al., 2014)	Designed technology for older adults to check in on each other (Arreola et al., 2014)	Proposed: Design technology to: *"blend in to a home's décor so that older adults will place them in commonly occupied spaces, such as a living room … <and> view and interact with these prototypes on a regular basis, even as their mobility declines."* (Arreola et al., 2014) Proposed: Created check-in devices with both manual check in (a button) and automatic (a motion sensor) (Arreola et al., 2014).
Research by communication grouping		
Online Communities		
Content isn't socially and culturally relevant (Kaur et al., 2012)	Literature review of pervasive computing through the lens of developing countries (Kaur et al., 2012)	Proposed: Design tech to be socially compatible with localized needs, at a minimum having content appear in the local language. (Kaur et al., 2012)
Families		
Low-cost Nokia phones have short battery life-spans, so families had to buy new batteries or recharge dead batteries (Wyche and Murphy, 2012)	Field studies in Kenya with mobile phone owners (Wyche and Murphy, 2012)	Proposed: Simple and standardized designs. *"Standardizing mobile phone design is more important than new features... Fewer design options … could reduce a bewildering and inefficient array of adaptors, chargers, and batteries. This would make handsets more durable, cost-effective…"* (Wyche and Murphy, 2012)
Research by health situations		
Disability		

Acute shortage of accessible educational content (Vashistha et al., 2014)	Interviews with 16 students, teachers, and content producers, to understand how they use technologies to consume, create, and share educational content." (Vashistha et al., 2014)	Success: Provided mobile resilient ways to communicate with others: *"Participants preferred mobile phones because mobiles are battery powered, and thus robust to the intermittent availability of electricity. Moreover, phones also offer ubiquitous availability of audio content."* (Vashistha et al., 2014)
Lacked access to diagnosis, treatment, and medication (Hebert et al., 2016)	Field tested an app with health workers and community members. (Hebert et al., 2016)	Proposed: Provide options for physical media, not just digital. Whether it's providing paper copies of instructional materials or braille instead of just audio books. (Hebert et al., 2016)
Challenges using social media when blind (Vashistha et al., 2015)	Qualitative study with low-income blind users in rural and peri-urban India. (Vashistha et al., 2015)	Success: Provided opportunities to increase social skills through social media: *"Five participants reported learning social skills by using the platform. An eighteen-year old student from a small city … reported that he 'learnt how to speak properly, how to behave, and how to respect others' by observing the interactions of other participants."* (Vashistha et al., 2015)
Patients		
Low income leads to less access to different medical resources (Mathes et al., 2013; Tang, 2015)	Field study in a non-profit clinic to investigate its current paper-based practices to inform the design and deployment of an impending electronic system (Tang, 2015)	Proposed: Consider supporting telemedicine as an alternative to on-site patient visits, because *"low socioeconomic patients … often have difficulties in finding transportation to and from the clinic."* (Tang, 2015)
Difficulty understanding medical information (Maitland et al., 2009)	Created mobile health app for parents of high-risk infants among home caregivers and health professionals." (Liu et al., 2011)	**Validated: Help parents monitor infant health: *"present data points using a traffic light analogy: red when an alert is urgent, yellow as a warning and green for success"* (Liu et al., 2011)**
Healthcare Professionals		
Difficulty understanding medical information (Maitland et al., 2009)	Interviews with families and their primary caregivers. (Maitland et al., 2009)	Proposed: Introduce digital surfaces into clinics for educational purposes: *"such as explaining how to identify different kinds of medications so that the patients can take the drugs with confidence."* (Maitland et al., 2009)
Research by societal assimilation disadvantage		
Low Literacy		

Websites with too many options can lead to a loss of focus (Chaudhry et al., 2012)	Had 17 low literacy participants use four different interfaces (Chaudhry et al., 2012)	**Validated: Offer users a way back *"Every screen should incorporate a BACK button for shorter recovery lengths, and a HOME button for longer recoveries"* (Chaudhry et al., 2012)** **Validated: Limit choice for navigation (Chaudhry et al., 2012; Dutta and Das, 2016)**
Difficulty comprehending textual information (Dutta and Das, 2016)	Case study on technology in rural India (Dutta and Das, 2016)	**Validated: Always provide the visual affordance, don't rely on the user intuiting it (Chaudhry et al., 2012; Dutta and Das, 2016)**
Minorities		
Cultural norms (Levy, 2009; Nacu et al., 2015)	Studied technologies used for second language learning (Levy, 2009)	Proposed: Have students use a website in their second language: "*authentic materials play an especially important role because they are designed by native speakers for native speakers and, therefore, provide real data for any exploration of the <second language> culture."* (Levy, 2009)

Table 6 raises a question of generalizability. Two types of generalizability are present in the solutions and successes: potentially generalizable solutions and solutions that have already been generalized to multiple subpopulations.

Solutions with some potentially generalizable aspects: Some papers provided design solutions in subpopulation-specific ways. For example, when Arreola et al. (2014) observed that low-SES older adults' low mobility reduced the reliability of being able to contact remote caregivers, they proposed a solution of allowing both manual check-in and automatic check-in via a motion sensor (Table 6, Older Adults-Row1) (Arreola et al., 2014). Another subpopulation-specific finding (in Table 6, Minorities-Row2) showed that an online forum designed with a low barrier to participation encouraged participation from minority students (Nacu et al., 2015). Although neither of these solutions were claimed to generalize to other subpopulations, they share a common abstract idea of removing physical or information barriers. A different sort of design proposal (Table 6, Parents-Row1), was to create custom tag labeling

structures for parents' keywords (Roshan et al., 2014), which abstracts to provide scaffolding. These examples suggest that some portions of the specific solutions may be generalizable beyond the subpopulations for which it was used—but whether this is the case is an open question.

Solutions already generalized to multiple subpopulations: Some design solutions were presented for multiple subpopulations. For example, Chaudhry et al.'s (2012) research on low-literacy subpopulations showed success when every screen incorporated a BACK button for shorter recovery lengths, and a HOME button for longer recoveries (Chaudhry et al., 2012). This design solution was validated specifically with low literacy subpopulation, but an argument could be made that this solution is simply an instance of more general UX guidelines on consistency and "undo" capabilities (Nielsen, 2994). In other cases, papers proposed similar solutions for different subpopulations. For example, Vashistha et al. observed that "Participants preferred mobile phones because mobiles are battery powered, and thus robust to the intermittent availability of electricity. Moreover, phones also offer ubiquitous availability of audio content" (Vashistha et al., 2014). This is similar to some of the guidelines suggested by Woelfer et al. (2011) (also shown in Table 6), of providing flexible powering options.

5.3 Systematic Mapping Study: Discussion

5.3.1 An Open Question: Low-SES populations vs Higher-SES populations

The research maps we have presented in this thesis point toward a wealth of understudied areas and open research questions. However, one open question not apparent in these research maps is the lack of investigation into *differences* between user experiences of lower-SES vs. higher-SES populations. Only 94 papers in our sample investigated low-SES populations but did not compare them with middle or upper SES populations. (e.g., Ames and Burrell, 2017; Yardi and Bruckman, 2012).

Understanding and investigating different populations, whether comparatively or not, relates to a core idea in inclusive design: that focusing on an under-served population can be useful to find issues that might not have been noticed with a more mainstream population, but that benefit the mainstream population (Ljungblad and Holmquist, 2007). That said, understanding the user experience *differences* correlating to SES status might enable evaluating and designing at a slightly higher level of abstraction, such as via the "facets" notion used with the InclusiveMag inclusive design meta-method (Mendez et al., 2019) . Understanding lower-SES vs. higher-SES population differences also enables designers to differentiate fairly universal phenomena—e.g., features that all SES levels seem to need—from needs that must be carefully thought out to accommodate "opposite" needs.

An example of fairly universal need for SES-HCI could be trust. It is possible that in recent years, distrust of technology's dangers has risen broadly, and might not be SES-specific. Alternatively, there may be nuances between the *kinds* of distrust that occurs, or the distrust in technology may need to be addressed in different ways for individuals of different SES. In either case, the universality of trust of technology makes it a potential candidate for a low SES facet, though more work would be needed to understand the exact nature of trust and distrust across individuals of different SES.

5.3.2 Comparison of Systematic Mapping to Team-SES Facets

In Chapter 4, one of the teams in the multi-case study examined SES as a diversity dimension. Their work produced four facets, Career Aspirations, School Experience, Home Life, and Psychological Health (full persona in Appendix C). Do their four facets overlap with any of the systematic mapping findings?

The facets of School experience and Home Life from Team-SES overlapped a bit with our findings in the systematic mapping. School Experience deals with disadvantages low-SES individuals may have in school by attending schools with less funding. A big part of this is around device access, something covered in Table 5.

Additionally, several of the papers from the systematic mapping reported findings around education (Figure 16).

There was also overlap in the Home Life facet, mainly from the papers in the systematic mapping where population of study was low-SES families or parents (Figure 15). That is not to say that they overlapped entirely, as Team-SES used primarily literature from psychology to build their facets. This means that some of the literature Team-SES used has findings that are complementary to ours. For example, the systematic mapping turned up more information about families or students' relationships to devices and issues they have. By comparison, topics like the authoritarian nature of parents or system justification were not covered by papers in our systematic mapping.

Career Aspirations and Psychological Health did not have as much overlap. Career aspirations is the kind of facet that can arise from the narrow scope of Team-SES's software type being a university website. That said, there seems to be utility in Career Aspirations as a facet, possibly even outside its original software scope of a University Website. A big focus of the Career Aspirations facet is about planning ahead, and the facet value for Team SES's low-SES population focused on how, according to their research, Low-SES individuals are less likely to plan ahead. Instead, their research indicated that they might tunnel vision on what is in front of them. This planning aspect of the facet was taken to account when the team was finding and fixing issues with their software. Shown in Appendix C, a heuristic Team-SES derived to support this was *"Present information for the here and now, but push towards future planning"*. One possibility is that generalizing the Career Aspirations facet as Team SES used it to something like "willingness to plan ahead" would be a useful facet beyond Team SES's narrow scope.

As for the lack of overlap relating to psychological health, Figure 15 shows that there weren't many SES-HCI papers on health . For example, papers on patients, healthcare

providers and individuals with disabilities accounted for only 13 out of 94 papers. In this sample, mental health did not show up as a research topic at all.

The differences in results between Team-SES's research and the systematic mapping study raise a question of whether pulling from prior literature, as is done in a systematic mapping study, is the only work needed to construct facets. Since SES-HCI is a young field, many of the gaps in the research haven't been filled in yet. Some of these gaps may be information necessary to build facets for an SES Inclusiveness Method. This may indicate that to build an InclusiveMag method with a population focus within a young field, that a systematic mapping may be a good first step but may not alone be enough to create a broad enough set of facets for long term use.

5.3.3 Intersectionality in SES-HCI

Intersectionality considers specific insights and problems that arise at the intersections of two or more criteria identifying a population of interest (Schlesinger et al., 2017). Intersectionality is a term originally coined to show how, through only considering only one identifying criterion (race or gender in this case), the experiences of people who were both black and women were being ignored by anti-discrimination legislation (Crenshaw, 1989). From this origin, the idea has been adopted by other fields, including HCI (Schlesinger et al., 2017). However, although intersectional research in HCI seems to be welcomed in theory, we have not seen many HCI papers that attempt to do it.

In contrast to this norm, the majority of SES-HCI papers in our sample were intersectional, as Figure 15 makes clear. As the figure shows, among the intersectional populations investigated were low-SES children (18 papers in our sample), low-SES individuals with disabilities (6 papers in our sample), and low-literacy low-SES subpopulations (10 papers in our sample). One possible reason for the more intersectional tendency of SES-HCI might be that SES-HCI is a relatively new subarea, so is starting "fresh" in modern times instead of building on decades-

long traditions. Another possibility could be that SES populations could inherently be so diverse, it is not possible to investigate them without using an intersectional approach. It is also possible that the intersectional tendency is a factor behind the lack of comparative investigations in SES-HCI that we pointed out in Section 5.3.1.

Finally, it is possible that the ways we categorized our populations emphasized the appearance of intersectionality. Our categorization attempted to provide groupings that didn't have too much overlap with each other (so the heatmaps weren't too skewed to any papers that had multiple subpopulations). However, it could be argued some of our groupings, like low SES minorities, could have been broken down further or combined further. To add clarity to the populations studied and how they fit into each category, the complete list of papers in our sample, given in Table A-1 (Appendix A), shows how we categorized each paper's population using the terminology of Figure 15, but also adds detailed information, when available on each paper's population specifics.

Chapter 6: Conclusion

In this thesis, we have introduced InclusiveMag, a systematic (meta-)method for inclusivity researchers to generate new inclusive methods. These generated methods are then used by software practitioners to evaluate the software they are creating.

In a multi-case study, eight teams used InclusiveMag to generate inclusivity methods along eight diversity dimensions, and then applied their generated methods to their software prototypes. Although the case study is early, it contributes encouraging evidence as to InclusiveMag's generality.

We emphasize that the first two steps of InclusiveMag method are for industrial (or academic) researchers, not for practitioners. However, the case study shows that InclusiveMag may also be useful to professors teaching classes on HCI research methods.

InclusiveMag provides a process to progressing inclusive design methods for different diversity dimensions. Following that process requires research into populations of different diversity dimensions. The SES-HCI systematic mapping served to establish research that can be used in the construction of SES-facets and lays out the landscape for other researchers.

In the systematic mapping study, our results revealed an uneven landscape, with widely varying amounts of research into different portions of the SES-HCI landscape. Among the results revealed were:

Populations and Topics: The low-SES subpopulations that the papers investigated varied widely, from low-SES children to homeless individuals, from low-SES disabled individuals to low-SES health professionals. The circumstances investigated also covered a wide range of personal and environmental circumstances. The papers' choices often feature intersectionality, and the emphasis on intersectionality may be greater in this area of HCI than what we have observed in other areas of HCI.

Goals: The goals these low-SES subpopulations had for using technology varied. Some were the same as what we have seen in other areas of HCI, such as using technology for work, gaming, and social media; whereas others uses were more like lifelines to critical needs, such as to improve their language skills, to connect with caregivers, or for their safety. One interesting goal was that some low-SES families particularly encouraged their children to familiarize themselves with technology, both to enable them to improve their socioeconomic status prospects and to serve as critical brokers of the family's information needs.

Access: The 94 papers enumerated 23 different ways by which low-SES subpopulations went about accessing technology (Table 5). For example, many of their devices were old or limited, and many had access only via shared, borrowed, or public devices. This suggests that in order to create inclusive technology for low SES populations, designers must accommodate users who may not have up-to-date technology that can run the latest features, or regular reliable access to the internet, etc.

Barriers: Low-SES populations' life circumstances often compounded the barriers they faced. For example, sharing devices led to limited access time, leading to extra stress in trying to accomplish their tasks on potentially outdated technology or with unreliable internet. Cultural mismatches sometimes added more barriers. Finally, low-SES subpopulations had an array of concerns about the security of their devices, trust in the services their technology connected them to (e.g., public ride sharing services), and concerns about identity theft and financial fraud.

Solutions: As Table 6 showed, the set of papers in our study contributed 16 design solutions to the barriers reported, and additional evidence of 6 more successes that low SES subpopulations had in overcoming the barriers.

As others begin to use InclusiveMag to generate new methods (Step 1 and 2), the methods they generate will cover more diversity dimensions. These additional methods and dimensions will then enable software practitioners (Step 3) to cover more

diversity dimensions—*early* in the lifecycles of the software they create. We believe that enabling this kind of early evaluation of software inclusivity is key to chipping away at software's implicit biases, one inclusiveness issue at a time.

Bibliography

T. Adlin and J. Pruitt, The Essential Persona Lifecycle: Your Guide to Building and Using Personas. Morgan Kaufmann/Elsevier, Burlington, MA, USA, 2010.

Kham Sila Ahmad, Jocelyn Armarego, and Fay Sudweeks. 2013. Literature review on the feasibility of mobile-assisted language learning (MALL) in developing vocabulary skills among non-English speaking migrant and refugee women. In Proceedings of the International Conference Research and Innovation in Information Systems (ICRIIS ‘13). IEEE, Kuala Lumpur, Malaysia, 335-341.

American Psychological Association, 2019. Socioeconomic status. Retrieved December 18, 2019 from https://www.apa.org/topics/socioeconomic-status/

Morgan G. Ames and Jenna Burrell. 2017. 'Connected Learning' and the Equity Agenda: A Microsociology of Minecraft Play. In Proceedings of the 2017 ACM Conference on Computer Supported Cooperative Work and Social Computing (CSCW '17). ACM, New York, NY, USA, 446-457. DOI: https://doi.org/10.1145/2998181.2998318

Morgan G. Ames, Janet Go, Joseph 'Jofish' Kaye, and Mirjana Spasojevic. 2011. Understanding technology choices and values through social class. In Proceedings of the ACM 2011 conference on Computer supported cooperative work (CSCW '11). ACM, New York, NY, USA, 55-64. DOI: https://doi.org/10.1145/1958824.1958834

Asam Almohamed and Dhaval Vyas. 2016. Vulnerability of displacement: challenges for integrating refugees and asylum seekers in host communities. In Proceedings of the 28th Australian Conference on Computer-Human Interaction (OzCHI '16). ACM, New York, NY, USA, 125-134. DOI: https://doi.org/10.1145/3010915.3010948

Panagiotis Apostolellis and Doug A. Bowman. 2016. Audience Involvement and Agency in Digital Games: Effects on Learning, Game Experience, and Social Presence. In Proceedings of the The 15th International Conference on Interaction Design and Children (IDC '16). ACM, New York, NY, USA, 299-310. DOI: https://doi.org/10.1145/2930674.2930700

Ingrid Arreola, Zan Morris, Matthew Francisco, Kay Connelly, Kelly Caine, and Ginger White. 2014. From checking on to checking in: designing for low socio-economic status older adults. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14). ACM, New York, NY, USA, 1933-1936. DOI: https://doi.org/10.1145/2556288.2557084

M. Arcand, and J. Nantel, Uncovering the nature of information processing of men and women online: The comparison of two models using the think-aloud method, Journal of Theoretical and Applied Electronic Commerce Research, vol. 7, iss. 2, pp. 106-120, August 2012.

Asmara Alias, Jamilah Hamid, Harnani Mat Zin, Saira Banu Omar Khan, and Norhasbiah Ubaidullah. 2011. Development of ICTL module-based on suitable teaching methodology for Orang Asli (ICTL-TeMfOA): The preliminary study of suitable teaching strategy. In Proceedings of the 7th International Conference on Information Technology. IEEE, Kuching, Sarawak, 1-4.

Kagonya Awori, Frank Vetere, and Wally Smith. 2016. Sessions with Grandma: Fostering Indigenous Knowledge through Video Mediated Communication. In Proceedings of the First African Conference on Human Computer Interaction (AfriCHI'16), Kagonya Awori and Nicola J. Bidwell (Eds.). ACM, New York, NY, USA, 1-11. DOI: https://doi.org/10.1145/2998581.2998585

Kartikeya Bajpai, Janelle B. Larson, and Khanjan Mehta. 2013. Like a hustler: aligning intervention design with informal labor practices. In Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1 (ICTD '13), Vol. 1. ACM, New York, NY, USA, 177-184. DOI=http://dx.doi.org/10.1145/2516604.2516624

Priscilla Barnes, Kelly Caine, Kay Connelly, and Katie Siek. 2013. Understanding the needs of low SES patients with type 2 diabetes. In Proceedings of the 7th International Conference on Pervasive Computing Technologies for Healthcare and Workshops. IEEE, Venice, Italy, 302-306. DOI: 10.4108/icst.pervasivehealth.2013.252153

L. Beckwith, M. Burnett, S. Wiedenbeck, C. Cook, S. Sorte, and M. Hastings, Effectiveness of end-user debugging software features: Are there gender issues?, ACM SIGCHI, pp. 869-878, 2005.

L. Beckwith and M. Burnett, Gender: An Important Factor in End-User Programming Environments?, IEEE VL/HCC, pp. 107-114, 2004.

L. Beckwith, C. Kissinger, M. Burnett, S. Wiedenbeck, J. Lawrance, A. Blackwell, C. Cook, Tinkering and Gender in End-User Programmers' Debugging, ACM CHI, pp. 231-240, April 2006.

M. A. Borkin, C. S. Yeh, M. Boyd, P. Macko, K. Z. Gajos, M. Seltzer, and H. Pfister, Evaluation of filesystem provenance visualization tools. IEEE Trans. on Visualization and Computer Graphics, vol. 19, Issue: 12, pp. 2476-2485, December 2013.

A. Bourazeri and S. Stumpf. 2018, Co-designing Smart Home Technology with People with Dementia or Parkinson's Disease. NordiCHI, pp.609–621, 2018.

Cynthia Breazeal, Robin Morris, Stephanie Gottwald, Tinsley Galyean, and Maryanne Wolf. 2016. Mobile Devices for Early Literacy Intervention and Research with Global Reach. In Proceedings of the Third (2016) ACM Conference on Learning @ Scale (L@S '16). ACM, New York, NY, USA, 11-20. DOI: https://doi.org/10.1145/2876034.2876046

David Brown, Georgina Cosma, Giovanni Acampora, Sarah Seymour-Smith and Alex Close. 2014. An Intelligent Serious Game for Supporting African and African Caribbean Men during Pre- and Post-Diagnosis of Prostate Cancer. In Proceedings of the International Conference on Interactive Technologies and Games. IEEE, Nottingham, 20-27. doi: 10.1109/iTAG.2014.9

David Budgen, Barbara Kitchenham, Stuart Charters, Mark Turner, Pearl Brereton, and Stephen Linjkman. 2007. Preliminary results of a study of the completeness and clarity of structured abstracts, in 'Proc. of the 11th Int. Conf. on Evaluation and Assessment in Software Engineering 2007', pp. 64–72.

Margaret Burnett, Simone Stumpf, Jamie Macbeth, Stephann Makri, Laura Beckwith, Irwin Kwan, Anicia Peters, William Jernigan, GenderMag: A Method for Evaluating Software's Gender Inclusiveness, Interacting with Computers, Volume 28, Issue 6, 19 November 2016, Pages 760–787, https://doi.org/10.1093/iwc/iwv046

M. Burnett, S. Fleming, S. Iqbal, G. Venolia, V. Rajaram, U. Farooq, V. Grigoreanu, and M. Czerwinski, Gender differences and programming environments: Across programming populations, ACM-IEEE ESEM, pp. 28, 2010.

M. Burnett, A. Peters, C. Hill, and N. Elarief, Finding gender inclusiveness software issues with GenderMag: A field investigation, ACM CHI, pp. 2586-2598, 2016.

Curtis C. Cain and Eileen Trauth. 2017. Black Men in IT: Theorizing an Autoethnography of a Black Man's Journey into IT within the United States of America. SIGMIS Database 48, 2 (April 2017), 35-51. DOI: https://doi.org/10.1145/3084179.3084184

Tusher Chakraborty, Taslim Arefin Khan, and A. B. M. Alim Al Islam. 2017. FLight: A Low-Cost Reading and Writing System for Economically Less-Privileged Visually-Impaired People Exploiting Ink-based Braille System. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17). ACM, New York, NY, USA, 531-540. DOI: https://doi.org/10.1145/3025453.3025646

Beenish Chaudhry, Kay Connelly, Katie Siek, and Janet Welch. 2012. Mobile interface design for low-literacy populations. In Proceedings of the 2nd ACM SIGHIT International Health Informatics Symposium (IHI '12). ACM, New York, NY, USA, 91-100. DOI=http://dx.doi.org/10.1145/2110363.2110377

Beenish M. Chaudhry, Christopher Schaefbauer, Ben Jelen, Katie Siek, and Kay Connelly. 2016. Evaluation of a Food Portion Size Estimation Interface for a Varying Literacy Population. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16). ACM, New York, NY, USA, 5645-5657. DOI: https://doi.org/10.1145/2858036.2858554

Iva W. Cheung. 2017. Plain Language to Minimize Cognitive Load: A Social Justice Perspective. In Proceedings of the IEEE Transactions on Professional Communication, vol. 60, no. 4, 448-457. doi: 10.1109/TPC.2017.2759639

Ming Ming Chiu, Bonnie Wing-Yin Chow, and Sung Wook Joh. 2017. How to assign students into sections to raise learning. In Proceedings of the Seventh International Learning Analytics & Knowledge Conference (LAK '17). ACM, New York, NY, USA, 95-104. DOI: https://doi.org/10.1145/3027385.3027439

P. J. Clarkson, R. Coleman, S. Keates, & C. Lebbon, Inclusive design: Design for the whole population. Springer Science & Business Media, pp. 1-23, 2013.

Sue Conger. 2013. Knowledge management in LLiSA ICT4D projects. In Proceedings of the South African Institute for Computer Scientists and Information Technologists Conference (SAICSIT '13), Philip Machanick and Mosiuoa Tsietsi (Eds.). ACM, New York, NY, USA, 225-232. DOI=http://dx.doi.org/10.1145/2513456.2513464

K. Crenshaw. 1989. Demarginalizing the intersection of race and sex: A Black Feminist critique of antidiscrimination doctrine, Feminist Theory and Antiracist Politics, University of Chicago Legal Forum, vol. 1989, Iss. 1, Article 8.

S. J. Cunningham, A. Hinze, and D. Nicols, Supporting gender-neutral digital library creation A case study using the GenderMag Toolkit, Knowledge, Information, and Data in An Open Access Society, vol. 10075, pp. 45-50, 2016.

Nicola Dell and Neha Kumar. 2016. The Ins and Outs of HCI for Development. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16). ACM, New York, NY, USA, 2220-2232. DOI: https://doi.org/10.1145/2858036.2858081

Tawanna R. Dillahunt, Nishan Bose, Suleman Diwan, and Asha Chen-Phang. 2016. Designing for Disadvantaged Job Seekers: Insights from Early Investigations.

In Proceedings of the 2016 ACM Conference on Designing Interactive Systems (DIS '16). ACM, New York, NY, USA, 905-910. DOI: https://doi.org/10.1145/2901790.2901865

Tawanna R. Dillahunt, Vaishnav Kameswaran, Linfeng Li, and Tanya Rosenblat. 2017. Uncovering the Values and Constraints of Real-time Ridesharing for Low-resource Populations. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17). ACM, New York, NY, USA, 2757-2769. DOI: https://doi.org/10.1145/3025453.3025470

Tawanna R. Dillahunt and Amelia R. Malone. 2015. The Promise of the Sharing Economy among Disadvantaged Communities. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, New York, NY, USA, 2285-2294. DOI: https://doi.org/10.1145/2702123.2702189

Tawanna R. Dillahunt, Sandy Ng, Michelle Fiesta, and Zengguang Wang. 2016. Do Massive Open Online Course Platforms Support Employability? In Proceedings of the 19th ACM Conference on Computer-Supported Cooperative Work & Social Computing (CSCW '16). ACM, New York, NY, USA, 233-244. DOI: https://doi.org/10.1145/2818048.2819924

Uttaran Dutta and Swayang Das. 2016. The digital divide at the margins: co-designing information solutions to address the needs of indigenous populations of rural India. Commun. Des. Q. Rev 4, 1 (January 2016), 36-48. DOI: http://dx.doi.org/10.1145/2875501.2875504

Sheena L. Erete. 2015. Engaging Around Neighborhood Issues: How Online Communication Affects Offline Behavior. In Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15). ACM, New York, NY, USA, 1590-1601. DOI: https://doi.org/10.1145/2675133.2675182

Sheena L. Erete, Ryan Miller, and Dan A. Lewis. 2014. Differences in technology use to support community crime prevention. In Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing (CSCW Companion '14). ACM, New York, NY, USA, 153-156. DOI: https://doi.org/10.1145/2556420.2556499

A. Fernandez, S. Abrahão, E. Insfran, Empirical validation of a usability inspection method for model-driven Web development, Journal of Systems and Software, vol. 86, iss. 1, pp. 161-186, 2013.

Karen Fisher, Ann Peterson Bishop, Lassana Magassa, and Phil Fawcett. 2014. Action!: codesigning interactive technology with immigrant teens. In Proceedings

of the 2014 conference on Interaction design and children (IDC '14). ACM, New York, NY, USA, 345-348. DOI: https://doi.org/10.1145/2593968.2610488

Robin Gauld, Shaun Goldfinch, Simon Horsburgh. 2010. Do they want it? Do they use it? The 'Demand-Side' of e-Government in Australia and New Zealand. Government Information Quarterly, Volume 27, Issue 2, Pages 177-186

J. Grudin, Why personas work: The psychological evidence. In The Persona LifeCycle: Keeping People in Mind Throughout Product Design, John Pruitt and Tamara Adlin. Morgan Kaufmann Publishers, SanFrancisco, CA, USA, 2005.

Tamy Guberek, Allison McDonald, Sylvia Simioni, Abraham H. Mhaidli, Kentaro Toyama, and Florian Schaub. 2018. Keeping a Low Profile?: Technology, Risk and Privacy among Undocumented Immigrants. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 114, 15 pages. DOI: https://doi.org/10.1145/3173574.3173688

Philip J. Guo. 2018. Non-Native English Speakers Learning Computer Programming: Barriers, Desires, and Design Opportunities. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 396, 14 pages. DOI: https://doi.org/10.1145/3173574.3173970

H. Rex Hartson, T. S. Andre & R. C. Williges, Criteria For Evaluating Usability Evaluation Methods, International Journal of Human–Computer Interaction, vol. 15, iss. 1, pp. 145-181, 2003.

J. Hassell, Including your missing 20% by embedding web and mobile accessibility, The British Standards Institution, 2015.

Emma Hebert, William Ferguson, Spencer McCullough, Margaret Chan, Arsen Drobakha, Sarah Ritter, Khanjan Mehta. 2016. mBody health: Digitizing disabilities in Sierra Leone. IEEE Global Humanitarian Technology Conference (GHTC), Seattle, WA, 2016, 717-724. doi: 10.1109/GHTC.2016.7857357

C. Hill, S. Ernst, A. Oleson, A. Horvath, and M. Burnett, GenderMag Experiences in the Field: The Whole, the Parts, and the Workload, IEEE VL/HCC, pp.199-207, September 2016.

C. Hill, M. Haag, A. Oleson, C. Mendez, N. Marsden, A. Sarma, and M. Burnett, Gender-inclusiveness personas vs. stereotyping: Can we have it both ways?, ACM CHI, pp. 6658-6671, 2017.

A. Huffman, J. Whetten, and W. Huffman, "Using technology in higher education: The influence of gender roles on technology self-efficacy," Computers in Human Behavior, vol. 29, pp. 1779-1786, 2013.

Puneet Kaur, Amandeep Dhir, Ibrahim A Albidewi and Daniyal M. Alghazzawi. 2012. Transforming traditional pervasive computing for emerging markets — Underlying challenges and opportunities. In Proceedings of the IEEE International Conference on Pervasive Computing and Communications Workshops, Lugano, Switzerland, 197-202. DOI: 10.1109/PerComW.2012.6197477

Danish Khan, Swamy Ananthanarayan, An Le, Christopher Schaefbauer, and Katie Siek. 2012. Designing mobile snack application for low socioeconomic status families. In Proceedings of the 6th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth) and Workshops, San Diego, CA, 2012, 57-64.

Danish U Khan, Swamy Ananthanarayan, Katie A. Siek. 2011. Exploring everyday health routines of a low socioeconomic population through multimedia elicitations. J Participat Med. 2011 Aug 29; 3:e39.

Barbara Kitchenham. 2004. Procedures for Undertaking Systematic Reviews. Joint Technical Report, Computer Science Department, Keele University and National ICT Australia.

B. Kitchenham, O. Brereton, D. Budgen, M. Turner, J. Bailey, S. Linkman, Systematic literature reviews in software engineering – A systematic literature review, Information and Software Technology, vol. 51, iss. 1, pp. 7-15, 2009.

René F. Kizilcec, Glenn M. Davis, and Geoffrey L. Cohen. 2017. Towards Equal Opportunities in MOOCs: Affirmation Reduces Gender & Social-Class Achievement Gaps in China. In Proceedings of the Fourth (2017) ACM Conference on Learning @ Scale (L@S '17). ACM, New York, NY, USA, 121-130. DOI: https://doi.org/10.1145/3051457.3051460

Amy J. Ko and Katie Davis. 2017. Computing Mentorship in a Software Boomtown: Relationships to Adolescent Interest and Beliefs. In Proceedings of the 2017 ACM Conference on International Computing Education Research (ICER '17). ACM, New York, NY, USA, 236-244. DOI: https://doi.org/10.1145/3105726.3106177

Neha Kumar and Richard J. Anderson. 2015. Mobile Phones for Maternal Health in Rural India. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, New York, NY, USA, 427-436. DOI: https://doi.org/10.1145/2702123.2702258

Stacey Kuznetsov, George Davis, Jian Cheung, and Eric Paulos. 2011. Ceci n'est pas une pipe bombe: authoring urban landscapes with air quality sensors. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 2375-2384. DOI: https://doi.org/10.1145/1978942.1979290

Javier A. Kypuros, Jessica Lavariega Monforti, Michelle Bothwell, Kelli Nakamura, Charles S. Sasaki, and Dwaine Plaza. 2016. Understanding intersecting social identities in engineering education and practice. In Proceedings of the IEEE Frontiers in Education Conference (FIE). IEEE, Erie, PA, USA, 1-4. doi: 10.1109/FIE.2016.7757710

Christopher A. Le Dantec and W. Keith Edwards. 2008. Designs on dignity: perceptions of technology among the homeless. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '08). ACM, New York, NY, USA, 627-636. DOI: https://doi.org/10.1145/1357054.1357155

R. Lee, T. Wong, & C. Sabanayagam, Epidemiology of diabetic retinopathy, diabetic macular edema and related vision loss. Eye and vision (London, England), vol. 2, iss.17, 2015.

Mike Levy. 2009. Technologies in Use for Second Language Learning. The Modern Language Journal, 93: 769-782. doi:10.1111/j.1540-4781.2009.00972.x

Soo Ling Lim, Peter J. Bentley, Natalie Kanakam, Fuyuki Ishikawa and Shinichi Honiden. 2015. Investigating Country Differences in Mobile App User Behavior and Challenges for Software Engineering. In Proceedings of the IEEE Transactions on Software Engineering. IEEE, vol. 41, no. 1, 40-64. doi: 10.1109/TSE.2014.2360674

Leslie S. Liu, Sen H. Hirano, Monica Tentori, Karen G. Cheng, Sheba George, Sun Young Park, and Gillian R. Hayes. 2011. Improving communication and social support for caregivers of high-risk infants through mobile technologies. In Proceedings of the ACM 2011 Conference on Computer supported cooperative work (CSCW '11). ACM, New York, NY, USA, 475-484. DOI: https://doi.org/10.1145/1958824.1958897

Jun Liu, Ying Liu, Pei-Luen Patrick Rau, Hui Li, Xia Wang, and Dingjun Li. 2010. How socio-economic structure influences rural users' acceptance of mobile entertainment. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). ACM, New York, NY, USA, 2203-2212. DOI: https://doi.org/10.1145/1753326.1753659

Sara Ljungblad and Lars Erik Holmquist. 2007. Transfer scenarios: grounding innovation with marginal practices. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '07). ACM, New York, NY, USA, 737-746. DOI: https://doi.org/10.1145/1240624.1240738

T. Mahatody, M. Sagar, and C. Kolski, State of the art on the cognitive walkthrough method, its variants and evolutions, International Journal of Human-Computer Interaction, vol. 26, iss. 8, pp. 741-85, 2010.

Julie Maitland, Matthew Chalmers and Katie Siek. 2009. Persuasion not required: Improving our understanding of the sociotechnical context of dietary behavioural change. In Proceedings of the 3rd International Conference on Pervasive Computing Technologies for Healthcare, London, UK, 1-8. DOI: 10.4108/ICST.PERVASIVEHEALTH2009.5928

Elsa Marcelino-Jesus, Joao Sarraipa, Gloria Andrea Cavanzo, Juan Carlos Guevara, Igor Almanza Lurita, and María Isabel Ginocchio. 2016. The importance of cooperation centres for HE students' dropout prevention. In Proceedings of the 7th International Conference on Software Development and Technologies for Enhancing Accessibility and Fighting Info-exclusion (DSAI 2016). ACM, New York, NY, USA, 92-98. DOI: https://doi.org/10.1145/3019943.3019957

Daniel J. Mathew, Amit Samarth, Zeena Johar, and Aaditeshwar Seth. 2013. Jury: an automation framework for protocolised primary healthcare delivery. In Proceedings of the 4th Annual Symposium on Computing for Development (ACM DEV-4 '13). ACM, New York, NY, USA, Article 7, 9 pages. DOI: https://doi.org/10.1145/2537052.2537059

Albert Mckeon 2019. Uber mall kiosks act as brick-and-mortar storefronts Retrieved December 18, 2019 From https://searchcustomerexperience.techtarget.com/feature/Uber-mall-kiosks-act-as-brick-and-mortar-storefronts

Christopher Mendez, Larissa Letaw, Margaret Burnett, Simone Stumpf, Anita Sarma and Claudia Hilderbrand, "From GenderMag to InclusiveMag: An Inclusive Design Meta-Method," 2019 IEEE Symposium on Visual Languages and Human-Centric Computing (VL/HCC), Memphis, TN, USA, 2019, pp. 97-106. doi: 10.1109/VLHCC.2019.8818889

C. Mendez, H. S. Padala, Z. Steine-Hanson, C. Hilderbrand, A. Horvath, C. Hill, L. Simpson, N. Patil, A. Sarma, and M. Burnett, Open Source barriers to entry, revisited: A sociotechnical perspective, ACM ICSE, pp.1004-1015, 2018.

Microsoft, Inclusive: A Microsoft Design Toolkit, 2015. [Online]. Available: https://scope.bccampus.ca/pluginfile.php/52293/block_html/content/MS-InclusiveDesignToolkit.pdf. [Accessed April 23, 2019].

Preeti Mudliar, Jonathan Donner, and William Thies. 2012. Emergent practices around CGNet Swara, voice forum for citizen journalism in rural India. In Proceedings of the Fifth International Conference on Information and Communication Technologies and Development (ICTD '12). ACM, New York, NY, USA, 159-168. DOI=http://dx.doi.org/10.1145/2160673.2160695

David Munoz. 2014. Low-income parents' perceptions of technology: value-based design insights. In CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14). ACM, New York, NY, USA, 969-974. DOI: https://doi.org/10.1145/2559206.2579420

J. Meyers-Levy and B. Loken, “Revisiting gender differences: What we know and what lies ahead,” Journal of Consumer Psychology, vol. 25, no. 1, pp. 129-149, Jan. 2015.

J. Meyers-Levy and D. Maheswaran, “Exploring differences in males’ and females’ processing strategies,” Journal Consumer Research, vol. 18, no. 1, pp. 63-70, June 1991.

Denise C. Nacu, Caitlin K. Martin, Jim Sandherr, and Nichole Pinkard. 2015. Encouraging online contributions in underrepresented populations. In Proceedings of the Research in Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT) Conference. IEEE, Charlotte, NC, USA, 1-4. DOI: 10.1109/RESPECT.2015.7296503

T. Neate, K. Bourazeri, A. Roper, S. Stumpf, and S. Wilson. Co-Created Personas: Engaging and Empowering Users with Diverse Needs Within the Design Process, ACM CHI, 2019.

Jakob Nielsen. 1994. Enhancing the explanatory power of usability heuristics. Proc. ACM CHI'94 Conf. (Boston, MA, April 24-28), 152-158.

Josef Noll, Sudhir Dixit, Danica Radovanovic, Maghsoud Morshedi, Christine Holst and Andrea S. Winkler. 2018. 5G network slicing for digital inclusion. In Proceedings of the 10th International Conference on Communication Systems & Networks (COMSNETS). IEEE, Bengaluru, 191-197. doi: 10.1109/COMSNETS.2018.8328197

E. O’Donnell and E. Johnson, Gender effects on processing effort during analytical procedures. International Journal of Auditing, vol.5, pp. 91-105, 2001.

Agnes Owuato Odongo and Gideon Cheruiyot Rono. 2016. Kenya Digital and Cultural Divide. In Proceedings of the 9th International Conference on Theory and Practice of Electronic Governance (ICEGOV '15-16), John Bertot, Elsa Estevez, and Sehl Mellouli (Eds.). ACM, New York, NY, USA, 85-94. DOI: https://doi.org/10.1145/2910019.2910077

Erick Oduor, Carman Neustaedter, Tejinder K. Judge, Kate Hennessy, Carolyn Pang, and Serena Hillman. 2014. How technology supports family communication in rural, suburban, and urban kenya. In Proceedings of the SIGCHI Conference on

Human Factors in Computing Systems (CHI '14). ACM, New York, NY, USA, 2705-2714. DOI=http://dx.doi.org/10.1145/2556288.2557277

Joyojeet Pal, Tawfiq Ammari, Ramaswami Mahalingam, Ana Maria Huaita Alfaro, and Meera Lakshmanan. 2013. Marginality, aspiration and accessibility in ICTD. In Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1 (ICTD '13), Vol. 1. ACM, New York, NY, USA, 68-78. DOI: https://doi.org/10.1145/2516604.2516623

Agnieszka Palalas and Norine Wark. 2017. Design Principles for an Adult Literacy Mobile Learning Solution. In Proceedings of the 16th World Conference on Mobile and Contextual Learning (mLearn 2017), Fernando Loizides, George Papadopoulos, and Nicos Souleles (Eds.). ACM, New York, NY, USA, Article 27, 8 pages. DOI: https://doi.org/10.1145/3136907.3136934

Sora Park, Julie Freeman, Catherine Middleton, Matthew Allen, Robin Eckermann, and Richard Everson. 2015. The Multi-layers of Digital Exclusion in Rural Australia. In Proceedings of the 48th Hawaii International Conference on System Sciences. IEEE, Kauai, HI, 3631-3640. doi: 10.1109/HICSS.2015.436

Miranda C. Parker and Mark Guzdial. 2015. A critical research synthesis of privilege in computing education. In Proceedings of the Conference of Research in Equity and Sustained Participation in Engineering, Computing, and Technology (RESPECT). IEEE, Charlotte, NC, 1-5.

Neil Patel, Deepti Chittamuru, Anupam Jain, Paresh Dave, and Tapan S. Parikh. 2010. Avaaj Otalo: a field study of an interactive voice forum for small farmers in rural India. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). ACM, New York, NY, USA, 733-742. DOI: https://doi.org/10.1145/1753326.1753434

Kai Petersen, Sairam Vakkalanka, and Ludwik Kuzniarz. 2015. Guidelines for conducting systematic mapping studies in software engineering: An update. Information and Software Technology. 64 (August 2015), 1-18. https://doi.org/10.1016/j.infsof.2015.03.007

Kai Petersen, Robert Feldt, Shahid Mujtaba, and Michael Mattsson. 2008. Systematic mapping studies in software engineering. In Proceedings of the 12th international conference on Evaluation and Assessment in Software Engineering (EASE'08), Giuseppe Visaggio, Maria Teresa Baldassarre, Steve Linkman, and Mark Turner (Eds.). BCS Learning & Development Ltd., Swindon, UK, 68-77.

H. Petrie, and N. Bevan, The Evaluation of Accessibility, Usability, and User Experience, The universal access handbook 1st ed., 2009, pp. 1-16.

PiazzaBlog, “STEM confidence gap,” 2015. [Online]. Available: http://blog.piazza.com/stem-confidence-gap/ . [Accessed April 20, 2018].

Emilee Rader, Margaret Echelbarger, and Justine Cassell. 2011. Brick by brick: iterating interventions to bridge the achievement gap with virtual peers. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 2971-2974. DOI: https://doi.org/10.1145/1978942.1979382

Ahmad Rahmati, Chad Tossell, Clayton Shepard, Philip Kortum, and Lin Zhong. 2012. Exploring iPhone usage: the influence of socioeconomic differences on smartphone adoption, usage and usability. In Proceedings of the 14th international conference on Human-computer interaction with mobile devices and services (MobileHCI '12). ACM, New York, NY, USA, 11-20. DOI: https://doi.org/10.1145/2371574.2371577

Ricardo Ramírez, Balaji Parthasarathy, and Andrew Gordon. 2013. From infomediaries to infomediation at public access venues: lessons from a 3-country study. In Proceedings of the Sixth International Conference on Information and Communication Technologies and Development: Full Papers - Volume 1 (ICTD '13), Vol. 1. ACM, New York, NY, USA, 124-132. DOI=http://dx.doi.org/10.1145/2516604.2516621

Nimmi Rangaswamy and Edward Cutrell. 2012. Anthropology, development and ICTs: slums, youth and the mobile internet in urban India. In Proceedings of the Fifth International Conference on Information and Communication Technologies and Development (ICTD '12). ACM, New York, NY, USA, 85-93. DOI=http://dx.doi.org/10.1145/2160673.2160685

Gabriela T. Richard and Yasmin B. Kafai. 2016. Blind Spots in Youth DIY Programming: Examining Diversity in Creators, Content, and Comments within the Scratch Online Community. In Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems (CHI '16). ACM, New York, NY, USA, 1473-1485. DOI: https://doi.org/10.1145/2858036.2858590

R. Riedl, M Hubert, and P. Kenning, “Are there neural gender differences in online trust? An fMRI Study on the Perceived Trustworthiness of Ebay Offers,” Society for Information Management and The Management Information Systems Research Center, vol. 34, 2010.

Tom A. Rodden, Joel E. Fischer, Nadia Pantidi, Khaled Bachour, and Stuart Moran. 2013. At home with agents: exploring attitudes towards future smart energy

infrastructures. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '13). ACM, New York, NY, USA, 1173-1182. DOI: https://doi.org/10.1145/2470654.2466152

Parisa Khanipour Roshan, Maia Jacobs, Michaelanne Dye, and Betsy DiSalvo. 2014. Exploring How Parents in Economically Depressed Communities Access Learning Resources. In Proceedings of the 18th International Conference on Supporting Group Work (GROUP '14). ACM, New York, NY, USA, 131-141. DOI=http://dx.doi.org/10.1145/2660398.2660415

Daniela K. Rosner and Morgan Ames. 2014. Designing for repair?: infrastructures and materialities of breakdown. In Proceedings of the 17th ACM conference on Computer supported cooperative work & social computing (CSCW '14). ACM, New York, NY, USA, 319-331. DOI: https://doi.org/10.1145/2531602.2531692

Florin D. Salajan, Dieter J. Schönwetter, Blaine M. Cleghorn. Student and faculty inter-generational digital divide: Fact or fiction?, Computers & Education, Volume 55, Issue 3, 2010, Pages 1393-1403, https://doi.org/10.1016/j.compedu.2010.06.017.

Nithya Sambasivan, Ed Cutrell, and Kentaro Toyama. 2010. ViralVCD: tracing information-diffusion paths with low cost media in developing communities. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '10). ACM, New York, NY, USA, 2607-2610. DOI: https://doi.org/10.1145/1753326.1753721

Nithya Sambasivan, Julie Weber, and Edward Cutrell. 2011. Designing a phone broadcasting system for urban sex workers in India. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 267-276. DOI: https://doi.org/10.1145/1978942.1978980

Ari Schlesinger, W. Keith Edwards, and Rebecca E. Grinter. 2017. Intersectional HCI: Engaging Identity through Gender, Race, and Class. In Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems (CHI '17). ACM, New York, NY, USA, 5412-5427. DOI: https://doi.org/10.1145/3025453.3025766

Hanna Schneider, Malin Eiband, Daniel Ullrich, and Andreas Butz. 2018. Empowerment in HCI - A Survey and Framework. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 244, 14 pages. DOI: https://doi.org/10.1145/3173574.3173818

A. Shekhar and N. Marsden, Cognitive Walkthrough of a learning management system with gendered personas. 4th Gender & IT Conference (GenderIT'18), pp.191-198, 2018.

Geeta Shroff and Matthew Kam. 2011. Towards a design model for women's empowerment in the developing world. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 2867-2876. DOI: https://doi.org/10.1145/1978942.1979368

A. Singh, V. Bhadauria, A. Jain, and A. Gurung, “Role of gender, self-efficacy, anxiety and testing formats in learning spreadsheets,” Computers in Human Behavior, vol. 29, pp. 739-746, 2013.

D. Sjøberg, T. Dybå, B. Anda, J. Hannay, Building Theories in Software Engineering. In: F. Shull, J. Singer, D. Sjøberg (eds) Guide to Advanced Empirical Software Engineering. Springer, pp. 312-336, 2008.

Saurabh Sood and Niti Saxena. 2017. Moving Beyond Digital Literacy and Towards e-Governance in Rural India. In Proceedings of the Special Collection on eGovernment Innovations in India (ICEGOV '17), Rehema Baguma, Rahul De, Tomasz Janowski, and Morten Meyerhoff Nielsen (Eds.). ACM, New York, NY, USA, 1-5. DOI: https://doi.org/10.1145/3055219.3055243

Fiona Ssozi-Mugarura, Edwin Blake, and Ulrike Rivett. 2016. Supporting community needs for rural water management through community-based co-design. In Proceedings of the 14th Participatory Design Conference: Full papers - Volume 1 (PDC '16), Claus Bossen, Rachel Charlotte Smith, Anne Marie Kanstrup, Janet McDonnell, Maurizio Teli, and Keld Bødker (Eds.), Vol. 1. ACM, New York, NY, USA, 91-100. DOI: https://doi.org/10.1145/2940299.2940311

Nick Statt. 2015. Microsoft CEO Nadella wants to help the world ‘to achieve more’. CNET. Retrieved December 18, 2019 From http://www.cnet.com/news/microsoft-ceo-satya-nadella-outlines-new-mission-statement/

Elizabeth Stowell, Mercedes C. Lyson, Herman Saksono, Reneé C. Wurth, Holly Jimison, Misha Pavel, and Andrea G. Parker. 2018. Designing and Evaluating mHealth Interventions for Vulnerable Populations: A Systematic Review. In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems (CHI '18). ACM, New York, NY, USA, Paper 15, 17 pages. DOI: https://doi.org/10.1145/3173574.3173589

Angelika Strohmayer, Rob Comber, and Madeline Balaam. 2015. Exploring Learning Ecologies among People Experiencing Homelessness. In Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems (CHI '15). ACM, New York, NY, USA, 2275-2284. DOI: https://doi.org/10.1145/2702123.2702157

N. Subrahmaniyan, L. Beckwith, V. Grigoreanu, M. Burnett, S. Wiedenbeck, V. Narayanan, K. Bucht, R. Drummond, and X. Fern, Testing vs. code inspection vs.

... what else? Male and female end users' debugging strategies, ACM SIGCHI, pp. 617-626, 2008.

D. S. Tan, M. Czerwinski, and G. Robertson, Women go with the (optical) flow, ACM CHI, pp. 209-215, 2003.

Charlotte Tang. 2015. Informing EMR System Design through Investigation of Paper-Based Work Practices in a Non-profit Clinic Serving a Vulnerable Population. In Proceedings of the 28th International Symposium on Computer-Based Medical Systems. IEEE, Sao Carlos, SP, Brazil, 7-12. DOI: 10.1109/CBMS.2015.18

Jennyfer Lawrence Taylor, Dhaval Vyas, and Tony Sharp. 2017. Diversity and coherence in a hackerspace for people from a low socioeconomic community. In Proceedings of the 29th Australian Conference on Computer-Human Interaction (OZCHI '17), Alessandro Soro, Dhaval Vyas, Bernd Ploderer, Ann Morrison, Jenny Waycott, and Margot Brereton (Eds.). ACM, New York, NY, USA, 238-247. DOI: https://doi.org/10.1145/3152771.3152797

Jacob Thebault-Spieker, Loren G. Terveen, and Brent Hecht. 2015. Avoiding the South Side and the Suburbs: The Geography of Mobile Crowdsourcing Markets. In Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing (CSCW '15). ACM, New York, NY, USA, 265-275. DOI: https://doi.org/10.1145/2675133.2675278

University of Cambridge, Inclusive Design Toolkit, 2017. [Online]. Available: http://www.inclusivedesigntoolkit.com/simsoftware/simsoftware.html. [Accessed April 29, 2019].

Aditya Vashistha, Edward Cutrell, Nicola Dell, and Richard Anderson. 2015. Social Media Platforms for Low-Income Blind People in India. In Proceedings of the 17th International ACM SIGACCESS Conference on Computers & Accessibility (ASSETS '15). ACM, New York, NY, USA, 259-272. DOI: https://doi.org/10.1145/2700648.2809858

Aditya Vashistha, Erin Brady, William Thies, and Edward Cutrell. 2014. Educational Content Creation and Sharing by Low-Income Visually Impaired People in India. In Proceedings of the Fifth ACM Symposium on Computing for Development (ACM DEV-5 '14). ACM, New York, NY, USA, 63-72. DOI: https://doi.org/10.1145/2674377.2674385

Aditya Vashistha, Neha Kumar, Anil Mishra, and Richard Anderson. 2017. Examining Localization Approaches for Community Health. In Proceedings of the 2017 Conference on Designing Interactive Systems (DIS '17). ACM, New York, NY, USA, 357-368. DOI: https://doi.org/10.1145/3064663.3064754

John Vines, Paul Dunphy, and Andrew Monk. 2014. Pay or delay: the role of technology when managing a low income. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '14). ACM, New York, NY, USA, 501-510. DOI: https://doi.org/10.1145/2556288.2556961

M. Vorvoreanu, L. Zhang, Y. Huang, C. Hilderbrand, Z. Steine-Hanson, and M. Burnett, From Gender Biases to Gender-Inclusive Design: An Empirical Investigation, ACM SIGCHI, 2019.

Dhaval Vyas, Stephen Snow, and Miranda Mallett. 2015. More than just Food: Field Visits to an Emergency Relief Centre. In Proceedings of the Annual Meeting of the Australian Special Interest Group for Computer Human Interaction (OzCHI '15), Bernd Ploderer, Marcus Carter, Martin Gibbs, Wally Smith, and Frank Vetere (Eds.). ACM, New York, NY, USA, 662-666. DOI: https://doi.org/10.1145/2838739.2838787

Greg Wadley, Adam Bumpus, and Ray Green. 2014. Citizen involvement in the design of technology for climate change adaptation projects in the Pacific. In Proceedings of the 26th Australian Computer-Human Interaction Conference on Designing Futures: the Future of Design (OzCHI '14). ACM, New York, NY, USA, 180-183. DOI=http://dx.doi.org/10.1145/2686612.2686640

Jenny Waycott, Sue Bennett, Gregor Kennedy, Barney Dalgarno, and Kathleen Gray. 2010. Digital divides? Student and staff perceptions of information and communication technologies. http://dx.doi.org/10.1016/j.compedu.2009.11.006

Web Content Accessibility Guidelines (WCAG) 2.0, 2008. [Online]. Available: https://www.w3.org/TR/2008/REC-WCAG20-20081211/. [Accessed: April 20, 2019].

C. Wharton, J. Rieman, C. Lewis, and P. Polson, The cognitive walkthrough method: a practitioner's guide, John Wiley & Sons Inc., 1994.

World Health Organization, Blindness and vision impairment, 2018. [Online]. Available: https://www.who.int/news-room/fact-sheets/detail/blindness-and-visual-impairment. [Accessed: April 23, 2019].

G. Williams, Are you sure your software is gender-neutral? ACM Magazine Interactions, vol. 21, iss. 1, pp. 36–39, January 2014.

Sarah A. Williams, Ben Lutz, Cynthia Hampton, Holly M. Matusovich and Walter C. Lee. 2016. Exploring student motivation towards diversity education in engineering. In Proceedings of the IEEE Frontiers in Education Conference (FIE). IEEE, Erie, PA, USA, 1-5. doi: 10.1109/FIE.2016.7757565

Jill Palzkill Woelfer, Amy Iverson, David G. Hendry, Batya Friedman, and Brian T. Gill. 2011. Improving the safety of homeless young people with mobile phones: values, form and function. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '11). ACM, New York, NY, USA, 1707-1716. DOI: https://doi.org/10.1145/1978942.1979191

Susan Wyche. 2015. Exploring mobile phone and social media use in a Nairobi slum: a case for alternative approaches to design in ICTD. In Proceedings of the Seventh International Conference on Information and Communication Technologies and Development (ICTD '15). ACM, New York, NY, USA, Article 12. DOI=http://dx.doi.org/10.1145/2737856.2738019

Susan P. Wyche and Laura L. Murphy. 2012. "Dead China-make" phones off the grid: investigating and designing for mobile phone use in rural Africa. In Proceedings of the Designing Interactive Systems Conference (DIS '12). ACM, New York, NY, USA, 186-195. DOI: https://doi.org/10.1145/2317956.2317985

Sarita Yardi and Amy Bruckman. 2012. Income, race, and class: exploring socioeconomic differences in family technology use. In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems (CHI '12). ACM, New York, NY, USA, 3041-3050. DOI: http://dx.doi.org/10.1145/2207676.2208716

David J. Yates, Girish J. Gulati, and Anas Tawileh. 2010. Explaining the Global Digital Divide: The Impact of Public Policy Initiatives on Digital Opportunity and ICT Development. In Proceedings of the 43rd Hawaii International Conference on System Sciences. IEEE, Honolulu, HI, 1-10.

He Zhang and Muhammad Ali Babar. 2010. On searching relevant studies in software engineering. In Proceedings of the 14th international conference on Evaluation and Assessment in Software Engineering (EASE'10), Mark Turner and Mahmood Niazi (Eds.). BCS Learning & Development Ltd., Swindon, UK, 111-120.

Appendix A: Full Paper List

Table A-1: List of all 94 papers in our sample, alongside the SES subpopulation and topic that we classified the papers under.

Title	Subpopulation	Topics
(Ahmad et al., 2013) …mobile-assisted language learning … among non-English speaking migrant and refugee …	Minority (refugee women), Low Literacy	Education
(Alias et al., 2011) …preliminary study of suitable teaching strategy	Minority (Indigenous peoples)	Education, Culture
(Ames and Burrell, 2017) Connected Learning'and the Equity Agenda …	Children	Education
(Ames et al., 2011) Understanding technology choices and values through social class	Families	Low income
(Almohamed and Vyas, 2016) …. integrating refugees and asylum seekers in host communities	Minority (Refugee)	Culture
(Apostolellis and Bowman, 2016) Audience Involvement and Agency in Digital Games…	Children	Education, Low income
(Arreola et al., 2014) … designing for low socio-economic status older adults	Older adults	Low income
(Awori et al., 2016) … fostering Indigenous Knowledge through Video Mediated Communication	Minority (indigenous), Online Communities	Age
(Bajpai et al., 2013) Like a hustler … informal labor practices	Children, Teenagers	Low income
(Barnes et al., 2013) Understanding the needs of low SES patients with type 2 diabetes	Patients	Health, low income
(Breazeal et al., 2016) Mobile Devices for Early Literacy …	Children	Education
(Brown et al., 2014) … game for supporting African and African Caribbean men … diagnosis of prostate cancer	Patients, Minority (African American and African Caribbean Men)	Health
(Cain and Trauth, 2017) Black Men in IT …	Minority (African American men)	Race
(Chakraborty et al., 2017) … Reading and Writing System for Economically Less-Privileged Visually-Impaired People	Disability	Low income
(Chaudhry et al., 2012) Mobile interface design for low-literacy populations	Patients, Low literacy	Education, Health

(Chaundhry et al., 2016) … Food Portion Size Estimation Interface for a Varying Literacy Population	Patients (dialysis), Low literacy	Education
(Cheung, 2017) … Minimize Cognitive Load …	Minority	Culture
(Chiu et al., 2017) How to assign students into sections to raise learning	Children, Low Literacy	Education
(Conger, 2013) Knowledge management … ICT4D projects	Low-SES Locations	Technology access
(Dell and Kumar, 2016) The ins and outs of HCI for development	Minority (populations)	Technology access
(Dillahunt et al., 2016) Designing for disadvantaged job seekers: Insights from early investigations	Low-SES Locations	Unemployment
(Dillahunt et al., 2017) Uncovering the values and constraints of real-time ridesharing for low-resource populations	Low-SES Locations	Low income, technology
(Dillahunt and Malone, 2015) The Promise of the Sharing Economy among Disadvantaged Communities	Low-SES Locations	Unemployment
(Dillahunt et al., 2016) Do massive open online course platforms support employability.	Online Communities	Low income, Technology literacy
(Dutta and Das, 2016) ... co-designing information solutions to address the needs of indigenous populations of rural India	Minority (indigenous), low literacy	Education
(Erete, 2015) … How Online Communication Affects Offline Behavior	Online Communities, Low-SES Locations	Low income
(Erete et al., 2014) Differences in technology use to support community crime prevention	Online Communities	Culture
(Fisher et al., 2014) Action!: codesigning interactive technology with immigrant teens	Children, Teenagers, Minority (refugee)	Technology literacy
(Salajan et al., 2011) Student and faculty inter-generational digital divide: Fact or fiction?	College students	Education
(Gauld et al., 2010) … e-Government in Australia and New Zealand	Low-SES Locations	Education
(Guburek et al., 2018) … Technology, Risk and Privacy among Undocumented Immigrants	Minority (immigrants)	Technology literacy
(Guo, 2018) Non-Native English Speakers Learning Computer Programming …	Minority (non-native English speakers)	Culture
(Hebert et al., 2016) … Digitizing disabilities in Sierra Leone	Disability	Health
(Kaur et al., 2012) … pervasive computing for emerging markets …	Online Communities	Low income

(Khan et al., 2012) Designing mobile snack application for low socioeconomic status families	Families	Low income
(Khan et al., 2011) …Health Routines of a Low Socioeconomic Population …	Minority	Health
(Kizilcec et al., 2017) Towards Equal Opportunities in MOOCs …	Online Communities	Low income, Culture
(Ko and Davis, 2017) Computing Mentorship … Adolescent Interest and Beliefs	Teenagers	Education
(Kumar and Anderson, 2015) Mobile phones for maternal health in rural India	Minority, Patients	Culture
(Kuznetsov et al, 2011) …authoring urban landscapes with air quality sensors	Low-SES Locations	Technology access
(Kypuros et al., 2016) Understanding intersecting social identities …	College students, Minority	Culture
(Le Dantec and Edwards, 2008) Designs on dignity: perceptions of technology among the homeless	Homeless	Technology literacy
(Levy, 2009) Technologies in Use for Second Language Learning	Minority	Culture, low income
(Lim et al., 2015) Investigating country differences in mobile app user behavior …	Online Communities	Technology literacy
(Liu et al., 2011) Improving communication and social support for caregivers of high-risk infants through mobile technologies	Parents	Education
(Liu et al., 2010) … Rural Users' Acceptance of Mobile Entertainment	Low-SES Locations	Culture, Technology literacy
(Maitland et al., 2009) … the sociotechnical context of dietary behavioural change	Healthcare professionals	Low income, Health
(Marcelino-Jesus et al., 2016) The importance of cooperation centres …	College students	Age, Low income
(Mathes et al., 2013) Jury: an automation framework for protocolised primary healthcare delivery	Patients, Healthcare professionals	Technology access
(Mudliar et al., 2012) … voice forum for citizen journalism in rural India	Online Communities, Low-SES Locations	Technology access
(Munoz, 2014) Low-income parents' perceptions of technology …	Families	Low income
(Nacu et al., 2015) Encouraging online contributions in underrepresented populations	Minority (Latino), Children, Online Communities	Culture
(Noll et al., 2018) 5G network slicing for digital inclusion	Low-SES Locations	Technology access
(Odongo and Rono, 2016) Digital and Cultural Divide	Low-SES Locations	Low income

(Oduor et al., 2014) How technology supports family communication in rural, suburban, and urban kenya	Families, low literacy	Education, Age
(Pal et al., 2013) Marginality, aspiration and accessibility in ICTD	Disability	Disability
(Palalas and Wark, 2017) … Adult Literacy Mobile Learning Solution	Low-SES Locations	Technology literacy
(Park et al., 2015) … Digital Exclusion in Rural Australia	Online Communities	Technology access
(Parker and Guzdial, 2015) … privilege in computing education	College students	Race, Low income
(Patel et al., 2010) Avaaj otalo: a field study of an interactive voice forum for small farmers in rural india	Low-SES Locations	Education
(Rader et al., 2011) Brick by brick: iterating interventions to bridge the achievement gap with virtual peers	Children	Education
(Rahmati et al., 2012) Exploring iPhone usage: The influence of socioeconomic differences on smartphone adoption, usage and usability	College students	Low income
(Ramírez et al., 2013) From infomediaries infomediation at public access venues…	Low-SES Locations, low literacy	Education, Disability
(Rangaswamy and Cutrell, 2012) … youth and the mobile internet in urban India	Teenagers	Low income
(Richard and Kafai, 2016) Blind spots in youth DIY programming …	Children, Teenagers	Culture
(Rodden et al., 2013) … Attitudes Towards Future Smart Energy Infrastructures	Low-SES Locations	Technology literacy
(Roshan et al., 2014) Exploring How Parents … Access Learning Resources	Parents	Low income
(Rosner and Ames, 2014) Designing for repair?: infrastructures and materialities of breakdown	Children	Technology access
(Sambasivan et al., 2010) ViralVCD: tracing information-diffusion paths with low cost media in developing communities	Online Communities	Low income
(Sambasivan et al., 2011) Designing a phone broadcasting system for urban sex workers in India	Minority	Health
(Schlesinger et al., 2017) Intersectional HCI: … Gender, Race, and Class	Minority (race)	Race
(Schneider et al., 2018) Empowerment in HCI …	N/A (literature review)	Technology literacy

(Sood and Saxena, 2017) Moving Beyond Digital Literacy …	Low-SES Locations	Technology literacy
(Shroff and Kam, 2011) …Women's Empowerment in the Developing World	Minority, low literacy	Technology literacy
(Ssozi-Mugarura et al., 2016) … rural water management through community-based co-design	Low-SES Locations	Low income
(Stowell et al., 2018) … Interventions for Vulnerable Populations …	Minority (race)	Technology literacy, Race
(Strohmayer et al., 2015) … Learning Ecologies among People Experiencing Homelessness	Homeless	Education
(Tang, 2015) Informing EMR System Design through Investigation of Paper-Based Work Practices in a Non-profit Clinic Serving a Vulnerable Population	Healthcare professionals	Low income
(Taylor et al., 2017) Diversity and coherence in a hackerspace for people from a low socioeconomic community	Online Communities	Low income
(Thebault-Spieker et al., 2015) Avoiding the south side and the suburbs: The geography of mobile crowdsourcing markets	Low-SES Locations	Low income
(Vashistha et al., 2015) Social media platforms for low-income blind people in india	Disability	Low income, disability
(Vashistha et al., 2014) Educational content creation and sharing by low-income visually impaired people in India	Teenagers, College students, Adults	Low income, Disability
(Vashistha et al., 2017) Examining Localization Approaches for Community Health	Low-SES Locations	Technology access, technology literacy
(Vines et al., 2014) Pay or delay: the role of technology when managing a low income	Low-SES Locations	Technology, Low income
(Vyas et al., 2015) More than just Food: Field Visits to an Emergency Relief Centre	Families	Low income
(Wadley et al., 2014) Citizen involvement in the design of technology for climate change adaptation projects in the Pacific	Low-SES Locations	Culture
(Waycott et al., 2010) Digital divides? Student and staff perceptions of information and communication technologies	College students	Technology literacy
(Williams et al., 2016) Exploring student motivation towards diversity education in engineering	College students	Culture
(Woelfer et al., 2011) Improving the safety of homeless young people with mobile phones: values, form and function	Homeless	Technology literacy, Technology access

(Wyche, 2015) Exploring mobile phone and social media use in a Nairobi slum: a case for alternative approaches to design in ICTD	Homeless	Technology access
(Wyche and Murphy, 2012) "Dead China-make" phones off the grid: investigating and designing for mobile phone use in rural Africa	Families, Low-SES Locations	Education
(Yardi and Bruckman, 2012) Income, race, and class: exploring socioeconomic differences in family technology use	Parents, Families, Minority (African American)	Low income, race
(Yates et al., 2010) Explaining the global digital divide: The impact of public policy initiatives on digital opportunity and ICT development	Online Communities	Culture, Technology access

Appendix B: top 5%, 10%, and 15% QGS papers

Table B-1: The top 5%, 10%, and 15% cited papers relating to the search string "socioeconomic status" on the ACM and IEEE databases

	ACM Database	IEEE Database	Final QGS Papers
Total Returned	896	1000	8
Top 5% cited papers also in top 5% of Google scholar papers	13	11	2
Top 10% cited papers also in top 10% of Google scholar papers	39	20	5
Top 15% cited papers also in top 15% of Google scholar papers	54	35	1

Appendix C: Documents from the Multi-Case Study Teams

C-1 Team-SES Use Case, Persona Foundations and Heuristic Evaluation

Low SES Persona Use Case

Lucas just got accepted to OSU and is about to start his first term, but has not selected a major yet. He is considering computer science and would like to figure out how much his first term would cost if he were to select computer science.

Mainstream Persona Use Case

Sarah just got accepted to OSU, she wants to know what textbooks she will need and what classes she should take her first year here as a CS major.

Underserved Population(Low SES)

Lucas: Male, Latino, age 24
Is from a Hispanic family and was raised by his single mother. After high school, he worked as a mechanic for a few years. With some of his savings from that, he began as a part time community college student in tandem with his work. He is transferring to OSU from community college. While he didn't grow up around computers, he did go to the library and use their computer about once a week. Sometimes his friends would go with him and they would play games on it. After getting his job as a mechanic he bought a used computer which he uses when he has time.

Home Life
Being raised by a single mom with several siblings[1], Lucas's home was a loud chaotic environment, and not very conducive to learning [2]. His mom was strict and authoritative with him and his siblings and Lucas's mom would tell him to do things "because I said so" [3]. Lucas didn't have many books or learning toys at home, and instead would have to spend time hanging out with friends or outside, without many learning opportunities[4].

School Experience
Attending a school in a poor neighborhood, Lucas's teachers were often ill equipped to deal with large class sizes and his classes often lacked new books and learning materials[5] [6]. As such, while Lucas can read, write and do arithmetic his skills relative to his peers are lacking[7]. Additionally, in the realm of digital skills, Lucas struggles [8]. Defining information problems, specifying proper search queries and evaluating the information of said search queries are difficult tasks for him[9].

Psychological Health
Due to the stressors of Lucas's environment, his psychological health has suffered. He is emotionally volatile, and as such can feel overwhelmed and lash out[10]. Often at home and

---

[1] Seven in 10 children living with a single mother are low income, compared to less than a third (32 percent) of children living in other types of family structures [14].
[2] Lower SES has been linked to domestic crowding, a condition that has negative consequences for adults and children, including higher psychological stress and poor health outcomes [9].
[3] Many studies have found a relationship between low SES and authoritarian parenting [17]
[4] Poor households have less access to learning materials and experiences, including books, computers, stimulating toys, skill-building lessons, or tutors to create a positive literacy environment [4, 10]
[5] The school systems in low-SES communities are often under resourced, negatively affecting students' academic progress and outcomes [1]
[6] Schools with students from the highest concentrations of poverty have fewer library resources to draw on (fewer staff, libraries are open fewer hours per week, and staff are less well rounded) than those serving middle-income children [11].
[7] Children from low-SES families enter high school with average literacy skills five years behind those of high-income students [12].
[8] There is a marginal effect of ESCS (economic, social and cultural status) as a whole on students' digital skills was equal to the effect on mathematics and greater than the effect on language [5].
[9] Research on information-problem solving shows that while students may have the ability to find information using digital technology, they have difficulty in defining information problems, specifying proper search queries and evaluating the information that they find [5].
[10] Lower levels of SES are associated with higher levels of emotional and behavioral difficulties, including social problems, delinquent behavior symptoms and attention deficit/hyperactivity disorder among adolescents [6, 13, 15].

school he feels powerless, unable to question authority[11]. This leads him to not question his economic situation either, rather he sees it as justified[12] and doesn't criticize any government authority[13].

Career Aspirations

Lucas does not aspire to have a career that will make him rich, rather he just wants to obtain and hold a job[14]. As such his career prospects focus on what is attainable not necessarily on other factors like glory and wealth[15]. Due to lacking digital skills and his school not having a guidance counselor, he has never searched out much online about career information[16]. Because of this he doesn't know exactly what kind of career he wants to pursue or what he might be qualified for or be good at[17].

---

[11] A sense of powerlessness fosters system justification [16]

[12] The strongest form of this hypothesis, which draws on the logic of cognitive dissonance theory, holds that people who are most disadvantaged by the status quo would have the greatest psychological need to reduce ideological dissonance and would therefore be most likely to support, defend, and justify existing social systems, authorities, and outcomes [8]

[13] low income Latinos were more likely to trust in U.S. government officials and to believe that "the government is run for the benefit of all" than were high income Latinos [8]

[14] A study showed that individuals from a lower social class generally had less career-related self-efficacy when it came to vocational aspirations [2].

[15] Career barriers are significantly higher for those from poor backgrounds, people of color, women, those who are disabled, and LGBTIQ-identified individuals [3].

[16] Those from higher social class backgrounds tend to be more successful in developing career aspirations and are generally better prepared for the world of work because of access to resources such as career offices, guidance counselors, better schools, high level "social actors," and familial experience with higher education [7].

[17] Diemer and Blustein (2007) found that racial, ethnic, and socioeconomic barriers generally hinder individuals' vocational development [7].

Home Life

L1: [LOW SES] Non-authoritative instructions. Instead frame in a question that they can answer or "suggest" as opposed to "instruct".

M1: [MID SES] Used to having technologies personalized and directed at helping her. Language should be friendly and helpful.

School Experience

L2: [LOW SES] Need language that he understands. Avoid overly complicated terms. Should try to present any numbers in digestible ways without a ton of math.

M2: [MID SES] She understands complex terms and phrases and is experienced in applying math to various parts of her life(like managing an allowance or a shopping cart).

Psychological Health

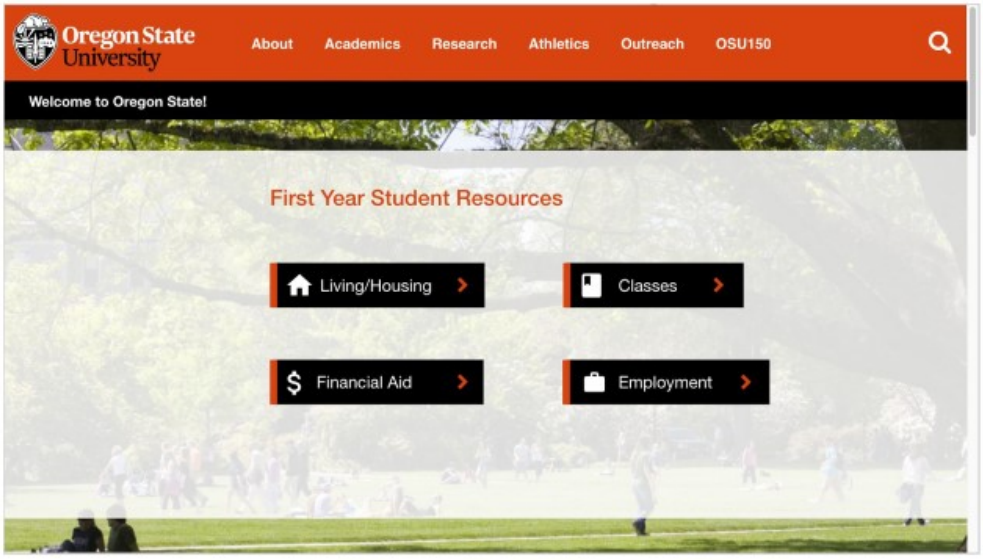
L3: [LOW SES] Don't overwhelm with options. Try to reduce the amount of choices(organize many links into categories).

M3: [MID SES] Wants to feel successful when using software and see clear signs of progress.

Career Aspirations

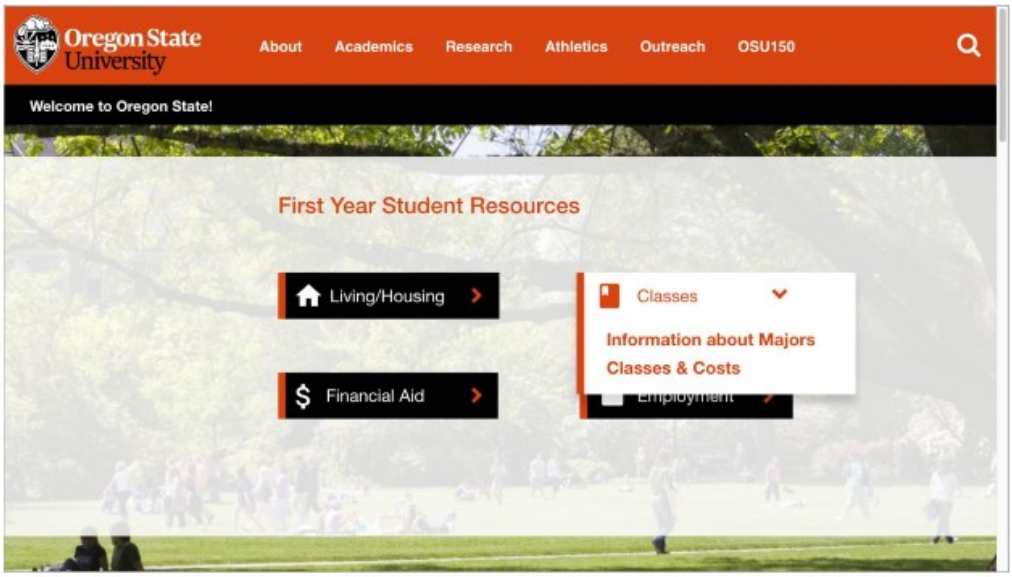
L4: [LOW SES] Often only thinks one step at a time. Present information for the here and now, but push towards future planning.

M4: [MID SES] She plans for the future and wants information that will help her with that.



First Year Student Resources Home Page.
Justifications:
Resource buttons: Four resource buttons, appear closed initially as to not overwhelm the user. "Career" button renamed to "Employment" to follow our language heuristic: **L3.**

Smaller Design Decisions:
-Top bar taken from current OSU website to provide consistency.
-Color scheme and photos are taken from OSU to be consistent.



Classes expand

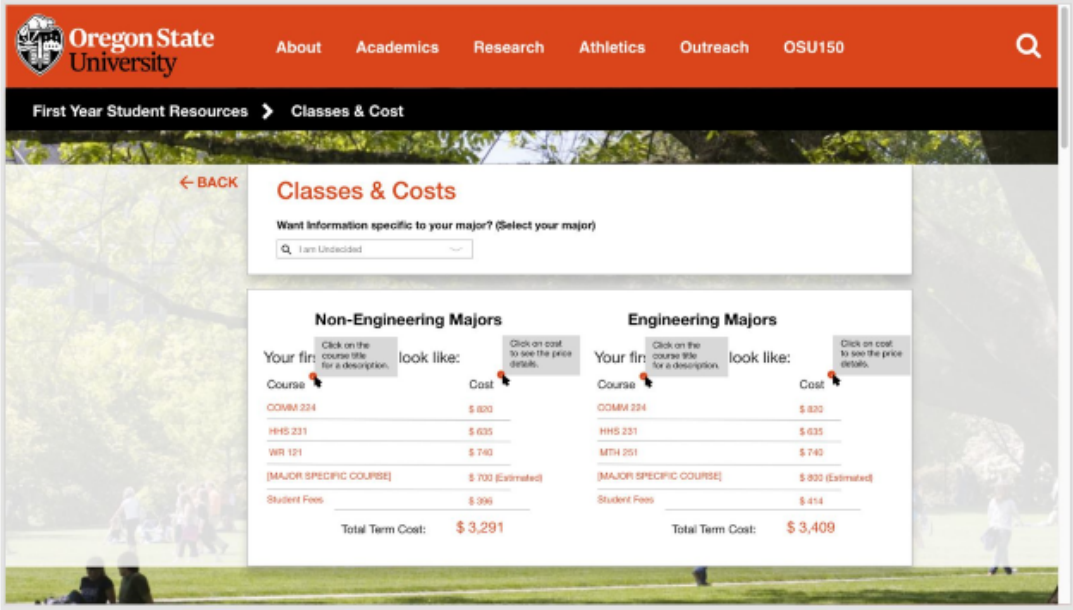
Justifications:

Smaller Design Decisions:

-Added the arrow and turned it to provide clear feedback.

-Renamed "Browse Class & Costs" to "Classes & Costs" for clarity based on **design gallery one feedback.**

-Renamed "Cost Overview" to "Information about Majors" based on **Design Gallery two Feedback.**



Majors Tab
New Justifications:
Side by side comparison: In our **second design gallery** we noticed multiple people missing the "engineering majors" "non-engineering majors" tabs in our interface. So we changed the layout of the page to not have either tab and instead have a side by side comparison model(the idea to do a comparison came from **design gallery 2 feedback** as well).

Default to undecided: Making the option undecided at first in the dropdown and to make the comparison for sort of generic view on the costs was something we added for **Lucas** since he might not have selected his career yet(**L4**).

Justifications:
Tooltips: Tooltips are an example of **surprise explain reward,** a design idea encouraged in the HCI 1 course. Of note clicking either the text or the cost will bring up the same modal we are just trying to support someone clicking for different reasons, but just because someone mainly wants class information, doesn't mean they don't care about cost and vise versa.

Paycheck layout: The layout of the page with various things adding up to a total is reminiscent of how paychecks are laid out. The idea here being that some of the only applied math familiarity **Lucas** would have is in receiving a paycheck**(L2). Example paycheck below**

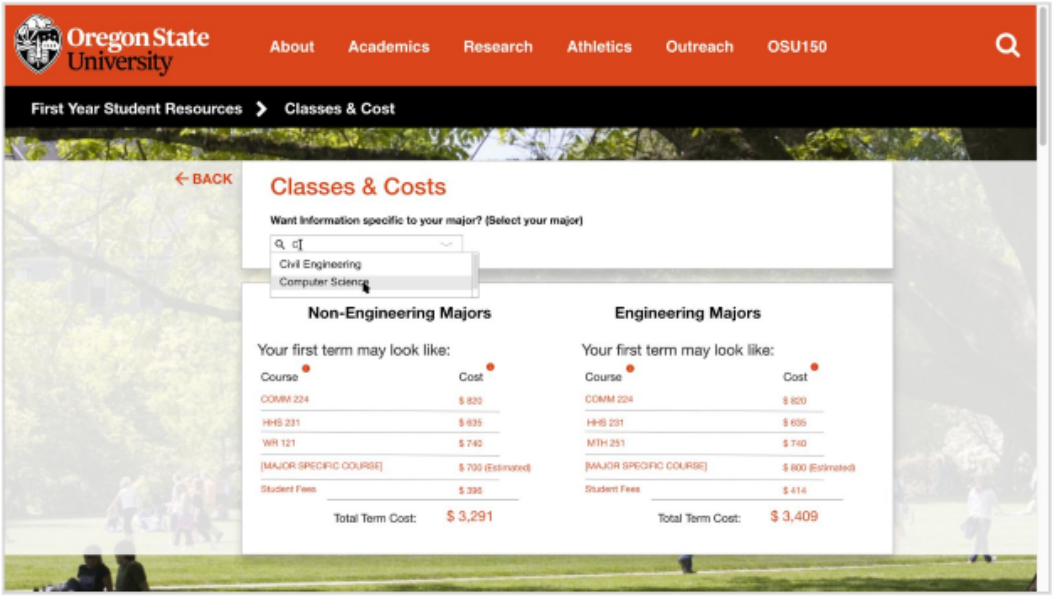
Required Deductions	
Federal Income Tax	00.00
FICA - Medicare	06.08
WI State Income Tax	00.00
FICA - Social Security	25.92
Other Deductions	
Health Insurance	00.00
401k	00.00
Parking	00.00
NET PAY	**$418.00**

Smaller Design Decisions:
Renamed "Non-Engineering Disciplines" and "Engineering Disciplines" to "Non-Engineering Majors" and "Engineering Majors" to simplify the language. **L2** (Changed wording to use simpler terms).

Page provides an estimate based on a "generic plan" to be either a non-engineering or engineering student at OSU. This is to support those who have not selected a major yet, recommended to us in **design gallery 1**. We put the dropdown at the top in the hopes they will see and select it if the user does have a major though.

Engineering Majors Tab
Justifications:
Majors Tab: "Engineering Majors" tab now in orange, to show it is the one selected. **M3** (confirms her progress visually)

Smaller Design Decisions:
-Cost breakdowns changed to be increased to represent that engineering classes cost more, and have more fees.
-Additionally traded out a bacc core writing class for a math class as most engineers need to take at least half math/science/engineering classes in their first year.



Select your major dropdown.

New Justifications:

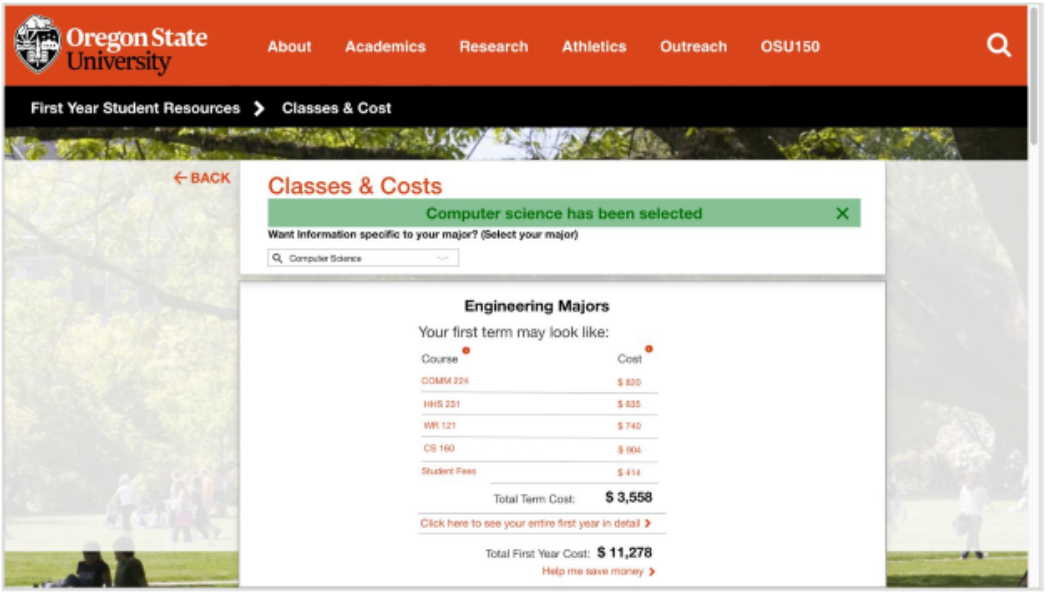
Searchable dropdown: Made the dropdown searchable so the user wouldn't have to scroll. This supports **Sarah** since it is likely to know exactly what her major would be**(M4)** and wouldn't want to scroll through all the options.

Also, the drop-down would display all majors as well if the arrow is clicked on while the text field is blank.

Justifications:

Dropdown field: Dropdown says "Select Your Major" to support **Sarah(M3)**,

Dropdown title: Title for dropdown is a question "Want information specific to your major?" to support **Lucas(L1)**

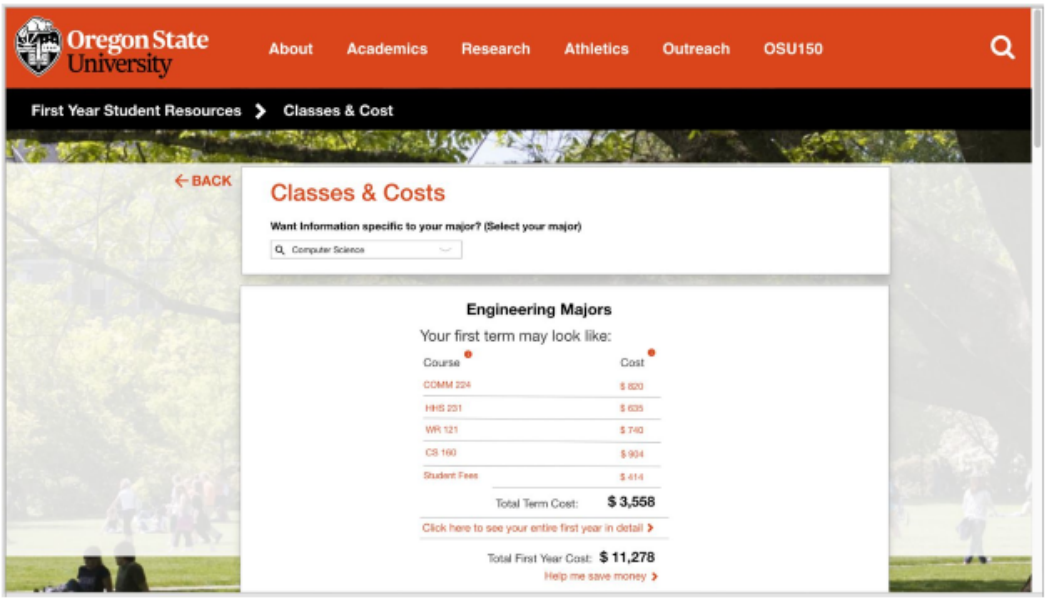


Confirmation Toast

Justification:

Toast: Included toast to give a sense of progress**(M3)**, as well as confirmation to previous action.

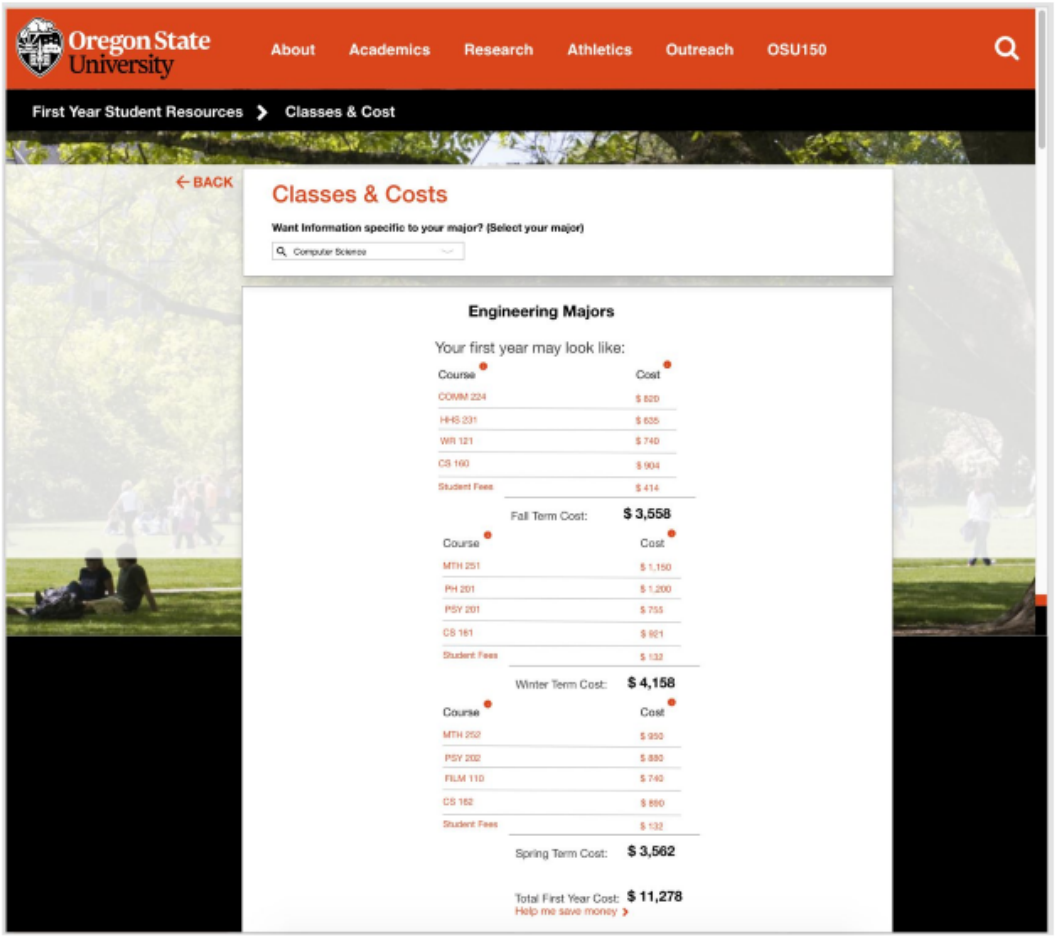
Wording: "Your first term may look like:" is trying to be friendly**(M1)** and non authoritative **(L1)**



First term CS costs.

New Justificiations: Added a new button(which links to a modal) at the bottom that says "Help me save money". This button is designed to sound non authoritative (**L1**) and put next to the yearly total since that is when it seems **Lucas** will see the cost.

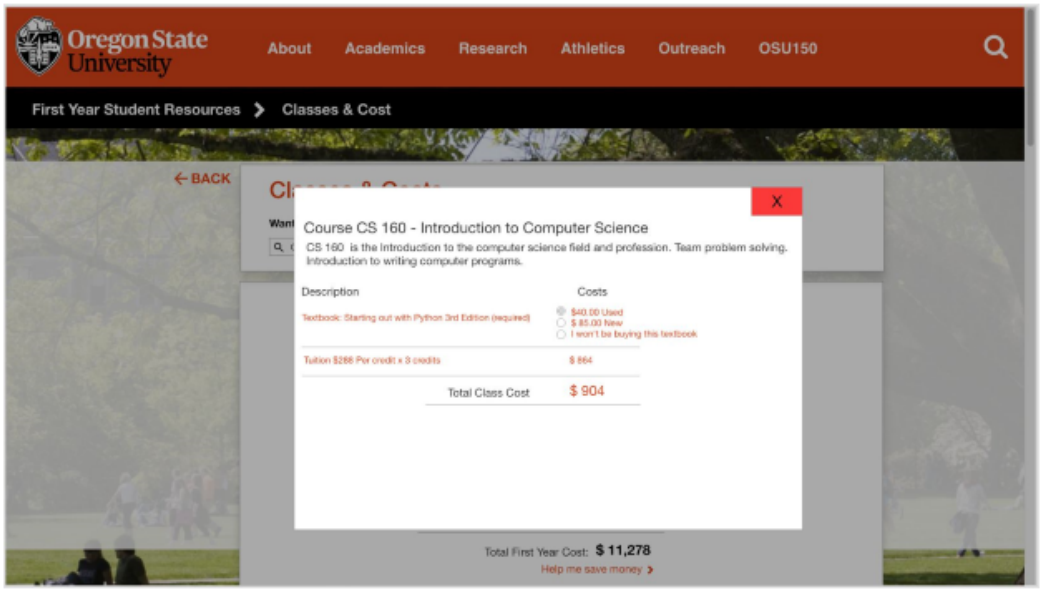
Justifications: We intended this to support both **L4** and **M4**, both planning for the here and now(this term view) and the future(view full year). We additionally think that **Lucas** would benefit from seeing the full year cost and perhaps planning ahead, even if it is not his instinct to do so (nor is it in his use case).



Classes and cost for the year

Justification: This screen is designed to adhere to the paycheck layout of before but including additional terms. We believe the different costs of different terms will be a **"surprise"** to a college freshman, and so this screen will help to **"explain"** and **"reward"** both our personas as well. **Sarah** will enjoy being able to see the classes she will be taking and plan ahead**(M4)**. **Lucas** might not end up here, but if he did, he would benefit from understanding exactly how

much he will be paying for the whole year, given that running out of money a term or two in would not be ideal.



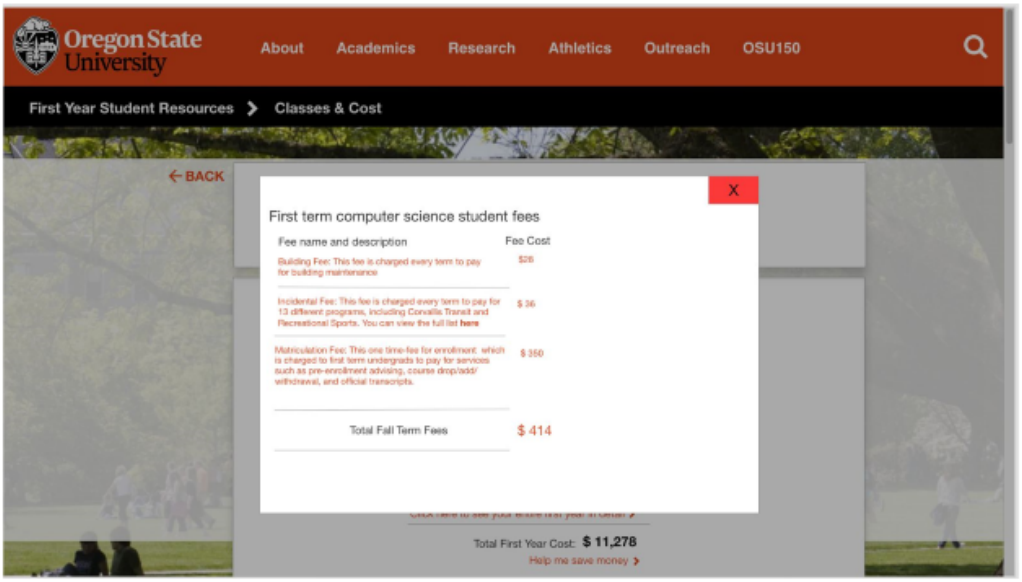
CS160 Modal

New Justifications:

Based on the feedback from **design gallery 2** we added a "I won't be buying this textbook" option for people who already own the book or in the event the book isn't required.

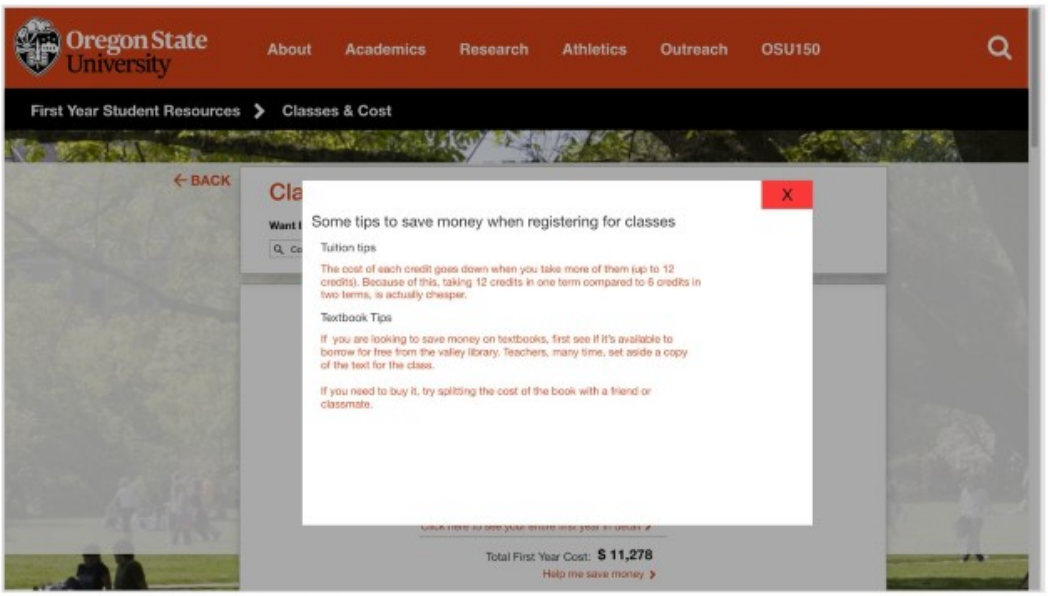
Based on feedback from the **Teaching Assistant** we state whether the book is required or optional.

Justifications: We wanted to show how courses can vary in cost based on number of credit hours, and book cost. When it applies, some courses also have lab fees or required equipment(like chemistry has goggles and lab coats you have to purchase) so this would be where we would list this as well. The interface is similar to online stores like amazon, which **Sarah** may be familiar with**(M2)**. It also provides the information to **Lucas** that he can save money by looking at cheaper textbooks.



Fees Modal

Justifications: Fee names are unchanged for consistency with how they are billed, but we did change the descriptions to try to get simpler wording(like using enrollment to describe matriculation fee). Whether a fee was one time or recurring was emphasized by placing it towards the front of the description. This also is geared at helping **Lucas** plan for the present while encouraging him to plan for the future**(L4)** by letting him know certain fees will be charged every term so that he could plan for them.



Tips for Saving Money Modal

New Justifications: We added this modal to help **Lucas** understand how to save money without requiring a ton of math **(L2)**. We received wording feedback and some of the tips themselves from classmates in **Design gallery 2** and also got feedback from **Dr. Burnett** after our presentation.

C-2 Team-ADHD Persona

Personas

Dean Thomas Persona Foundations

Dean represents a fraction of users who are diagnosed with ADHD, or exhibit significant but non-diagnosed attention, memory, and/or organizational challenges.

- 23 years old
- Employed as a TA at his university
- Lives in Portland, OR

Background Knowledge and Skills

- Dean works as a TA at Portland State University. He is comfortable learning new technologies, generally using a "tinkering" process[1], and is very comfortable with the technologies he uses daily.

Focus

- Dean has trouble maintaining focus on one task for an extended period of time[2,8]
- Dean has trouble reading large blocks of text, because external stimuli (specifically visual, but also audio)[8] will distract him before he can finish, forcing him to have to re-read the text[3].
- Dean often finds it difficult to follow instructions[8].

Organization

- Dean has trouble with material organization[8], so he often leads a messy life. In addition to this, Dean struggles with temporal planning[8], specifically scheduling things ahead of time. This negatively affects his finances, because he will forget to pay bills on time[4].

Impulsivity

- Dean has issues controlling impulsive actions[5,8], which can lead to trouble with things like online shopping[4,9].
- Dean's often mixes up his Needs vs his Wants when it comes to shopping.[9]
- Dean tends to make hasty decisions, and act on them quickly[8].

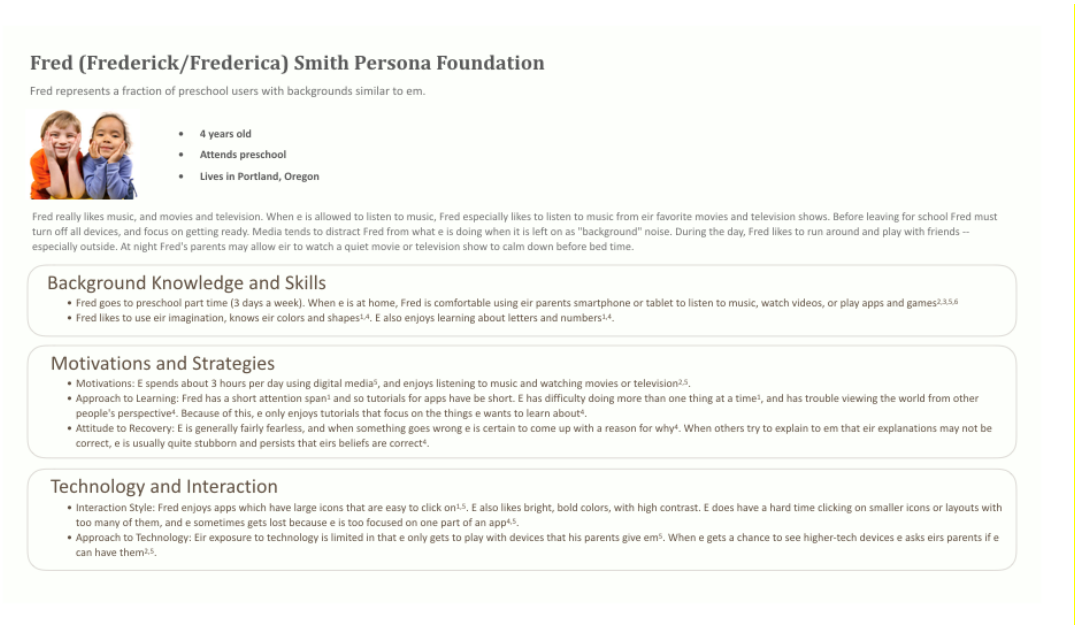
Memory

- Dean tends to forget long-term dates and other information[8]. This can lead to trouble with paying bills on time[4].
- Dean tends to be forgetful, even with daily activities[8].
- Dean's working memory deficit serves as an amplifier of many of his other ADHD symptom[8].

Financial Responsibility

- Dean is not particularly excited by finances, and tends to make poor financial decisions because of this[7].
- Dean will forget to pay bills if he isn't reminded[3].
- Dean will impulsively buy things online, but generally they are smaller things like clothes or small electronics[3].

C-3 Team-Preschool Persona



Fred (Frederick/Frederica) Smith Persona Foundation

Fred represents a fraction of preschool users with backgrounds similar to em.

- 4 years old
- Attends preschool
- Lives in Portland, Oregon

Fred really likes music, and movies and television. When e is allowed to listen to music, Fred especially likes to listen to music from eir favorite movies and television shows. Before leaving for school Fred must turn off all devices, and focus on getting ready. Media tends to distract Fred from what e is doing when it is left on as "background" noise. During the day, Fred likes to run around and play with friends -- especially outside. At night Fred's parents may allow eir to watch a quiet movie or television show to calm down before bed time.

Background Knowledge and Skills

- Fred goes to preschool part time (3 days a week). When e is at home, Fred is comfortable using eir parents smartphone or tablet to listen to music, watch videos, or play apps and games[2,3,5,6]
- Fred likes to use eir imagination, knows eir colors and shapes[1,4]. E also enjoys learning about letters and numbers[1,4].

Motivations and Strategies

- Motivations: E spends about 3 hours per day using digital media[5], and enjoys listening to music and watching movies or television[2,5].
- Approach to Learning: Fred has a short attention span[1] and so tutorials for apps have be short. E has difficulty doing more than one thing at a time[1], and has trouble viewing the world from other people's perspective[4]. Because of this, e only enjoys tutorials that focus on the things e wants to learn about[4].
- Attitude to Recovery: E is generally fairly fearless, and when something goes wrong e is certain to come up with a reason for why[4]. When others try to explain to em that eir explanations may not be correct, e is usually quite stubborn and persists that eirs beliefs are correct[4].

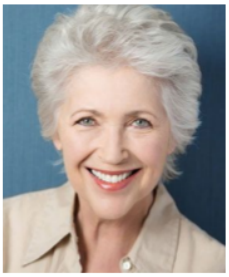
Technology and Interaction

- Interaction Style: Fred enjoys apps which have large icons that are easy to click on[1,5]. E also likes bright, bold colors, with high contrast. E does have a hard time clicking on smaller icons or layouts with too many of them, and e sometimes gets lost because e is too focused on one part of an app[4,5].
- Approach to Technology: Eir exposure to technology is limited in that e only gets to play with devices that his parents give em[5]. When e gets a chance to see higher-tech devices e asks eirs parents if e can have them[2,5].

C-4 Team-Older Persona

Personas

Female age 65, Muriel



Background

- Muriel is retired, lives alone,[1] and has a kid and grand kids who seldom visit.[2]
- She lives comfortably, with savings & pensions plentiful for living costs.[3]
- In her free time, she enjoys watching dramas on TV with a cup of tea.

Technology she is comfortable with

- Muriel uses a regular landline phone to call her families,[4] and she loves to chat with her grandchildren.[5]
- She bought an iPad[6] and tried to learn how to use it, but wasn't able to figure it out until her granddaughter helped her [7].
- Muriel also goes on the web[8] to check the news.[9]
- She wrote letters when she was younger[10] and enjoyed receiving handwritten letters from friends [11].

Attitude Towards Technology

- Interested in modern technology but doesn't know where to start with learning new technology.[12]
- It takes a long time for her to learn to use new technology.[13]
- Muriel is interested but hesitant to learn new technologies[14], and gives up quickly due to low confidence[15], blaming herself when things don't work exactly how she wanted on the first try.[16] She gives up very quickly if the results are not what she expected.[17]
- She needs someone to set up the environment and demonstrate the features for her.[18]
- Muriel is motivated to use the web to connect with her family.[19]
- She would like to send mail & photos faster to communicate with more immediacy.[20]

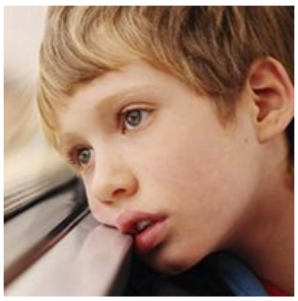
Physical difficulties

- Due to her age, Muriel's eyesight isn't very good, she can't read words that are too small.[21]
- She also finds it difficult to perform actions like double clicking.[22]
- She's not good at hearing but not in a way that affects her everyday life.[23]

C-5 Team-Autism Persona

Personas

Underserved Persona:



Nick

- 8 years old
- Boy
- Lives in Corvallis, Oregon

Comprehension ability

Nick is a 3rd grade student who likes to see and read books about dinosaurs and particularly enjoys the pictures in these books. [a, b] He also finds things easier to understand when they are explained using topics he is familiar with and if he can do some physical activity associated with the topic. [b, c] Nick tends to get drawn into learning material which is taught at a slow speed and he tends to retain more amount of information when doing frequent revisions of the learning material. [a, b, d]

Ability to follow instructions

Nick finds it tough to process a lot of information at the same time and this often confuses him so he prefers to deal with one thing at a time. (For example, he would rather be given one instruction at a time, fulfil that and move on to the next one than be provided with an entire set of instructions in one go.) [e, f, k] He tends to respond more positively to familiar characters or faces (for example, a comic or a cartoon character) that he has grown to trust over time which help him remain focused and calm in some familiar environments. [e, f]

Concentration level

Nick has a short attention span and tends to get distracted with thoughts or questions quite often while performing activities or tasks. [g, h] He finds it tough to concentrate when there are a lot of things happening at the same time within a context, which in turn tends to rile up his anxiety issues. [g, i] He tends to lose focus easily if any activity is not engaging enough with multiple acknowledgements. He likes interacting with things that give some sort of a feedback or response at short intervals. [g, i, j]

C-6 Team-Literacy

a. David (Dave) Miller Persona Foundations (Underserved Population)

- 43 years old
- Employed as a construction worker
- Lives in Pittsburgh, Pennsylvania

Dave starts his day by drinking black coffee and reading the newspaper. He gets to the construction site for work by his truck and listens to cassette tapes of country music on the way. When he gets to work, the first thing he does is clock in using punch-cards instead of his company's mobile application for scheduling. At the end of a long day, he gets off work and goes home to his wife and kids and watches whatever sports games are on. [Sources: 7]

Background Knowledge and Skills

- Dave works in construction[1].Despite a lot of his work being manual labor, he encounters a fair amount of construction-related software. He feels uncomfortable with the technology he does know and doesn't enjoy learning new technology, though he wants to improve in both of these fields because of outside pressures such as his employer and his kids[2]. [Sources: 1, 3, 8]

- Dave describes himself as a blue-collar worker. When he was growing up, technology meant the radio, television, records, and VCRs. He has no formal education outside of high school. When he was in school, he rarely attended. He finds his work in construction satisfying in that it is physically stimulating, not mentally stimulating. [Sources: 7]
- In his free time, Dave likes to spend time with his family. He has three kids, one in high school and two in middle school. When not spending time with his kids or his wife, he enjoys watching the Pittsburgh Steelers. Aside from the television, he doesn't spend much time interacting with technology[3]. [Sources: 3, 5, 8]

Confidence in using technology

- Dave uses technology only when he has to and has low confidence not only when learning new computing tasks but also approaching a lot of familiar tasks. He tries to learn new technologies when he must, but generally is unable to due to his confidence being inhibited by issues with touch-screen interfaces, large blocks of text that lose his attention, and forms that require input that are too long[4]. [Sources: 2, 3, 5, 6]
- When help messages arise to guide him through an interface, his confidence is decreased because he doesn't understand what they say[5]. [Sources: 2, 4]

Reading Skills

- Dave feels like he has higher than average reading skills. In reality, his level of reading ability is far below average[6]. [Sources: 1, 4]
- Dave tends to avoid reading whenever possible[7]. [Sources: 1]

Learning Style

- When learning new technology, Dave often gets frustrated because audio describing what he should do to complete a task are not offered[8]. [Sources: 5, 8]
- He is able to overcome the lack of audio descriptions if there are clear navigation buttons with images near them telling him what to do[9]. [Sources: 5, 8]

Motivations and frustrations when using technology

- Dave wants to use technology to connect with family. But, due to his low literacy, he gets frustrated when reading texts[10]. [Sources: 3, 5]
- He likes the idea of doing things like his taxes using an online service but feels uncomfortable providing his signature to things digitally because he can't read the fine print[11]. [Sources: 1, 5]
- He finds it annoying and embarrassing when he has to have other people read things for him, but is forced to when using a digital interface. [Sources: 4, 5]

Susceptibility and sensitivity towards technological products that require a lot of reading

- Dave finds the things he used to do such as pay the bills or do his taxes that he used to be able to do in person or over the mail have been moved onto the internet. [Sources: 1]
- Even in his line of work, technology that requires reading to use it has begun replacing the manual operations of the past which leaves him feeling obsolete and hampers his self-esteem[12]. [Sources: 1, 4]

C-7 Team-Dementia Persona

4. Personas

Lillian (Underserved) Persona

Lillian represents a fraction of people with dementia users with backgrounds similar to hers. For data on females (and males) similar to and different from Abby, see the Footnotes.

- **81 years old**
- **Retired for many years. Before her retirement, she worked as a dentist**
- **Lives in Santa Barbara, California, United States**
- **She lives alone, her husband passed away 3 years ago**

> *Lillian likes gardening and spending time with her grandson and granddaughter. However, she is unable to visit her family herself because she is no longer able to drive herself due to the severity of her Dementia. She goes to a Christian church one day per week and is a social person that hates being alone. She plays Bingo with her friends which makes her happy, but her dementia has made it more difficult to attend different events without someone to drive her.*

Motivations

- Motivations: Lillian uses products upon being advised about their benefits. She prefers to use technology which helps her life, but she perceives most technology as difficult to use. [Sources:1,2,3,4,6,10,11]
- Hobbies Drives Her Motivation: Lillian is willing to try new technologies if the technology can help her maintain her social life and hobbies such as playing Bingo with her friends. [Sources:1,2,3,10,11]
- Family Inspiration: She would be more likely to use a new technology that would enable her to visit her family more often since she can no longer drive. Alzheimer's is a burden on her family and she would like to be more self-sufficient.[Sources:1,2,3,4]

Memory

- Disease: Lillian has trouble with remembering a sequence of instructions. She was diagnosed with Alzheimer's two years ago and it has since progressed to middle-stage. This has harmed her memory ability greatly. She has difficulty remembering names and places [e]. [Sources:1,3,4,6,8,12]
- Forgetful: She can not learn new technologies as quickly as she would like due to her short-term/working memory deficits—rapid forgetting of information recently seen or heard. She remembers faces better than names [f]. [Sources:1,3,4,12]
- Mood: Lillian feels frustrated when she forgets appointments with her family members or her friends. She also gets irritated when she forgets important events, such as seeing her private physician. She frequently becomes anxious when she can't remember where she is or what she was doing.[g][Sources:1,3,4,6,8,12]

Problem Solving and Learning Ability

- Problem Solving Ability: Lillian has very low confidence about doing unfamiliar tasks which seriously affects her problem solving and learning ability. She learns in-vehicle technology slower than the average person [h].[Sources:2, 4, 5, 6, 11,12]
- Learning Ability: Lillian feels it is very difficult to use new in-vehicle technology because it is hard for her to comprehend the technology. She easily forgets previous procedures when she learn the new stuff [i]. [Sources:2, 4, 5, 6, 11]
- Attitude to Learning: Lillian will give up learning if problems have arisen. If the technology does not make sense to her, she will stop using it rather than trying to figure out whether can use it in a new way [j].[Sources:2, 4, 5, 6, 11,12]

Self-sufficiency/Independence

- Driving Ability: Lillian's driving privileges were taken away due to the progression of her Alzheimer's so she needs to rely on her family and friends [l] to take her places such as the grocery store, appointments, etc.[Sources:1, 2, 3, 4, 6]
- Living Ability: Lillian has lived alone for about 3 years and since she is a very social person it makes her depressed.[Sources:1, 2, 3, 4, 6]
- Physical Ability: She can only walk short distances and feels unsafe using public transportation [n].[Sources: 3,4]

Attention

- Information Process Style: Lillian can be easily distracted [m] so she is unable to perform tasks that involve many steps.[Sources:3,5,8,12]
- Preference of Interface: Lillian prefers restricted/simplified input interface [n] since she has difficulty attending.[Sources:3,5,8]

C-8 Team-Diabetic Retinopathy Persona

Suzie (Susan) Williams

- 32 years old
- Librarian at the Spokane public library
- Lives in Spokane, Washington

Background:

- Suzie is a senior librarian for the Spokane public library. She has worked there for the past 10 years. At her job, she works with the library's internal database software on a regular basis to locate books for patrons and check materials in and out.
- Suzie isn't the kind of person to own a large number of gadgets, but she does have a smartphone because she likes the convenience that it provides with its constant connectivity.
- Suzie has been married for 8 years. Her two children, aged 7 and 5, go to the same elementary school.

Attributes

Physical/Visual Ability

- Suzie was diagnosed with Type 2 diabetes 5 years ago [4.d][1]. Her vision has been getting blurrier for a while now, but three months ago Suzie started having spots covering her vision [1.c][2], which at worst cover half her visual field. Her vision has been getting even worse over the last three months [1.c][3].
- Because of the blurriness of her vision, and the spots that now cover roughly half of her visual field, Suzie has trouble performing day-to-day tasks like driving, reading, and recognizing faces [1.c][4] [3.b][5]. She no longer trusts her ability to drive, and has to have her husband take her to work when he used to drive the kids to school (so her kids now have to take the bus) [3.c][6].
- In general, tasks that Suzie could do easily before are now slower for her [3.c][7]. She trips over and runs into things much more often than she used to [3.c][8].

Technology Preferences

- Outside of what she is required to use for her job, Suzie tends to use technology mainly for email and social media [2.b][9] - she is an avid poster on Facebook and Twitter, and tends to like apps that pre-generate posts for her, so that she only has to press a button to send it off [2.b][10].
- Because of her DR, she prefers to spend her free time *not* staring at screens, since she can only really look at a screen for an hour before her eyes get tired [2.h][11]. To avoid this problem, Suzie prefers audio interfaces and feedback over visual interfaces. For instance, she would rather listen to an audiobook than read the same book on her Kindle [2.h][12].
- In addition, her diabetes occasionally causes her to experience numbness in her hands, which can make using a touchscreen difficult (though not impossible if the icons are large enough) [4.h][13].

Emotional State and Well-Being

- Suzie has a busy life, with stressors coming from her career and, since she was diagnosed with DR, the changing status of her vision [3.a, 3.c][14].
- At work, she is hoping to get a promotion to Head Research Librarian but is now worried her decreased ability to see will decrease her effectiveness at helping library patrons in a timely manner, and may even result in the loss of her job [3.c, 3.j][15]. Already, she feels stressed when a patron is waiting and seemingly impatient. She is emotionally on edge because of her DR [3.c][16], and so is especially sensitive to things going wrong at work.

- After work on Fridays, she goes to trivia night with her friends but wishes the event happened earlier the evening since she has difficulty with night vision [1.c, 3.c][17]. She worries about embarrassing herself in front of her friends by running into things [3.c][18].

Financial Stability and Status

- Suzie has a middle-class income. She is a frugal shopper, and one of her financial goals is to put money in savings for retirement and also into her children's college funds. However, since being diagnosed with DR, she hasn't been able to save as much because of increased costs [3.c][19] related to her condition.
- Suzie doesn't feel comfortable driving herself to appointments because of her vision [3.b, 3.c][20], and also because her eyes are dilated at every appointment [3.c][21]. Because her husband works, she often has to use Uber, taxis, or other types of hired transportation to get to her appointments [3.c][22]. Her retinal specialist is located 5 hours from her home [3.a, 3.c][23], so transportation costs can be very expensive [3.c][24].

Social Interactions

- Suzie feels like she is placing a strain on her and her husband's relationship whenever she has to ask for help because she can't see or read something clearly [3.c][25]. She worries that her DR is causing her to be a burden on others, and as such prefers to figure things out on her own before asking for help [3.b, 3.c, 3.j][26].
- Due to complications from her DR, Suzie has found herself relying more on social services than she did previously [2.i][27]. For instance, the level of DR that Suzie has allows her to collect a small disability check each month to cover the times that she is not able to work for the entire day [2.i].