Pers Ubiquit Comput (2011) 15:565–573
DOI 10.1007/s00779-010-0341-5

ORIGINAL ARTICLE

Designing ubiquitous information systems for a community of homeless young people: precaution and a way forward

Jill Palzkill Woelfer · David G. Hendry

Received: 10 March 2010 / Accepted: 16 July 2010 / Published online: 7 December 2010

Abstract Drawing upon and distinguishing themselves from domestic, public, work, and natural settings, homeless communities offer new cultural frontiers into which ubiquitous computing could diffuse. We report on one such frontier, a community of homeless young people, located in Seattle, WA, seeking both to foresee the consequences of pervasive access to digital media and communications and to prepare for its seemingly inevitable uptake. The community consists of hundreds of young people living without stable housing, often in the public, and an alliance of nine service agencies that seek to stabilize youth and equip them to escape homelessness. We examine the opportunities for ubiquitous computing in this community by, in part, developing a precautionary stance on intervention. This stance is then used to critically examine a scenario in which information about the service agencies is made public. From this scenario, and a description of the social and material constraints of this community, we argue that "precaution" offers productive counsel on decisions on whether and how to intervene with ubiquitous computing. A precautionary point of view is especially important as ubiquitous computing diffuses into communities that, by their social and material conditions, are vulnerable. In such communities, the active avoidance of harms and plans for their mitigation is particularly important.

J. P. Woelfer (✉) · D. G. Hendry
The Information School, University of Washington,
Seattle, WA 98195-2840, USA
e-mail: woelfj@u.washington.edu

D. G. Hendry
e-mail: dhendry@u.washington.edu

Keywords Homelessness · Poverty · Youth · Community informatics · Non-profit service agencies · Precautionary principle · Designer value · Value Sensitive Design · Value scenario · Envisioning

1 Introduction

The field of ubiquitous computing, broadly construed, has developed great "know-how" for augmenting human bodies and physical spaces with computational capacities [1]. For evidence, enter any café near the University of Washington, Seattle, and you will see students, professionals, and people of all kinds engaged with digital devices. People move their fingers across their cell phones, talk, smile, and gesture, as if their caller were physically present. At shared tables, people often take out their phones to mark spaces or cluster around power outlets, typing fast into their laptop computers. Bodies are sometimes augmented with headsets for audio and voice, reminiscent of the space age. Ears can flaunt blinking electronics, which, once detected, offer an explanation for those who are, on closer inspection, not simply talking to themselves. Large-sized displays can provide patrons with additional information about each other, prompting conversations, either in-person or online, promising additional means for socialization [11]. Through personal digital devices, many people in the United States have come to reflect something of the cyborg ideal [14], if not the original, particular vision for ubiquitous computing [3].

At the same time, tucked into the corners of this eight-block neighborhood is a community of homeless young people, aged 13–25, living in public view on the streets, together with an alliance of nine service agencies that assist young people with basic needs, health care, advocacy, and

education. Like most adolescents and emerging adults in the United States, we have found homeless young people in this community to be keenly interested in personal digital devices and digital media. Unlike the people in the cafés, however, access to digital media is not immediate. Rather, it requires planned visits to public libraries, service agencies, or perhaps a friend's apartment where a computer can be borrowed. At such sites, access time is often limited, typically must be scheduled, and is subject to various kinds of oversight.

Since 2007, we have engaged this community in research, design, and service, with a twofold question. First, what is the meaning and experience of personal digital devices, digital media, and, generally, information systems by homeless young people? Second, how might information systems be designed to improve the welfare of homeless young people, to enfranchise young people with ordinary experiences with information and to help young people escape homelessness?

To address these questions, we have collaborated with a service agency to create and run a community technology center for homeless young people, where over 80 young people have participated in classes since February 2009, and we have investigated the use of digital and non-digital information systems in this community [28, 29]. In one study of information use [28], we found that fliers, brochures from governmental agencies, and paper handouts of all kinds are pervasive within the alliance of service agencies. They are readily available within drop-in spaces, where young people might eat and attend to other basic needs, relax, socialize, or talk with a case manager. We observed, furthermore, that paper materials are frequently used, in part, to construct places for information sharing and conversation around collapsible card tables, in front of slat walls and bulletin boards, and in the entrance ways of service agencies. In turn, these places are used by service agency staff and volunteers to interact with homeless young people. Fliers and other paper materials seem to be used to trigger and mediate conversations between homeless young people and agency staff or volunteers. Paper materials, in addition, can be taken away, brought back to re-establish a conversation, shared with peers on the street, and so forth. These ordinary, subtle places seem very important for initiating trusting relationships between young people and adults, an essential step toward escaping homelessness. By analogy to the use of ubiquitous computing in cafés, we asked the following: What purposes, if any, do smart phones, large-sized displays, laptops, along with pervasive wireless access to information, come to play in such places?

In the coming years, digital infrastructure and applications will surely expand and deepen their presence in this community. Already, for example, the local government has made wi-fi access, albeit sometimes spotty and slow, freely available to all; though, at present, it is rare to see homeless people with laptops in public settings. Newspaper reporting of other homeless communities in the USA, however, has described the importance given to laptops and the know-how that develops for extracting power and wireless access from urban infrastructure [9]. Nevertheless, based on information obtained at the community technology center, we know that young people frequently use digital media but typically lack immediate, discretionary access to the necessary technology. Service agencies, on the other hand, while ambivalent on the benefits of social media for young people, believe that access and skills for digital technology will be useful for escaping homelessness. Still, to be seen as relevant by homeless young people, service agencies also need to develop a social presence in digital media. Accordingly, several of the service agencies have profiles on MySpace and Facebook, with hundreds of links established by young people, along with separate Web sites that contain program-related information. In any case, the evident norms of many in this neighborhood, as seen in cafés, imply that access to digital experience is ever-present, straightforward, and ordinary. Why should not this be the case for homeless young people and the staff and volunteers at the service agencies?

As inexpensive devices, perhaps found, second-hand, or stolen, and the necessary infrastructure become readily available, a key question arises: *how should this community take on ubiquitous access to information for improving the welfare and quality of life of homeless young people*? In this paper, we take up this question from a precautionary design stance: a point of view characterized by concern for our ignorance of present conditions, caution in our ability to foresee contingent futures, and circumspection. Through this perspective and by the analysis of a *value scenario* [19], in which we attempt to foresee the systemic effects of making particular kinds of information pervasive, we reveal some of the characteristics of this community. Specifically, we shall examine how the values of this community might be perturbed or displaced by pervasive access to information about the operating hours and locations of service agencies. Thus, counter to the general goals of this journal, we discuss a particular purpose to which ubiquitous computing ought not to, at present, be applied. In doing so, we unveil some of the unique characteristics of this frontier for ubiquitous computing, a frontier that, as we shall see, appears to share the same basic "identifying features" as ICTD research [7], but, also, substantial differences. On the other hand, in the affirmative, we also show that a precautionary stance, as a designer value, might be generally efficacious for the creation and critique of everyday technology. Addressing the need for understanding the actual uses and meanings of ubiquitous

computing [3], we show that "precaution" can help create an alternative "proximate future" for ubiquitous computing.

2 Community of homeless young people

The community we have engaged since 2007 is located in the University District [24], in urban Seattle, near the University of Washington, a large public university with approximately 35,000 students. While reliable population statistics do not exist, it is believed that hundreds, not thousands, of homeless young people visit the neighborhood for extended periods of time each year. It is thought that homeless young people come to the neighborhood to separate themselves from adult homeless populations located elsewhere in Seattle, to readily mix in with the student population, people of similar age, and to take advantage of an alliance of service agencies that offer food, shelter, health care, respite from the street, and services for transitioning out of homelessness. All who approach a service agency are treated with dignity and respect, and service agencies will work with a young person for months and years to get him or her off the streets.

We have reported in some detail on the elements of this community, especially the relationship between young people and service agencies, elsewhere [28, 29]. Here, we introduce some of the major social and material considerations, germane to the value scenario presented below. To make sense of this community as a setting for information system design, we have developed a provisional framework of the major ecological considerations (Fig. 1). The framework, subject to change as we learn more, is based primarily on our reading of the literature on homeless young people [2, 10, 20, 27] and our reflections arising from working in the community technology center [29]. The framework distinguishes between three broad categories of forces. The first concerns societal expectations about the diffusion of technology (A), which follows from the anticipated trajectory of ubiquitous computing [3]. The second (B) concerns "life" on the street for homeless young people, characterized by a certain kind of *freedom* to pursue one's own interests but under conditions of *vulnerability* and an ever-present focus on *basic needs*. The third category (C) concerns "work" in service agencies, where young people are invited and supported to orient themselves toward *conforming* to civil expectations, developing *resiliency* through positive relationships with adults, and to envision a positive future by *goal setting*. This category is called "work" because to learn these elements and other basic life skills requires a very substantial amount of effort for most young people, due to neglectful or abusive developmental backgrounds, often

A. Societal Expectations	A1. The network and data cloud are readily available to all at any time (*Infrastructure*) A2. All members of society own personal digital technology (*Access*) A3. Quality of life will increase with digital systems use (*Use*)	***B. Life on the Street*** B1. Desire for freedom (Self-*Reliance*) B2. Susceptible to harm (*Vulnerability*) B3. Focus on the present (*Basic Needs*) ***C. Work in Service Programs*** C1. Mainstream orientation (*Conformity*) C2. Youth-adult relationships (*Resiliency*) C3. Envisioning a positive future (*Goals*)

Fig. 1 Provisional framework of ecological considerations

growing up in poverty and often enduring broken familial structures and inadequate remediation from social and government services.

Within this ternary structure, many tensions, constraints, and opportunities arise for any design project or intervention. For the deployment of ubiquitous technologies, two particularly relevant ones follow. First, young people, in general, do not have *reliable* digital devices and service plans, and access to power and wireless access in the urban infrastructure can be difficult to obtain. Similar to the challenges of "natural places" for ubicomp [4], the street presents youth with variable lighting and thermal conditions, which can cause significant situational impediments such as glare and cold, stiff fingers. With perhaps only a backpack for storing one's possessions, it can be difficult to keep digital devices safe, even relatively simple, non-fragile devices such as thumb drives. Young people, furthermore, may be compelled to sell or to pawn digital devices to satisfy immediate, basic needs. That said, homeless young people are resourceful, making use of older or discarded phones, finding places to obtain power for charging batteries, finding free wireless access points, gaining access to computers at libraries, and so on. This ability to be resourceful and adapt to whatever technology is at hand is enabled by the existence of the "data cloud." Centralized servers and reliable access to information are particularly beneficial to people who are highly mobile.

Second, the distinction between "life" and "work" suggests that the purposes to which computer technology is put might be quite different. For instance, like most young people and emerging adults in the USA [6, 22], homeless young people seek opportunities to socialize online with friends and to experience digital media. At the same time, the alliance of service agencies, in a sense, takes on a role normally held by parents or close relatives. Like a parent who is responsible for his or her child, staff at service agencies take responsibility for homeless young people, seeking to improve their welfare and equip them to be independent, productive citizens off the streets. Service

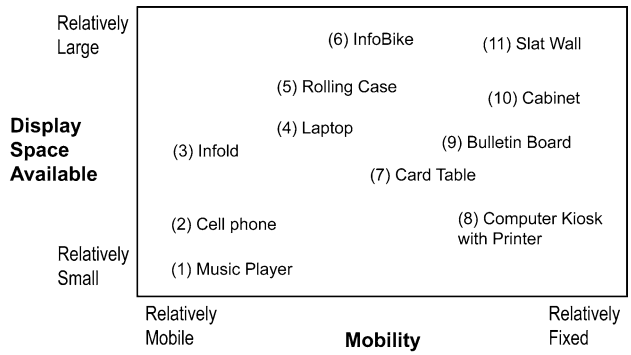

Fig. 2 Design space of digital and non-digital information systems, real and envisioned, in the community of homeless young people

agencies, therefore, are particularly interested in promoting the use of computers for developing skills that position young people to escape homelessness and, like many parents, frown upon young people's use of social networking sites which they see as a means for reinforcing street identities not as tools for increasing young people's skills for digital technologies.

Complementing this framework of ecological considerations that arise from social and developmental sources is an analysis of information artifacts and systems that exist in this community. Figure 2 maps some of these digital and non-digital artifacts by rough assessments of mobility and display size. These artifacts are not like a personal computer or docking station, fixed in an office, or a media center at home. Rather, these are artifacts that are visible and used in public or semi-public settings often broken down, packed away, to be set up later. They give homeless young people access to information and reconstitute, at least to some degree, a place within which they may communicate. Times and locations of free meal services, for example, when accessed and presented on a cell phone and shared between two young people on a street corner might prompt discussion about attending a drop-in after dinner.

Four of the systems are commonly used by the service agencies: folding card tables (7), filing cabinets (10), bulletin boards (9), and slat wall (11). Other systems are envisioned: the infold (3), a passport-sized organizer for service agency materials, with paper inserts standing in for larger-sized brochures; the rolling case (5), containing brochures, folders, and other materials, organized to standardize the presentation of information, and easily moved by service agency staff from place to place; the InfoBike (6), an adult-sized, industrial tricycle equipped with information and an Internet access point, which can be ridden to places where youth hang out, to provide information and outreach; and the computer kiosk (8), a small-sized display, fixed in an outdoor location, perhaps with an attached printer.

We have used this space of artifacts to explore how different kinds of information systems might be used by the service agencies in a coherent, integrated fashion, extending existing systems through standardization and leading to greater integration, reuse of materials, and a more consistent "brand." Envisioning analogs, constructed from digital materials and infrastructure, lead to, for example, deploying the brochures through cell phones, replacing slat walls and folding tables with large-sized displays, making brochures more dynamic, with content tailored to individual's needs, and so forth. Would any of this, however, improve the welfare of young people or be instrumental for helping them to escape homelessness?

3 Interlude: the methodological orientation

We have presented the research site as a *frontier* in which various social and technological elements mix together, providing many opportunities for intervention. Here, we pause, first, to briefly introduce the framework that has guided this work and, second, to present the specific problem that we take up below.

Value Sensitive Design has provided the theoretical and methodological approach for our ongoing inquiry of this community of homeless young people. Under development for over two decades [5, 13, 19], the approach counsels designers of technology to identify and account for human values in a principled and comprehensive manner during design processes. As an interactional theory, values are viewed as neither being determined solely by technology nor solely by social systems, but in combination. The approach orients the designer toward being cognizant of value-related concerns, rather than operational improvement alone, providing a methodological bridge between problem-solving-first and values-first approaches [7]. It stresses the consideration of *indirect stakeholders*, those people who do not directly use a system but are affected by its use, and the consideration of value tensions that can arise among stakeholder groups. Finally, Value Sensitive Design employs a tripartite methodology in which conceptual, empirical, and technical investigations are applied integratively and iteratively throughout a design process.

Value scenarios, one of many specific methods that have been developed within Value Sensitive Design, provide a method for envisioning the systemic, long-term effects of a technological intervention [19]. Value scenarios extend the typical application of scenario-based design, which gives emphasis to functionality and immediate use, to focus on four criteria: multiple stakeholders, time, values, and pervasiveness. These "envisioning criteria" lead the designer, for example, to identify non-targeted uses of systems by malicious stakeholders, to consider technological trends

5 years hence, to consider values to be represented in the system and values that are implicated through the design of the system, to consider the wide-scale, pervasive adoption of a proposed technology, and so forth. These four criteria, in short, direct the designer toward particular kinds of explications in a scenario's narrative.

In the next section, we use a value scenario to examine one kind of intervention. We pursued this conceptual investigation prior to deciding on possible empirical investigations. The objective is to further describe and give interpretation of the community of homeless young people and, at the same time, to present a problem where ubiquitous computing could be readily applied but is probably unwarranted at the present time.

4 A value scenario: the service agency flier

We now examine a particular case in which a piece of information—the *service agency flier*—is made into a ubiquitous digital resource. For this analysis, we leave aside the question of who would actually design and implement a working solution. In fact, a church, the city government, an alliance of service providers, among other stakeholder coalitions could implement solutions to the problem that we now discuss.

Of approximately 250 different brochures, fliers, and paper handouts that were collected at four service agencies, the service agency flier was identified as the most important [28]. As evidence, we found that at least one stack of 20–50 of these fliers was prominently displayed at each of the service agencies. The flier is not disseminated to the general public; instead, it is available only within the service agencies, where it can be handed out by staff members or picked up by young people.

Measuring 3.8 inches by 8.5 inches, the flier is nondescript, having no title, affiliation, date, or version. Yet, this mundane slip of paper gives the only comprehensive overview of the locations, opening times, and services offered at all nine service agencies. As a boundary object [21], it reveals in one comprehensive document how the service agencies coordinate their opening times so that much of the day is covered by at least one of the agencies. On one side of the flier is a map of the neighborhood, with the service agencies marked by letter. On the other side is the list of service agencies and index for decoding the map of locations, together with a detailed weekly schedule with hours of the service agency programs, telephone numbers, and brief descriptions. The information presented in the flier is very complex because the service agencies are open at different places and at different times throughout the week, and because the information covers both the front and back of the flier, resulting in a small document with high information density. The flier reminded us of a difficult to understand bus schedule, with many opportunities for improved usability. Given its importance and given the spectrum of reading abilities among homeless youth, we reasoned that usability improvements would be quite impactful. With an improved visual design, moreover, the flier could also be used to better "brand" the service agencies as being different but related within the overall alliance.

At the same time, we also thought that the flier would make an ideal candidate for pervasive online presentation. We envisioned making usability improvements, placing the schedule and map online, making it accessible by smart phones and Web browsers, while also creating a high-quality printable version. In addition, we envisioned that the flier could be disseminated by placing links to it on community resource pages for the neighborhood, accessible from sturdy outdoor kiosks, located at key bus stops in the neighborhood and other places where young people congregate.

Yet, if the flier were turned into a pervasive digital resource, what would likely happen? On the one hand, for young people newly arrived in Seattle, without friends or a place to stay, the pervasive digital presentation of the flier, as outlined in the previous paragraph, might be beneficial. A public kiosk, designed to be attractive to young people, might allow young people to more readily learn of the alliance of service agencies, their locations, and opening times. For young people already knowledgeable about the alliance, a digital service flier might give convenient access to such information. In a different vein, the digital resource might represent a normalizing sign, creating interest and demand for access to such information. On the other hand, such an approach would change the flier from a semi-private, confidential resource into freely available public information. "Public" because, once online, physical barriers to its access disappear—one does not need to enter into a service agency and talk to someone. This enhanced visibility adds new aspects to three existing issues in connection with information resources related to the alliance of service agencies.

First, with the schedule and locations of the service agencies readily accessible, young people's safety could be compromised because abusive parents, pimps, and drug dealers would be able to more easily locate and come looking for young people—a dark example, indeed, where one must bring into account direct stakeholders in non-targeted roles [19]. Second, it could also bring unwanted attention to the alliance from business and home owners in the neighborhood, with these stakeholders asking, for example, "Are the service agencies attracting these homeless drifters and making it easier for them to stay in my neighborhood?" Alternatively, the enhanced visibility might attract more community goodwill, financial support, and volunteers. Third, while the digital flier would offer a

degree of convenience to those young people with personal digital devices, it might also reduce the communication between service agencies and young people. That is, when information about locations and opening times of service agencies is pervasive, young people are less dependent upon staff and volunteers of service agencies for this basic information. In business, this would normally be an economically desirable outcome for reducing transaction costs; however, for homeless young people, who are generally distrustful of adults, it is desirable to *increase* the opportunities for interpersonal communication with caring adults [27].

This analysis shows potential positive and negative consequences of making the flier pervasive. However, if we appreciate the flier for what it is, we can see that, in its current paper form, it strikes a balance between conflicting purposes. On the one hand, it is desirable to veil the service agencies and keep young people from the scrutiny of abusive parents, business owners, and others; on the other hand, it is desirable, quite obviously, that homeless young people know of and can locate the service agencies. The paper flier strikes a very good balance: It is available only within service agencies but can be easily passed around and referred to. In a different vein, it is also relatively easy to make updates and replace the supplies of fliers in the service agencies. In fact, this kind of balance may be critical to the vitality of the service agencies in the alliance, allowing it to survive and operate with limited resources so it can engage its raison d'être: care for young homeless people.

5 Discussion

The description of the community of homeless young people and the analysis of the value scenario illuminates a particular site of ubiquitous computing with distinguishing characteristics. First, homelessness in this setting is a kind of "frontier" in that distinct perspectives—nature, urban, domestic, public, work—run up against each other. Like most natural and many rural settings [4], a homeless young person living mostly out of doors, albeit in an urban setting, is likely to have difficulty finding electricity and wireless access and is exposed and firmly coupled to the daily and seasonal rhythms of nature. This urban setting, however, has an abundance of digital infrastructure, made visible by public displays of technological use. Yet, homeless young people are often unable to afford access. And, they are unable to own a lot of stuff, perhaps limited by what they can carry. Moreover, what they do own seems to frequently change, as they find, sell, pawn, and trade possessions to satisfy basic needs and create goodwill on the street, a topic that we are currently investigating. In a different vein, using email or social networking sites to stay in touch with family and friends and similar private uses of technology must often be conducted in public or semi-public places, or at least not in intimate, personal places such as an office or dining room table.

Second, the account of this community is given focus in large part by the alliance of service agencies. Staff and volunteers take on a duty to improve the welfare of homeless young people, with responsibilities similar to those of parents [28, 29]. Service agencies seek to develop caring relationships with youth, which are the basis for stabilizing young people and helping them escape homelessness; young people can win or lose privileges based on behavior in drop-in; and young people seek advice from service agencies and assistance with life skills. Analogous to all families [16], as new communication technology and digital media become available, choices need to be made concerning their adoption and use. Thus, service agencies seek to position technology in ways that may be in tension with young people's own desires.

How do the locales of ICTD research compare with this community of homeless young people? We can begin to address this question by using four identifying features of ICTD research [7]. First, as ICTD is concerned with positive socioeconomic change, so too this work is concerned with helping young people move into the mainstream. However, this work takes place in a pocket of poverty within an economically prosperous society. Second, as ICTD research often places the researcher in the position of outsider—politically, culturally, and ecologically—we have found ourselves to be outsiders. Developing trusting relationships with insiders and learning the basics of homeless youth culture have taken years. This is despite the fact that we live and work in the exact same neighborhood. Third, as ICTD research involves both studies of interaction between people and technology and interventions, we too have sought to address this tension with, at present, more of a focus on developing an understanding. That said, our orientation is long term, which is made easier because of proximity to the community. Finally, as ICTD research is richly interdisciplinary, we too have encountered a wide variety of perspectives—including political, activist, and practitioner centered—that bear on homeless young people. So, while the geographic location and specific intersection of factors—youth, poverty, inadequate social support but within an alliance of caring service agencies—are distinguishing characteristics, this site appears to hold many commonalities with ICTD research.

Designers, no matter the locale of their work, are not impartial. They bring their own values, tenets, and inclinations to the design process. It therefore can be useful for designers to explicitly state their own values, as well as those of their stakeholders, and bring them into account during design [12]. Indeed, Value Sensitive Design has

made sharp distinctions between *explicitly supported values*, those that are required to be supported by the system; *stakeholder values*, those held by different stakeholders (not all stakeholders of course will hold the same values); and *designer values*, those values that are held, or preferred, by designers of a system [5]. Consequently, as we began to appreciate the complexity of this setting and to develop trust with our collaborators, we recognized a need and preference to proceed with care.

Accordingly, we have sought to develop an explicit perspective to guide thinking and action in this community of homeless young people. We refer to this perspective as a precautionary design stance, by which we mean an orientation toward action, subject to a thorough analysis of an intervention's harms and benefits to avoid adverse consequences, stakeholder engagement, a favorable assessment of its economic and social sustainability, and a general humility and concern about technological interventions. Several factors have motivated this design perspective. The first is that homeless young people are vulnerable. Poor nutrition, living without adequate shelter, and limited health care increase the risk of illness. Keeping personal items safe is very difficult—a backpack, holding all that a young person owns, can be stolen during a moment's worth of inattention. And, living on the street makes young people susceptible to encounters with drug dealers, pimps, and others who seek to exploit young people for economic advantage. At the same time, while focusing on the welfare of young people, the service agencies also operate under conditions of low and uncertain funding levels and rely upon volunteers and the goodwill of the larger community. Their orientation, furthermore, is long term—they will work for years to stabilize a young person and help him or her escape homelessness. In addition, our collaborators also spoke of negative experiences with researchers who entered the community, seemed to treat it as an exotic culture, and left without enhancing the capacity of the community to care for the welfare of young people. Thus, in this context, it seemed particularly important to guard against short-lived interventions, with marginal positive impacts. In short, we came to accept the duty of this prudent, ancient aphorism: Do no harm.

We recognized that information systems could be introduced into this community for many different purposes—to improve access to information, to educate young people, to improve operations reporting, and so on. For example, undergraduate computer science students at the local university could develop an application that made the service flyer a pervasive digital resource throughout the University District. Or, a library might provide a social media application, targeted to mobile devices, specifically designed so that youth could meet caring adults and socialize around shared interests in music. Or, in a subversive direction, we could help young people develop a "spot a cop" application which would allow youth to improve their situational awareness in the neighborhood. Thus, a second motivating factor became Norbert Wiener's distinction between "know-how," the skills and knowledge to create new things, and "know-what," which he discussed as the *quality* "by which we determine not only how to accomplish our purposes, but what our purposes are to be" [26, p. 183]. Early in our investigation, we found many opportunities for systematizing the control and dissemination of information in the alliance of service providers and for improving the usability of the written materials. Simultaneously, we also came to appreciate that the systems already in place, which had emerged over many years, seemed to be resilient to low and uncertain funding levels and varying levels of volunteer commitment. By reflecting upon the difference between our know-how for information organization, document control, and usability, on the one hand, and the messy but evidently sustainable, long-term usefulness of the information system already in place, on the other hand, we became particularly cognizant of Wiener's imperative.

Finally, we considered the "precautionary principle," influential in environmental ethics and policy formation [23, 25]. While the principle has many different formulations, one definition is "when an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically" [17, p. 871]. The principle has emerged to avoid or mitigate catastrophes, such as nuclear war, environmental collapse, and so forth. Still, it seems to offer an evaluative point of view useful for technological interventions. In short, it mandates thoroughness, a focus on future contingencies, and public involvement in scientific-technological discussion.

Objections have been raised against the precautionary principle, which might also be applied to our notion of precautionary design. In particular, it has been characterized, in serious scholarship, as the "paralyzing principle" because it does not provide guidance on how to act and leads to inaction, which might be worse that action [23]. Precaution, moreover, can have negative connotations, of stasis, problem avoidance or deferment, even disengagement. In contrast, we choose to draw from the precautionary principle the imperative to actively foresee future contingencies, to take actions now that can be useful as future contingencies unfold, and to accept the possibility that a thorough design process might lead one to conclude that inaction is the best way forward under present circumstances. This point of view, we believe, does lead to progress, though also debate.

Precaution is a designer value. Quite obviously, it is not a method. However, methods—such as value scenarios

[19], which structure envisioning work around such systemic effects as direct and indirect stakeholders, time, values, and pervasiveness—can provide concrete direction when working within a precautionary stance. We do not think, however, that value scenarios are in themselves inherently precautionary. Conceivably, conversely, one might use value scenarios to explore paths for triggering rapid, potentially destabilizing change.

From this stance of precaution, we have pursued specific steps that prepare the ground for understanding ubiquitous computing and its adoption in this community. For one example, the analysis of the service agency flier presented above provides a clear case where ubiquitous information access is likely to cause harm, against which other scenarios can be compared and analyzed, including other community-oriented scenarios [8]. Second, we have seeded the community with ideas and prototypes that can be taken up in the future. For example, we have developed video prototypes of the InfoBike and other tools for disseminating information to homeless young people [28]. To build interest and to create concrete working examples, during recent local elections we deployed an InfoBike with community information and informally explored how it could become a mobile place for civic engagement. Finally, and most importantly in light of the long-term nature of our engagement with homeless young people, we have created the community technology center. It provides a site for addressing the problem of access and teaching young people technological skills useful for escaping homelessness. At the same time, it provides a setting for engaging homeless young people and for learning about technology uses and desires in this community. We have identified specific questions that arise through service, in the role of volunteer instructors, and can be pursued in current and future research projects [29]. These and similar steps have allowed us to develop understanding for the community and to work toward interventions.

6 Conclusion

The diffusion of ubiquitous computing requires consumer demand, which, in turn, seems to require that consumers be convinced that improvements in quality of life will accrue through adoption. Thus, under this view, the advance of ubiquitous computing is part rhetorical, as design in general has been characterized [18]. In this paper, we have described an urban setting in which a marginalized group lives but without resources commonly held by others in this society. While consumer demand is clearly important, that is, young people seek media and social experiences by digital means, this desire is in tension with a frontier, holding limited resources, in which the natural and the urban, life and work, and the domestic and the public collide.

The value scenario and its analysis, within the social and material conditions that were discussed, showed that key information about the service agencies should probably not be turned into a ubiquitous resource because of the possible harms that could emerge in this community. Specifically, the value scenario together with a precautionary stance has enabled us to envision some systemic concerns that are raised by a relatively simple possible intervention. This envisioning work, in turn, has enabled us to gain insight into the merits of ubiquitous computing in this community. This current conclusion, of course, does not mean that ubiquitous computing has, in general, no role in this or similar neighborhoods. It does, however, provide a clear example that arises from a precautionary stance. That said, one designer's precaution is another's missed opportunity for development. For ubiquitous computing and homeless young people, this is the essential predicament to be engaged. It is a predicament, moreover, common to ICTD, and one that calls for a focus on "information," in digital and non-digital forms as we have here, rather than solely on the technology [15]. In this work, we have sought to resolve this predicament through service, research, and design at the community technology center. This center provides a hybridized venue for mutual understanding, among homeless young people, service agencies, and information system designers. At the same time, as personal digital technology and the accompanying infrastructure surely diffuse into this community in the years ahead, this venue provides a place for making sense of ubiquitous computing and for taking it on—a way forward, indeed.

Acknowledgments We thank the Washington State Community Technology Opportunity Program for funding the purchase of hardware for the community technology center. We thank Mike Crandall for alerting us to this state funding; our collaborators at Street Youth Ministries, especially all of the young people with whom we have learned so much; Batya Friedman, Alan Borning, Lisa Nathan, and members of the Value Sensitive Design Research Laboratory for creating a stimulating intellectual environment; and the Globi-Comp 2009 workshop participants and the reviewers for their insightful feedback on this work.

References

1. Abowd GD, Mynatt ED (2000) Chartering past, present and future research in ubiquitous computing. ACM Trans Comput Hum Interact 7:29–58
2. Barry PJ, Ensign J, Lippek SH (2002) Embracing street culture: fitting health care into the lives of street youth. J Transcult Nurs 13:145–152
3. Bell G, Dourish PY (2007) Yesterday's tomorrows: notes on ubiquitous computing's dominant vision. Pers Ubiquitous Comput 11:133–143

4. Bidwell NJ, Browning D (2010) Pursuing genius loci: interaction design and natural places. Pers Ubiquitous Comput 14:15–30
5. Borning A, Friedman B, Davis J, Lin P (2005) Informing public deliberation: value sensitive design of indicators for a large-scale urban simulation ESCW 2005 (18–22 September 2005), pp 449–468
6. boyd d (2008) Why youth (heart) social network sites: the role of networked publics in teenage social life. In: Youth, identity, and digital media, MIT Press, pp 119–142
7. Burrell J, Toyama K (2009) What constitutes good ICTD research? Inf Technol Int Dev 5(3):82–94
8. Carroll JM, Rosson MB (2008) Theorizing mobility in community networks. Int J Hum Comput Stud 66:944–962
9. Dvorak P (2009) On the street and on facebook: the homeless stay wired. Wall St J: A1
10. Ensign J, Bell M (2004) Illness experiences of homeless youth. Qual Health Res 14:1239–1254
11. Farnham SD, McCarthy JF, Patel Y, Ahuja S, Norman D, Hazlewood WR et al (2009) Measuring the impact of third place attachment on the adoption of a place-based community technology. In: Proceedings of CHI'09, pp 2153–2156
12. Flanagan M, Howe DC, Nissenbaum H (2005) Values at play: design tradeoffs in socially-oriented game design. In: Proceedings of CHI'05, pp 751–760
13. Friedman B, Kahn PHJ, Borning A (2006) Value sensitive design and information systems. In: Human-computer interaction in management information systems: foundations, M.E. Sharp, pp 348–372
14. Haraway D (1991) A cyborg manifesto: science, technology, and socialist-feminism in the late twentieth century. In: Simians, cyborgs and women: the reinvention of nature, pp 149–181
15. Heeks R (2002) i-development not e-development: special issue on ICTs and development. J Int Dev 14(1):1–11
16. Horst HA (2010) Families. In: Hanging out, messing around, and geeking out. MIT Press, Cambridge, pp 149–294
17. Kriebel D, Tichner J, Epstein P, Lemons J, Levins R, Loechler EL et al (2001) The precautionary principle in environmental science. Environ Health Perspect 109(9):871–875
18. Krippendorff K (2005) The semantic turn. CRC Press, Boca Raton
19. Nathan LP, Friedman B, Klasjna PV, Kane SK, Miller JK (2008) Envisioning systemic effects on persons and society throughout interactive system design. In: Proceedings of DIS '08, pp 1–10
20. Slesnick N, Glassman M, Garren R, Toviesse P, Bantchevska D, Dashora P (2008) How to open and sustain a drop-in center for homeless youth. Child Youth Serv Rev 30(7):727–734
21. Star SL (1989) The structure of ill-structured solutions: boundary objects and heterogeneous distributed problem solving. In: Readings in distributed artificial intelligence 3, Morgan Kaufmann, pp 37–55
22. Steinfield C, Ellison N, Lampe C (2008) Social capital, self-esteem, and use of online social network sites: a longitudinal analysis. J Appl Dev Psychol 29:434–445
23. Sunstein CR (2005) Laws of fear: beyond the precautionary principle. Cambridge University Press, Cambridge
24. University District, Seattle, Wikipedia: <http://en.wikipedia.org/wiki/University_District_Seattle>
25. Whiteside KH (2006) Precautionary politics: principle and practice in confronting environmental risk. MIT Press, Cambridge
26. Wiener NA (1950/1954) The human use of human beings. Da Capo Paperback
27. Wingert S, Higgitt N, Ristock J (2005) Voices from the margins: understanding street youth in Winnipeg. Can J Urban Res 14(1):54–80
28. Woelfer JP, Hendry DG (2009) Stabilizing homeless young people with information and place. J Am Soc Inf Sci Technol 60(11):2300–2312
29. Woelfer JP, Hendry DG (2010) Homeless young people's experiences with information systems: life and work in a community technology center. In: Proceedings of CHI'10, pp 1291–1300