

Office window of the future?—Field-based analyses of a new use of a large display

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Abstract

We installed large plasma displays on the walls of seven inside offices of faculty and staff at a university, and displayed, as the default image, real-time HDTV views of the immediate outside scene. Then, utilizing a field-study methodology, data were collected over a 16-week period to explore the user experience with these large display windows. Through the triangulation of data—652 pages of interview transcripts, journal entries, and responses to email inquiries—results showed that users deeply appreciated many aspects of their experience. Benefits included a reported increase in users' connection to the wider social community, connection to the natural world, psychological wellbeing, and cognitive functioning. Users also integrated the large display window into their workplace practice. However, users expressed concerns particularly about the impacts on the privacy of people whose images were captured in the public place by the HDTV camera. Discussion focuses on design challenges for future investigations into related uses of large displays.

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1. Introduction

An ongoing challenge for organizations is to improve workplaces that are limited by their architectural structure. One important structural feature involves windows. For, on the one hand, windows are enjoyed by workers, and have been shown in certain contexts to reduce immediate and long-term stress and to promote physical and psychological health (Ulrich, 1984; Kahn, 1999). On the other hand, many buildings have been built with inside spaces (e.g., inside offices and basement facilities) where it is difficult if not impossible to provide workers with visual access to the outside environment.

The purpose of our research was to investigate whether it is viable—through a new use of large displays—to create a technological window to the outside world. Toward this end, we installed large plasma displays on the walls of seven inside offices of faculty and staff at a large university, and displayed real-time HDTV views of the local outside scene. In this paper, we report on the user experience with these large display windows.

To date, large displays have been used in interesting ways in organizational contexts. One type of use has sought to support co-located group collaboration. Typically, there is one large display visible to a co-located group of individuals who engage in face-to-face interactions and share a common goal or task. For example, studies have examined the use of shared displays for group meetings as whiteboard systems (e.g., Stefik et al., 1987; Mantei, 1988; Mandryk et al., 2002) and as electronic bulletin boards integrated with other applications (e.g., Greenberg and Rounding, 2001; Fass et al., 2002; Churchill et al., 2003; Huang et al., 2004).

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A second type of use of large displays has been to connect physically distributed individuals. As with the first use, people interact with one another to achieve a common goal or task, but here the interactions are mediated by the displays themselves. For example, some projects have linked common rooms in research organizations by video, such as the VideoWindow system at Bellcore (Fish et al., 1990), or the “virtual kitchen” project at Microsoft Research (Jancke et al., 2001). Other variations have involved “office-to-office” video connections on desktop systems (e.g., Mantei et al., 1991; Dourish and Bly, 1992; Gaver et al., 1992; Adler and Henderson, 1994; Tang and Rua, 1994; Dourish et al., 1996; Monk and Watts, 2000; van der Kleij et al., 2005).

A third type of use has been explored more tangentially, and that is to turn the camera and point it to the outside. For example, as part of the Portholes project which linked XeroxPARC in Palo Alto with EuroPARC in England, at least one of the cameras pointed to the outdoors. Dourish and Bly (1992) report: “Another late night worker at PARC was pleased to tell his local colleagues that he had watched the sun rise in England (over Parker’s Piece). Similarly, a EuroPARCer says she likes to ‘watch the day begin’ at PARC” (p. 545). More recently, in BlueSpace (Lai et al., 2002), a workspace prototype was equipped with multiple displays with the purpose of supporting workplace dynamics, and users could display web cams of outdoor settings on the large screens. Though limited to 30 min demonstrations of the display technology, Lai et al. (2002) state that BlueSpace has the potential to be a “window office” (p. 425).

In many of the above uses that involve capturing people’s images and displaying them in the course of enhancing group awareness, fundamental concerns arise around the value of privacy. For example, when Jancke et al. (2001) linked three kitchen areas within a workplace by means of video cameras and semi-public displays, they found roughly 20% of the individuals continued to voice concerns about privacy throughout the system’s deployment. Historically, a good deal of people’s privacy protections arose, because it was simply too much effort to collect and sort through relevant information about other individuals (Friedman and Kahn, 2003). But as digitized displays of visual information increasingly make it possible to garner and share large amounts of information within groups and organizations, increasing attention needs to be paid to the value of privacy (Hudson and Smith, 1996; Fuchs, 1999; Boyle et al., 2000; Jancke et al., 2001; Svensson et al., 2001; Tan and Czerwinski, 2003; Little et al., 2005; Price et al., 2005; Friedman et al., 2006a–c).

Our current research extends the above literature. Instead of webcams, we provided real-time access to video of the local outdoor scene, “as if” one had a real window looking out onto the nearby outdoors. Instead of a short 30 min demonstration, we installed the large display in workers’ actual offices for a 6-week period. And unlike the

single use of a large display to support co-located group interactions or to link two remote sites to support back-and-forth interactions among distributed participants, our use served primarily to provide a one-way view to the outdoors and, secondarily, as participants desired, to share work-related information among co-located individuals.

The real-time view shown on the large display was chosen based on research from environmental psychology. Kaplan and Kaplan (1989) have found that people tend to prefer natural environments more than built environments, and built environments with water, trees, and other vegetation more than built environments without such features (see also, e.g., Kaplan, 1973, 1977, 1983, 1987). In addition, low action waterscapes are “a highly prized element in the landscape” (Kaplan and Kaplan, 1989, p. 9), as are “savanna-like” landscapes that are open, yet defined, with “relatively smooth ground texture and trees that help define the depth of the scene” (p. 48). Accordingly, we chose a view that included the built environment (a public plaza and buildings in the background) and a large fountain, background deciduous trees, and an expanse of a grassy area (see Fig. 2). This view could be seen from many offices that had windows in the same building in which the participants of this study worked. Moreover, Kaplan and Kaplan (1989) found that an important feature of preferred landscapes embody what they call “mystery”—that one can acquire more information by venturing deeper into the scene and changing one’s vantage point. Such scenes include winding paths, meandering streams, and brightly lit areas partially obscured by some foliage. Accordingly, as best we could, we optimized the view along these lines such that visually one’s eyes could be drawn further along the grassy area.

We employed a field-study approach over a 16-week period (6 weeks with the large display window itself), triangulating multiple data sources: semi-structured interviews, journaling, email inquiries, mood surveys, and worker satisfaction surveys. Our research questions included the following: Does the large display window increase people’s satisfaction with their office environment? Is there a “novelty effect” such that over time (6 weeks) people tire of looking at the large display window? Or do benefits actually increase as comfort with the technology increases? How do people integrate the large display window into their displays of work-related information? Does the large display increase people’s awareness of other people and of the larger university community? Does the large display window increase people’s awareness of a sense of place and a sense of time? Do the natural aspects of the large display view (e.g., water, trees, and sky) contribute to a sense of physical and psychological well-being (Kahn et al., *in press*)? Finally, are people concerned about the installation’s possible impact on the privacy of indirect stakeholders (Friedman et al., 2006a, b)—those individuals who in the course of their regular business on the university campus pass through the scene and have their images displayed in an inside office?

2. Methods

2.1. Participants

Seven university employees with inside offices participated in this study: Nina (faculty, age 40–50); Barbara (faculty, age 45–55); Daniel (student services staff, age 25–35); Lara (student services staff, age 20–30); Brin (student services staff, age 25–35); Doug (faculty, age 35–45), and Sue (student services staff, age 20–30). Participants were part of the same university unit, co-located on two floors of a university building and aware of each others' participation in the study (pseudonyms are being used).

2.2. Large plasma display installation and research setting

We installed an HDTV camera on top of a university building (see Fig. 1, left) that over-looked a popular public plaza and fountain area on the campus. We ran cabling directly from the camera to participants' offices and displayed the real-time image of the fountain area on a 50" plasma display installed on the wall in each participant's inside office (see, for example, Fig. 1, right). Each participant determined where in his or her office the large display window would be installed. Participants could not change the camera (e.g., its direction, zoom, or focus). Apart from installing the large display, no other changes were made to the participants' office environments, work duties, or responsibilities. Participants could use the display to view the university plaza in real-time or switch the display to view output from their computers, including personal files and the Internet.

2.3. Data collection

The field study was completed during the span of 1 year, from February, 2003 to February, 2004. Utilizing a naturalistic field-study methodology (McGrath, 1995), data were collected with each participant over a 16-week period: 6 weeks with the inside office "as is," 6 weeks with the large display window and live video feed installation, and 4 weeks following the removal of the display window

with the office returned to its original state. Across the 16-week period, each participant completed seven 30–45 min semi-structured interviews which focused on the participant's (a) impressions and use of the large display window, (b) perceived effects of the real-time views of the outdoor scene, (c) awareness of people walking through the plaza area (the indirect stakeholders), (d) assessment of the importance of the large display window, (e) intuitions about work performance and health, (f) social interaction related to the large display window, and (g) experiences, reflections, and comments on any other related topics. Because we had only two displays, data collection for the seven participants was staggered (e.g., while one participant used the display, we began the "as is" data collection with another participant). In total, 30-plus hours of interviews were conducted with the seven participants and yielded 652 pages of interview transcripts. In addition, each participant completed 10 work satisfaction surveys, 10 mood surveys, 10 office perception surveys, journal entries, and responses to email queries.

2.4. Data analysis

To provide a robust account of the user experience, we triangulated data sources (Pelto and Pelto, 1978; Krathwohl, 1998) and conducted the following three types of overarching analyses: narratives, themes, and evaluations. These three complementary analyses rely on the same general body of data, each at a different level of granularity as described below.

Narratives: The narratives provide a cohesive telling of participants' experiences in the study, utilizing rich qualitative data. We drew on each participant's journal, email responses, and seven interviews to construct an integrative narrative describing that person's particular experience. Through the series of focused, semi-structured interviews, roughly the same set of questions was asked of each participant across a range of weeks. This format and the careful reading of text provided rich qualitative data that stands in contrast to less structured anecdotal reporting and interpretation. Generating the narratives involved reading all of the interview transcripts, journal entries, and email responses for a given participant. While



Fig. 1. HDTV Camera (circled) mounted on the roof of the university building (left). Brin at work in her office with the plasma display window (right).

reading, consistent ideas, issues, concerns, and cohesive features that carried across the data sources were documented. Analyses focused particularly on participant experiences that were consistent across time or experiences that showed a coherent evolution of change from one point in the study to another.

Themes: Toward a systematic and synthetic account of the user experience *across* participants, we drew on the seven interviews for each participant to develop a set of overarching themes. By theme we mean a recurring idea or concern, such as references to activities around the technology, sense of place, or ethical issues. The themes emerged from the data. Specifically, to develop the thematic coding scheme, two independent coders read all the interviews as well as each participant's journal and email responses for the presence of themes; disagreements during the coding scheme development phase were resolved through a consensus process. A theme was identified only if it was mentioned multiple times or discussed once but with a substantive, in-depth character. In addition, once a theme was identified, it was coded with a valence (positive, neutral, or negative) to reflect the participant's judgment about its content. After the thematic coding categories were finalized, all of the interviews were recoded by the two coders.

Evaluations: Based on each participant's seven interviews, we conducted a quantitative analysis for a subset of the standard questions contained in the interview. Questions included in this analysis conformed to a binary response (e.g., "yes/no"; "agree/disagree"; "recommend/do not recommend") or ranking ("What would you choose first...") format. For this analysis, only the participants' evaluation responses were analyzed. Two-sided binomial tests with a test proportion of $\theta = .5$ were performed to assess whether a statistically significant majority of participants provided the same answer to the question.

2.5. Coding and reliability

For the themes (content and valence) which required qualitative judgments about the presence or absence of the theme across an entire interview, as described above, all of the interviews for all of the participants were coded by two individuals trained in the finalized theme coding scheme. For evaluation questions (that were systematically asked in the semi-structured interviews) which required a simple binary or ranking judgment (e.g., "yes" or "no"), 14 interviews (30% of the data) randomly sampled from the full set of interviews were recoded by a second individual. Intercoder reliability was assessed through testing Cohen's kappa at the $\alpha = .05$ significance level. All tests were statistically significant. For content of themes, $k = .72$ ($Z = 42.36$); for valence of themes, $k = .86$ ($Z = 15.31$); for evaluations, $k = .86$ ($Z = 16.12$). Reliability for content of themes was established on the category level as reported in Table 1.

3. Findings

We report here on the three types of overarching analyses: narratives, themes, and evaluations.

3.1. Narratives

The narratives provide the reader with a sense of the complexity, depth, and diversity of user experience. Due to space limitations, we present here only three narratives, those of Nina, Barbara, and Daniel. We selected these three of the seven participants to profile as their narratives, taken together, represent a broad spectrum of experience with and reaction to the large display that accounts for much of the diversity of experience reported by other participants. In particular, Nina's experiences reported below reflect workplace considerations, Barbara's a concern with connection to nature, and Daniel's a concern with issues of privacy in public.

3.1.1. Nina: window metaphor, restoration, community connection

Nina is a 40–50-year-old part-time lecturer. Her office is the only one without a window along a long hallway. Therefore she notices the change from bright to dark as she enters her office. Due to her office's small size and layout, Nina decided to place the large display window on the wall behind her desk (see Fig. 2).

Before the display was installed, Nina described her office as a "deprivation chamber" where "there is nothing to make [her] feel connected at all." Soon following its installation, Nina said that while the display did not "agitate her," it did not soothe her either. She also still expected the screen to display static images:

I find I look at the screen as a static picture, and then I'm somewhat startled to see people, objects



Fig. 2. Nina with her plasma display window highlighting the local plaza and fountain view.

moving. So initially, I am not using a window metaphor in my brain.

However, by the second week of using the large display window, Nina experienced a change. She wrote, for example, in her journal: “The screen feels much more window-like. I’m more aware it’s dynamic.” This idea was expressed even more fully in an interview during that week:

I have gotten over the initial like ‘it [the display] is a type [of] picture’. No. It’s a live feed to me now.... I turn to look at [it], see what’s going on outside and see people wearing shorts so I really do get a sense of ‘this is what is going on outside’.... You know, now I’m looking at, I’m really looking out the window.

Once Nina adopted a window-like perspective of the large display, psychological benefits appeared to accrue:

With effort I can now find some peace in the room that wasn’t there before. It’s not pervasive, it doesn’t completely change the nature of the office, it does help when I choose to.... I’ve been working at my desk with my back to [the display window] and periodically I will just kind of stop and look at it, if only just for a moment to get a sense of “oh yeah, outside....”

After 6 weeks of working with the large display window in her office, Nina says that it “has helped to temper some of that frustration and agitation” that she had felt in her windowless office. She also says:

I’ve felt like if I’ve wanted to at any moment I could sort of refer to, take a look at the screen and get a sense of it’s nice out, it’s not nice out, there are people out there, there aren’t people out there.... It’s also a reminder, it’s like there is a world out there so...you want to get done with what you’re doing because you want to get back out in the world.

Nina particularly came to value the “soothing” effects of the display, and how it helped to focus her mind: “to help my thought process, to help my state of mind.”

While Nina increasingly interacted with the display as a window, she also recognized its limitations, particularly insofar as it did not allow for parallax (the apparent shifting of objects when viewed at different angles):

I probably would look out a [real] window a little bit more [than the large display window] because you do have that opportunity to kind of move around and vary the angle of what you’re looking at.

It took some weeks for Nina to begin to integrate the display window into her workplace practice, and then the integration took her by surprise:

The use of it [the display] in the course of a meeting was really surprising to me because that was not something I had anticipated at all... I originally intended to just be displaying an image during a meeting. But in the course of the discussion and wanting to look something up that

we could look at together, it led to through the rest of the meeting, sharing information up on the screen, instead of sharing it on my monitor here on my desk.

Nina also recognized that displaying work-related information changed the social interaction in substantive ways:

If I’m just talking to you, I have this nature of having the chair in such a way that it’s almost like a barrier that I’m leaning across. But while I’m using this [the display] and I’m talking, I’m actually more open to the person I’m talking to.... It just opens up the conversation more. And I think an interesting reversal is that, to some extent I’m relying on the computer less. I’m not working and talking at the same time. Part of it is that I’m aware that if I want to sneak a look at this e-mail during this thing that they know it, and it’s being displayed in very large type, but more of a case of where we both really should look at something. There are a couple of times where I would want to look at something just for my own reference in the conversation and it’s sort of like I might not do that because I don’t want it displayed all over the room, all over the office wall.

Thus, for Nina, the large display window, used as a work place display, increased the intimacy of conversation and a visitor’s access to information, but decreased Nina’s control over that information and her own privacy.

Connection to the outside afforded by the display window also became a catalyst for interpersonal interaction “that wasn’t there before.” Such interactions particularly arose when special events occurred by the fountain. For example, Nina wrote the following in her journal:

There are some, I mean there were, at 5pm, 20 people swimming in the fountain, plus those being thrown in- and within minutes of turning the screen on, I had 5 people in the office watching the antics, pulling other people in to see. Even [another faculty member with a window] came into this office to help provide commentary.

Such connections to local activities by the fountain helped provide Nina with a sense of motivation and connection to the larger university community as well as why her work as a lecturer at the University is meaningful:

Graduation Day—what fun to have a “view” of all the hustle: hustle out by the fountain while I get ready for the commencement ceremony. Everything is all neat and clean and the presence of all the families reminds us that something does come all of all this!!

Four weeks after the large display window was removed from her office, Nina reflects back on her experience. She says:

I miss having the ability to take time to just look at what’s going on outside...to just watch the world

outside and kind of shift your thinking a little bit. That to me was probably the greatest asset.

3.1.2. Barbara: sense of peace, weather, time, and place—local and global

Barbara is a 45–55-year-old full-time faculty member. In addition to having worked with a rescue association for nearly 30 years, it is important to her to be engaged in outdoor activities, and with her local community and with the larger world, natural and social.

Part of what Barbara appreciates about real windows is that they allow her to see that all is well, and from that sense of security she is able to move forward creatively with her work. In an early interview, for example, she expresses this point by an analogy to the horrendous event that occurred in the US on September 11, 2001:

I really do think that's possible [that windows support thinking better]. It's the old connecting out there with the environment. It's sort of all is well so I can think. ... There's a sense of solace and peacefulness. Things are OK out here. You know, I think that would be an interesting question to ask of people on September 11th where all is not well outside. And therefore their focus immediately changed. They were no longer creative thinkers in many ways, they were survival thinkers. Not just in New York either, all over.

Barbara describes her windowless office as a “pretty isolating office,” “a real disconnect.” And she makes a concerted effort “to have a sense of peace” by “bring[ing] things in that do connect it [her office] to nature, like the screensaver [of a nature scene]” and a full-spectrum lamp.

Barbara chose to install the large display right above her desk. Within several weeks, she began to experience its window-like aspects. For example, she says that it allows her to “reconnect,” “to not feel so closed in,” and to have a “sense of relationship to what's going outside of this office.” Such connection helped provide the sense of security that she spoke of earlier. For example, she says that while she does not look out the large display window too often, “there's a comfort-zone in knowing it's there, and I think that's the difference. It's a peripheral knowledge of knowing it's there if I want it...and I think that is very supportive.”

The large display window also provided Barbara with a sense of weather and time, which then impacted her work practice. For example, sometimes she looked out the display window and saw that it was raining, and decided to work more before leaving the building. Other times: “Lunch! It's a beautiful day out so I think I want to go for a walk.” One journal entry noted: “Beginning to darken with clouds at 3:30 pm. Item errands to run—Screen allows me to see that I need to get going.” Barbara also considered “a sense of sunrise, sunset” basic to daily functioning, which she partly regained through the display window.

Soon after its installation, and in the weeks that followed, Barbara began to display various webcam images on the display: notably of local traffic conditions, Mt. Saint Helens, the Grand Canyon (see Fig. 3), and London. She particularly enjoyed the visual real-time contact with parts of the world that she has traveled to. In these ways, it is important to recognize that Barbara created more interactions with the large plasma display window than she could have with a real window, garnering connection to both the local and the global.

Barbara was keenly aware that the display images did not fully substitute for the experience of being elsewhere; but they were not that far off, either, especially given the importance Barbara placed on knowing that all is well elsewhere:

This [large display] window will take me anywhere in the world, but it won't let me smell anywhere in the world. You know what I'm saying? So, the image is still an image. It's not actually being there, but it is very close. I'm mean it is very good and it's a very safe way to look at what's going on in the world.

Finally, given the importance that Barbara placed on global awareness and visual access to remote locations, it is noteworthy that she judged the local scene even a little more important:

I think these two—the Grand Canyon and [the fountain plaza] are my favorites. Probably [the fountain plaza] more than anything just because it's where I am right now...I think it connects me closer to what's going on immediately outside.

3.1.3. Daniel: aesthetics, sense of office space, objectification and intrusion of privacy, technological generational amnesia

Daniel is a 25–35-year-old student services staff person. His desk is situated in a central open office space which he



Fig. 3. Barbara in her office with the plasma display window (showing a webcam of the Grand Canyon).

shares with three other staff members, and which provides access to four other enclosed offices. Daniel is the first person people encounter when entering Student Services. Thus his job entails frequent social interaction, and diversified, if not stressful, responsibilities. He chose to place the large display window within view of his forward gaze, replacing a white board that had been on the wall (see Fig. 4).

Initially, Daniel thought that the main benefit of the large display window was simply one of aesthetics: “I use it as just something very, something pretty to look at. That’s the main interaction with it.” But then, as with Nina, Daniel came to recognize that the large display window allowed him to take short mental breaks that helped refocus his mind and to see his work in the larger university context:

It helps me to see the bigger picture of what I’m doing and how to respond to an e-mail; to not get so hooked and hung up on all the annoying little details of this particular person you’re corresponding with.... Maybe it’s like a metaphor of analogies: that I can see that person or that e-mail or that particular work in a greater context because I can look out and I can see other contexts.

In addition, Daniel thought the large display window eased the confinement of the office space:

It is a cramped space or at least it feels like [it is]. Last year, during the crunch of admissions, we would have typically 13 people in the office at one time and, for that space, anything that can make it expanded feel would help. Although the proportion of that screen, the screen looks much better in Brin’s office than it does in ours. If it [the display window] were even larger, if it



Fig. 4. Daniel working in the student services reception area and office with the plasma display window.

took up the wall in a better way, I think it would make the space feel better.

Its comparatively small size notwithstanding, Daniel clearly appreciated the large display window.

But Daniel was also critical of such new technological forms. One of his critiques centered on the potential objectification and intrusion into the privacy of people in the plaza:

I’ve known about this project for, probably since maybe around when it started. And, you know, I knew that the camera was out there. I never really thought about it. But when we installed the screen in our office and I saw that we could actually see the data that was coming through, it really, it started making me be very, feel very self-conscious around that fountain. And so it does kind of bother me.

The interviewer then asked Daniel if he thought it bothered other people. Daniel responded:

If they were aware of it? Yeah, I think it would. I think it would bother them, the fact that they aren’t made aware of it...It’s some connection between the idea of technology and how it intrudes upon the ability to live your life without being scrutinized, without being moderated, without all these socially constructed technology evil things! [Daniel laughs.] Not quite that bad, but...it is an unease with technology and it’s intrusion into my personal and private time...If someone is just looking out the window, all they have to rely upon is their memory, all we have to rely upon is subjective human experience, but technology somehow objectifies me in my life.

Moreover, Daniel worried that people are “short-sighted” when adopting technology, unaware of its effects and passing it to newer generations as a given—what can be referred to as technological generational amnesia:

If we have this kind of thing [a display window] in every single office on every city block in America, yes, the people, the younger generations will be used to it; but that doesn’t mean it’s okay. Just because you’re used to it doesn’t mean it has to be that way. We don’t have to be videotaped twenty-four hours a day. We don’t have to always be... accessible to the public, you know? Just think about for example the telephone. It’s changed how we live and how we interact with the world. Just think, prior to the telephone, there was public space and there was private space... there were public places to meet where you didn’t have to pay to go to and now if you want to meet with someone...typically you’d have to meet them at a café.... And it’s very hard for people to imagine that there used to be a time where you could meet with people at the village square.... Now we move into a world where we’re video taped at all times, what kind of things will we, they take as givens that don’t need to be taken as givens.... What society

considers acceptable privacy now will be considered too stand-offish.

Daniel's ambivalence—on the one hand, his attraction to the technology and its aesthetics, on the other hand, his critique of the way in which technology unnecessarily objectifies people and intrudes into personal and public spaces—continued throughout the entire time he spent with the large display window, and into his final interview a month after the display window was removed:

There's part of me that's missing the niceness that came with it [the large display window], but another part of me is quite alright with having that lack because...I do not want it to be the norm, to be expected that we should get used to the idea that people in offices across the world may be watching me out there.... I'm surprised that in the end what bothered me tended to outweigh how much I enjoyed it.

3.2. Themes

Complementing the narratives' "thick" description (Geertz, 1984) and providing for analyses across participants, the themes provide a systematic and synthetic account of the user experience with the large display window over time. Ten overarching themes were identified.

Experience of Technology refers to the user's characterization of the large display window including references to the quality of the image, dynamic nature of the screen, cost of the technology, preoccupation with gadgetry, malfunction of the technology, and novelty (e.g., "The screen was flickering slightly this morning, and I turned it off during a meeting." [Brin, email]).

Activities around Technology refers to the user's behavior in response to the large display window including references to work practice, decorative actions, physical movement, and rituals or routines (e.g., "...realizing how ingrained it [display] was becoming in my natural patterns, the number of times I'm looking to where it was and having that, 'Oh, it's not there anymore'" [Nina, interview]).

Sense of Place refers to the effect of the large display window on the user's perceptions of the physical surroundings including references to the office and outdoor environment (e.g., "there was a wonderful moment earlier today where it was sunny and rainy at the same time—a joy to see if not experience" [Doug, email]).

Social Connection refers to the effect of the large display window on the user's relationships to other people either reciprocally in the user's office environment or non-reciprocally through the live video feed (e.g., "I felt more connected to...the department" [Barbara, interview]).

Personal Interest refers to the user's emotional attachment to or general enjoyment of the large display window (e.g., "I've really enjoyed [the display window]...it makes things better" [Sue, interview]).

Cognitive Function refers to the effect of the large display window on the user's cognitive processes, including references to focus, efficiency, and creativity (e.g., "I think...[the display] leads into thinking better" [Lara, interview]).

Psychological Well-Being refers to the effect of the large display window on the user's mental restoration, relaxation, and general morale (e.g., "I think it helped me think a little more positively...it had sort of more of a mood effect" [Lara, interview]).

Status refers to user's perception of the large display window as signifying power or prestige (e.g., "it [the display window] certainly could start to convey status, I mean I worked at ___ and the bigger the monitor you had the bigger, you know, the more important you were. So there's status I guess it can convey" [Nina, interview]).

Social Expectation refers to the user's recognition of conventional practices around the use of camera and display technology (e.g., "it wouldn't bother me if someone...could see me walking... by the fountain, you know what I mean, because that's sort of what happens with the web cam... it could capture me for a second" [Brin, interview]).

Ethical Issues refers to the user's recognition of ethical implications of the large display installation for either direct or indirect stakeholders, including references to privacy, informed consent, security or safety, intellectual property, and objectification of individuals and/or their images (e.g., "It feels slightly voyeuristic watching folks going about their business through the monitor...it feels sort of Big Brother-like" [Daniel, journal]).

Table 1 characterizes the pattern of individual experience with the plasma display window (PDW) from the interview data by means of a timeline of themes for each participant. In reading Table 1, the first column of the timeline (Install PDW) refers to themes from the interview conducted in week 7 when the plasma display window was first installed in the participant's office. The second column (During PDW) refers to themes from the three interviews (weeks 8, 10, and 12) conducted while the large display window was in the participant's office. If a theme was present during any one of the interviews, it was coded here. The third column (Remove PDW) refers to themes from the interview conducted at the time the display window was removed from the participant's office (the beginning of week 13). The last column (Post PDW) refers to themes from the interview conducted 4 weeks after the display window was removed (the end of week 16).

As shown in Table 1, Nina's, Barbara's, and Lara's reflections began with some mixed anticipation of positive and negative experience, but as time progressed their reflections became increasingly positive. For Brin, the least conflictful of the participants, the user experience was consistently positive throughout. In contrast, Doug and Sue anticipated a positive experience but over time negative aspects emerged and persisted. And for Daniel, as explicated in his narrative, the experience began with

Table 1
Timelines of themes by participant

Participant	Theme	Timeline			
		Install PDW	During PDW	Remove PDW	Post PDW
Nina	1. Exp. of Tech.	—	+	+	+
	2. Act. around Tech.	+	+	+	+
	3. Sense of Place	+	+	+	+
	4. Social Connection		+	+	+
	5. Personal Interest		+	+	+
	6. Cogn. Function	+	+	+	+
	7. Psych. Well-Being	+	+	+	+
	8. Status		+		
	9. Social Expect.				
	10. Ethical Issues			+	
Brin	1. Exp. of Tech.	+	+	+	+
	2. Act. around Tech.	+	+	+	+
	3. Sense of Place	+	+	+	+
	4. Social Connection		+	+	+
	5. Personal Interest	+	+	+	+
	6. Cogn. Function				
	7. Psych. Well-Being		+	+	+
	8. Status				
	9. Social Expect.				
	10. Ethical Issues				
Bar.	1. Exp. of Tech.		+	+	+
	2. Act. around Tech.		+	+	+
	3. Sense of Place		+	+	+
	4. Social Connection		+	+	+
	5. Personal Interest		+	+	+
	6. Cogn. Function	+	+	+	+
	7. Psych. Well-Being	+		+	+
	8. Status				
	9. Social Expect.				
	10. Ethical Issues	—	—	—	—
Doug	1. Exp. of Tech.		—		
	2. Act. around Tech.				
	3. Sense of Place	+		+	+
	4. Social Connection		—	—	
	5. Personal Interest		+		
	6. Cogn. Function			—	
	7. Psych. Well-Being		+		
	8. Status				
	9. Social Expect.		—		
	10. Ethical Issues		—		
Dan.	1. Exp. of Tech.		+	+	+
	2. Act. around Tech.	+	+	+	+
	3. Sense of Place	+	+	+	+
	4. Social Connection	—	+	+	+
	5. Personal Interest			+	+
	6. Cogn. Function	+	—		
	7. Psych. Well-Being				+
	8. Status			+	
	9. Social Expect.		—	—	
	10. Ethical Issues	—	—	—	—
Sue	1. Exp. of Tech.	+	+	+	+
	2. Act. around Tech.	+	+	+	+
	3. Sense of Place	+	+	+	+
	4. Social Connection	+	+	+	+
	5. Personal Interest		+	+	+
	6. Cogn. Function	+	+	+	+
	7. Psych. Well-Being	+	+	+	+
	8. Status				
	9. Social Expect.		—	—	
	10. Ethical Issues		—	—	
Lara.	1. Exp. of Tech.	+	+	+	+
	2. Act. around Tech.		+	+	+
	3. Sense of Place	+	+	+	+
	4. Social Connection	+	+	+	+
	5. Personal Interest		+		+
	6. Cogn. Function	+			
	7. Psych. Well-Being	+	+	+	+
	8. Status				
	9. Social Expect.				
	10. Ethical Issues		—		

+ Theme with positive valence.
 — Theme with negative valence.
 + — Theme with both positive and negative valence.
 Theme with neutral valence.
 Theme not present.
 PDW = Plasma Display Window.

mixed judgments and continued to reflect these tensions throughout the duration. In the narratives (see above) we have provided detailed descriptions of Nina’s and Barbara’s increasingly positive experiences and the ongoing tensions Daniel continued to experience. Here, drawing out the themes, we provide greater specificity on Brin’s, Lara’s, Doug’s and Sue’s experiences with the display.

Brin was consistently positive about the large display and its effects on her office environment. She believed that the display improved her ability to see beyond specific workplace tasks to a larger more meaningful picture of work and life (Activities around Technology; Personal Interest). Brin spoke frequently of the ways in which the display improved her connection with others in her office environment and beyond (Social Connection). She anticipated and, indeed, through her experience with the display enjoyed a broader sense of place (Sense of Place). Brin’s accounts across time were largely devoid of negative remarks—hers was an unconflictful pleasant and beneficial experience.

Like Brin, Lara’s experience with the display was overwhelmingly positive, with perhaps two notable exceptions both of which dissipated over time. Initially, Lara expressed concerns about working with the technology (Experience of Technology). Then during the installation period, she expressed concerns that people whose images were captured by the camera might feel uncomfortable (Ethical Issues). As she gained greater familiarity with the display, both of these concerns became less salient and eventually disappeared from her discourse. Like Daniel (see the narrative above), Lara had high expectations for the display’s impact on the aesthetic appeal of her office space and she was not disappointed (Sense of Place). She was particularly taken with the way in which the contents of the camera view motivated social interaction. For example, at one point a spider spun a web in view of the camera lens; watching the spider work at spinning its web generated much discussion among Lara and her co-workers (Social Connection). When the display was removed, Lara’s reflections were extremely positive—she missed the outside natural scene and felt her work place

lacked a significant catalyst for social interaction among her colleagues.

Doug began his participation in the study with a strong desire to have a view of nature in his office but was somewhat skeptical that a real-time display of the outdoors could meaningfully provide such (Sense of Place). Once the display was in place, that skepticism disappeared. Moreover, throughout the display period, Doug reflected positively on his personal attachment to the display (Personal Interest Theme) and the display's impact on his sense of well-being as a result of the nature view (Psychological Well-Being). That said, shortly after the display was in place concerns of a social and ethical nature surfaced (Social Connection; Social Expectation; Ethical Issues), primarily tied to negative responses Doug felt that others were having when they encountered the display in his office. One important incident occurred early on in the display period. Specifically, a student who came to Doug's office for a scheduled meeting was upset to discover that Doug could witness the student's approach through the camera view. In turn, Doug was upset by this incident and tended to view many of his subsequent interactions with the display through this filter. Doug also became concerned about how the expensive and unique display impacted others' perceptions of his position within the work community (Experience of Technology). Thus, during the display period, Doug's experiences were strongly conflictful. Interestingly, after the display was removed, Doug returned to positive reflections on the display's role in improving his connection to nature (Sense of Place) and a relatively neutral perspective on the display's value for improving his office environment and work process (Social Connection).

Unlike Doug, Sue began the study with little ambivalence and a great deal of excitement about the installation—for improving, among other things, social interaction (Social Connection), work activities (Activities around Technology), and office lighting (Experience of Technology). However, similar to Doug, Sue quickly became aware of the ethical implications of the real-time view of a public place (Ethical Issues). She was concerned enough about the infringement on the rights of those who walk through the camera view, that Sue primarily used the display to project static images of art rather than the real-time nature view. In addition, Sue used the display for co-editing documents with others in the context of her work practice. Both the display of artwork and co-editing activities contributed to improving Sue's work environment (Activities around Technology).

Taken as a whole (averaging across participants and themes), participants provided more than twice as many positive themes (69%) as negative ones (23%). Their positive experiences and reflections primarily entailed references to participants' sense of place (22%), psychological wellbeing (17%), activity about technology (14%), social connection (13%), experience of the technology (12%), and personal interest (12%). In contrast, their

negative experiences and reflections entailed references to ethical issues (29%), particularly privacy and security, and their experience of the technology (27%), particularly image quality and technical malfunctioning.

3.3. Evaluations

To complement the narratives and themes reported thus far, we now add a quantitative analysis of participants' responses to questions that appeared in the semi-structured interviews. On every one of the questions we analyzed, a majority of the participants gave the response we had predicted. However, due to the very small sample size, statistically significant evidence to support the prediction was only obtained on questions where the participants were unanimous in their responses. Table 2 provides a summary of the evaluation responses grouped by the interview period: pre-intervention, intervention, and post-intervention.

During the first week of the field study, we asked participants five questions to establish their perceptions about the potential value of windows in offices. All participants (100%) said they would choose an office with a window over an office without a window ($n = 7$, $p = .016$), viewed windows as conveying status ($n = 7$, $p = .016$), and thought that working in a room with a window would make them think better ($n = 6$, $p = .032$). Though not statistically significant, the majority of participants also thought that working in a room with a window would make them more creative and physically healthier.

While the participants engaged with the large display window (interviews for weeks 8, 10, 12, and 13), they were asked questions about their perceived effects of the display window on their activities and awareness of the local outside venue. Specifically, participants were asked about changes in their personal behavior, awareness of the local weather, and awareness of local activities. Over the course of these interviews, all participants (100%) answered "yes" at least once to each of the individual questions ($n = 7$, $p = .016$ for each question) and always answered "yes" each time the question was asked about an increase in awareness of local weather and activities.

During the display window period, participants were also asked explicitly about their awareness of indirect stakeholders. In each of the four interviews, all participants (100%) answered "yes" each time the question was asked ($n = 6$ for weeks 8 and 12, $p = .032$; $n = 7$ for weeks 10 and 13, $p = .016$).

Participants were also asked during this period in two ways about the importance of the large display window. First, they were asked to rank-order choosing among an office with a window, without a window, and without a window but with a large display ("Let's say you just got a new job and you get to pick your office. What would you choose first: an office with a window, an office without a window, or an office without a window but with a large

Table 2
Percentage of respondents who provided affirmative (“Yes”/“Agree”/“Recommend”) responses to binary evaluation questions by intervention period

	Percent (Agree/N)
<i>Pre-intervention period evaluation questions</i>	
1. Let's say you got a new job and you get to pick your office. Would you choose an office with a window or without a window?	100 (7/7)*
2. Some people say that windows in an office convey status. Do you agree or disagree?	100 (7/7)*
3. Some people think that working in a room with a window makes them more creative compared to being in a room without a window. Do you agree or disagree?	83 (5/6)
4. Some people think that working in a room with a window makes them think better compared to being in a room without a window. Do you agree or disagree?	100 (6/6)*
5. Some people think that working in a room with a window makes them physically healthier compared to being in a room without a window. Do you agree or disagree?	83 (5/6)
<i>Intervention period evaluation questions[†]</i>	
6. Did viewing real-time images ever cause you to change what you were doing?	100 (7/7)*
7. Did viewing real-time images make you more aware of the local weather?	100 (7/7)*
8. Did viewing real time images make you more aware of local activities?	100 (7/7)*
9. Did you notice any people walking by?	100 (7/7)*
10. If a co-worker came down the hall and asked you about the plasma display, would you recommend that they get one or tell them it's a waste of money?	100 (7/7)*
<i>Post-Intervention Period Evaluation Questions</i>	
11. Do you miss not having the display?	86 (6/7)
12. Now that you no longer have access to viewing real-time images, do you feel less connected to the local area?	100 (7/7)*
13. If a co-worker came down the hall and asked you about the plasma display, would you recommend that they get one or tell them it's a waste of money?	100 (7/7)*
14. Do you think having the plasma display in your office made you more creative on your work-related tasks?	71 (5/7)
15. Do you think having the plasma display in your office made you think better on your work-related tasks?	83 (5/6)
16. Do you think having the plasma display in your office made you physically healthier compared with working now in your office without the plasma display?	71 (5/7)

Note: *Results with a statistically significant majority of agreement using a two-sided binomial test at the 0.05 significance level.

[†]Results reported for the intervention period interview (weeks 8, 10, 12 and 13) with the greatest number of participants in agreement.

screen plasma display? What would you choose second [from the remaining two]?”). Although the majority of participants tended to rank the window first and the display second, the only statistically significant result was the choice of the window first in week 12 (100%, $n = 6$, $p = .032$). In addition, participants were asked if they would recommend the large plasma display window to a co-worker. In weeks 10, 12, and 13, all participants (100%)

unanimously recommended the large display to a co-worker ($n = 7$ for each week, $p = .016$).

Four weeks after the display window was removed from participants' offices, we returned to ask follow-up questions in a post display window interview (week 16). At this time, 100% of participants reported that they felt less connected to the local area ($n = 7$, $p = .016$); that they would recommend a large display window to a co-worker ($n = 6$, $p = .032$), and that if given the choice they would choose an office with a window first ($n = 7$, $p = .016$) and an office (without a window) with a large display second ($n = 7$, $p = .016$). Though not statistically significant, the majority of participants missed the large plasma display window and also thought that working in a room with the display window had made them more creative, think better, and physically healthier.

4. Discussion and lessons learned

Windows have been shown in certain contexts to promote physical and psychological health (Moore, 1981; Ulrich, 1984). People tend to like windows, too (Kaplan, 2001). Yet many buildings have inside spaces, such as inside offices and basement facilities, where it is difficult if not impossible to provide people with visual access to the outside environment. Thus the purpose of our research was to investigate whether it is viable—through a new use of large displays—to create a technological window to the outside world. In the coming years, large displays will become increasingly sophisticated and pervasive in society. However, as with television, perhaps more so, it has not been readily apparent what is interesting and worthwhile information to display on large displays. Thus, this study—“Office Window of the Future?”—can be understood as part of the larger enterprise of exploring new uses of technology that support meaningful connection to the larger social community and natural world.

The results from our field-based analyses show that participants—especially over time—deeply appreciated many aspects that the large plasma display window afforded. In this section, we reflect more specifically on the lessons learned thus far and their broader implications.

Acts like a window, could be a window? One key question this research sought to address was the following: Could a large display that showed real-time images of the building's immediate outside location provide a user in an inside office with a reasonably viable replacement for a window? Our results suggest that in some ways the answer is yes. Nina, for example, made a shift in thinking of the large display as something static to something dynamic, like a window. Participants, such as Barbara and Daniel, also often took brief mental breaks and stared out the large display window, and said that they returned to their work a bit more refreshed and refocused. Through looking out the large display window, participants also spoke of feeling connected to the outdoors, and to the wider social community. That said a few participants also spoke of

the limitations of the large display window insofar as they could not change their perspective on outside objects by shifting their position, what is known as the parallax problem (cf. Kalai and Siegel, 1998; Radikovic et al., 2005).

Novelty: Given that large displays can function in some ways like a window to the outside environment, the question arises whether that function persists over time or whether, as the novelty wears off, so do the benefits. This research provides evidence to support their continued value beyond a few hours or days. Notably, as previously discussed in Section 3.3, after 6 weeks of using the large display the participants in this field study unanimously recommended the large display window to other co-workers with inside offices, and—4 weeks after the installation was removed—were clear that they themselves would choose to have one again in their inside offices. Moreover, as seen by the thematic codes presented in Table 1, several participants (e.g., Nina, Lara, Brin, and Sue) developed rituals around their use of the display (e.g., looking at the same outdoor scene each day at the same time of day; anticipating daily events such as the turning on of the fountain) that continued to sustain their interest and engagement.

Reconnecting with organizational values and larger community: Participants in the field study felt less isolated and alienated in their inside offices, and more connected to the people they helped to serve as reflected by the number of participants who were identified as having positive social connection themes in their interaction with the technology. The window also connected participants to the wider social functioning of their institution, providing meaning to their work.

Integrated into work practice: To greater or lesser extents, most of the participants integrated the display into their workplace practice. Nina used it, for example, to display common documents while working with a student or colleague, and as a display for PowerPoint presentations.

Connecting to nature: Research across many disciplines supports the proposition that there exists a fundamental human need and propensity to affiliate with nature (Wilson, 1984; Kaplan, 1992; Ulrich, 1993; Kahn, 1999; Taylor et al., 2001; Kahn and Kellert, 2002). This literature helped us conceive of our installation insofar as we sought not only to “bring the outside in”—by means of the large display window—but to incorporate some natural views in the real-time outside images. Participants in the field study reported benefits in line with our expectations. For example, as noted earlier, participants often took brief mental breaks and stared out the “window,” returning to their work more refreshed and refocused. Nina and Barbara, in particular, appreciated feeling connected to the day’s passing, to the movement of the sun, and to the changing weather. Participants, in general, adjusted their work schedules to capitalize on the environmental information the window afforded, taking an earlier lunch break outside, for example, while the weather was known to be favorable.

Privacy in public: A good deal of research within the human–computer interaction and computer-supported cooperative work communities has documented tensions between group awareness and individual privacy (Boyle et al., 2000; Jancke et al., 2001; Svensson et al., 2001). Moreover, when the camera is pointed toward the outside, concerns about privacy in public come to the fore (Friedman et al., 2006a). In our study, participants experienced both concerns, though they primarily articulated uneasiness with the way in which this use of a large display could invade the privacy of individuals who walked through the public fountain area and had their images captured by the camera and displayed. It was not the case that participants had an initial concern about privacy which then subsided as they became more comfortable with the installation. Rather, the concerns here were sustained through the entire time frame. It is important to notice that the camera (and hence view) was fixed without any zoom capability. Thus the installation largely mimicked the visual access afforded by a glass window and did not allow for the sort of monitoring of individual activity when users have control over what the camera points at and at what level of granularity (cf. Goldberg, 2005). Given the similarity of view with a glass window, further work would do well to examine if looking at the scene through a fixed camera view raises more ethical concerns than looking through a glass window and, if so, why. It is also important to notice that the level of control and granularity provided here was sufficient to provide meaningful connection to the organization, community, and nature.

The larger societal question remains of how best to balance the benefits that accrue from the technology with the costs to individual privacy. At stake here is the human experience of privacy in public—the ability of individuals to go about their activities in public places while largely being “left alone”, without their images being captured, displayed elsewhere in real-time, and potentially recorded for later viewing. While a full discussion of this issue is beyond the scope of this article, several elements seem critical to the discourse. The changing nature of the technology needs to be recognized, anticipated and brought into the dialog. For example, the study reported here used a fixed camera with only moderate granularity of view; in the near future, display walls are likely to incorporate increasingly sophisticated technical functions such as better control over what the camera points to, zoom, and perhaps the overlay of other information. The experience, views and values of those individuals whose images are captured in public places need to be brought into the debate. Prior research, for example, suggests that women may be more concerned than men about such installations (Friedman et al., 2006b); further work is needed to understand the implications for others, particularly those in less powerful positions in society (e.g., based on race, ethnicity, and social economic status). Moreover, when considering the impact of installations of cameras in public places, attention should be paid to the importance of

informed consent (Friedman et al., 2005): both alerting the public to the presence of the cameras and the public's ability to avoid those cameras should they wish to do so. Ultimately, however, protection of privacy in public may be a matter to be dealt with through legislative policy and contractual agreements (cf. Friedman et al., 2006c).

Conclusion: In brief, we believe the research reported here provides initial evidence for a potentially successful new use of an existing technology. To be clear, we are not suggesting from the standpoint of psychological functioning, that large display windows afford benefits as good as real windows; and on this point more directed experimental data are needed. Moreover, we are in no way advocating that buildings be designed without windows, with the assumption that the technology (large display windows) can replace more direct interaction with the outside environment. What we are saying is that when workers must work in an inside office (e.g., because of the utilization of inside spaces or basements), that this new use of a large display may provide workers with important physical, psychological, and social-organizational benefits. In the coming years, large displays will become increasingly sophisticated and pervasive in society. However, as with television, perhaps more so, it has not been readily apparent what is worthwhile information to display on large displays. Thus, this study—"Office Window of the Future?"—should be understood as part of the larger enterprise of exploring new uses of technology that support meaningful connection to the larger social community and natural world.

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