"The Technology Garden"

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Abstract
We introduce the Technology Garden, a novel interactive environment to promote human-plant interaction. The Garden is a sensor-equipped garden in an office, supplemented by a software system to encourage social interaction. In a one week observational and interview study we found that participants were very positive about their experiences. Many said they wished to further explore how technology can mediate human-plant interactions.

Keywords
Ubiquitous computing, experience design, CSCW, sustainability

ACM Classification Keywords
H5.m. Information interfaces and presentation.

Introduction
The Technology Garden is a technology enriched community garden in a university office building created to invite interaction with both plants and people. Our goals in creating the Technology Garden were threefold: (1) to promote thinking about ecological sustainability; (2) to create a pleasing office environment promoting relaxation; and (3) to encourage social interaction in an organization.

Ecological sustainability is gaining much-deserved attention within the CHI community [1]. Sustainability is the ability to maintain processes or states indefinitely. Unfortunately, meeting the needs of the present without regards to the needs of the future has resulted in the adoption of a wide variety of practices

and pollutants that have wide ranging negative effects on our health and on the ecology of our planet.

The notion of *ecologically sustainable organizations* has taken root in the literature on organizations and management [6]. Methods for making sustainable organizations include environmental audits, technical responses based on the industry's core technologies, waste management, and product review with consumer input [12]. While prescriptions for sustainable organizations have focused on functional activities, such as changes associated with production or marketing, organizations are increasingly being called upon to embrace environmentally responsible values and behaviors and not just technical fixes [4, 13, 14]. Research has shown that the cultures within an organization can help or hinder the greening of an organization and that small symbolic events, such as managers publicly declaring their opinions about sustainability, can influence internal politics, as well as the adoption of "green culture"[4]. With regards to fostering a culture of sustainability within an organization, small actions can have large effects. Most approaches within HCI have traditionally focused on the means by which to create efficient, easy to use interfaces, and collaborative spaces. Newer trends such as experience design [2, 5, 8], affective computing [11], and emotional design [10] focus on stimulating emotion, fun, and beauty. Our research takes the latter point of view and embraces enjoyable uses of computing as a way to stimulate feeling and thinking.

Our research explores how technology can encourage relationship building or the building of a community of interest through common activities and to discover whether participants find the Technology Garden enjoyable and relaxing. Distinct from approaches that seek to minimize or remove the need for human intervention by automating plant care [7], we wish to draw attention to the needs of plants and to encourage human participation. Our approach shares the philosophy of the Botanicalls system [3] in promoting plant-human interaction and of the Telegarden [9] in promoting social interaction through collaborative gardening, but is also distinct from these other approaches in being place-based and in seeking to promote organizational sustainability.

The Technology Garden

In community gardens, fellow gardeners may lack opportunities to interact with each other unless they happen to be at the garden at the same time, usually after work or on weekends. The Technology Garden is available during work hours and provides supplemental methods of interaction and the ability to check on plants remotely. The Technology Garden is comprised of several components including the Garden room, plants, sensors, and a web-based application. We conducted a one week observational and interview study to see how participants responded to the Garden. Each participant was given a plant, attended an orientation, and completed a survey and interview. Participants could check on the status of their plant and other plants remotely through a computer application that reported the moisture level of the plants.

Garden Room

Shown in Figure 1, the Garden room has two large floor-to-ceiling windows. One window faces a busy hallway and the other faces outdoors. The room has a large plant stand and a sofa table for placing plants, a bar-height table with a monitor connected to a computer underneath, an ornamental solar fountain, a couch, and two armchairs.

Figure 1. Technology Garden Room (L), Plants with Tags (R)

The Plants

We provided plants for study participants to choose from. The three types of plants provided were Fatsia Japonica, Caladium, and Philodendron. These were chosen primarily because they are thirsty plants requiring frequent watering, thus stimulating more frequent changes in status. Each plant was provided with a name tag that was filled in by its owner after adoption and naming. One plant was designated the "Community Caladium" and was put in the collective care of all the study participants.

Sensors

Almost all commercially available soil moisture monitoring systems are designed for large-scale agricultural use. Therefore we developed our own simple soil moisture sensors comprised of metal probes, a simple circuit of our design, and off-the-shelf data acquisition devices (DAQs). By measuring the resistance between two probes embedded in soil, we were able to measure soil moisture content. We used AC current to avoid corrosion problems and enable us to achieve galvanic isolation to avoid cross current leaks between probes. We used the general purpose 555 timer in a standard oscillator configuration, where the resistance between the probes determines the frequency of the output of the timer. We then measure this output frequency with the DAQ to arrive at a measure of the soil moisture content.

Technology Garden Application

The Technology Garden's web-based application supports several tasks such as adopting a plant, creating a user/plant profile, accessing the profile of one's own plant and that of other gardeners, and a community blog. The website also acts as a mini social networking application. In order to befriend another plant, a request must be sent and the plant's owner must accept the request. A plant's friends are listed in its profile. An automated email service alerts gardeners when a friend request is received and when soil becomes very or extremely dry. Participants can also view the soil moisture level of any plant in the Garden to see if the plant's soil is extremely moist, very moist, moist, dry, very dry, or extremely dry. A Garden Status view depicts the temperature of the room and the soil moisture levels of all plants. Soil moisture conditions for a plant are depicted with an icon.

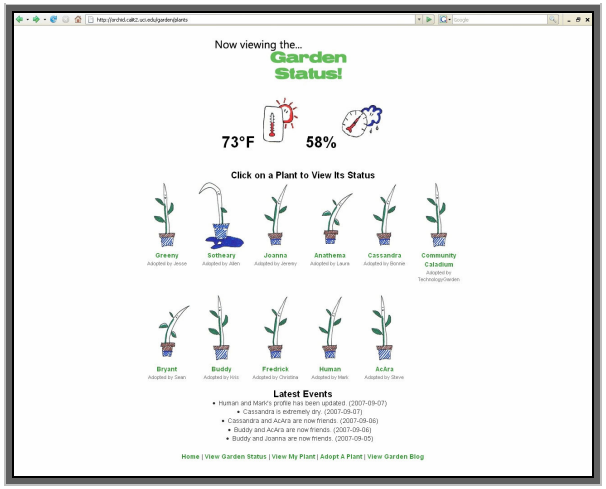

Figure 2. Garden Status View

The web-based application is composed of two separate programs: a Java application that interfaces with the

sensors and the DAQ, and a Ruby on Rails web application framework that interfaces with the database and the users. During specified time intervals, the Java program will read the room temperature and soil moisture readings from the various sensors and upload the data to the Ruby on Rails application. The Ruby on Rails application interprets the data, stores it in the database, and displays it to the users upon request.

Study

We conducted 50 hours of observations in the Technology Garden followed by a survey and 30 minute interviews at the close of the study. Ten participants (six males and four females) were solicited from university mailing lists and bulletin boards: three staff members, one graduate student, and six undergraduates. Five participants described themselves as having no prior experience caring for plants and five as having a lot of experience. At the beginning of the study, we held orientations to acquaint participants with the study, each other, and the Technology Garden itself. At the orientation, participants were asked to adopt and name one of ten provided plants.

Findings

As the plants did not require daily care, average time spent in the Garden was 6.3 minutes per day. Participants used the web application to check the soil moisture of their plants an average of 2.75 times per day. Participants checked the blog 0.82 times per day.

Participants found using the Technology Garden to be fun and enjoyable. Nine mentioned that using the Technology Garden was "fun" or mentioned specific elements that they found to be enjoyable, including being able to check on the status of all the gardeners' plants at once, being able to "friend" other plants in the fashion of social networking software, and having plants at work. One participant enjoyed decorating his plant with a doll and others thought that the technological aspect made plants "hip." Another participant said that some of the whimsical profiles of his fellow gardeners were "hilarious." One person named her plant Anathema and said in her profile: "Myself: intellectual rebel. ANATHEMA: Greek word which means 'a thing accursed'. I do not have high hopes for his survival."

In the survey, 100% of participants said they would like to continue to interact in the Technology Garden. Four showed their friends or coworkers the Technology Garden or the website. Several took photos of their plant to post to a blog or send to friends. Participants uniformly found the Technology Garden to be fun and enjoyable. Half the participants said that the Technology Garden room itself was relaxing, a finding that is in accordance with earlier research about the effect of plants in the workplace. One participant said, "Plants make me happy. They help me relax." One summer school student remarked, "I really liked it. It was different from outside, because outside there's a park and everything is very systematic and stuff like that, but in here it's kind of like your own room, with greenery. That's different from a lecture hall where everything is machines, technology driven. But here it's more natural, so you feel more comfortable. Or I feel more comfortable in here." Later he added, "Coming here is more soothing, it relaxes you. I feel like I actually have a summer coming here."

The Technology Garden encouraged interactions between humans and plants. As expected, all the participants watered their plants if the system told them their plant was dry and some participants watered their plants at other times also—such as before leaving for the weekend. Participants also cared for their plants by moving their plants to give them more or less direct sunlight. The sunlight demands of the

plants were listed on care tags from the nursery. Half the participants relied on that information or their previous knowledge. Three also looked up their plant on Wikipedia, and two others referred to plant books that were in the room. One participant mentioned learning about her plant by reading another plant's profile. Participants undertook creative ways to care for their plant. When asked what else he had done to care for his plant, one participant said, "I breathed on it. They like CO2 so I made a point of breathing on it." Another participant answered, "I played some music for it. Part of it was because I wanted to listen to music and part of it was I could go study somewhere else or I could just study in here and play my music and have the plant hear the music 'cause I've heard classical music is supposed to be good for plants, but I didn't have any classical music on my computer at the time so I played some kind of folk—easy listening—and I played some Turkish music." The variety of activities undertaken by participants suggests that the Technology Garden did indeed encourage interactions between humans and plants.

Three of the five participants with little plant experience said that they had become more interested in plants after having participated in the study, one noting that he was particularly interested in the link between plants and technology. One participant with high interest in plants said she had become more interested and that her interest had grown particularly with regards to the Technology Garden system. Two participants mentioned exploring how the system worked, for example learning how the soil moisture icons correlated to how the soil looked and felt and trying to determine how accurate they felt the sensors were. In the interview, four participants discussed blending technology and nature. One said, "Just the way technology has been embedded in nature. That was interesting. I never thought the two would collide, even though they do." Two said the sensors made them think about how sensors might help grow plants in the future. One participant became acquainted with the concept of sustainability because the word was used on the blog and he then researched the topic online.

We did not expect relationships to form in the course of this short study, although our research found signs of interest in building relationships and participating in a longer-term Technology Garden community. Two participants felt that by virtue of their participation they belonged to a "select group of people." Most wished that the study had been longer. One participant felt that the friending feature implied an obligation to keep an eye on their plant's friends. Four participants wanted more face to face time to meet other participants and suggested opportunities such as group watering events. One said, "More interaction would be nice. So if you're off on vacation… then you're like 'Oh, can you water the plant for me?'" Some participants wanted the web-based application to support more forms of interpersonal interaction, such as personal messages, guest books, or a community wall for public messages. There was also one communal plant. Three participants watered it. Two pulled dead leaves from it and two others checked on it and decided it needed no care.

Conclusion

The Technology Garden shows promise as an interactive hybrid of place, plants, and technology. In addition to providing a relaxing environment in the workplace, it stimulated an interest in plants among those with little experience cultivating plants. The addition of better sensors and more direct prompts related to ecology and sustainability in future system iterations would enhance the educational value of the system. Yet we want to keep the system simple and promote experiential, self-directed learning. Said one user, "I'm a biochemistry major and in bio you have to

memorize a lot of processes. This is more simple. I kind of think of the poet, Thoreau, and how he described the forest, how it's all very natural and simple and when I come here it's kind of the same thing." The Technology Garden allows remote awareness of plant condition, through the sensors and the web-based application—a feature that students and staff alike appreciated during busy days at work. At the same time, the Technology Garden stimulated a desire for more connection with fellow gardeners both online and face to face. Ultimately, the Garden can and should do more to foster relationships and encourage an organizational subculture surrounding plants and gardening and stimulate greater awareness of plants, natural processes, and green culture. We hope that further development of the Technology Garden can make a difference in organizational culture while also being fun, beautiful, and relaxing.

Sustainability is not a monolithic concept. The development of systems that directly reduce carbon emissions and chemical waste are a very important area of application within HCI. We must resist the urge, however, to oversimplify sustainability as being simply a game of chemical one-upmanship. Sustainability is fundamentally concerned with changing human values and culture. A whimsical approach need not preclude a serious shift in values and a lighthearted design need not preclude the heavy work of community building.

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