

Accounting for (Dis)advantages in Capability Sensitive Design for Marginalized Communities

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Abstract

Marginalized communities often face interconnected barriers that undermine well-being, yet design methods rarely explicitly account for how disadvantages compound or how strengths can reinforce each other. Building on Capability Sensitive Design (CSD), this research extends the framework to address corrosive disadvantages—barriers that undermine multiple capabilities—and fertile functionings—capabilities that positively reinforce others. We applied this extended framework in a participatory study with newcomers to Canada. Using capability hierarchy mapping, co-design workshop, and field study, we identified key capability gaps and their interconnectedness, surfaced community knowledge, and translated values into actionable design requirements. Our findings show that explicitly mapping advantages and disadvantages

enables more targeted, contextually grounded interventions. We conclude with methodological guidance for applying this approach to other marginalized contexts in HCI, where designing for equity requires accounting for how capabilities interact.

CCS Concepts

- Human-centered computing → Collaborative and social computing design and evaluation methods; Empirical studies in collaborative and social computing.

Keywords

CSD, design, disadvantage, marginalized, well-being

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1 Introduction

The Capability Approach (CA) [38, 59] as developed by Sen and Nussbaum, has been widely used as a human rights approach to

frame one's capacity for well-being through basic capabilities everyone ought to have. CA offers a powerful lens for social justice in technology design, moving beyond the requirement of *usability* or *efficiency* and towards enabling equitable opportunities for human flourishing. Capability Sensitive Design (CSD) is one attempt to operationalize CA in technology design [28], guiding the translation of high-level capabilities into actionable design requirements. One of the core ideas that CSD has implemented from the CA is the idea of conversion factors, i.e., social, environmental, and personal factors that enable people to engage in and benefit from opportunities available to them. CSD and the broader CA have been used to guide the design of systems for health [65], sustainability [69], and data ethics [51], especially in contexts involving marginalized or vulnerable communities [49].

CSD can translate abstract well-being goals into concrete design requirements; however, designing for marginalized communities poses inherent challenges due to intersecting disadvantages, diverse needs, and complex social determinants. Barriers in one area—such as language, mobility, or social connection—can compromise other capabilities, creating cascading disadvantages. Existing CSD methods fail to account for the interdependencies between capabilities, another key idea from the Capability Approach (CA). This limits the ability of CSD to surface *corrosive disadvantages*—capabilities, if lacking, that exacerbate harm—and *fertile functionings*—capabilities that, if supported, can unlock additional benefits [75].

In this work, we explore how CSD can explicitly account for both “corrosive disadvantages” and “fertile functionings” in the design of technologies for marginalized communities. Building on Jacobs’ capability hierarchy [28] with theoretical additions from Wolff and de-Shalit [74], we developed CSD-Cascade, a structured participatory design workflow that translates abstract capability needs into concrete and implementable design features, while explicitly mapping the cascading effects capabilities or the lack thereof have on others. Our study explores the use of this new CSD approach in the context of designing, developing and assessing a health navigation mobile app for newcomers, who often despite given resources, struggle to take advantage of or benefit from the opportunities [32]. Our core questions are:

RQ1: How can CSD be adapted to account for corrosive disadvantages and fertile functionings in marginalized communities?

RQ2: What are the lessons learned by applying CSD-Cascade to the design, development and evaluation of the Newcomer App?

Through capability hierarchy mapping in interviews, a co-design workshop, and in-field evaluation of a developed version of the Newcomer App, we demonstrate how various empirical and technical investigations can be conducted using CSD-Cascade. Furthermore, we illustrate how design requirements and capability gaps are surfaced and translated into concrete features through research and community involvement. Finally, we discuss our experience as researcher-practitioners in using CSD as a design methodology through a structured workflow, and space for future work and development on the framework.

2 Related Work

To provide context, this section describes Capability Approach and Capability Theory in marginalized communities, and how ideas

from this political philosophy have been appropriated in Capability Sensitive Design. We then summarize the various ways in which prior work has leveraged CSD in the design of technology.

2.1 Capability Approach and Capability Theory

The Capability Approach (CA), pioneered by Sen [59–62] and extended by Nussbaum [34, 40–42] and others [5, 19, 52], offers a lens for addressing inequities in marginalized communities. Marginalized communities are those excluded from mainstream social, economic, educational, and cultural life based on race, gender identity, sexual orientation, age, physical ability, language, or immigration status [8]. Traditional academic approaches can inadvertently reproduce stigma and power imbalances, while the conditions of marginalization themselves may limit the ability of some groups to participate meaningfully in research [47, 73]. According to Sen’s Capability Theory, “capabilities are what people are actually able to do and to be.” [61] These doings and beings, which Sen calls *achieved functionings*, together constitute what makes a life valuable. In their earlier work, Gigler [24] and Kleine [31] applied Sen’s capability theory to Information and Communication Technology for Development (ICT4D) where Gigler argues that social context does matter in digital development, while Kleine’s Choice Framework examines how ideologies, systemic constraints, and design choices affect *real* freedoms. Building on Sen’s broader framework, Nussbaum’s Capability Theory [34, 38, 39] is a more structured version of the Capability Approach that posits that all human beings should be entitled to have ten basic capabilities, such as being able to live a normal length of lifespan, maintain bodily integrity, have control over one’s material and political environment, have social affiliations that are meaningful and respectful, etc.

Nussbaum emphasizes that capabilities should be understood as *freedoms*, where individuals have the choice of whether or not to utilize the available capabilities; and these freedoms are partly what determines the extent of one’s functioning. For example, imagine two individuals: Alice relies on specialized medical equipment to maintain mobility; this not only addresses her medical needs, but enables her to pursue her interests, engage in social activities, and lead an independent life. In contrast, Bob, in good health, receives routine healthcare services. According to Robeyns [53], Alice fares better, because her healthcare provisions enhance her capabilities beyond health and align with her values. This example illustrates the implication of Capability Theory for service provision—well-being is not solely determined by access to services, but by the extent to which the services *enable* individuals to lead lives they value. It is important to note that Nussbaum’s list of ten capabilities has faced some criticism for being paternalistic [14, 16]. This is intentionally kept abstract to allow citizens and stakeholders to actively shape the definitions of these capabilities for their problem specific contexts [40].

2.1.1 Corrosive Disadvantage and Fertile Functioning. To enable practical applications of Capability Theory, Wolff and de-Shalit [74] expand upon the Capability Approach by defining *disadvantage* as a genuine lack of opportunities to exercise one’s functionings. They argue that true capabilities exist when the associated costs, including the impact on other functionings, are reasonable, and this is context-dependent. Their vision of a more equitable society

involves not only targeting the most deficient functionings but also understanding why multiple disadvantages tend to cluster. They advocate for a “society of equals,” where it becomes increasingly unclear who is the worst off. To achieve this, they emphasize identifying the least advantaged by comprehending the interconnected nature of their disadvantages.

Wolff and de-Shalit further propose a relational approach, with governments focusing on how patterns of disadvantages are created and sustained, distinguishing between *corrosive disadvantages* that exacerbate harm and *fertile functionings* that provide additional benefits [75]. Corrosive disadvantages represent obstacles that not only harm individuals directly but also tend to lead to further disadvantages, thereby restricting their ability to achieve other capabilities. For instance, physical violence is highly corrosive as it impacts one’s physical and emotional health, sense of safety, security, and mobility [48]. Likewise, lack of access to quality healthcare is a corrosive disadvantage, impacting an individual’s health and subsequently limiting their educational and employment opportunities. On the other hand, fertile functionings are valuable capabilities that hold intrinsic worth and also promote the development of other important capabilities [75]. Social affiliation is a fertile capability that not only fosters well-being but also leads to additional advantages. In practice, when an individual from a low income family gains access to a fertile functioning like social affiliation through community support, it not only enhances their well-being, but also serves as a catalyst for overcoming educational and economic limitations.

2.2 Capability-Sensitive Design

Several ideas from Capability Approach and Theory have been operationalized by Jacobs [28] into a design methodology, called Capability Sensitive Design (CSD). For example, a key tenant of CSD, based on Sen’s [54, 58] and Nussbaum’s Capability Approach [40], is that the provision of resources/opportunities alone does not guarantee that people can actually take advantage of them, and that a host of conversion factors—personal factors (e.g., metabolism, physical condition, gender, intelligence, technical competence), social factors (e.g., public policies, social norms, societal hierarchies, power relations introduced by gender/race) and environmental factors (e.g., the physical or built environment in which a person lives, access to transportation, etc.)—are required to convert resources/opportunities into functionings, e.g., what people can achieve in terms of beings and doings [45, 46, 66, 67]. Jacobs’ CSD follows a tripartite methodology similar to Value Sensitive Design [22] (VSD). In CSD [28], practitioners first conduct a conceptual investigation to select capabilities and identify stakeholders, then an empirical investigation (e.g. interviews, surveys) to confirm the conceptual investigation, and lastly a technical investigation to surface design requirements.

Claassen recommends that CSD practitioners follow the “philosopher-investigator” approach [17] of actively engaging with real-world contexts, learning from public debates, and conducting social scientific research to identify the capabilities that people value most. These values can then be translated into technology features through the construction of a value hierarchy [68], first translating values to norms (i.e., a set of prescriptions for and restrictions on action), and then translating the norms to design requirements.

Jacobs [28] extends the value hierarchy and proposes the use of a *capability hierarchy* for CSD practitioners. As an example, in designing a technology for mental health, a path through the capability hierarchy can be “maintain bodily integrity” (capability), “have confidential conversations” (norm), “ability to choose between private and broadcast messaging in a group therapy platform.” (design requirement).

2.3 Application of CSD in Practice

Several studies have demonstrated how the Capability Approach (CA) can serve in HCI as a lens for examining ethical dimensions during the early stages of technology development. Prior work has primarily applied CA in evaluations to assess how systems influence individual, collective, or broader societal goals [18]. For example, how technology attributes can develop empowerment in marginalized communities through the use of assistive technology for older adults [6] or supporting societal goals in designing well-being technologies [64]. While these efforts highlight CA from a theoretical approach for reflecting on societal impacts, there is limited work to apply CSD in concrete design practices to enhance user capabilities. One way that CSD has been applied in practice is through the use of Capability Cards, e.g., Steen [64] and Jansen et al. [29], to support discussions about human capabilities in different problem contexts. Van de Poel et al. [70] applied capability cards [29, 64] in participatory workshops with small-scale farmers across Spain, Colombia, and Namibia, aiming to support fairer and more socially just bio-based value chains. The cards helped participants articulate capabilities they valued, such as economic stability, environmental stewardship, and social inclusion, thus grounding technical decisions in local aspirations. Similarly, Gebarski [23] used customized capability cards with street-connected children to explore how they perceive and prioritize their own capabilities. These studies illustrate that capability-based tools can successfully bridge the gap between normative theory and participatory practice, and capability cards need to be contextualized.

While the application of CSD offers significant benefits in technology design, researchers have identified key challenges in real-world contexts. Gebarski [23] noted that the abstract nature of capability cards can present difficulties for certain groups, such as children, unless adapted through long-term engagement. Similarly, Van de Poel et al. [70] highlighted that in marginalized contexts such as local farmers in Namibia, barriers such as language, trust-building, and resource constraints can limit meaningful participation using CSD. However, the most severe limitation of current CSD practices is the lack of attention towards how capabilities impact one another. For example, a deficit in one capability (e.g., limited language proficiency) can constrain another capability (e.g., trust-building and control over one’s surroundings). In another context, such as clinical environments, practical constraints, such as limited consultation time, may restrict the depth of ethical dialogue needed to fully align rehabilitation technologies with patient goals [65]. As a result, the current CSD approach fails to reify the very inequalities it aims to address by focusing on isolated capabilities rather than the linked, cascading nature of well-being challenges.

Overall, these studies demonstrate both the promise and the limitations of CSD in practice. While capability cards and related tools

make the framework actionable in participatory design, current applications often lack clear guidelines for iterative engagement, contextual adaptation, and usability refinement. These limitations motivate our work to extend CSD by explicitly incorporating corrosive disadvantages and fertile functionings [74], enabling designers to capture systemic interdependencies across capabilities and identify both constraints and enablers of well-being in marginalized communities.

2.4 Participatory Design Methodologies in HCI

CSD is a relatively nascent design methodology, compared to Participatory Design (PD), which has been applied more widely to design activities involving marginalized or equity-deserving communities. The history of PD in HCI began in Scandinavia with *Cooperative Design*, focusing on decision-making, democracy and power in work environments with trade unions [10]. Research adopting PD tends to use the methodology in exploratory ways (i.e. understanding users' experiences), in the design of novel solutions (i.e. involving participants either throughout the whole process or as an evaluatory step), or as a philosophical or methodological framing for their own approaches to research [50]. PD has been used with a variety of marginalized or equity-deserving groups such as women and gender minorities [4], immigrants and newcomers [20, 37], and the LGBTQ+ community [25]. At its core, PD involves granting affected communities a voice in shaping design decisions impacting themselves [50]. Involving community voice in PD or HCI for Development (HCI4D) processes informs researchers about a community's context, understanding and empathizing with a community's lived experiences, and with sufficient trust built, grants researchers access to a community's local knowledge [55]. However, conducting PD with equity-deserving groups has been criticized for failing to adequately respond to privilege and power in its current conception [27] and faces issues with respect to inclusion [21]. In response, Harrington et al. [27] encourages researchers to further engage with their communities on the community's terms, consider historical barriers to research, and emphasize the community's own metrics in evaluation. Elsayed-Ali et al. [21] further discuss strategies to make PD more inclusive for these communities, focusing on creating comfortable shared spaces and finding common ground between researchers and participants. By adopting a CSD approach in our research, we both expand on work practising PD with marginalized groups and aim to respond to contemporary criticisms of PD through the methodology.

3 CSD-Cascade: A Proposed CSD Workflow for Marginalized Populations

Jacobs' [28] tripartite methodology gives an outline for research practitioners to actualize CSD; however, there is no standardized workflow used in practice. Thus, building off of Jacobs' CSD [28] with theoretical additions from Wolff and de-Shalit [74, 75] and practical additions from participatory studies using the Capability Approach [29, 64], we propose a novel standard workflow to apply CSD in technology design for the context of marginalized communities (Figure 1) that take into account inter-dependencies between capabilities.

Our workflow begins in a similar manner to Jacobs' conceptual investigation [28]. First, stakeholders are identified: the marginalized community of focus (e.g. newcomers and refugees, people with a Disability, etc.), acting as the direct stakeholders, and other relevant groups to the community (e.g. supporting organizations, governmental bodies, etc.) as indirect stakeholders. During this phase, we also identify an initial list of needs and challenges faced by the community through prior literature. With this preliminary information, Nussbaum's [43] initial list of capabilities are revised and adapted to the community at hand.

After the initial capabilities are determined, an empirical investigation is held to first involve the community of interest and stakeholders. Individual interviews or focus groups with community members can act as a starting point for exploratory studies to determine where more conceptual work is needed. This community involvement should be aimed at defining various *capability characteristics*, similar to what Jacobs describes as "norms". In CSD, norms are prescriptive objects, where the specification of a norm drawn from a capability is what adds additional context from the community onto the abstractness of capabilities [28]. Van de Poel [68] further describes "end-norms" as those important to design; norms referring to the objectives, goals, or constraints in the creation of design artefacts. In CSD-Cascade, these are surfaced as the following characteristics: (1) *capability priorities*, outlining what the greatest needs and gaps communities have with their capabilities, (2) capabilities expressed as *corrosive disadvantages* and *fertile functionings* through the lack or realization thereof, and (3) the *conversion factors* required to transform a capability into a functioning.

With a richer understanding of the community's capability characteristics, the design requirements can then be defined. These design requirements are then checked back on the norms and capabilities determined from prior investigations to confirm they satisfy the current understanding of stakeholders' needs. Afterwards, the design requirements are evaluated through further community involvement in a technical investigation: prototype or proof-of-concept evaluations, in-field or diary studies, etc. This process is intentionally iterative, where after characteristics have been determined from an initial set of interviews, they can be further refined through additional empirical investigations (e.g. co-design, town halls). After evaluating design requirements through a technical investigation, the cycle can be restarted and adapted to sub-communities and more.

This workflow takes inspiration largely from Jacobs' *capability hierarchy* [28], a modification of Van de Poel's [68] value hierarchy, initially proposed by Oosterlaken [46]. In Jacobs' hierarchy, capabilities are translated to norms and norms to design requirements through the process of 'specification': design requirements fulfill the norm and norms fulfill capabilities 'for the sake of' each. This translation process involves verifying that the norm or design requirement is both appropriate and sufficient at addressing the capability or norm within the community context [68]. Engaging in translation allows researchers to go from abstract notions to concrete features incrementally and arrive at a state in which prototyping and further community involvement can be done.

Justification. Value-Sensitive Design (VSD) and Capability-Sensitive Design (CSD) share a commitment to embedding ethics in

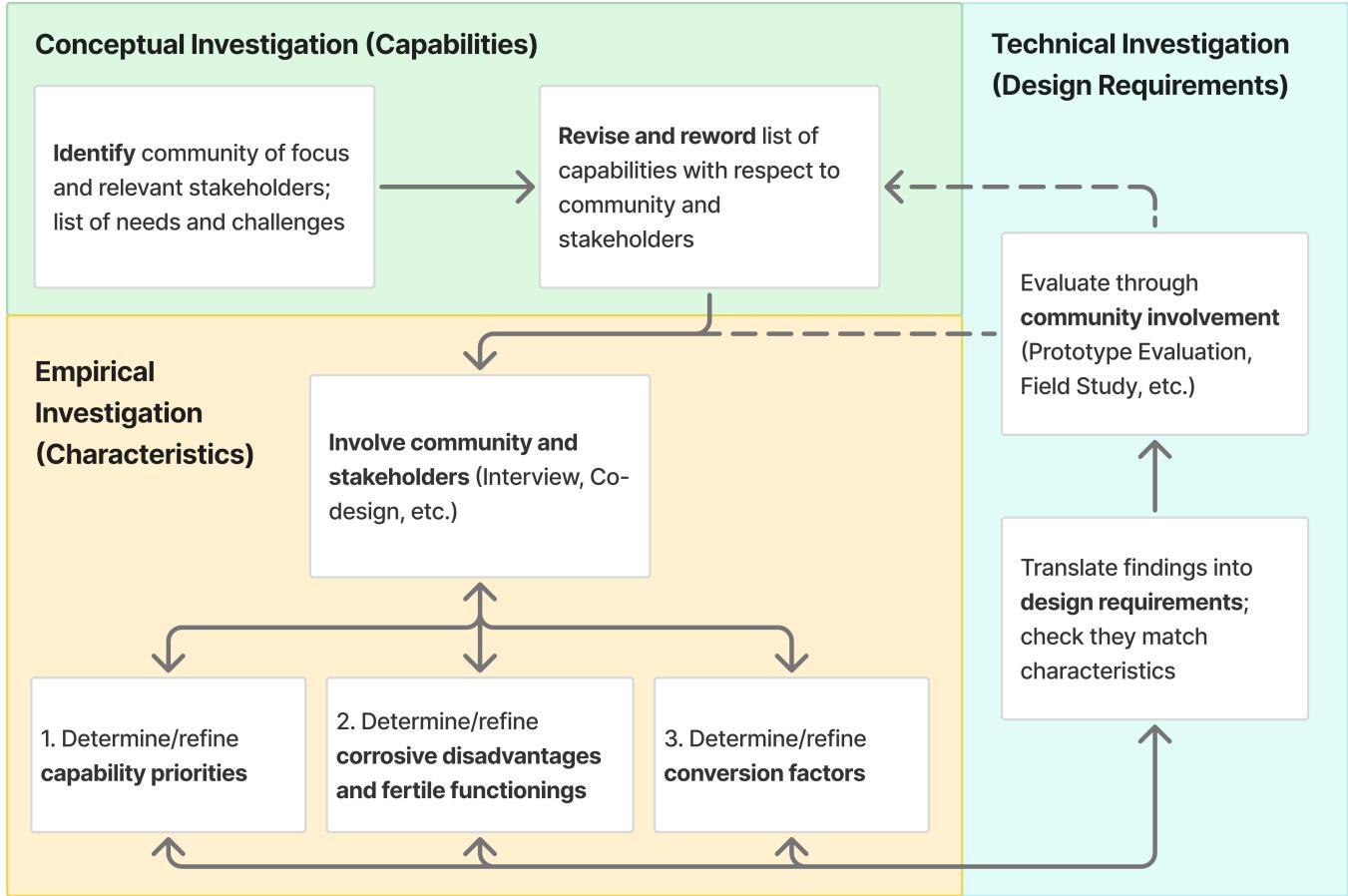


Figure 1: Our proposed workflow for CSD-Cascade, building upon Jacobs' capability hierarchy [28] to include corrosive disadvantages and fertile functionings from Wolff and de-Shalit [74, 75] and give a structured set of steps to the design process for future iterations.

technology, but they diverge in how to define and operationalize the “object” of ethical concern. Jacobs [28] notes how VSD focuses on abstract values (e.g., autonomy, privacy), creating challenges in: (1) obscuring the voice of the practitioner, (2) mutually conflating what is valued by stakeholders with what *ought* to be valued, and (3) lacking a normative foundation to manage value trade-offs. In adapting Nussbaum’s Capability Approach [39] as a normative basis for ethics, Jacobs’ CSD accounts for these pitfalls by granting practitioners a source of theoretical justification for values and their conflicts.

However, CSD as a methodology actively faces challenges around capability sufficiency (whether design requirements are sufficiently accounted for by norms; e.g., how much autonomy/privacy is enough?), capability conflicts in design requirements, and multistability (i.e., the same capability can take on different, sometimes incompatible, meanings across contexts and stakeholders). For example, in community health technologies, “autonomy” may be interpreted by clinicians as encouraging independent self-management, while for recent immigrants it may mean having culturally trusted guidance rather than making decisions alone. These shifting interpretations

make it difficult to translate norms into concrete design requirements, especially in marginalized settings.

Jacobs argues that CSD practitioners are able to address the problem of sufficiency though iteratively retracing the capability hierarchy through conceptual, empirical, and technical investigations and stakeholder consultation. Our workflow accounts for this by introducing iterative reflection: after design requirements are created from findings, and checked against the various characteristics, the process enables further community consultation to further refine characteristics, or even the wording used for capabilities if needed. Sufficiency is also achieved by enforcing evaluation through a technical investigation such that design requirements are checked against characteristics, and additional empirical investigations can take place if sufficiency is not met.

With respect to capability conflicts and multistability, we claim our addition of corrosive disadvantages and fertile functionings aids in managing these challenges. By seeking out these concepts in empirical investigations, practitioners are able to draw out the unnamed relationship between capabilities that they were not aware of prior. By having these disadvantages and advantages named,

practitioners can more easily understand and visualize where capability conflicts in design requirements arise.

4 Case Study: The Newcomer App

In this section, we describe a case study of using the CSD-Cascade method on the creation of the Newcomer App, a resource navigation mobile app for newcomers.

4.1 Designing for Newcomers

Research demonstrates that immigrants are generally healthier than the local population upon arrival; however, across every immigration category, the longer they live in the country, the more their health deteriorates. This phenomenon of arriving with a health advantage and losing it over time is called the “Healthy Immigrant Effect” (HIE) [12], which has been found in North America, Europe and Australia [9, 30, 35, 63]. Diverse factors contribute to declining health outcomes among immigrants, such as income levels, official language proficiency, circumstances of arrival (e.g., refugees who experienced oppression, conflict, violence and persecution), unfair treatment or discrimination, health literacy, ability to integrate, and secure meaningful and fulfilling employment [71]. In applying the HIE, we recognize that this phenomenon is not uniform across all newcomer groups. Our participant recruitment considers nuanced stories of individuals with different migration circumstances (migration pathways), socioeconomic status, language proficiency, country of origin, etc.

These reasons motivate us to design the Newcomer App, a resource navigation mobile app for addressing social determinants of health, and using our CSD-Cascade approach throughout the design, development and evaluation process. This project, supported by a local non-profit partner organization, spanned two years between May 2023 and April 2025 from conceptualization to field deployment, and involved participatory design with newcomer-serving organizations and over 100 newcomers in 9 different languages. In this section, we will describe the study phases, participants, and our experience applying CSD-Cascade to different phases of creating this technology.

4.2 App Overview

The Newcomer App is a multilingual app for both Android and iOS, designed as a resource navigation and planning tool, keeping the 12 capabilities contextualized for newcomers and their corresponding categories at the core of the design. The app was programmed using React Native and Django, and supports ten languages through the integration of Meta’s Seamless language model [7].

The home tab displays a welcome message on the top, an upcoming days of significance, easy access to key phone numbers and websites useful for newcomers (Figure 2a), and a list of posts regarding tips, events, and organizations. The search tab (Figure 2b) allows users to search for all services, events, and activities by through a directory or a search bar in their own language. The plan tab enables users to create customized plans without or with assistance from a chatbot (Figure 2c). The ask tab allows the users to ask a chatbot open-ended questions, discuss one of their planned actions, or learn more about an event, organization, or activity (Figure 2d).

There is another option in the ask feature where users are able to chat in real-time with another person in their respective preferred language. Finally, the saved tab (Figure 2e) allows users to save any posts for future references and displays statistics about addressed capabilities (i.e., capabilities that newcomers have considered, either through planning or reading/saving posts).

4.3 Study Phases and Participants

The Newcomer App was created through multiple stages, including a semi-structured interview with newcomers (Phase 1a) and representatives from health and social service providers (Phase 1b), co-design session with both newcomers and representatives from newcomer-serving organizations (Phase 2) and an 8-week in-field evaluation (Phase 3).

We conducted a conceptual investigation to identify stakeholders and revise our initial list of capabilities. We determined our primary community would be newcomers within the region our partner organization supports, further defined as those who are 18+ and immigrated to Canada in the last 5 years. Indirect stakeholders for this project were determined to be members of settlement agencies and health or social service organizations that support newcomers in the recruitment region. Newcomers were recruited primarily through flyer distribution at places newcomers generally visit or seek support (e.g. settlement agencies, community centers, medical clinics, places of worship) and in-person events targeted towards newcomers (e.g. Newcomer Family Days, Multicultural Festivals, Information Nights, English Conversation Circles). To converse with participants who speak little to no English, we used an on-demand interpretation service called VOYCE [72] during the recruitment process and hired professional interpreters to attend the interviews.

Both newcomers and organization representatives were recruited to take part in semi-structured interviews (Phase 1). For Study 1a, we interviewed 50 newcomers (male = 17, female = 32, 1 prefer not to say) from 18 countries and 9 immigration pathways (i.e., the formal legal process, such as the Refugee Settlement Program, Study Permit, etc.). One limitation of this study is the gender imbalance in our sample, produced by a self-selection bias of our recruitment strategy. Our participants included protected persons, permanent residents, temporary resident workers and students. We conducted the majority of our sessions in small groups (18 sessions, 2-3 participants, 2 hrs), while the remaining were conducted one-on-one (13 sessions, 1 hr). For the group interviews, we clustered participants of similar ethnicity and language to leverage common cultural ground and build trust during these sessions. For Study 1b, we interviewed 16 members of 13 organizations who primarily support newcomers. We conducted the majority (14) of the interviews in a one-on-one format (1 hr) and one session with two participants (2 hrs), all in English. Prior to the interview, each participant read and signed a consent form, and answered a short demographic survey. All interview sessions were audio-recorded. We began the interviews by asking participants to describe their background and general experiences as newcomers or organization members serving newcomers.

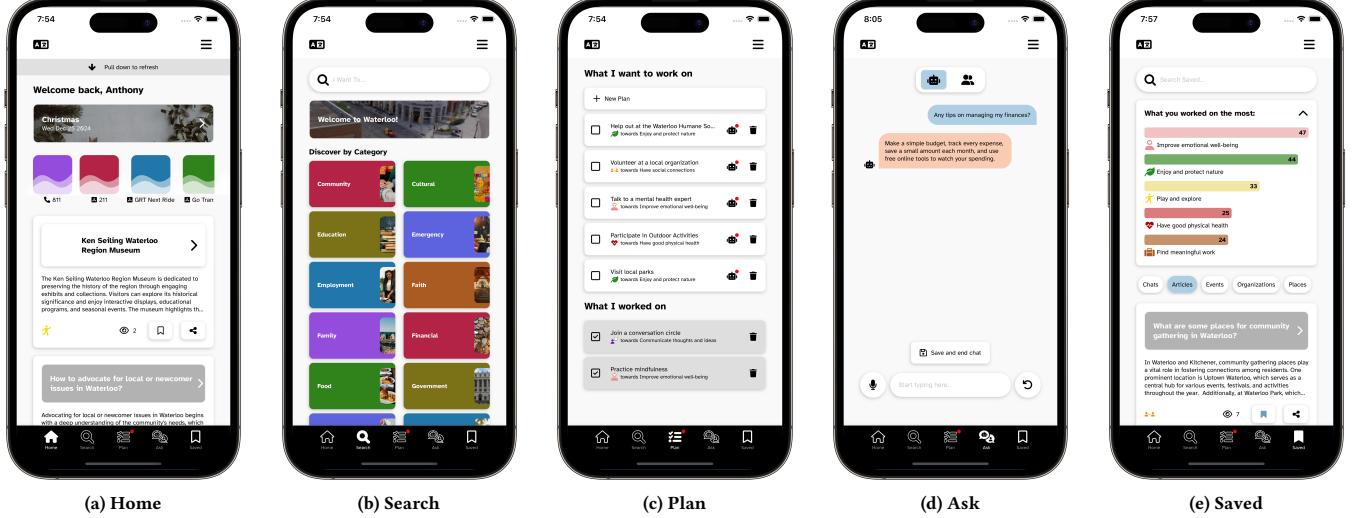


Figure 2: The Newcomer App is used for finding resources and creating action-based plans based on capabilities that consists of: (a) a home screen that shows newcomer-specific articles, events, and organizations, (b) a search screen that allows users to search and find events, articles, and organizations, (c) planning workflow that shows a list of plans to accomplish and a list of accomplished actions, (d) ask workflow that allows user to ask or type a question and have a conversation with a chatbot or another person in their preferred languages, (e) saved screen displaying statistics and saved content.

In the second phase of the study, we continued the workflow's cycle through a co-design session. The co-design process was organized into two parts, with part 1 taking 60 minutes, and part 2 taking 90 minutes. Both parts of the session involved collaborative brainstorming through various group activities to surface challenges related to newcomer settlement, and technological solutions to overcome them. A total of 29 participants took part, comprising 22 newcomers and 7 representatives from newcomer-serving organizations. Participants were formed into groups of 4 to 6 from different backgrounds for collaborative ideation and dialogue, and seated at a table with a facilitator from our research team. Prior to the start of the session, participants read and signed a consent form, and were given a brief agenda of the session, outlining each part and the duration.

To evaluate the final version of the Newcomer App, we recruited 42 newcomers (female = 28, male = 14) from 12 countries who are 18+, immigrated to Canada in the last 5 years, and living in the region where the study was conducted to take part in an in-field evaluation. Participants were to use the developed Newcomer App in their daily lives for a total of 8 weeks, planning at least one action per week to address a capability they care the most about. Prior to usage, participants read and signed a consent form, answered a short demographics survey, and were given instructions on how to install and use the application in a group training session. After the 8 week period, participants were invited to answer a post-study survey to share their general experience of using the Newcomer App. In addition, participants took part in a follow-up interview session, which aimed to elicit deeper insights into how they engaged with the app to pursue their most valued capabilities, the plans they

formulated, and the actions they successfully carried out. These interviews lasted approximately 30 to 45 minutes.

When necessary, materials were translated by professional translators in each newcomer's preferred language, and discussion components were conducted in up to nine languages, including English, based on our participants' preferences and supported by professional interpreters. We worked with local organizations supporting newcomers to determine an appropriate type of and monetary amount for remuneration. Across all studies, participants were paid approximately \$25 an hour for their time and contributions.

5 Application of CSD-Cascade: Methodologies and Findings

In the CSD-Cascade framework, there are three important steps for translating needs to design requirements, which is the identification of capability priorities (i.e., what are important to newcomers), fertile functioning and corrosive disadvantages (i.e., what capabilities have the most cascading effects on other capabilities) and conversion factors (i.e., what factors are most influential in enabling people to turn resources into actual functioning). In this section, we talk about how we derive and refine these concepts in the newcomer context in order to generate requirements and evaluate outcomes.

Elicitation: Capability Board as a Methodology. To elicit this information, we introduce a new design tool called the capability board, as shown in Figure 3b and 3c, which was used to guide the semi-structured interviews (Study 1a and 1b). For Study 1a, we created CSD cards that include (a) ten capability cards (see Fig. 3a), (b) navigation cards, representing what newcomers did (e.g., participate in a program, workshop, course, or event) or where they



Figure 3: An example of our setup with CSD cards and capability boards used during the interview sessions: (a) our ten capability cards, (b) a capability board of a newcomer participant in Study 1a, and (c) a capability board of an organization participant in Study 1b.

sought help to address a capability, and (c) experience cards, representing whether their experience in addressing the capability was positive (✓ cards) or negative (✗ cards). The capability cards were adapted from similar cards proposed by Steen [64] and Javornik et al. [29]. During the brainstorming activity, each newcomer first ranked five capability cards that were most important to them and placed them on the capability board. They then used experience cards to describe how each capability was affected in either a positive or negative way after immigration. After that, they used navigation cards to write down what they did or where they found help to address each of the ranked capabilities. Finally, they used experience cards to write about the successes and challenges in their attempts to address each capability. Newcomers also shared personal stories relating to the notes they wrote on the cards. For Study 1b with organization members, we used a similar set of CSD cards. The major difference was the introduction of service cards instead of navigation cards, representing the services the organization provides for each ranked capability, where experience cards now represent their ability to deliver these services to newcomers. The procedure is identical to Study 1a, except that we end with a discussion of potential technology solutions that would aid organizations in providing services to newcomers. The list of questions and tasks that guided the brainstorming sessions can be found in Table 1 (with newcomers) and Table 2 (with organizations).

Analysis. We transcribed approximately 100 hours of interview data and analyzed them using a mixed coding method, e.g., deductive and inductive coding, using NVivo [44]. We developed a codebook with (1) an initial set of codes corresponding to the ten capabilities (our ten capability cards), (2) three conversion factors from Capability Theory: personal, social, and environmental to relate with a capability code, and (3) capability valence: negative (where the lack of a capability negatively impacts other capabilities) or positive (where the possession of one capability improves other capabilities) in order to address the Corrosive Disadvantages and Fertile Functioning. In addition, we analyzed the content of all the capability boards created by our participants.

5.1 Capability Priorities and Gaps

Our approach in characterizing capability priorities and gaps is to understand what capabilities are most important to newcomers individually, but also how capabilities have evolved (i.e., whether it got better or worse) as a result of their transition to Canada. In general, when applying CSD to marginalized populations (e.g., becoming a single parent, retiree, veteran, etc) these two pieces of information would be likewise useful to collect.

To determine these priorities, we used the data from the capability boards and performed a weighted rank aggregation [3] using the PyFLAGR [2] library to understand in aggregate how newcomers and organization participants rank capabilities (Table 3). We then categorized and counted all the experience cards to see which

Background Questions

Can you share a little bit about yourself and your family?

Why did you decide to settle in Canada?

Brainstorming Exercise

Here is a set of capability cards that represent different capabilities that are important to well-being.

Please pick 5 cards that represent the capabilities that are most important to you.

Using a “service card”, please write down some services that you looked for or used to achieve each of these capabilities that are important to you, and the method you used to find these services.

Sharing Session

Can you briefly share what's on your capability board?

During your transition to Canada, how much have you relied on other [participant's cultural group, e.g., Syrian], e.g., friends, people from cultural organizations?

Application Discussion

We are trying to design a new app to help newcomers find health and social services in the region.

What would you imagine this application to do that would be helpful for newcomers?

How would you be most likely to hear of an app like this? What are some ways in which this app can be advertised to reach the most newcomers?

Table 1: Interview Guide for Newcomers (Study 1a).

Background Questions

Can you describe your organization - what kinds of services it provides, and what mission drives the organization?

How would you define the word “newcomers” from your organization’s point of view?

Brainstorming Exercise

Here is a set of capability cards that represent different capabilities that are important to well-being.

Please pick 5 cards that represent the capabilities that your organization is trying to promote.

Using a “service card”, please write down some services that your organization provides to promote these capabilities.

Sharing Session

Can you briefly share what's on your capability board?

Application Discussion

What would you imagine this application to do that would be helpful for newcomers and organizations that serve newcomers?

How do you envision the people in your organization to use such a newcomers app?

Table 2: Interview Guide for Organizations (Study 1b).

Voter (Capability)	Newcomer Rank	Score	Organization Rank	Score
Receive Care and Support	1	38.80	2	12.00
Feel Safe	2	34.95	1	13.83
Have a Healthy Lifestyle	3	25.10	3	10.5
Have Social Connections	4	24.95	5	8.39
Be Who I Want to be	5	21.50	6	8.33
Enjoy Culture	6	20.30	4	8.67
Have Control Over Political and Material Environment	7	17.85	8	5.28
Express Feelings	8	17.35	7	7.89
Enjoy and Protect Nature	9	16.50	10	0.00
Play	10	13.70	9	5.11

Table 3: Rank aggregation of the ten capabilities by 50 newcomer participants and 16 organization participants [3]

capabilities have improved (✓ cards) or declined (✗ cards) for newcomers after their move to Canada. For organization participants, we counted the experience cards to understand the frequency of their successes and failures in providing newcomer-specific support. The navigation cards were coded for each capability and analyzed to generate themes of coping strategies that newcomers adopted during their settlement period. Our findings show that the capabilities newcomers value are highly individualized. However, we found an alignment between newcomer and organization priorities. Similar to newcomer participants, organization participants prioritize *Feel Safe*, *Receive Care and Support*, and *Have a Healthy Lifestyle* as the top three capabilities that their organizations promote or support.

5.2 Corrosive Disadvantages and Fertile Functionings

We also analyzed capabilities to understand the inter-dependencies between capabilities, so that we can identify the few capabilities that have the most positive impact (i.e., fertile functioning) and negative influence (i.e., corrosive disadvantages) on other capabilities. Two of the authors first independently identified all participant quotes that mention two or more capabilities, and coded which capabilities are mentioned and what effects (negative or positive), if any, one capability has on the other capabilities. We ran Cohen's κ to determine the inter-rater reliability between the two authors and found a moderate agreement [36], $\kappa = 0.737$, $p < .001$.

Corrosive Disadvantages. Figure 4 shows these relationships: namely, the head capability of an arc was mentioned by participants to be negatively affecting the tail capabilities, and the weight of the arc denotes the number of such mentions. We identified two main corrosive disadvantages: *Have Control over Political and Material Environment* and *Have Social Connections*.

Lack of Control over Political and Material Environment. Not having control over one's material environment, such as lack of employment, can have detrimental effects on other capabilities. With foreign credentials not being recognized, newcomers often have to take jobs that are irrelevant to their expertise, affecting their self-identity (*Be Who I Want to Be*). Volatile work conditions (e.g., not knowing "what will be tomorrow" (N15) and lack of control over work locations/hours) compounded by high cost of living hurts newcomers' ability to *Play* (N21, N40, N42) as well as their physical and mental health (*Have a Healthy Lifestyle*). Facing discrimination due to status (N18, N42), or language and ethnicity (N17, N18, N40), some newcomers (N40) see discrimination as being inescapable because it is happening at their place of employment, on which they depend.

Lack of Social Connections. Not having social connections, whether professional, personal, or familial, can put newcomers at a disadvantage in their ability to *Receive Care and Support*. Many newcomers (N16, N17, N25, N8) discussed how not having family or friends in Canada made it harder for them to get access to government-supported care and peer support. As N8 said, "We didn't know one person that would even say [to us], 'how are you doing?', 'are you guys good?' There was [no one] to check on you, ... even if you

were dying." A lack of social connections also negatively impacts one's ability to find employment and housing (N27, N44), i.e., affecting *Have Control over their Political and Material Environment*. In the other direction, not having work and housing can make it more difficult to gain social connections in the first place. As N27 explains, "If you work from home, if you don't have colleagues, then there are not a lot of ways to meet people", creating a negative feedback loop between the two capabilities (as seen in Figure 4).

Fertile Functionings. Figure 5 shows these relationships in a similar manner: the head capability of an arc is mentioned by participants to be positively affecting the tail capabilities, and the weight of the arc denotes the number of such mentions. *Having Social Connections* is overwhelmingly the most fertile capability, as indicated by the number of outgoing arrows and the thickness of those arrows.

Having Social Connections. In creating and forming professional connections, newcomers were able to feel less discriminated against and learn more about equity and diversity (N41, N48), a key aspect of the capability of *Be Who I Want to Be*. Having various kinds of social connections helped newcomers *Express Feelings* more often and more openly. Having the ability to speak with family (N43), friends (N5), or neighbors (N7) helps newcomers to have an outlet for expression and sense of belonging. Newcomers were able to use various kinds of social connections to help them *Feel Safe* in their new environments. N5 relied on her spouse, who had lived in Canada for 10 years, to find a safe neighbourhood to live in. Other newcomers (N37, N48) used various contacts from their post-secondary institutions to navigate potentially unsafe situations (e.g., St. Patrick Day's street parties) about which they have little knowledge. Social connections enabled newcomers to not only stay in touch with one's own culture (N39 and N46), but also learn about other cultures (N4, N17, N25, N36) (*Enjoy Culture*).

Social connections are crucial for satisfying basic needs during settlement. Newcomers with existing connections in Canada (N1, N34, N44, N50) have an improved ability to obtain housing, jobs, and legal documentation (*Have Control Over Material and Political Environment*). N44 connected with family, who lives outside the local region, for employment advice, prompting her to "do [that] core certification course ...to get the jobs in the bank." N6 was made aware of NPower, a tech career mentoring program, through friends. Through online (N39, N47, N49, N50) and in-person (N17) ethnic group connections, newcomers were able to secure housing.

Having social connections can positively impact newcomers' ability to *Have a Healthy Lifestyle*. N49 leveraged connections with family and friends as incentives to cook good food and go for walks. Exercise clubs enabled newcomers (N4, N11) to learn the "correct way of exercising or running" and to "build physical health". N50 leveraged community connections to learn about physical health benefits eligibility. Having social connections also creates opportunities to *Receive Care and Support*, such as accessing healthcare (N1, N5, N9, N26, N32) or food (N39). For N1, navigating the system was made easier by her brother acting as a guide, driving her everywhere and directing her to different places for different needs. Meeting neighbors (N7, N37, N44), new friends (N15, N48, N49), community members (N1, N2, N7, N10, N45, N46, N48), or tutors



Figure 4: Graph visualizing the relationships between corrosive capabilities and the capabilities they disadvantage

(N14, N15) helps with health navigation. The ESL teacher of N15, for example, taught him how to find a family doctor or get help from the community center; he adds, “It’s really simple ... [except if] you don’t know what you should do in some situations.” N37, N38, and N41 all found care through connections with faith-based organizations.

Finally, social connections helps newcomers in small ways to *Enjoy and Protect Nature* and *Play*. N15 and N43 learned from new connections about the rules and regulations related to garbage and recycling. Various hobbies such as gardening (N9), camping (N14), ice skating (N48), and arts and crafts (N45) were all facilitated through social connections.

5.3 Conversion Factors

To determine conversion factors, we aimed to further understand the capabilities that newcomers prioritized and the challenges they faced in trying to maintain these capabilities during their settlement in Canada. In coding this data, the inter-rater reliability between two of the authors (25% data coded independently by second author) shows a moderate agreement [36], $\kappa = 0.779$, $p < .001$. Similarly, we aimed to understand which capabilities organizations prioritized when they structure their newcomer programs and services, and the successes and challenges they encountered in the delivery. The same two authors independently coded the data (25%) which shows

a moderate agreement [36], $\kappa = 0.72$, $p < .001$. A list of conversion factors for each capability can be found summarized in Table 4.

Some key conversion factors were found across capabilities. One such was having proficiency in the local language or access to interpreters that speak the newcomer’s language. With respect to the capability of *Receive Care and Support* (noted by N1, N11, N28, N27, N41, N33, N50), N1 and N50 discussed the importance of interpreters for explaining their symptoms accurately, while N11 mentioned how being proficient in a shared language helps them “make good use of the medical care”. For *Feel Safe*, N26 communicated that “the best thing to protect yourself is to learn the language; this way you can defend yourself and understand what people are talking [about] nearby”. With respect to *Have a Healthy Lifestyle*, N11 found it would be easier “to get involved in certain physical activities, especially group activities, or try to sign up for anything” if they were proficient in a shared language.

Another shared conversion factor was an understanding of social norms for the both the local community newcomers join and those prescribed by the broader society. For *Enjoy and protect nature*, newcomers were able to understand social norms for waste disposal, with N20 “making sure the waste items are properly separated [for recycling]” and “picking up waste” when they see it. Related to *Express Feelings*, N19 was able to learn the social norm around help-giving, and came to perceive that local people value privacy,

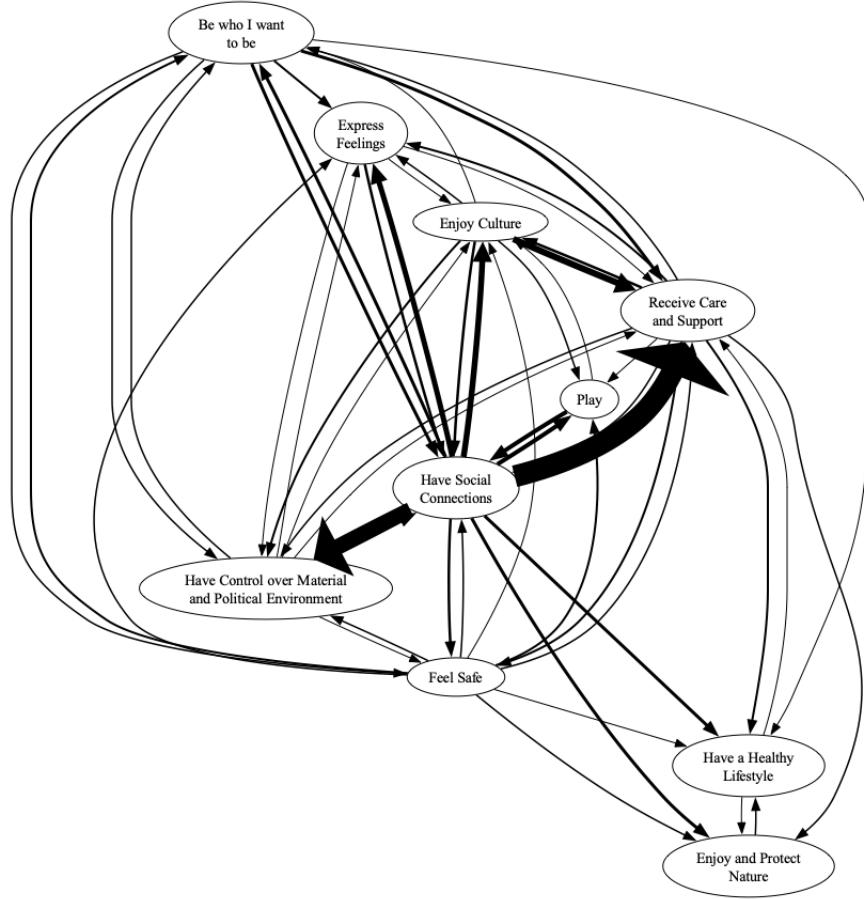


Figure 5: Graph visualizing the relationships between fertile functionings and other capabilities they aid in turning to functionings

independence, individualism, and “self-oriented” care. Understanding how others wish to receive aid can help newcomers learn how they can express their feelings effectively. N1 discussed how learning social norms helped them with the capability of *Have Social Connections*: in particular, local norms about when it is appropriate to call or show up at people’s houses.

5.4 Deriving and Refining Design Requirements

To design the app, we incorporated findings from interviews, co-design, and an iterative design process with intermittent usability evaluation to first derive an initial set of design requirements, then refine them by making each requirement more concrete, and arrive at a final set of application features.

Deriving Design Requirements from different sources of insight. At the end of each interview in Study 1a and 1b, we briefly discussed what potential technological solutions to the mentioned problems could look like, and subsequently coded our data for the

technology used or proposed for addressing newcomers’ challenges. These discussions surfaced four broad categories of requirements newcomers wanted in the application: (1) access to local and procedural knowledge, (2) forming connections, (3) expressing oneself or communicating, and (4) “managing the big picture”. Jointly using the capability characteristics described in previous subsections and broad requirement categories from newcomer input, we were able to derive a set of design requirements—the major needs that the app aims to address—for our technology.

Access to Local and Procedural Knowledge. The understanding of local and societal social norms was a key conversion factor mentioned by newcomers within the interview. To convey these norms to newcomers, we require the app to give access to local and procedure knowledge and information. By giving newcomers access to knowledge usually held by locals to the region, they are able then to understand where they can contribute to and receive from the broader community. In discussions with newcomers, features such as details on conservation areas, parks, sites and trails, and

Capability	Conversion Factor	What does the factor enable?
Receive Care and Support	Language proficiency (Personal)	Ability to explain symptoms, ask questions and advocate for oneself
	Access to proper care at the proper time (e.g. short and flexible wait time, having access and choice to doctors) (Environmental, Social)	Ability to experience better health and care for children and other family members
Feel Safe	Language proficiency (Personal)	Ability to understand local news sources, feel more secure
	Effective public services (e.g. transit, emergency, supportive housing) (Social, Environmental)	Ability to improve one's mobility and access to essential locations
Be who I want to be	Freedom of expression (Personal, Social)	Ability to feel less discriminated and protected for one's identity
	Freedom of religion and access to places of worship (Social, Environmental)	Ability to practice one's religious or spiritual beliefs with a local community
Enjoy and protect nature	Abundant outdoor public green spaces (Environmental)	Ability to appreciate nature's beauty in one's own time
	Understanding of environmental protections and norms (e.g. recycling bins, composting) (Social)	Ability to make an individual positive difference towards the planet
Enjoy Culture	Access to multi-cultural experiences (e.g. cultural food stores, community centres) (Social, Environmental)	Ability to retain one's cultural roots while experiencing local and other cultures
Express Feelings	Access to help with local community organizations (e.g. volunteer positions, clothing donation boxes) (Environmental)	Ability to obtain a sense of belonging within a broader community
	Understanding of local norms (Social)	Ability to know where and how one can effectively contribute to my community
Have a Healthy Lifestyle	Language proficiency (Personal)	Ability to engage in local fitness programs and group classes
	Access to a wide range of physical activities (e.g. outdoor paths, affordable gym memberships) (Social, Environmental)	Ability to practice self-care year-round
Have Control over Material and Political Environment	Language proficiency (Personal)	Ability to form better connections in order to secure employment or understand housing
	Recognition for previous foreign credentials (Social)	Ability to find and meet requirements for work that is meaningful towards oneself and future career mobility
Have Social Connections	Language proficiency and an understanding of social norms (Personal, Social)	Ability to have more open and easier forms of communication with local communities
	Access to local affinity groups and community spaces (Personal, Environmental)	Ability to form deeper connections with others based off of shared interests, identity, or location
Play	Access to local events and recreational activities (Environmental)	Ability to relieve stress and have fun

Table 4: Conversion factors discussed by participants in the interview study, separated by the categories of personal, social, and environmental.

whether these spaces are family-friendly (N6, N11, N14) help towards *Enjoy and Protect Nature*. To *Receive Care and Support*, N4, N9 and N16 wanted more transparency, such as information about doctors' educational backgrounds, languages spoken, estimated wait times, patient ratings, etc. Other participants (N3, N4, N6, N11, N15, O1, O5, O13) highlighted the need for simplified explanations of procedural information (e.g., how to seek medical support, how to prepare for a Canadian winter), looking for a 'one-stop-shop' platform for newcomer information (N17, N38, N42, and N43) to *Have Control Over Material and Political Environment*.

Forming Connections. A key fertile functioning surfaced in interviews was the capability to *Have Social Connections*, with its ability to have a positive cascading effect on every other capability once realized as a functioning. To aid the conversion of the most fertile capability, we require the app to have features that enable forming local, cultural, and professional connections. When discussing

features with newcomers, they primarily mentioned this in terms of capabilities such as *Play*, desiring centralized information about local activities, including festivals and concerts (N21, N25, N40). They further highlighted the importance of real-time updates and a user-friendly interface, suggesting features like maps, listing of upcoming events, explanations of associated costs, and safety ratings for family-friendly events. Currently, newcomers have mixed success seeking advice from people they can relate to, using social media platforms like Facebook (N14, N27), WhatsApp (N7, N8, N16, N17), Instagram (N42) to form/maintain social connection.

Expressing Oneself or Communicating. Having language proficiency in the local language or access to services in a language newcomers are proficient in was found to be a major conversion factor across half of the capabilities without accounting for positive cascading effects. Thus, we require the app to be both multilingual and support alternative interfaces for newcomers to aid in communication

and self-expression, and seek support through the application in a comfortable manner. In interviews, many participants (14 newcomers and 4 organization members) discussed features to help with accessing content and services in the language of their choice. Two of our participants (N32, N33) in fact had difficulties reading the translated documents and relied solely on verbal communication with the interpreter during the focus group, highlighting the need for a conversational interface feature (e.g., translation of spoken speech) in newcomers' preferred language. N38 and N39, in particular, would envision using such a feature to connect with their faith-based organizations. Consequently, by enabling newcomers to express themselves (*Express Feelings*) comfortably, such translation support would also bolster capabilities such as *Be who I want to be*, *Enjoy Culture*, *Social Connection* and *Receive Care and Support*.

Managing the Bigger Picture. Last, the Newcomer App aims to support all of the previously mentioned categories and beyond through features to "manage the big picture". Many newcomers were seeking step-by-step guides and checklist systems (N26, O2, O3) to support a variety of needs from survival (*Feel Safe*) shelter (N1) and basic furnishing (e.g., mattresses) (N43), legal documentation and other essential services (N27, N37), preparing for resumes/certifications (N43, N44) and ways to find employment (N20, N21, N29, N37) (*Have Control Over Material and Political Environment*). Thus, we require a checklist or similar life management system to act as a unified method to realize conversion factors and activate the fertile functionings of capabilities.

Making Design Requirements Concrete through Co-design. After the initial design requirements were defined, we conducted a co-design session to both confirm our findings and refine our requirements through concretizing topics related to each capability on the Newcomer App.

To elicit concrete topics and design features, we used a new set of more "concrete" capability cards based off of feedback from Study 1 participants and ran two participatory activities with both newcomers and members of organizations supporting newcomers centred around these capability cards. In part 1, newcomers and organization members engaged in affinity mapping [33] their challenges. They first thought of and wrote down on sticky notes challenges in any events, programs, courses, activities, etc. that they had personally experienced or something that had helped them in their journey as a newcomer or in supporting newcomers (see Figure 6a). This was followed by sorting, grouping, and naming similar notes under each of the 14 capability cards. Finally, participants were asked to write down on sticky notes the ways they would prefer find and filter the various services, discuss potential features, and make any changes to the mapped notes in front of them. In part 2, newcomers and organization members were separately prompted to imagine possible solutions to overcome newcomer settlement challenges with the use of technology through an enactment (role-playing) [13] exercise. To do so, we shared a rectangular-shaped piece of cardboard that looked like a tablet/computer with each group of newcomers or organization members. This represented a potential tool that could solve any challenges the participants shared during session 1. The participants held it in turn, thought aloud, and listed possible solutions on sticky notes and paper to

address each challenge. Finally, this was followed by sorting and grouping these sticky notes as potential solutions to the relevant challenges under each capability card (see Figure 6b).

Overall, findings from the co-design session aligned with our interview study, only under our newly worded capabilities. As a corrosive disadvantage, lacking the ability to *Have social connections* impairs one's ability to *Find meaningful work* (N10, N12) or *Build a home* (N3, N7, N10, N20) (both capabilities previously merged as *Have Control over Political and Material Environment*), where without Canadian references or co-signers, many newcomers struggle to find employment or reliable housing respectively. The conversion factor of "Access to proper care at the proper time" for both *Have good physical health* and *Have emotional well-being* (previously merged under *Receive Care and Support*) was found in discussions of short and flexible wait times for doctors (N1, N3, N4, N10, N11, N20, O1), specialists (N11, N19, O2), and emergency departments (N10).

As our characterizations matched between studies, we then used resources discussed by participants to outline general content topics per capability the app must include for plans, organizations, events, and articles. Table 5 outlines each capability, the topics clustered, and an example resource and related topic for each capability. All capabilities but one were assigned topics; *Be who I want to be* did not have any clear topics from our findings to subdivide it.

Feature Specification for the Newcomer App. With both a general set of design requirements and concrete topic requirements for the Newcomer App, we were able to develop features in the app that directly meet both.

In the Newcomer App, features related to local and procedural knowledge are expressed through the content found throughout the app: brief, newcomer-friendly information about local organizations (Figure 7a), articles about key topics related to their transition (Figure 7b), and quick access to local numbers and contacts in their daily lives. This content must be about a wide range of topics within each capability in line with those outlined in co-design, and must be easily accessible; making the Newcomer App a true 'one-stop-shop' for users.

In order to form connections, the Newcomer App contains an up-to-date repository about local events both tailored towards newcomers and accessible to the broader public (Figure 7c). When accessing an event page in the app, they are able to see time, location, and links to the host's website in order to sign up to attend. Additionally, users can save these events for future reference and access it on the saved page. Popular social media groups for newcomers are also surfaced as 'organizations' to enable online connections for those who find it useful.

For language proficiency, a conversational interface was realized by the "Ask" page of the Newcomer App, where users could talk about various pieces of content, including articles, organizations, or events by text or voice, in any language of their choice. Additionally, the entire app was created to be multilingual, supporting 8 of the top non-English languages located in the region for all content, interface buttons, and other features (Figure 7d).

Giving newcomers the ability to "manage the big picture" was actualized through the "Plan" feature, a capability-driven planner connected to all parts of the app. All plans were tied to a parent



(a) Part 1 - Table 2: Newcomer challenges grouped and categorized by each capability



(b) Part 2 - Table 3: Proposed technological solutions categorized by each capability

Figure 6: Some examples from our participant tables during the co-design session

Capability	Topics	Example Resource
Be safe and secure	Place of Living, Financial, Safety services, Security	Access to police (N18), for <i>Safety services</i>
Have good physical health	Healthcare, Recreational	Finding a trustworthy family doctor (N1, N4, N5, N6, N12, N18, O1), for <i>Healthcare</i>
Have emotional well-being	Professional support, Support groups, Regulation	Access to counselling services in my native language (N5), for <i>Professional support</i>
Have social connections	Interpersonal, Professional	Newcomer mentorship programs (N12), for <i>Professional (connections)</i>
Be mobile	Accessibility, Transportation services	Getting a monthly bus pass (N1, N5, N6, N17), for <i>Transportation services</i>
Be who I want to be	-	Set goals and ways to achieve them (N3, O1)
Enjoy cultural experiences	Own culture, Local culture, Other cultures	Access to local multicultural centres (N21), for <i>Own culture</i>
Seek justice and equality	Community Advocacy, Government Services, Navigation	Join groups and associations that support equity, inclusion, and human rights (N1, N2, N6), for <i>Community Advocacy</i>
Play	Indoor, Outdoor	Access to recreation centres (N1, N6), for <i>Indoor</i>
Participate in politics and community building	Politics, Community building	Volunteer with a food bank (O2), for <i>Community building</i>
Find meaningful work	Career development, Finding a career	Engage in volunteer work (N6, O1), for <i>Career development</i>
Build a home	Renting, Financial awareness, Financial security and growth	Access to financial education (N1), for <i>Financial awareness</i>
Enjoy and protect nature	Adventure and recreation, Connect with nature	Access to parks and lakes (N18, O2, O15)
Maintain connection to my home country	Connection, Resources	Plan weekly video calls with parents (N6, N10), for <i>Connection</i>

Table 5: An outline of what resource topics content in the application must cover in order to satisfy a capability's norm.

capability, grounding their actions and helping them reach their needs. Plans suggested to newcomers by the research team have recommended organizations, events, and articles linked to each (Figure 7e), and each plan (and its related content) can be discussed in a conversational interface on the “Ask” page in their own language.

5.5 Addressing Capabilities in Practice: Field Deployment of the Newcomer App

After the final version of the Newcomer App was developed from the design requirements and characteristics defined in interview and co-design, a field study was conducted to discover its ability to address capabilities in practice. All meaningful application usage

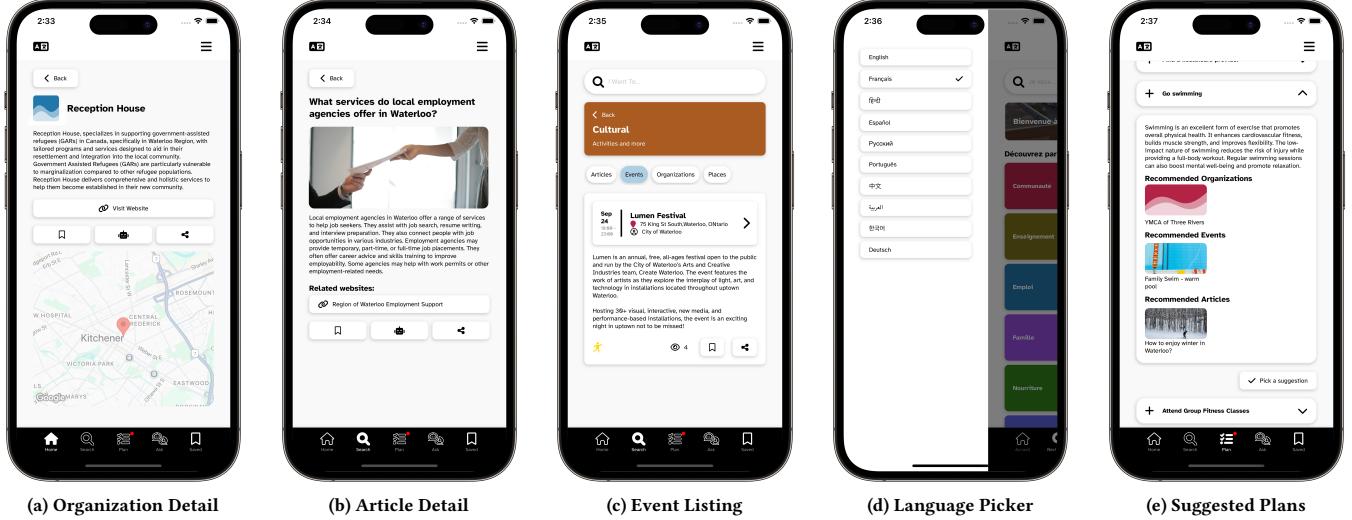


Figure 7: Various features of the Newcomer App aligned with the derived design requirements: (a) organization details (b) articles tailored towards newcomers, (c) event listings, (d) a list of languages the app can be navigated in, and (e) an example of content related to a suggested plan.

over the time course of the field study (e.g., creating or completing a plan, searching for and accessing content) was logged in a secure database and used as a part of our analysis. From the post-study interviews, we transcribed approximately 10 hours of data and analyzed it using Thematic Analysis [11]. Of the original 42 participants from the field study, 3 participants were dropped due to inactivity, and only a total of 32 participants completed both the post-study survey and interview. Hence, any application data was taken from the 39 active participants, and our thematic analysis was based off of the 32 participants whom completed both post-study procedures. Guiding questions from our post-study interviews can be found in Table 6.

5.5.1 Addressing Capability Priorities and Gaps in Practice. Newcomers in our study were able to use various features of the app in order to address some of their individual capability gaps and priorities in an effective way. In searching for content, the most common queries were related to *Play and Explore* (previously *Play*), with participants such as N27 seeking social activities.

In the planning feature, newcomers were able to address capabilities through the pursuit and completion of capability-driven actions. Several (11 out of 32) participants pursued physical activity goals (supporting *Have Good Physical Health*, previously *Have a Healthy Lifestyle* from our original capability list) by engaging in exercise-related actions such as joining a gym, attending aerobics or Zumba classes, or maintaining home-based workouts (N2, N4, N5, N6, N7, N25, N27, N34, N35, N39, N40). Other participants planned actions to *Have Social Connections*, with participants attending local events, game nights, or visiting community centers to meet new people (N4, N5, N6, N13, N27, N34, N35, N39, N40). In addressing basic needs and access to support services (*Manage Basic Needs*, previously *Have Control Over Political and Material Environment*), several participants reached out to local employment agencies, healthcare

providers, or food and housing assistance services (N4, N5, N6, N27, N34, N40). In terms of health and wellness (*Have Good Physical Health* and *Improve Emotional Well-Being*, previously *Receive Care and Support*), actions ranged from scheduling massages to health checkups, healthy eating, or practising yoga and mindfulness (N5, N6, N7, N13, N35, N39, N40). These patterns of actions highlight the diverse and individualized strategies newcomers use to satisfy their needs for all parts of their lives.

5.5.2 Addressing Conversion Factors and Fertile Functionings in Practice. The capability-driven planning feature developed for the app, and the requirement for it to “manage the big picture” was, at a meta level, aiming to aid newcomers in accessing conversion factors, and enabling the positive cascading effects of fertile functionings. In discussions with newcomers about their experiences using the app to meet capabilities, we found that the majority of participants (20 out of 32) were able to use the suggested contents within the app to create concrete plans for activities that aligned with their capability goals. N35, who migrated from Bolivia, found a restaurant as a suggestion she wanted to try out. “I didn’t even know that we have a nice Korean restaurant ... I should go and try out”. N34 shared, related to the capability *Have Good Physical Health*, “... the app helped me to book [the workout class], to have it as my plan. That way I was more intentional, and I was able to go for those”. N5 used the app to search and read an article about the importance of volunteering, and then continued to search for nearby organizations looking for volunteers. While many participants directly used the suggested plans, others, such as N35, used them more as inspiration. Instead of following the exact suggestions, she created personalized plans after reviewing them:

“[The suggestion] gives you a better idea of how to make a ... plan by your own. That’s why I used to pick

Post-study interview

In this app, we try to get you to focus on specific capabilities and plan actions for them.
 Can you tell us one capability that you have planned actions for. Did it go well or not, and why?
 Tell us about a capability that improved in the last two months. Can you please explain how?
 Does the app have anything to do with this change?

What are your favourite features in the app and why? What feature did you find most frustrating and why?

Table 6: Guiding questions from our follow-up semi-structured interviews (Study 3).

first the suggestions plans, and then I can make my own plans according to that.”

Several participants described how the app’s recommendations supported them in moving from suggestion to concrete plan, and ultimately to deliberate action. For N4, the app’s prompt to visit the Farmers Market transformed prior awareness into action. This experience was framed as both a discovery and a turning point: “This was not the first time that I was hearing about it, but after the app prompted me, I went ... Now we regularly go to the Farmers Market.” Similarly, N9 shared how the app supported her in accessing employment services through the planner. This shows the connection between information and intentional follow-through as N9 shared, “I found some employment services... I tried reaching out to them... that was one thing that the app helped me with the planner.” Newcomers were thus able to not only discover new conversion factors as expressed through plan suggestions, but additionally complete the plan, converting the capability into a functioning and benefiting from any fertile advantages.

Across all newcomer participants, 436 plans were created, 344 plans were completed, with 309 (89.8%) reported as “helpful” in supporting the capabilities. Figure 8 outlines the degree each capability was helped by newcomers’ completed actions, where based off of the initial capability chosen for the completed plan, the plan was marked as helpful for the same capability, marked as helpful for one or many different capabilities other than the initial one, and plans not marked as helpful towards any capability. Notably, *Have Good Physical Health* was the capability with most plans completed and marked as helpful at completion for the same capability. This aligns well with our initial top priorities newcomers had in interviews (*Receive Care and Support* and *Have a Healthy Lifestyle* which *Have Good Physical Health* evolved from), showing how newcomers were able to address their top needs through the application’s features.

Additionally, capabilities were expressed as fertile through the completion of a plan when one was marked as helpful for other capabilities in addition to the initial one. A total of 43 completed and helpful plans were found to be fertile, where Figure 9 displays the proportion of how many plans per initial capability were noted as fertile compared to all helpful plans towards the initial capability. From this data, we found that the top fertile capabilities in this study were *Have Social Connections* (29.17% of plans fertile), *Have Good Physical Health* (23.26% of plans fertile), and *Care for others* (19.0% of plans fertile). This data also aligns well with our initial studies, where social connections was found as the most fertile capability.

5.5.3 Addressing Design Requirements in Practice. In its deployed form, the Newcomer App met the design requirements outlined

by previous phases. However, many newcomers pointed out areas of improvement with respect to content or functionality. Several participants expressed a desire for additional planning supports, including daily checklists and goal-tracking features, that could simulate a form of behavioural accountability. Additionally, N34 suggested integrating features that foster social accountability: “...if possible, having it like a challenge, like I can invite friends. And then my friend and I are competing to support each other’s planned actions for the week”. This suggests a desire for additional opportunities to meet the broad design requirement of forming social connections, tying it into the central goal-setting functionality of the app to enhance user motivation and persistence.

6 Discussion

The notion of capability is central to Capability Sensitive Design (CSD), yet most prior HCI work has treated capabilities as discrete outcomes to be supported by technology. CSD-Cascade as a methodology takes a different perspective, examining how capabilities interact in practice through the explicit introduction of corrosive disadvantages, fertile functionings, and conversion factors within the investigations themselves. Implementing our workflow with a newcomer population, we identified interdependent characterizations of capabilities that shaped both the design process and the value of the resulting technology.

6.1 Extending CSD to include Disadvantages and Functionings

While Capability Sensitive Design (CSD) has been considered as a promising approach for embedding values and well-being into technology design [1], recent work also points to challenges in its practical application. For example, Van de Poel et al. [70] show how language barriers constrained participation in a CSD process with local farmers, yet these barriers were treated as isolated issues rather than as expressions of a broader system of interconnected capabilities. In practice, capabilities interact: enhancement in one can enable others (fertile functionings) or undermine them (corrosive disadvantages). For example, in our newcomer study, improving access to language learning also enhanced social integration (fertile functioning), while financial instability undermined access to both healthy food and mental well-being (corrosive disadvantage). Basic CSD offers a strong foundation for translating abstract values into concrete design requirements, but without systematically accounting for these cross-capability effects, the design process risks overlooking systemic barriers and enablers. Prior CA-inspired HCI work [6, 18] has demonstrated the value of focusing on capabilities in marginalized contexts, but has tended to stop short

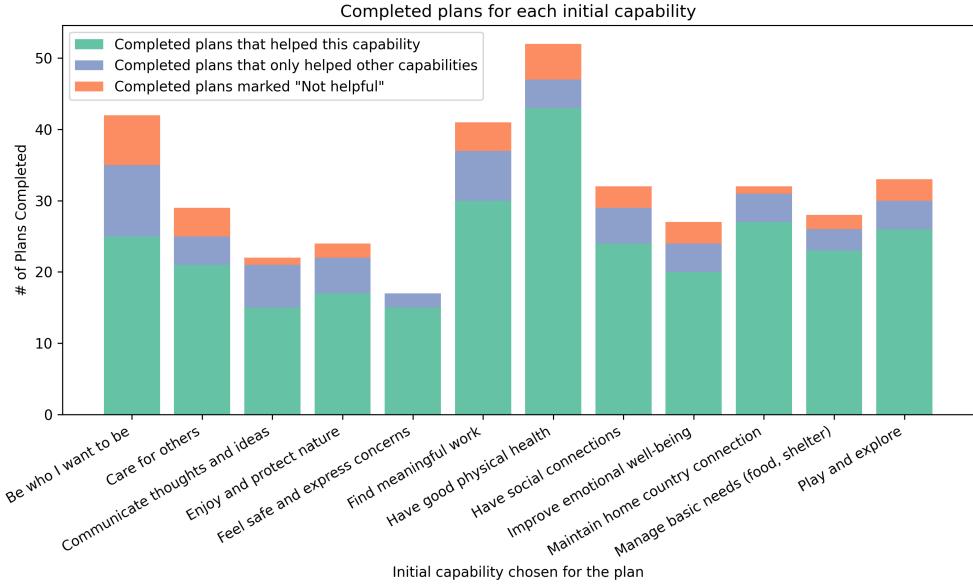


Figure 8: Plans completed based off of the initial capability chosen, and whether the completed plan was marked helpful towards the initial capability, marked helpful towards only different capabilities, or marked not helpful overall.

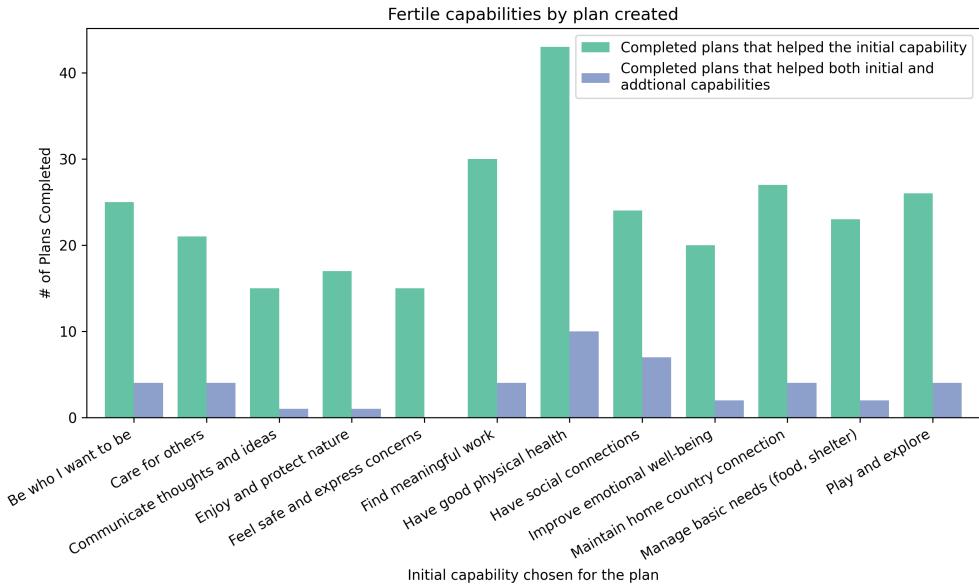


Figure 9: Plans completed based off of the initial capability chosen, showing the proportion of plans marked helpful towards the initial capability and ones that included additional relevant capabilities.

of tracing their interdependencies or mapping how disadvantages propagate across domains. Similarly, Participatory Design (PD) excels at surfacing user priorities but often lacks a structured framework for connecting those priorities to broader social determinants of well-being [26]. User-Centered Design (UCD), while powerful for usability and individual experience, focuses primarily on user

needs for a given system, not the social context in which those needs arise. CSD-Cascade bridges these approaches by preserving PD's community engagement, UCD's attention to usability, and CSD's normative grounding—while adding a systematic layer for identifying and addressing cross-capability interactions.

Our design process demonstrated that capabilities are neither static nor singular in expression. Initial discussions often surfaced broad aspirations (e.g., “stay healthy,” “feel connected”), but only through iterative engagement did more nuanced and context-specific understandings emerge (e.g., “access to affordable winter clothing” as a precondition for both physical health and social participation). Recognizing and deliberately designing for these cross-capability dynamics shifts the role of technology from addressing isolated problems to supporting interconnected pathways of well-being. For HCI practitioners, this means treating each design choice as part of a network of social, material, and institutional factors that shape how a community can use and benefit from a system.

Importantly, the design process itself benefits from explicitly mapping these interdependencies early, allowing teams to anticipate how changes in one area could cascade into others. This shifts the focus from delivering a static “solution” to enabling adaptive, interconnected systems that evolve with community needs. By approaching capability building as a collective and iterative process, designers can create technologies that are resilient, contextually grounded, and more likely to sustain long-term impact.

6.2 Implementing CSD-Cascade in Practice with Marginalized Communities

Our study highlights that extending CSD with explicit attention to disadvantages and functionings can inform future HCI research with marginalized groups.

First, we suggest beginning with broad capability elicitation—using participatory workshops, interviews, or probes—to surface the aspirations and barriers communities face. Rather than treating these capabilities as static, researchers should iteratively refine them across multiple engagements, allowing the nuances of lived experience to emerge over time. Second, mapping fertile functionings and corrosive disadvantages offers a structured way to identify interdependencies across domains. We found that visual mapping exercises, where participants reflected on how one barrier or resource affected another, supported both co-analysis with the community and the research team’s design reasoning. For example, if we consider disability-centered HCI, mapping could highlight how access to assistive technology can enhance employment and independence (fertile functioning), while inaccessible transit undermines both (corrosive disadvantage). In rural healthcare contexts, improved connectivity might enable telemedicine and reduce isolation, but financial precarity could still block access to consistent care. Finally, using these mappings in design requires combining different methods. Explicitly combining Participatory Design’s community-driven priority and CSD’s normative framing in CSD-Cascade enabled us to situate technology design within broader systems of social determinants. For researchers, this means designing not only for immediate functionality but also for the effects technologies may generate across interconnected aspects of well-being. For instance, a digital employment tool for newcomers should not only match job listings but also surface related enablers, such as childcare or transportation resources, that are necessary for job access.

By framing design conversations around both disadvantages and functionings, we see how one capability (e.g., access to education)

depends on others (e.g., reliable transportation, mental health support), and how improving one can unlock gains in several others. This iterative reasoning process allowed us to identify leverage points—places where small design changes or policy shifts could produce outsized benefits—that would have remained hidden under traditional CSD or other design frameworks. Our findings suggest that extending CSD in this way is not just a conceptual exercise, but a practical necessity when working in contexts where multiple, interdependent barriers shape technology use. This approach may help future HCI work move beyond isolated interventions and toward designs that meaningfully shift the conditions that sustain inequity.

In CSD-Cascade, many of the capabilities were initially expressed through content, such as articles, events, and suggestions tagged to specific capabilities. However, to go beyond that and truly aid the community with “managing the big picture”, we designed functionalities like the goal planner, category-based search, and contextual prompts to scaffold user action toward improving those capabilities. For example, the “Plan” feature not only lists goals related to ‘Have Good Physical Health’ but also supports users in selecting relevant actions, scheduling them and tracking completion. In practice, these goals were not only able to meet the user’s capability needs, but exhibit the same cascading effects theorized in empirical findings. However, we recognize that not all capabilities were equally integrated into the interactive functionalities of the application. While capabilities such as ‘Find meaningful work’ and ‘Play and explore’ were covered by application features (i.e. the “Plan” feature), ‘Have social connections’ and ‘Maintain home country connection’ were expressed primarily through the app’s content, enabling newcomers to make social connections through local events and digital groups. Beyond content, integrated features such as virtual “speed-friending” or more direct lines of communication with organizations could expand newcomers’ capability to have these connections; these were explored in our design process, however were deemed infeasible due to the lack of organization bandwidth to host such events or support multilingual content moderation. This opens a space for further work to ensure that capability-based frameworks are not only represented in content curation, but also embodied in the core features and user pathways of the app.

6.3 CSD-Cascade as an End-to-end Methodology

Many works employing participatory methods with marginalized or equity-deserving groups tend to derive design [4, 15, 37, 57] or engagement [25] recommendations based on either empirical (e.g., co-design) or technical (e.g., field evaluation) investigations [56]. In CSD-Cascade, we instead cover the entire process of the design, development and evaluation cycle, from capability board-supported interviews to field deployment. This end-to-end application of CSD enables design requirements to be iteratively re-defined to align with the community’s core values (e.g., how they prioritize capabilities) and evaluation metrics (i.e., what does it mean for their capabilities to have been improved). If a technical comparison between an existing app and app developed through CSD-Cascade were to take place, additional community engagement (e.g., interviews) must take place to account for unique features and construct a mapping

between the existing app's features and capabilities of interest to the community. In this way, CSD-Cascade as a design methodology provides a feasible direction for improving PD, which has been criticized by Harrington et al. [27] to be adopting "corporate" design thinking with equity-deserving groups through the decentering of community interests. Rather than applying a particular evaluation metric or benchmark in a technological study, CSD-Cascade as an end-to-end methodology uses community-defined metrics of capability priorities, gaps, and inter-dependencies surfaced through empirical investigations to evaluate effectiveness of technological solutions.

Many Canadian provinces have invested in "digital frontdoor" apps that help newcomers navigate their new life in Alberta (e.g., "Welcome to Alberta"), Saskatchewan ("Welcome to Saskatchewan"), BC and Manitoba (e.g., "Arrival Advisor") and Ontario ("ArriveON"). These digital frontdoor apps typically provide educational or informational materials and a customized checklist of services to visit and things to do based on an initial questionnaire. The purpose of this paper is not to focus on benchmarking against existing newcomer tools, but to introduce a new capability-based framework for designing newcomer technology. Although one can use general benchmarking metrics (e.g., number of services visited by newcomers) to compare newcomer tools, as already mentioned, the CSD-Cascade perspective advocates for the use of community-derived metrics (e.g., the extent to which the highest priority capabilities are addressed). Our recommendation is that future work focusing on benchmarking should use both general and community-derived metrics for comparing solutions with equity-deserving groups.

7 Conclusion

This work extends Capability Sensitive Design by the creation of a framework, CSD-Cascade, to provide both a structured workflow and extend capability characteristics previously discussed in theory. By explicitly incorporating the concepts of corrosive disadvantages and fertile functionings as characteristics surfaced by empirical and technical investigations, we were able to better account for the inter-dependencies between capabilities found within marginalized communities. Through our collaboration with newcomers in the creation of the Newcomer App, we showed how CSD-Cascade surfaces systemic leverage points and concretizes design requirements to help HCI practitioners apply CSD to design for community health and well-being technologies. Designing for marginalized communities means designing for systems, not just individuals—by tracing how capabilities interact and addressing them in practice, we can create technologies that not only meet needs but go beyond and enhance their functioning.

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