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interactions

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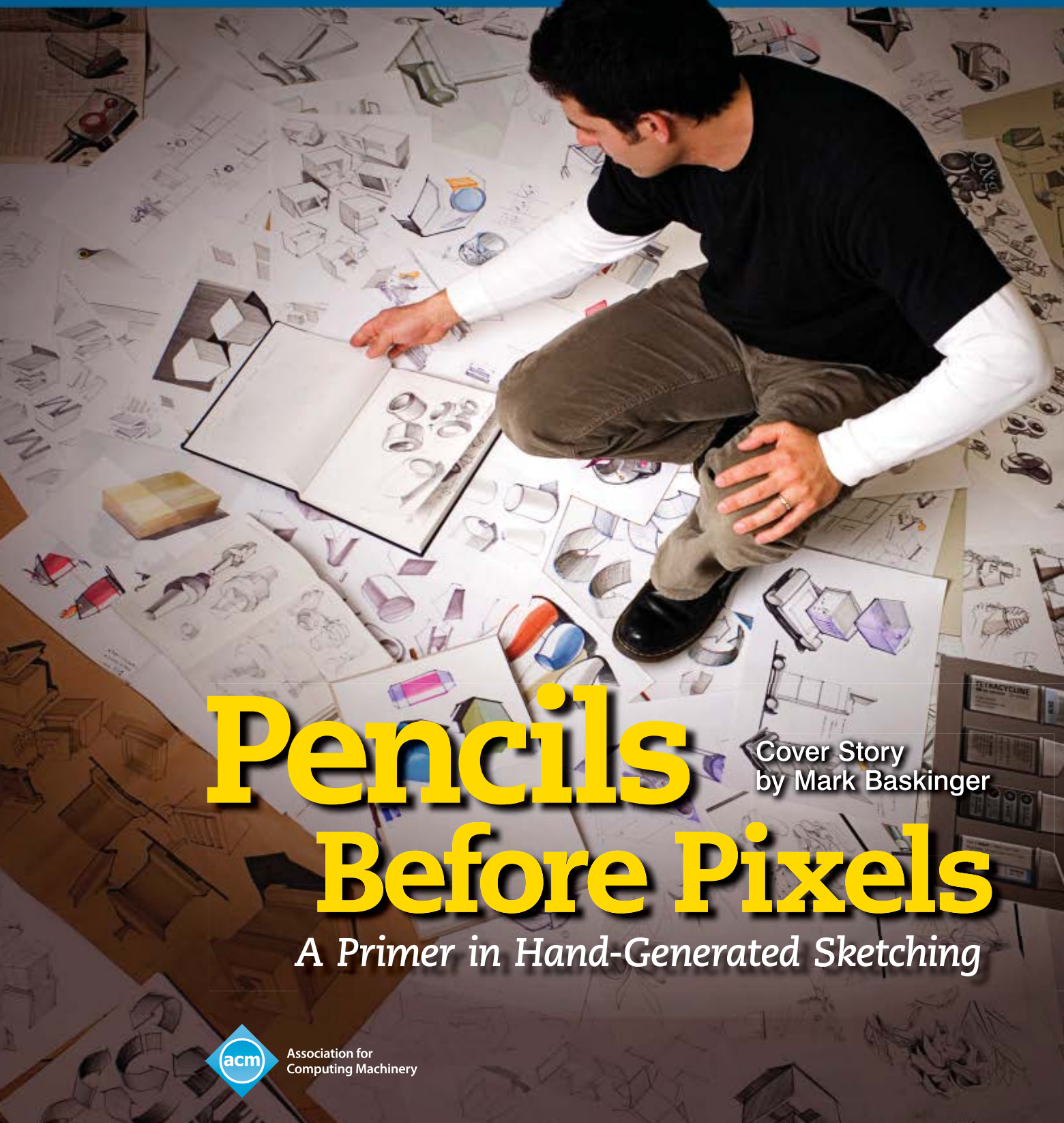

Pencils Before Pixels

Cover Story
by Mark Baskinger

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►PAGE 16


►PAGE 28


►PAGE 42


►PAGE 46

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The Mess We've Gotten Ourselves Into

While our efforts are frequently well intentioned, there are a number of negative results of our design, engineering, and business practices. These articles explore some of the problems we've created for ourselves, and suggest some solutions to clean up the mess.

►Cover photo by Dylan Vitone.

Design: What it is, and How to Teach and Learn It

Design is beginning to evolve into a comprehensive, thoughtful, and definable subject. We've collected some thoughts on what Design means in our technological world, and what it means to teach—and to learn—Design.

Crossing the Thresholds of Indignation and Inclusiveness

As we begin to make headway toward defining a discipline based on designing interactions, it becomes apparent that an exclusive approach is not sustainable. These articles describe some of the thresholds we must cross to surpass indignation and achieve inclusiveness.

Interactions Cafe

Making the right decisions can lead to a design "sweet spot."

▶ Richard Anderson

▶ Jon Kolko

Interactions: Bridging Communities

Currently, a subscription to *interactions* is linked to membership within ACM SIGCHI, the Special Interest Group for Computer-Human Interaction. Hence, to some extent, *interactions* is intended for each of the "CHI communities"—design, management, usability, engineering, education, and research. And to some extent, members of these six communities are our primary audience.

However, an assortment of individual and institutional subscribers outside of SIGCHI also receive *interactions*. Is *interactions* no less intended for them and others as well?

In structuring the publication and assembling the new *interactions* team, we have looked to the definitions and boundaries of the six CHI communities and of SIGCHI as a whole for some degree of guidance. But we have found those definitions and boundaries to be unclear. As such and in multiple ways, this lack of clarity has been both freeing and undesirably limiting. Community boundaries matter and have their value, yet they also restrict and obstruct valuable interaction.

As implied by the name and tagline of this magazine, our focus is on "interactions"—the dialogues and conversations, connections, and relationships that involve experiences, people, and technology. Such interactions often cross design, management, usability, engineering, education, and research-community boundaries and are of no less relevance and importance to multiple communities outside of SIGCHI. Therefore, it is our intent to greatly extend this publication's reach. As we do so, we believe we will greatly increase its value to SIGCHI and to all.

This is our version of inclusive design—addressing the professional community "mess we've gotten ourselves into"—"crossing the threshold of indignation" that community boundaries sometimes impose. In our view, much of the benefit of communities lies not in their exclusiveness but in the muddy grayness between disciplines, such as where design meets education, research informs usability, or engineering collides with management.

For our second issue of *interactions*, we've selected articles that discuss, embrace, or react to the messiness of inclusive design or the lack thereof. These articles explore the interactions of design and the interactions of importance to design, without positioning design as an exclusive community. (Our particular thanks to Mark Baskinger, who went above and beyond the call of duty in providing two outstanding contributions of this nature.)

• • •

Four special individuals are joining us to help ensure we adequately address and bridge the many communities of importance to *interactions*. These individuals have tremendously diverse backgrounds and interests but all share a professional, and personal, outlook on the world around us. This shared outlook indicates an integrated, holistic, and ultimately, human way of considering issues of experiences, people, and technology.

Katie Minardo Scott works for The MITRE Corporation, a nonprofit research and development center, doing human factors and visualization consulting for government clients. Katie has worn a variety of hats in her career: doing field research on tools for infantry soldiers, using agile development to build an intelligence news aggregator, designing taskflows for logistics and collaboration software, and authoring a case study on enterprise engineering. Katie earned a B.F.A. and a Master of HCI from Carnegie Mellon. She is currently training for her third marathon.

Dave Cronin is the director of interaction design at Cooper, where he's worked since 1999 leading interaction design projects in domains ranging from computer-assisted orthopedic surgery to institutional investment management to museum information systems to online shopping. He also speaks

and teaches frequently on the subject of interaction design and is a co-author of *About Face 3*.

Kerry Bodine is a principal analyst at Forrester Research. Her research explores how user-centered design processes, design-centric corporate cultures, and organizational structure contribute to the creation and sustainability of superior customer experiences. She also covers the interactive-design-agency industry and advises customer-experience professionals about how to get the most out of agency partnerships. Kerry was instrumental in the development of many of Forrester's evaluation methodologies. Her earlier work included an extensive focus on wearable technologies.

Ame Elliott is a senior human factors specialist at IDEO in Palo Alto, CA, where she conducts fieldwork, designs interactions, and facilitates workshops for companies interested in innovating through user-centered design. Prior to joining IDEO, Ame was a research scientist at the Palo Alto Research Center (PARC) and at Ricoh Innovations. Her past projects include leisure guides for Japanese youth, services for managing chronic diseases, a device for sharing media on home A/V networks, and paper interfaces for interacting with collections of digital media. Ame has a Ph.D. in architecture from the University of California, Berkeley, and a Bachelor of Environmental Design from the University of Colorado, Boulder.

We are calling Katie, Dave, Kerry, and Ame our four "community editors," and we are delighted to have such an intellectually strong and professionally deep group of people ensuring our continued relevance to the multiple communities for which *interactions* is intended.

—Richard Anderson and Jon Kolko
eic@interactions.acm.org

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PUBLICATIONS OFFICE
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When Users "Do" the Ubicomp

Antti Oulasvirta
University of California at Berkeley and
Helsinki Institute for Information Technology HIIT | antti.oulasvirta@hiit.fi

Computers have become ubiquitous, but in a different way than envisioned in the 1990s. To master the present-day ubicomp—a multilayered agglomeration of connections and data, distributed physically and digitally, and operating under no recognizable guiding principles—the user must exhibit foresight, cunning, and perseverance. Preoccupation with Weiserian visions of ubicomp may have diverted HCI research toward problems that do not meet the day-to-day needs of developers.

The Two Ubicomps

Ubiquitous computing can be viewed from two distinct perspectives. On the one hand there is the avant-garde that gets presented in scientific conferences and follows Mark Weiser's and others' visions on context awareness, beyond-GUI interfaces, and new networking techniques. On the other, present-day IT infrastructure, "the real ubicomp," is a massive noncentralized agglomeration of the devices, connectivity and electricity means, applications, services, and interfaces, as well as material objects such as cables and meeting rooms and support surfaces that have emerged almost anarchistically, without a recognized set of guiding principles. This infrastructure is not homogenous or seamless, but fragmented into several techniques that the user has to study and use. These techniques typically connect only two devices or applications at a time. This form of ubicomp is not embedded in the environment, but its logic is affected by remote factors often opaque to the user, such as servers, and by other people.

In their paper, entitled provocatively "Yesterday's Tomorrows," Bell and Dourish lamented that "ubicomp has turned out to be characterized by improvisation and appropriation; by technologies lashed together and maintained in synch only through considerable efforts; by surprising appropriations of technology for purposes never imagined by their inventors [1]." The image in Figure 1 is an example of what those look like in their best (or worst).

It may be that complexity of the existing ubicomp is one key explanation to why ubicomp applications have not conquered the consumer market, although more than a decade of research has produced numerous should-be-convincing demonstrations. According to a keynote speech at MobileHCI 2006, Nokia lost $4.5 billion in a year because of product returns and complaints, of which approximately 20 percent was caused by problems attributable to usability and complexity.

Yet the bulk of empirical studies looking at ubicomp at an extra-application level has been close to nonexistent, arising only recently. To mention a few, Mainwaring and colleagues studied the things urbanites carry with them and how these things are perceived to "interface" with the urban environment [2]. Woodruff and colleagues examined temporal patterns of using a laptop at home [3]. Our own study of mobile information workers at Nokia's internal IT division, reported in Oulasvirta and Sumari [4], explains some of the tactics and discipline people develop and the ensuing burden when working with multiple portable and nonportable computing devices. These articles show many ways in which it is the users who have to "do" ubicomp; that is, actively create the resources for using an application in a heterogeneous, multicomputer environment.

A Study of Computer Jugglers

To explain what is behind these dramatic-sounding claims, let us revisit observations from one of the aforementioned studies [4]. Eleven workers, all extreme users to whom ubicomp means both the content and means of work, were interviewed and observed. In their daily pursuits, much of what is wrong about ubicomp became visible.

All workers had multiple devices to choose from: at least a smartphone plus a laptop, and a mobile phone, as well as various necessary accessories such

[1] Bell, G., and P. Dourish, "Yesterday's tomorrows: Notes on ubiquitous computing's dominant vision." *Personal and Ubiquitous Computing* 11, no. 2 (2006): 133-143.

[2] Mainwaring, S.D., Anderson, K., and Chang, M.F. Living for the global city: Mobile kits, urban interfaces, and ubicomp. In Proc. Ubicomp'05, Springer (2005): 268-286.

[3] Woodruff, A., Anderson, A., Mainwaring, S.D., and Aipperspach, R. Portable, but not mobile: A study of wireless laptops in the home. In Proc. Pervasive'07, Springer (2007): 216-233.

[4] Oulasvirta, A., and Sumari, L. Mobile kits and laptop trays: Managing multiple devices in mobile information work. In Proc. CHI'07, ACM Press (2007): 1127-1136.

Theo Humphries

▶ **Figure 1.** Present-day ubicomp: the desk of a designer at the Royal College of Arts.

as docking stations, chargers, headsets, cables, etc. In their work situations, and when moving between them, the workers switched the primary device they used quite often. There were even "frenzies" where this kind of juggling took place at intervals of less than five minutes. The workers actually perceived many benefits for having multiple devices instead of just one: more suitable display and manipulation mechanisms to choose from, reducing the time and effort needed to set up a device, being able to multitask, having devices as backup storages of data, improving personal "ergonomics," choosing devices that are socially more acceptable, improving privacy, and securing company-sensitive data.

However, they were not able to achieve these feats easily—considerable effort, improvisation, and knowledge were needed. The main problems did not relate as much to the interconnection and operation of devices in situ, but to three things that we discuss below: 1) "being context-aware," i.e., actively creating resources from what is available for using a computer; 2) "achieving seamlessness," i.e., ensuring access to necessary data across situations and devices; and 3) "doing nondisruptiveness," i.e., being able to gracefully align the use of computers with the physical, cognitive, and social demands of the situation at hand.

Being Context-Aware

Pre-trip planning is a nodal moment where beliefs about infrastructure become visible. There, a user must choose what devices to bring along and how to prepare them. The workers' strategies of choosing devices ranged from conservative—always taking the same set of devices along—to opportunistic—taking devices "just in case"—to planned—planning the use of devices for each day or trip.

In the two strategies mentioned last, users exhibited being somewhat knowledgeable of which resources will be available and which not. The decision to take devices was accompanied by a variety of concerns—the battery life, wireless connectivity, or social acceptability in the future site of use.

Workers also exhibited perceptual skills used to see opportunities in the surrounding environment to transform it for use. Figure 2 shows such "context-awareness:" While waiting for a meeting to start, the worker made room for the use of his laptop by clearing the support surface of a beverage trolley.

The present-day ubicomp does not automatically adjust its provided resources according to users' situations. Rather, it is the users who have to anticipate, search for, and plug into the computational resources, and for that they need knowledge of the upcoming situations and skill to adjust their own behavior accordingly.

Achieving Seamlessness

The notion of information access "anywhere, anytime" has been argued to be mainly a rhetorical notion [5]. Users are not really capable or even interested in having information available everywhere.

Trying to achieve "anytime, anywhere" when operating in

[5] Perry, M., O'Hara, K., Sellen, A., Brown, B., and Harper, R. Dealing with mobility: Understanding access anytime, anywhere. ACM Transactions on Computer-Human Interaction (TOCHI) 8, 4 (2001), 323-347.

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▶ **Figure 2.** Using a laptop on the corner of a beverage trolley [4].

the present-day multidevice environment implies having additional tasks of transferring operation and data across devices and places. For this, users must be conscious of the various technological "seams" working counter to their goals, such as discontinuities in connectivity or electricity.

The workers exhibited intricate knowledge of the supportive and constraining factors particularly in local and frequently visited places. For other kinds of trips they had to choose strategies that addressed uncertainty over possible seams.

Some workers used server backups that they knew they could access in a place with a wireless connection. When anticipation was not possible or desired due to cognitive cost, users disciplined themselves to take backups of important files on their smartphone, for example, when going on a longer trip. If, for some reason, the laptop was not available, a product presentation would then be available from the smartphone. Such "just in case" backup devices were taken along also on shorter trips within the office, where there was a possibility of encountering an important colleague.

The workers also employed a variety of strategies to share documents between their devices. Each device provides different affordances to access information, and users were sensitive to those. Some users did "data mirroring," copying files to the smartphone for read only. Two-way synchronization, updating file versions on each device after each update, was the most laborsome strategy as it required its adopter to discipline herself to do it, for example, in the mornings. When upcoming situations were predictable, a worker could get by with opportunistic synchronization of a single device.

Some workers accepted the risk of not having certain information conveniently accessible in all situations. By dedicating certain documents exclusively to certain devices, they could avoid synchronization work.

Interestingly, these strategies of distributing data between devices go hand-in-hand with physical demands and impediments, and vice versa. A superior strategy in carrying one's mobile devices may be poor as it requires excess synchronization. We reported on the users' "mobile kits," i.e., keeping the repertoire of things carried fixed [2]. While having a more or less static kit reduces cognitive effort, it does so with the cost of manual labor, time, and physical effort stemming from the burden of packing, maintaining, and carrying the kit.

Weiser warned against "making everything the same," to which aiming for seamlessness would lead. Instead, we should design "beautiful seams" and seams that can be appropriated [6]. The present-day ubicomp, unfortunately, is not there yet. The seams are not visible and certainly not beautiful. The disconnected and fragmented technological resources must be known in advance, planned and prepared for. The nature of seams is not only a problem of the digital but they are also inherently linked to the way we structure our action and share efforts to tasks of physical nature, such as carrying devices.

Doing Nondisruptiveness

The final point concerns nondisruptiveness. Followers of Weiser's vision have referred to concepts like calmness, ambience, and invisibility as design drivers. The user should be able to peacefully concentrate on the task at hand and not disrupt others.

On the positive side, the workers were indeed able to use devices nondisruptively; or, at least, they did not problematize it. On the negative side, it was not because of devices' clever design but because of new habits they acquired. Some learned how to set up their devices only one small step at a time in the beginning of meetings so that they could appear to be concentrating on the meeting, not on the laptop. To streamline the transition of computing state from one meeting to another, one worker had adopted the habit of closing the laptop lid but leaving the computer running and piling all auxiliaries on the top surface. Some workers thought that others perceive working on a bigger laptop while in a meeting as less disrupting than working on a smaller-screen smartphone that demands less attention.

Similarly to context-awareness and seamlessness, making choices that determine disruptiveness is a task left to the users.

Toward Fluent Multidevice Work

Imagination is open for ideas on design. In the paper we presented what was basically a laundry list of approaches to improving ubicomp infrastructures: 1) minimizing overheads that create temporal seams between activities; 2) making remote but important resources, such as connectivity or cables, better transparent locally and digitally; 3) propagating metadata on migration of data from device to device; 4) supporting ad hoc uses of proximate devices' resources like projectors, keyboards, and displays; 5) triggering digital events like synchronization of predetermined documents with physical gestures; and 6) supporting appropriation of material properties for support surfaces. Users essentially need new and more efficient ways to interoperate devices, plan action in the face of "seams," understand and manage technological complexity, plug their data into other devices, and align use fluently with everyday activities.

The drifting apart of HCI research and real-world ubicomp is worrisome because improving the state of affairs is not the duty of engineers alone. Ethnographers and user researchers can contribute to the efforts in improving ubicomp by studying practices that construct and keep it together [7].

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ABOUT THE AUTHOR

Antti Oulasvirta is a postdoctoral scholar at the School of Information, University of California at Berkeley, and a research scientist at the Helsinki Institute for Information Technology HIIT, Finland.

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[7] Star, S.L. The ethnography of infrastructure. American Behavioral Scientist 43, 3 (1999).

David Gartner

Designing for Digital Archives

Elizabeth Churchill
Yahoo! Research| churchill@acm.org

***with* Jeff Ubois**
Fujitsu Labs of America | jeff@ubois.com

Have you amassed a collection of photos and other media without quite knowing how to manage it? Have you spent hours trying to locate a precious or extremely important file? Have you ever wished you'd backed up your files after a computer crash?

More and more of our work and personal content is digital. And mobile, digital technologies like camera phones are changing the nature of capture and collection—what and how we collect. We are living in a world of continuous accumulation.

This is relatively new. Ten years ago fewer people had home computers, fewer services existed, and we weren't surrounded by all those appealing, shiny devices that promise to record our every action in case we want to take a step down memory lane or revisit an article written a while back to snaffle some useful content. Back then terms like "moblogging", "lifelogging," "microblogging," and "lifestreaming" were not in common parlance.

Ironically, this ease of capture and replication actually makes it more likely that we'll lose stuff. The sheer volume of data we are able to collect makes organization daunting and specific content difficult to locate. Frankly, the logically extreme vision of life as constant accumulation offered by Gordon Bell and his collaborator Jim Gemmell, with their MyLifeBits project, is apt to make anyone with old-time curatorial sensibilities erupt in hives.

Amplifying the challenge is the fact that content tends to accumulate in various places—on internal or external flash and other portable drives; on recording devices themselves (cameras, audio recorders, phones); and hosted at ISPs and by services like YouTube and Flickr. Few people have a centralized repository of all their stuff. We curate, consolidate, and/or back up randomly or not at all, and have muddled mental models regarding file formats, backup, and archive practices and services. Prospective retrospective—that is, imagining now what we will want to remember in the future—is hard; we have a limited ability to gauge such future value. So we have a propensity to defer decisions about whether something is worth keeping or not.

Consequently, most of us are what Microsoft's Cathy Marshall and her collaborators have called "lazy preservationists," who rely on "opportunism, optimism, and benign neglect." And most of us are living in a world of digital bloat, our untamed and insecure data strewn all over the place. We skip along on a wing and a prayer, explaining away catastrophes and rethinking data importance in the face of loss: "I guess it must not have been important if I lost it." Sometimes this kind of loss and revision is therapeutic. Sometimes it is not. Sometimes we spend hours reconstructing content or creating passable replacements. For our own archives this is personally troubling, but as a culture it is positively terrifying that our data and our memories are at risk.

Some see this problem as a commercial opportunity. GYMA (Google, Yahoo, Microsoft, AOL) are exploring the business of archiving, backup, and storage, and services; others, like Seagate's Mirra Personal Server, Apple's .Mac account, EMC's Mozy promise storage and a "data cloud" where our stuff will be safe … forever. Or until we fail to pay the subscription fee. Or until they have business or technical problems. Or, as happened to one of our own *interactions* columnists, some malicious miscreant masquerades as you and in a click of a button or two, deletes all your precious material. Under most terms of service agreements, users have no recourse and companies have no obligation to restore the "lost" material even if back-ups exist.

We need to develop a finer

appreciation for the risks to our data posed by "solutions" to other problems (such as DRM), and understand that data preservation is becoming a struggle with active adversaries—malware authors, political partisans, and scammers conducting phishing attacks. Commercial organizations have a mixed record as long-term custodians of personal artifacts and of cultural works.

So in the light of all this, what are some approaches designers and other stakeholders may be interested in exploring? After all, service, application, and interface designers will be the ones implementing the experience now, and thus have a direct impact on the future of our personal and collective digital memories. And who are the stakeholders whom we need to be talking to and designing with, for, and around?

Here are our top five clusters of points and questions on this emerging area. These are overlapping, and there are more, so consider these a seed list.

1. Guide users between backups, archives, and collections. Good design for archival services can help users make decisions based on anticipated future uses and perceived risks.

For starters, it is helpful to distinguish between archiving and backup. Apple's Time Machine, which is part of Mac OS X Leopard, is an interesting step in the right direction. People report learning that *a backup is not the same as an archive* when old (but important) versions of files have been overwritten by backup software whose check boxes were clicked (or not). The options the checkboxes offered required knowing the distinction. Perhaps systems need to ask questions like the following: "Are you sure you want to overwrite this file with all future versions?" Yes, that means *overwrite* it. Not store another version and keep track of all that you have done with the file.

Users must choose between a wide range of file format and compression options (think of ZIP, TAR, JPEG, MPEG, PDF…). Some are proprietary, some may be unsupported in the future, and some are "lossy," meaning file sizes shrink by reducing resolution. Purists in the archival community rule out the use of lossy compression (MP3 or MPEG 2) altogether when there are non-lossy options available (FLAC or JPEG2000). But for personal collections of audio and video, lossy algorithms may be the best way to limit storage costs. Systems that allow users to preview the difference, or that explain the implications of loss, may help.

As professional librarians and archivists know, you cannot have archives without curation. At a more personal level, psychologists view strategic forgetting as what constructing a (more or less) stable sense of self is all about. In this case, a question posed to the user might be, "Are you sure you want your kids to see this when they go through your archives?"

The importance of forgetting should not be lost on us. However, we need to guide users through these concepts with intelligently designed systems and interfaces if people are not going to inadvertently lose the digital materials they *want* to keep. Unfortunately, the consequences of bad decisions may be felt only days, months, years, and decades later. It is hard to learn best practices when there is this lag, so once again designers need to surface the results of choices and knock-on effects at the time of action.

2. Be involved in conversations about the differences between algorithmic search and human memory. Over time we may be able to follow Google's directive, *search don't sort,* because improvements in search algorithms and applications will eliminate the need to file content manually. This search-don't-sort perspective is also reflected in David Weinberger's book, *Everything is Miscellaneous*, in which he explains how the ordering of our collections can be reworked on the fly, as the situation demands. This argument is most compelling if metadata is well designed and standardized. So, for this approach to work, we should be active in communities where forms and standardization of metadata are discussed. Simply asserting that people can be less careful about providing metadata because search is improving is an unacceptably risky approach for materials that are worth saving.

A complementary approach is to leverage our understanding of the way in which human memory works—by recreating context to facilitate retrieval. This would entail providing time frames punctuated by memorable events (salient or regular events), congruent activities ("I was working on the Rosebud project when I took that picture"), and so on. The point is,

what we remember is sometimes not the *searchable* content. In these instances we narrow the search space through circumstance reconstruction—a kind of semantic way-finding to the content… "*something from 2004 when Mum came to visit, so it must have been August and it was a picture and it would have been….*" Again, Apple's Time Machine in Mac OS X Leopard explores this, giving you a snapshot in time of your files. This is an appealing idea.

A lot of human information interaction is serendipitous, based on vague, ill-formulated, semantic associations not clear on text and numbers, and enacted as browsing, encountering, and being reminded—not explicitly remembering. A text-search string still does not find a figurative image, and file metadata are volatile. But reconstructing context is a powerful memory-jogger bringing back the abstract textual that goes with the recognized visual.

Search will also need to return results that cut across different media. Google's Universal Search, which provides results from video, images, new, local, and book search, is a step in this direction. Yahoo!'s OneSearch does this nicely for cell phones. Ask.com does it too, but prettier.

The world is waiting for the designer who can (re)create and implement the memory palaces and mnemonic techniques used by renaissance scholars and described by Frances Yates in *The Art of Memory*.

3. Data is dynamic, not static. The great promise of an archive is to assure long-term access to information. That sounds like stasis, but it isn't. To be effective over decades, archival systems need to migrate data from disk to disk, and in some cases, emulate the environments of the applications that use the data.

In considering personal data storage, we need to consider the easy migration of personal data from one location to another. But personal and social data are always evolving; they are not stable. Formats change, data migrates between storage methods and places, and security and access methods evolve. Smart organizations are looking to support users in their understanding of the consequences of that volatility. Services are beginning to take on the responsibility of educating users as well as funding research into data migration and fighting against format obsolescence (often by supporting current as well as legacy formats).

Digital rights management schemes that allow limited access today may fail in ways that allow no access tomorrow.

For designers these considerations may lead to uncomfortable practices. Refusing to innovate in favor of traditional practices and technologies; sticking close to the file system rather than adding a layer on top; and avoiding the unique in favor of the conventional as a way to support future users and avoid evolutionary dead ends all go against the desire to improve on past practice.

4. From personal to social data. Archives sit at the boundary between public and private data. Data that was once private may, through an archive, gradually be made public. That presents new opportunities and challenges the digital environment.

One opportunity is in cataloging, which is expensive for both institutions and individuals. When the individual is overwhelmed with too much content to name, tag, sort, and store, we could always harness the crowd, get the group to tag and organize. Crowdsourcing and services like Amazon's Mechanical Turk harness human intelligence to solve problems that computers find hard—like tagging and organizing and storing. Archiving is a collaborative practice, and it is going to become ever more so.

But this solution brings up another issue we need to keep in mind: Who becomes responsible for the content created through a collaborative enterprise, and how are ownership and responsibility for that content conceived of by the service providers? An article in Wikipedia is distinct from the contributors who created it, but if a photo that has been collectively tagged in a photo-sharing site like Flickr "belongs" to an individual who subsequently leaves Flickr, what happens to the content? Many people are crushed when the comments they have made on blogs disappear because the blog "owner" stopped maintaining the blog.

Relying on social approaches to archiving may be a practical necessity, but open archives must be built to withstand and respond to a wide variety of attacks, not only from individual malware authors, but from political partisans, abusers of copyright law, and even governments that wish to control access to historical records.

The Society of American

Archivists Code of Ethics states "archivists protect the privacy rights of donors and individuals or groups who are the subject of records." We need to think also about the "rights" and caretaking of the collectively created data. There are questions about ownership of the augmented data that need to be addressed. We need to create a place for discussion of practices around data augmentation with socially contributed metadata.

5. *Designing for sustainability.* We have heard much in the press recently about establishing provenance, considerations of authenticity and integrity, and content rights. Recent efforts from groups such as the Organization for Transformative Works address the trials of remix and fandom with their statement: "We envision a future in which all fannish works are recognized as legal and transformative and are accepted as a legitimate creative activity," wanting to protect fans, the work, the commentary, the history, and thus identity, "providing the broadest possible access to fannish activity for all fans." Access is certainly part of it, but as a secondary point preservation must be central; if the content is not maintained, issues of ownership and control are moot. Who wants to be in control of nothing?

Services and technologies bring with them responsibility if they are to be sustainable. Alfred de Grazia, a pioneer in personal digital archiving, has reframed the problem as one of "managing intellectual estates." The beneficiaries are not just the individual user, but also our culture as a whole, and our descendants. Part of the solution is in an economic model that can be used to sustain and encourage preservation and allow intellectual estates to be maintained. De Grazia focused on the needs of the academic arena. However, with many of us now producing portfolios of mixed-media content for work and being archivists of our own past and those of others, these points are clearly generalizable and more relevant to a broader audience today. As blogger Dave Winer put it, "With all possible humility, I'd like to tell you that a few days after I die my entire Web presence will likely disappear…And when my sites disappear, so will my uncle's. He died in 2003. His site is still accessible because I keep it that way." He points out that his uncle's thoughts may not be something the world at large cares about, but if Dave's uncle were a Nobel Laureate, it would likely change things. In the same post he also points out that most universities do not have a plan for archiving the Web-based content of their professors. Clearly, some folks need to be reminded that the Web is an extensible publishing platform, not an Etch A Sketch.

Digital technology makes it possible to extend the walls of the archive beyond a single space or person, as well as ensure preservation and access in locations around the world in what the Library of Congress is calling a "content stewardship network." Libraries, museums, and archives will need to collaborate with business interests to build lasting social structures that are sustainable over time. There is much work to be done and many stakeholders to be engaged and heard in the merging of content from multiple sources.

A Final Note

To close, it is worth pointing to Terry Kuny's 1997 paper that circled library science networks, warning of a coming *digital dark age* when our data will be lost and/or irretrievable unless we individually and collectively recognize the vulnerability of digital data and design better tools, procedures, services and policies. We say: Let's appeal to greed, fear, utopianism, and good design and make sure we prove him wrong.

ABOUT THE AUTHORS

Dr. Elizabeth Churchill is a principal research scientist at Yahoo! Research leading research in social media. Originally a psychologist by training, for the past 15 years she has studied and designed technologies for effective social connection. At Yahoo, her work focuses on how Internet applications and services are woven into everyday lives. Obsessed with memory and sentiment, in her spare time Elizabeth researches how people manage their digital and physical archives. Elizabeth rates herself a packrat, her greatest joy is an attic stuffed with memorabilia.

Jeff Ubois is exploring new approaches to personal archiving for Fujitsu Labs of America in Sunnyvale, California, and to video archiving for Intelligent Television and Thirteen/WNET in New York. He has been published in *First Monday*, *Release 1.0*, *Computerworld*, the *Journal of Digital Information*, and *D-Lib*, and he blogs at http://www.archival.tv.

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A Fetish for Numbers

Donald A. Norman
Nielsen Norman Group and Northwestern University | norman@nngroup.com

It's 6:30 in the morning, and I'm with a group of surprisingly awake, cheery physicians and nurses doing grand rounds on the pediatric-care ward of one of the best hospitals in the United States. I'm part of a study group for the National Academies, looking at the ways in which information technology is used in health care. This hospital is a leader: I see computers everywhere.

I've been spending a lot of time in hospitals recently. No, not as a patient, but as an observer—following doctors and nurses on their grand rounds, watching patients get admitted, nurses doing shift changes, pharmacists filling prescriptions, and then watching nurses actually deliver the prescribed medication to their patients, waving bar-code readers over the prescriptions, the medication, and the patients.

We walk down the hall toward the first set of patents. We are quite a crowd: the attending physician and approximately five medical residents, physicians completing the last stage of their training, plus one or two nurses. The attending physician is responsible for treating patients and is also supervising the residents, each of whom is wheeling a computer cart. The hospital calls them "COWs"—Computer on Wheels. (One hospital switched the name to WOW, Workstation on Wheels, after a patient heard physicians outside her room talking about "the cow" and thought they were referring to her.) A COW is a chest-high cart with computer screen and keyboard at a height appropriate for stand-up reading and typing; the computer itself and batteries are located at the bottom of the unit. Five COWs, plus a nurse wheeling a big filing cabinet of papers, plus the attending physician, plus the members of my observation team. We take up a lot of space. We stop at each patient's doorway to review progress. The attending physician asks for a review, and each of the residents flips through the windows displayed on their computer screen and summarizes status: "Calcium level is fine, white count low." Each resident has different information for the patient, or to be more precise, has screens that describe test results from different laboratories.

The patient was a bunch of numbers. Moreover, the numbers were not organized by symptoms or diagnoses: They were organized by what tests were run and which laboratory within the hospital had processed the results. The patient's history, the record of past events and health care, was in a different location from current test results. Current results were in a different place than past results. Different hospitals might have different laboratories, so their results would be organized differently. But the attending and resident physicians and nurses were experts at piecing together a mental model of the state of the patient from all these numbers. Or so they said: Evidence is difficult to come by.

"That's interesting," I said to myself, stepping into a room filled with displays. There were multiple infusion pumps, multiple computer readouts, and multiple monitors. The entire room was filled with the red glowing lights of display readouts and the dim white of graphs on the computer screens. "Fascinating," I said. "You've brought all of the monitors into one place so you can see how all the patients are doing."

"No," said one of the physicians, "what do you mean?"

"So where are the patients?" I asked, expecting to be told that they were in rooms adjacent to the instruments.

"Right there," said the physician, obviously puzzled by my question. "Right there in the room, right in front of you."

I looked closely and still couldn't see a patient. One of the nurses walked over and pointed. "Oh," I said.

There were so many medical devices, so many readouts and displays, that I could not even see the patient until someone showed me. Now, this was an infant ward, so this particular patient was tiny, but even so, it's a good illustration of modern

medicine: From the physician's point of view, the patient is a set of test results and numerical readouts. The patient as a person tends to be forgotten.

I saw this later in a different hospital in yet another ward. The attending physician would stand outside of the patient's door and listen to the review of the test results by all the residents. They would then discuss the results and make further recommendations. Then, as we all left to go to the next doorway and the next patient, the attending physician would knock on the open door, stick his head in and say, "How are you doing today, Mr. Forbes?" That was the extent of patient interaction.

So many numbers, we lose sight of the person. Scientists measure what they can measure and pronounce the rest to be unimportant. But the most important parts of life are qualitative. One of the physicians on my study team told us that she is allowed only 15 minutes to attend to each patient in her internal-medicine practice, but it can take as long as 20 minutes to fill out all the required paperwork. She has to force herself to look at and interact with the real patient. One hospital center estimates that nurses spend only a third of their time in direct care of a patient. The remaining two-thirds is spent on documentation and medication record keeping. One physician told of watching a nurse who busily recorded all of the numerical indications about the patient's circulatory and respiratory system, but was too pressed for time to consider the meaning of the numbers or look at the patient—a five-second glance would have revealed that the patient was having extreme difficulty breathing.

Modern medicine is a complex undertaking. It is highly technical, highly specialized. The patient has been carved up into little kingdoms, with different specialties competing for ownership of each piece, leading to occasional flashes of territorial wars. Nowhere is this more vividly presented than in the operating room, where a vertical sheet placed over the patient at the level of the neck divides the territory belonging to the anesthesiologist (the upper part of the patient—the head) from the territory belonging to the surgeon (the lower part of the patient—the body). But even when everything works as planned, the complexity of the process—involving multiple specialists and disciplines—combined with the fetish for numbers and regulations, makes attention to the needs of the patient almost seem like an afterthought.

Those of us who have spent time in hospitals, in whatever capacity, know how frustrating it can be. All of us, friends, relatives, and even the patient, are all pushed aside in the interests of efficient medical care. And even where there is a caring physician or nurse attempting to help, nasty though well-intended legal restrictions block attempts of the patient and especially of relatives and friends to gain access to information.

The hospital is a complex system, with multiple complex interactions among people, equipment, laws, institutions, and a confusing wealth of information. The opportunities for improvement are numerous: Health care is a problem awaiting

Donald A. Norman

improvement, a problem that can keep many people occupied for many years. A problem so complex that we need to start now, for it is already life-threatening.

A final comment: Many hospitals recognize these issues and are working to improve them. Some have patient rooms with special areas for family. Others are trying to address the extreme attention to displays at the expense of the patient. Even more reason for us to be involved. The opportunity is right.

ABOUT THE AUTHOR Don Norman wears many hats, including co-founder of the Nielsen Norman group, professor at Northwestern University, and author, his latest book being *The Design of Future Things*. He lives at www.jnd.org.

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Situated Sustainability for Mobile Phones

Elaine M. Huang
Motorola Labs and RWTH Aachen University | elaine.m.huang@motorola.com

Khai N. Truong
University of Toronto | khai@cs.toronto.edu

Worldwide sales of mobile phones are expected to exceed one billion by the year 2009 [1]. In 2006, 143 million mobile phones were sold in the United States alone [2], and a 2007 study showed that American consumers use their phones for only an average of 17.5 months before replacing them [3]. Despite the global proliferation of phones, only 5 percent of phones are ever recycled [2], thus leading to a massive potential problem of e-waste.

[1] http://www.gartner.com/press_releases/asset_132473_11.html

[2] NPD Group: "143 Million Mobile Phones Sold in the US in 2006" http://www.itfacts.biz/index.php?id=P8297

[3] "U.S. Wireless Mobile Phone Evaluation Study," J.D. Power and Associates, 2007.

Phones as Disposable Technology?

There is an increasingly common trend of acquiring technologies, most notably consumer electronics, with the expectation that they will be replaced or disposed of before they cease to be functionally viable. We refer to this trend as the *disposable technology paradigm*, and it is visible in increasingly ubiquitous devices such as laptops and portable mp3 players, which are typically replaced within a few years and whose usage lifetime is often much shorter than their functional lifetime. Mobile phones appear to be the most widespread example of such "disposable" technologies, and we therefore chose them as the starting point for our research into this phenomenon. The proliferation of these devices is a leap for communication capability, but their rapid consumption and turnover pose an increasingly urgent problem of waste and pollution. Mobile phones are a unique case of e-waste in many ways. Unlike most other personal devices, they often have a built-in replacement cycle as users receive a new device on a regular basis by renewing their service contracts, regardless of the state of their previous device. And in the case of North America, where we conducted our study, technology incompatibility can also necessitate getting a new phone, for example when someone switches from CDMA service to GSM service. These factors add to the proliferation of devices and disposal of technically functional phones.

When we began our study of mobile phone replacement and disposal practices, we were motivated by two goals stemming from the disposable technology paradigm. Our first goal was to understand what factors influenced people's decisions to replace their phones and what their practices for doing so were. Our second motivating goal for studying this phenomenon was to take that understanding and apply it toward the design of "greener" phones—those that would encourage longer use, less frequent disposal, more sustainable replacement practices, and overall reductions in e-waste. After undertaking our study, however, we discovered the importance of context in how people replace and dispose of their phones and realized that this context, in addition to the design of the object itself, should be taken into account when designing for and assessing the sustainability of objects. This approach, which we term *situated sustainability,* supports the identification of the various challenges and opportunities for improving the sustainability of the object on a broader scale.

Toward Sustainable Mobile Phone Design

Our perspective in approaching this work was strongly influenced by the rubric posited by Eli Blevis, in which he suggests several ways to understand and critique the sustainability of a design by considering such crucial issues as whether its components can be recycled, whether it lends itself to being shared or passed along to others, and whether the design promotes longevity of use [4]. We did not harbor illusions that the treatment of mobile phones as disposable technologies was either solely due to their design or a problem that could be solved entirely through better interaction design.

[4] Blevis, E. "Sustainable Interaction Design: Invention & Disposal, Renewal & Reuse." In the Proceedings of CHI 2007, 503-512.

EDITOR
Eli Blevis
eblevis@indiana.edu

We knew that contract-renewal incentives of free phones and fashion trends were part of the picture. We knew as well that achieving sustainable phones would also entail changes in terms of materials science, engineering, business, and economics. But understanding and influencing the user experience with phones through interaction design, especially with regards to the replacement and disposal experiences, seemed necessary and complementary steps along the path to greener phones.

We undertook a qualitative study examining people's practices and perceptions of their phones in which we surveyed 79 mobile phone owners and then interviewed 10 of them who had had very varied experiences—from throwing still-functioning phones away in the trash to collecting the old phones of others for use at a center for victims of domestic violence. We probed users' experiences with acquiring, replacing, and disposing of mobile phones and reporting our findings regarding people's practices and attribution of value to their phones [5].

Our findings showed that while physical design and functionality played a role in how people selected a new phone, contract-renewal incentives were far more likely to motivate the actual decision to replace an existing phone. We also found that many people were not enthusiastic about receiving new phones with a contract renewal, but rather accepted it as standard practice in which they engaged, even when they preferred their older phone to the newer model. Additionally, we found that people were generally aware of the potential environmental hazards of throwing a phone in the trash, but were often unaware of what their options for responsible disposal were and found that getting information about their options was difficult or required too much effort. Considering our data from this perspective, we identified several opportunities for rethinking mobile phone design in which the phone itself or aspects of the phone encourage sustainable actions [5]. Our findings suggest that many users would be receptive to phones that are designed to be easily upgraded for aesthetics or functionality as a viable alternative to complete technology replacement with a contract renewal. To address the difficulty of obtaining information about end-of-service options, we suggested the design of phone that is aware of when the user's contract is close to expiration and takes advantage of location awareness to send the user an SMS suggesting local facilities for donation and recycling, or other environmentally responsible actions.

Considering the Context of a Phone

While considering ways to redesign phones is an important step toward mobile phone sustainability, in talking to people about their experiences with mobile phones, it became clear to us that situation was also a driving factor in the extent to which people engaged in sustainable practices of disposal and replacement. Thus we need to think not only about the design of the phone, but also about how to leverage and influence context outside of the device itself to support sustainable phone practice. More broadly, we introduce the notion of *situated sustainability*, that idea that both a device and the context in which it exists should be considered first-order areas for design, and that an object's context must also be considered when evaluating the sustainability of the object.

Aspects of the context in which a mobile phone exists offer cues for design. Our findings indicated that serendipitous information and chance encounters with resources in the environment played a major role in the majority of sustainable interactions. For example, some people learned about recycling services because a friend happened to mention one that they had used. Other participants learned the locations of phone-donation drop boxes by seeing them in places they normally went to, such as a synagogue or a cosmetics shop. These findings suggest that we need to consider not only how to change phones themselves, but also how to change the contexts and environments in which phones exist to amplify this information and make it more visible, discoverable, and easily available.

We also discovered that there was a strong social or community component to engaging in sustainable phone disposal. Our study participants often told us that engaging in phone recycling was in some way a group activity, for example that one member of a family would contact all of the other members and collect the phones for recycling. Another common practice was to "ask around" when replacing a phone to try to find a recipient for an old but still functional phone. We found that people were generally unsuccessful in trying to find a taker for the phone and gave up after asking a few friends or family members, eventually putting the phone in storage or disposing of it in

[5] Huang, E. M., Truong, K. N. "Breaking the Disposable Technology Paradigm: Opportunities for Sustainable Interaction Design for Mobile Phones." To appear in the Proceedings of CHI 2008.

► *Cell Phones #2,* Atlanta 2005

another way. However, the fact that people attempt to find another owner for their phones shows that they perceive it as an object of some value, and more important, an object that holds potential value for others. Their practices suggest that social networks and their supporting technologies could be leveraged as a way of amplifying the communication involved in giving a phone away. This would extend the usage lifetime of phones by increasing the likelihood of finding a subsequent owner for it.

Rethinking How to Evaluate the Sustainability of Objects

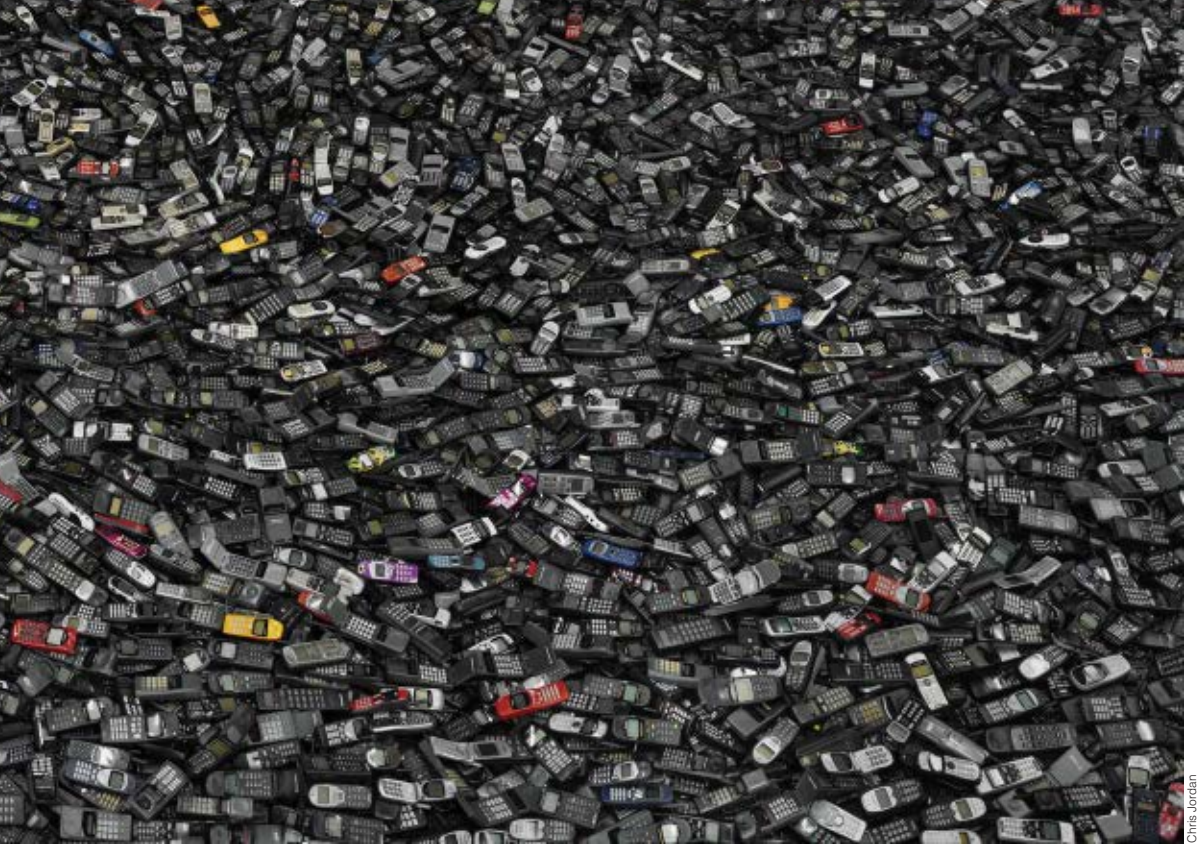
It also became clear that when we assess the sustainability of a device or object, the design of the object cannot be considered in isolation but rather must be examined in the context of the information and resources available in the object's environment. It is important to consider both the design of the object as well as the ecology in which it exists. As a simple example, we consider the case of a lithium-ion phone battery. Such batteries contain chemicals and nonbiodegradable materials and are even prone to explosion when exposed to high temperatures; they therefore should not be disposed of with household trash [6]. In the European Union, standardized recycling drop boxes for batteries are present in many frequently visited locations, such as supermarkets and post offices, thus making the infrastructure for sustainable action readily available to users of the object through serendipitous opportunity. Information about the availability of battery recycling is also implicitly conveyed simply through the visibility of these resources. In comparison, recycling of the same battery in much of the United States poses challenges because information about recycling services is not as readily available, and taking sustainable action may require the effort of locating a recycling service and then making an extra trip to bring the battery there. As this example illustrates, when assessing the sustainability object, in addition to considering how the object's design promotes recycling, reuse, reappropriation, or environmentally responsible disposal, it is also critical to consider the extent to which the ecology of which the phone is a part supports access to information about options, low-effort sustainable interaction, and easy access to other resources necessary to engage in sustainable actions.

[6] "Lithium Ion, Nickel Cadmium, Nickel Metal Hydride Battery Best Practise Guide." http://www.hpcfactor.com/support/cesd/h/0015.asp

Five HCI Challenges for Sustainable Mobile Phones

The path to sustainable mobile phones is a complex one that suggests the need to look not only at phones but also at the contexts in which they exist. Clearly, interaction design alone will not solve all of the issues of proliferation and e-waste generated by "disposable" technologies. That being said, we believe interaction design will play a substantial role in achieving sustainable mobile phones and phone practices. We therefore put forth what we believe to be the five most pressing interaction design challenges for mobile phones and their environments from the perspective of situated sustainability.

1. Make information more available. Information about sustainably responsible options needs to be delivered or made more readily available at low effort and cost to the user. Of particular importance is that information be available in a timely



Chris Jordan

manner. For example, information about proper battery disposal could be made available near or at the end of the battery life.

2. Put opportunities in the environment. Resources for and information about sustainable phone actions should be made available where they will be most useful or most easily accessible. It is important to consider how to integrate opportunities for sustainable interactions in ways that leverage users' everyday routines to lower the effort necessary to engage in such interactions and increase the likelihood of serendipitous opportunities for sustainable action.

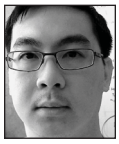
3. Develop novel alternatives to disposal. To avoid the unnecessary discarding of functional devices and lessen the need for the production of new devices, it is important to find novel alternatives that facilitate the reappropriation of phones or their components to extend their lifetime and transition them into other roles to which they are suited. It is of value here too to consider how both design in the environment and design of the phone could support and encourage reappropriation.

4. Create reasons for keeping. The value and purpose of a device may change over time. In order to foster a longer lifespan, another challenge is to create reasons for users to keep a phone. Perhaps designs that foster a stronger personal connection to the phone or create long use will enable an aging device with declining value to continue to offer benefit to users. It may also be worthwhile to consider ways to design phones that "get broken in" over time, such that users actually derive explicit benefits from maintaining a phone for a longer period.

5. Support upgrading and extension. Along with opportunities for reuse and reappropriation, phones and their environments should offer novel and valuable ways of upgrading and extending the phones to reduce the need for complete replacement. This requires consideration of how to design a phone that can be easily stripped and reconfigured. For example, adding new hardware should become as simple as changing the skin of the phone and plug-and-play capabilities on a desktop computer.

Mobile phones present a particular challenge for sustainability because of their increasing ubiquity and frequent replacement. In considering how interaction design can play a role in reversing the tide of mobile phone e-waste, examining the problem through the lens of situated sustainability may open possibilities for solutions that go beyond our devices.

ABOUT THE AUTHORS Elaine M. Huang is a researcher in the Social Media Research Lab at Motorola Labs. She recently completed a Humboldt Fellowship in the media computing group at RWTH Aachen University, where she began research on e-waste and sustainability. She received her Ph.D. in computer science with a focus in HCI from the Georgia Institute of Technology. She can be reached at www.elainehuang.com.



Khai N. Truong is an assistant professor in the University of Toronto's Department of Computer Science. His research lies at the intersection of human computer interaction and ubiquitous computing, and focuses on usability and acceptance issues surrounding automated capture and context-aware applications. He received his Ph.D. in computer science from the Georgia Institute of Technology. For more information visit www.cs.toronto.edu/~khai.

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David Gartner

Everybody's Talkin' at Me

Steve Portigal
Portigal Consulting | steve@portigal.com

In a 2005 *New York Times Magazine* article, "Watching TV Makes You Smarter," adapted from his book *Everything Bad Is Good for You: How Today's Popular Culture Is Actually Making Us Smarter*, Steven Johnson identifies the increasingly complex narrative structures that we've become accustomed to in series television. Compare the density of plot and character in "Curb Your Enthusiasm," "The Wire," "The Shield," or "Lost" with "The Rockford Files," "Adam-12," or "Gunsmoke." Pop culture reveals a maturing in our appetite for stories. This voraciousness continues to grow, with social media emerging to deliver us stories in all shapes and sizes. We get big stories from blogs; miniature stories via Twitter; multimedia stories on Flickr and YouTube. All of them are equipped with handles to make it easy for us to retell the narrative to others (something we've dubbed "viral").

Procter & Gamble is selling stories, too, with products like Febreze Scentstories. Positioned as more than a traditional air freshener, the product offers "a variety of scents from an assortment of scent-themed fragrance discs" such as "farmer's market," "spa day," or "world treasures." In 2004 Nissan advertised heavily around "Tell Better Stories," suggesting that the end result of using their products was the story a driver and passengers would tell. And screenwriting guru Robert McKee coaches corporations on how to be better storytellers, while author Steve Denning has analyzed what types of stories can be used by business leaders across a range of situations.

While this commercialization of stories is all lovely, the emphasis is unfortunately placed on the *telling* of stories, rather than the act of *listening* to stories.

Let me tell a story about that. Recently, we worked with a company that sold a niche B2B software product. They had wonderful relationships with their small set of customers, thanks to the account executives, who were essentially salespeople. The account executives did a great job of advocating for the company and touting the benefits of their software. That inevitably created a conflict when their customers offered feedback. A sales channel isn't necessarily the best way of getting information back from customers, and it certainly shouldn't be the only way. At our recommendation, the client instituted a "listening channel," and we began training product managers and developers on the basics of having an open-minded and open-ended conversation with customers.

Skip ahead a few years. Our client has been acquired by a larger company that has developed a crucial software product enthusiastically derided by users. Yet when these new corporate masters are introduced to The Listening Channel, the reaction is instantly negative—"I don't want The Listening Channel. I want The Telling Channel." As in, "We'll tell you why our product is the best. And we aren't interested in listening to your problems with our product." Meanwhile, it's proving difficult for them to hold on to their spot in a tightly competitive market.

We can find more common examples of telling over listening in the marketing rhetoric of "educating the customer," commonly used when companies realize that the public isn't doing what they want them to be doing. By labeling their customer as "uneducated," they place responsibility on someone else's shoulders. No need to look at the solution being offered if you can marginalize those who haven't adopted it. The recent fluorescent-bulb hype is a timely example; California, like Australia, has introduced legislation to mandate the use of fluorescents in the home, while companies such as Wal-Mart are putting a lot of money into marketing these products. Wal-Mart is trying to persuade us to use these new bulbs, even as people express frustration over the poor quality of light they produce. Instead of investing this money and effort in refining the

product, Wal-Mart continues to pressure a marketplace that has already indicated its objections. Do we need (re)educating, or just a better bulb? The problems with the current product are well-documented; the pathway to consumer acceptance has been lit from within. It would be nice (and ultimately more effective) if they worked on the bulb, not on changing the meaning of the bulb. As we know, the bulb has to really want to change.

PR people are masters at making telling sound like listening. Sound bites that supposedly come from CEOs typically feature hollow customer-centric phrases that serve to validate any business decision (a new product, a new feature, a change in a previous way of doing business, the removal of a feature, etc.). "Our customers tell us that food packaging is extremely important to them and can determine what they buy," and "We've done research, and research shows us that our customers like . . . movies." Maybe these companies are listening to their customers and maybe they aren't; they're so busy telling us how hard they are listening that it's difficult to sort out what's real.

The retro chic of AMC's "Mad Men" has reminded us in a rather quaint way of the role of advertising to persuade (some may say "manipulate"). And it's in advertising that we see the biggest disconnect between the story that is being told by the producer and the story that is being told by the consumer. It's in their interest not to listen. Oil companies care about the environment, and McDonald's loves to see us smile? Do we still believe that Target is a champion for good design when we go into a store and see huddled masses yearning to shop cheaply?

These businesses tell a good story (we call that "innovative" advertising), but they fail to deliver the promised experience. We measure advertising by the attention it can grab, but who measures coherence? The Cluetrain folks told us this was supposed to be a conversation, but it's hard to consider it a dialog if it's one-way.

Listening can bring value to all parts of the organization and the product development process. Indeed, to reach the stage of *conversation*, we need to better utilize the listening tools we have at our disposal, even as we find more effective and impactful ways to tell.

We can find examples of telling over listening in the marketing rhetoric of "educating the customer," commonly used when companies realize that the public isn't doing what they want them to be doing.

ABOUT THE AUTHOR Steve is the founder of Portigal Consulting, a boutique agency that helps companies discover and act on new insights about themselves and their customers. He is an accomplished instructor and public speaker, and an avid photographer who curates a Museum of Foreign Grocery Products in his home. Steve blogs regularly for All This ChittahChattah, at www.portigal.com/blog.

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Ron Baecker's initial chapter in the 1987 volume of readings that he wrote and edited with Bill Buxton was a very influential reflection on HCI history. It was widely read, reprinted, and served as a model or starting point for subsequent histories. In this review of major themes, Ron poses questions and encourages us to seek out answers while we can. In the 1970s and 1980s I worked for two leading technology companies that eventually went out of business. They left surprisingly few traces. It would be ironic to lose knowledge of the origins of an industry that may preserve almost everything that transpires in the future. Ron's questions demand continued attention; finding the answers may require years of effort. —Jonathan Grudin

Themes in the Early History of HCI—Some Unanswered Questions

Ronald M. Baecker
University of Toronto | rmb@kmdi.toronto.edu

We are grateful to the editors for this series, as it encourages us to reflect on the past and to understand that technological miracles do not spring fully formed from the minds of researchers. More typically, they arise from the thoughts and inspirations and long nights of effort of many who have worked in HCI in the past. As this series shows, the interplay among researchers can often be represented by timelines portraying strands of development or thought.

Because our work (variously called "human-computer interaction," "interaction design," and "knowledge media design") has transformed the way human beings create knowledge, learn, think, communicate, and collaborate, we must record and understand our history. By gathering original sources, we can produce accurate, rich, and nuanced accounts of the intellectual history of our field. This is urgent because our opportunity to talk to and record the experiences of many who made seminal contributions is limited. Several have already passed away—Vannevar Bush on June 30, 1974, J.C.R. Licklider on June 26, 1990, Allen Newell on July 19, 1992, Herb Simon on February 9, 2001, Kristen Nygaard on August 10, 2002, Jeff Raskin on February 26, 2005, and, most recently, Brian Shackel on May 9, 2007.

Some valuable contributions have already been made. Several short histories provide useful overviews of HCI. There are books about Licklider and Doug Englebart, and excellent accounts of the early history of personal computing (*see page 26*).

From these and other sources we can sketch a timeline of significant early threads of our discipline (Figure 1), namely, hypertext (HT), interactive graphics and the concept of direct manipulation (DM), GUI and WIMP interfaces (GUIs), the role of graphic and industrial design (design), usability testing (testing), and understanding workplace context (context).

These six phenomena have been chosen from an even longer list of topics that could be considered highly significant in the development of HCI [1]. To me, they seem the most significant. Do we understand how these ideas and developments arose? What important unanswered questions come to mind?

[1] Other worthy concepts and paradigms include (in no particular order) user-interface toolkits, evaluation methods, mental models, formal methods for describing human-computer interactions, interaction techniques, input devices, mobile devices, virtual reality, computer games, information visualization, speech input and output, and multimodal interfaces.

Hypertext

The origin of hypertext is generally credited to Vannevar Bush's 1945 article introducing the "Memex," a mechanism he envisioned for storing documents and linkages among them, and for enabling paths of exploration through the document space. Technological visionaries Doug Engelbart and Ted Nelson creatively elaborated Bush's vision in the 1960s. They envisioned using computers to build and manipulate richly structured complexes of interconnected, interlinked bodies of text. They realized, as Bush had not, that most information would be stored digitally rather than on microfilm. Yet their approaches differed substantively. Engelbart focused on hierarchic structures for ordinary documents to enable computers to support their preparation; Nelson was more interested in lateral links and interconnections to create novel text "spaces." Engelbart looked to support creativity and problem-solving in teams; Nelson was excited by individual exploration and combining contributions from people with no formal ties.

Yet interesting questions still come to mind. Why, besides the need to wait for Moore's Law to make hardware sufficiently inexpensive, did

EDITOR
Jonathan Grudin
jgrudin@microsoft.com

almost 20 years pass before we started to realize Bush's vision? To what extent and how did Bush's writings influence Engelbart and Nelson? Did Nelson and Engelbart interact and influence one another? What triggered the explosion of research on hypertext in the late '60s and '70s that led to the first annual conference in 1987 and the first commercial products? What were the key milestones in the path from there to the Web, regarded by many as the "killer app" of hypertext?

Interactive Computer Graphics and Direct Manipulation

Recent publications document the pioneering interactive computer graphics research at MIT Lincoln Laboratory, including Ivan Sutherland's influential Sketchpad system in the early '60s. Sketchpad demonstrated the potential for effective computer-aided sketching and design through innovative concepts including hierarchic internal structure of computer-represented pictures; recursively defined operations on these pictures; master copies and instances; constraints on picture geometry; iconic representations of constraints; and elegant input techniques using a light pen. Yet questions remain. How and to what extent was Sketchpad influenced by early computer graphics projects such as that of Stephen Coons and Douglas Ross at the MIT Electronic Systems Lab? How did these developments inspire and launch the vigorous field of interactive computer graphics?

Sketchpad and other systems developed at Lincoln Lab were direct manipulation systems, satisfying the four criteria posited by Shneiderman in his important 1983 paper: "1. continuous representation of the object of interest; 2. physical actions … instead of complex [typed] syntax; 3. rapid, incremental, reversible operations whose impact … is immediately visible; and 4. layered or spiral approach to learning." Yet this paper cites no work earlier than the late '70s, so the intellectual history of direct manipulation has yet to be written. The concepts were also present in early videogames such as Spacewar—developed at MIT in 1961-1962—in early computer-aided design programs, and in the pioneering computer-aided molecular-chemistry work of Cyrus Levinthal at MIT. Why did it take two decades to abstract this interaction style as a new paradigm?

GUIs and WIMP Interfaces

Related concepts are that of the Graphical User Interface (GUI) and the Windows Icons Menus Pointers (WIMP) style of interaction. In introducing a CHI 2005 panel on early work at Lincoln, Bill Buxton stated "it is hard to imagine the innovation that happened at Xerox PARC in the '70s having been possible without the foundation that Lincoln Labs provided." I believe this is true, but the case needs to be made.

Did the work at Lincoln Lab inspire the development of what arguably was the first personal computer, the Alto, at the Xerox Palo Alto Research Center (PARC)? If so, how? Are there direct links between interactive graphics at Lincoln on calligraphic displays and the Alto bit-mapped display? The same question can be asked of the development, also at PARC, of Dick Shoup's Superpaint color frame buffer. How did these lead to Xerox's late and unsuccessful attempt to commercialize personal computing in the Star system, which influenced the design of the Apple Lisa, the predecessor of the Macintosh? Where are the earliest manifestations of each key component—bit-

	HYPERTEXT	DIRECT MANIPULATION	GUIs	DESIGN	USABILITY TESTING	WORKPLACE CONTEXT	OTHER HCI
1945 Bush's "As We May Think"	◆						
1946 Tavistock Institute founded in London							◆
1959 Shackel's "Ergonomics for a Computer"							◆
1960 Licklider's "Man-Computer Symbiosis"							◆
1962 Norwegian Industrial Democracy Program							◆
1962 Engelbart "Augmenting Human Intellect"	◆						
1962 Spacewar videogame		◆					
1963 Sutherland Sketchpad Ph.D. thesis		◆					
1965 Nelson hypertext	◆						
1969 Engelbart SJCC Demo	◆						
1969 Kay Reactive Engine Ph.D. thesis		◆					
1970 Founding of Xerox PARC							◆
1970 Founding of HUSAT							◆
1971 Weinberg's *The Psychology of Computer Programming*							◆
1973 Martin's *Design of Man-Computer Dialogues*							◆
1973 Alto personal computer			◆				
1973 Superpaint color frame buffer			◆				
1974 Gypsy WYSIWYG word processor			◆				
1975 Altair personal computer kit in *Popular Electronics*							◆
1976 Kay and Goldberg's "Personal Dynamic Media"			◆				
1980 Aaron Marcus's first tutorial				◆			
1981 Xerox Star			◆				
1981 IBM PC			◆				
1982 Gaithersburg Conference/CHI formation							◆
1983 Card, Moran, and Newell's *Psychology of Human-Computer Interaction*						◆	
1983 Shneiderman's "Direct Manipulation"		◆					
1983 Tufte's *Visual Display of Quantitative Information*				◆			
1984 Apple Macintosh			◆				
1985 Gould and Lewis's "Designing for Usability"					◆		
1986 Norman and Draper's *User Centred System Design*							◆
1987 First Hypertext conference	◆						
1987 Suchman's *Plans and Situated Action*					◆		
1990 Tim Berners-Lee Web browser	◆						
1990 First Usability Professionals Association conference					◆		

►**Figure 1.** Timeline of Early HCI History

mapped displays, the desktop metaphor, What You See Is What You Get (WYSIWYG) document editing, overlapping windows, icons, and menus? How did the invention and refinement of these concepts interrelate?

A Broadening of Focus

We now reach a turning point in HCI history. The invention and widespread success of the PC enabled hundreds of millions of humans to interact with computers, in contrast to a few million organizational mainframes and tens of millions of minicomputers. A wider set of issues became relevant.

Graphic Design and Industrial Design in Interaction Design

For computers to become mainstream consumer products, they had to look as good as sports cars and hair dryers. Thus industrial design would play a key role. Furthermore, one reason the GUI became the dominant interface paradigm of the '80s was that graphic designers and visual artists began to exploit bit-mapped displays to make interfaces more attractive and communicative.

What were the roles of design pioneers such as Aaron Marcus and Edward Tufte in inspiring such developments? How did this movement influence hardware and interface software in seminal products such as the Star, the Apple II, and the Macintosh? How did the graceful design sense of these products manifest itself and become an essential element in other mainstream software products? How did industrial research groups, product-development teams, and scholars and practitioners from universities and design schools contribute and interact?

Usability Testing

By the '80s it became apparent that there was another implication of the fact that the computer had become a mass-market product for nonspecialists. To design software successfully required usability testing, a set of techniques that draw their inspiration from human factors.

What are the *earliest* known examples of user testing? How did the concept of "usability testing" evolve into more comprehensive "usability engineering?" Who built the first usability lab? What were the important innovations by hardware companies such as IBM and DEC, and by systems

and software-development organizations? How did an understanding of the importance of usability testing spread from organization to organization? What was the role of CHI and other new conferences? To what extent were such innovations guided by systematic principles of user-centered, iterative design, such as those articulated by John Gould and his collaborators at IBM?

Understanding Workplace Context, and Designing for Humanization and Democratization

Another phenomenon that started in Europe and spread to North America was the commitment to ground system design in a deep understanding of workplace context. The British sociotechnical design movement and the Scandinavian collective-resource approach both aimed at humanizing the technology's impact in the workplace. The latter philosophy later became the participatory design movement as it spread worldwide. North American recognition of the importance of workplace context and the role of methods rooted in anthropology and sociology was spurred by the influential work of Lucy Suchman at Xerox PARC in the mid-'80s. Since then many social scientists have been hired by corporations such as IBM, Microsoft, and Intel. Yet we lack a comprehensive scholarly history of the roles in these developments of various individuals, corporations, and academic institutions.

Toward a Richer Understanding of the History of HCI

I have reviewed the *early* history of HCI—hypertext, direct manipulation, and the development of the GUI, then suggested that what happened next was a broadening of the field's focus to incorporate the skills of graphic and industrial designers, applied psychologists, and social scientists. This brief article is not intended as the final word on any of these topics. Each short treatment could be a sketch of a future Timelines article, or, better yet, a Ph.D. thesis in the history of science and technology. This is my challenge to the readers.

We generally know the names of important contributors, but how they built on one another's work is, for the most part, yet to be written. We don't know what was happening in different places and the way ideas spread from country to country, especially in the days before email, the Internet, and the Web. We also have little insight into the interplay between academic research and industrial R&D, between publications and patents. Finally, except for the line from direct manipulation to the GUI, we have little understanding of how lines of development influenced each other.

Can we do better? Consider the history of medicine. The Wellcome Trust for the History of Medicine at University College London created the "Wellcome Witnesses to Twentieth Century Medicine"in 1993. There are currently 31 volumes, available in hard copy and online, that comprise important papers, records, photographs, and transcripts of daylong seminars in which significant figures in 20th-century medicine discuss specific discoveries or events in recent medical history.

There are some hopeful signs of similar activities in our field. Goldberg's 1988 volume, *A History of Personal Workstations*, contains transcriptions of talks by major contributors to the development of personal workstations. More recently, the DigiBarn Computer Museum has held and recorded events with pioneers in the development of direct manipulation, the Alto, the Apple, the IBM PC, and the Macintosh.

Nonetheless, let us hope that some visionary corporation will step up and create the <your company's name> Witnesses to Twentieth Century Human-Computer Interaction. It is urgent that this happen soon.

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Louis Fabian Bachrach

ABOUT THE AUTHOR Ronald Baecker is professor of computer science, the Bell University Laboratories chair in human computer interaction, and founder and chief scientist of the Knowledge Media Design Institute at the University of Toronto. He was named one of the 60 "Computer Graphics Pioneers" by ACM SIGGRAPH, elected to the CHI Academy by ACM SIGCHI, and awarded the Canadian Human Computer Communications Society Achievement Award. He has been working in "HCI" since 1966.

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The Early History of Personal Computing: A Bibliography

PART ONE: GENERAL SOURCES ON THE HISTORY OF HCI

One useful historical overview is Chapter 1 of Baecker, R.M. and Buxton, W. (1987), *Readings in Human Computer Interaction: A Multidisciplinary Approach*, Morgan Kaufmann. (A slightly improved version appears in Baecker, R.M., Grudin, J., Buxton, W., and Greenberg, S. (1995), *Readings in Human Computer Interaction: Toward the Year 2000,* Morgan Kaufmann.) Three others are Shackel, B. (1997), "Human-Computer Interaction—Whence and Whither," *Journal of the American Society for Information Science* 48(11); Myers, B. (1998), "A Brief History of Human-Computer Interaction Technology," *interactions*, March-April; and Grudin, J. (2007), "A Moving Target: The Evolution of Human-Computer Interaction," in A. Sears and J. Jacko (Eds.), *Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*, Erlbaum.

Two excellent edited volumes on the early history of personal computers are Gupta, A. and Toong, Hoo-min D. (Eds.) (1985), *Insights into Personal Computers*, IEEE Press; and Goldberg, A. (Ed.) (1988), *A History of Personal Workstations*, ACM Press. A good journalistic account is Levy, S. (1984), *Hackers*, Anchor Press/Doubleday.

Licklider is discussed in depth in Waldrop, M.M. (2001), *The Dream Machine: J.C.R. Licklider and the Revolution that Made Computing Personal*, Penguin Books.

More than 40 recent interviews with important interaction designers are reported in Moggridge, B. (2007), *Designing Interactions*, MIT Press. Erickson, T. and McDonald, D. (Eds.) (in press), *HCI Remixed*, MIT Press, presents personal accounts of the impacts of seminal papers. A useful website is maintained by the Georgia Tech Program in Human-Centred Computing, see http://hcc.cc.gatech.edu/taxonomy/cat.php?cat=2.

PART TWO: HYPERTEXT

The original article is Bush, V. (1945), "As We May Think," *Atlantic Monthly* 176(1). But see also Rayward W. B. (1994), "Visions of Xanadu: Paul Otlet (1868–1944) and Hypertext," *Journal of the American Society for Information Science* 25(4), May, describing an early Belgian "information scientist" who anticipated some key aspects of hypertext.

Much has been written about Engelbart and Nelson. Most useful for learning about Engelbart is Bardini, T. (2000), *Bootstrapping: Douglas Engelbart, Coevolution, and the Origins of Personal Computing*, Stanford University Press, and Oinas-Kukkonen, H. (2007), "From Bush to Engelbart: 'Slowly, some little bells were ringing,'" *IEEE Annals of the History of Computing* 29(2), April-June, 31-39, which relies on interviews, includes a comprehensive bibliography, and details Bush's influence. A monumental early book is Nelson, T. (1974), *Computer Lib: You Can and Must Understand Computers Now,* and, on the flip side, *Dream Machines: New Freedoms Through Computer Screens—a Minority Report*, self-published, out of print.

A useful set of resources, http://www.cs.brown.edu/memex/, includes Andy Van Dam's keynote address at the first Hypertext Conference in 1987.

PART THREE: INTERACTIVE COMPUTER GRAPHICS AND DIRECT MANIPULATION

For accounts of the early history of interactive graphics, see Hurst, J., Mahoney, M.S., Taylor, N.H., Ross, D.T. & Fano, R.M. (1989), "Retrospectives: The Early Years in Computer Graphics at MIT, Lincoln Lab, and Harvard," *ACM SIGGRAPH'89 Panel Proceedings,* Part I and Part II; Machover, C. (1978), "A Brief, Personal History of Computer Graphics," *IEEE Computer* 11(11), November; Wayne Carlson's "Critical History of Computer Graphics and Animation," (http://design.osu.edu/carlson/history/ID797.html); and also chapters by Gordon Bell, Doug Ross, and Wesley Clark in *Goldberg* (1988).

An important historical panel is Buxton, W. (2005), "Interaction at Lincoln Laboratory in the 1960s: Looking Forward — Looking Back." Panel Introduction, *Proc. CHI 2005,* 1163-1167, also see http://www.billbuxton.com/Lincoln.html, and the ePresence video archive of the panel, http://epresence.tv/Presentation/3.

The Sketchpad thesis has been reprinted as Sutherland, I.E. (1963), "Sketchpad: A Man-Machine Graphical Communication System," MIT Ph.D. Dissertation (http://www.cl.cam.ac.uk/techreports/UCAM-CL-TR-574.html).

Direct manipulation was defined in Shneiderman, B. (1983), "Direct Manipulation: A Step Beyond Programming Languages," *IEEE Computer*, August.

The development of Spacewar is recounted in Levy, S. (1984), *Hackers: Heroes of the Computer Revolution*, Anchor Press, Chapter 3. A series of computer-aided design history timelines is at http://mbinfo.mbdesign.net/CAD-History.htm. An archive devoted to the history of using computer graphics to visualize biological macromolecules, starting with the work of Cyrus Levinthal and colleagues at MIT in 1964-67, is http://www.umass.edu/molvis/francoeur/.

PART FOUR: GUI AND WIMP INTERFACES

The best account of the development of the Xerox PARC Alto personal computer, the Superpaint color frame buffer, and the earliest implementations of the graphical user interface is Hiltzik, M. (1999), *Dealers of Lightning: Xerox PARC and the Dawn of the Computer Age*, Harper Business. An earlier journalistic account focusing more on the business context is Smith, D.K. and Alexander, R.C. (1988), *Fumbling the Future: How Xerox Invented, Then Ignored, the First Personal Computer*, William Morrow.

An excellent scholarly account of the desktop metaphor is in Blackwell, A. (2006), "The Reification of Metaphor as a Design Tool," *ACM Transactions on Computer-Human Interaction* 13(4). The earliest WYSIWYG word processors were Bravo and Gypsy developed at Xerox PARC; for information about Gypsy development see the interviews with its developers, Tim Mott and Larry Tesler, in Moggeridge (2007).

Overlapping windows, a key feature of most GUIs, emerged in the pioneering Smalltalk environment developed by Alan Kay's group at PARC (Kay, A., and Goldberg, A., 1976, Personal Dynamic Media, Xerox PARC Technical Report SSL-76-1). Early thoughts that led to the concept of personal dynamic media are found in Kay, Alan, "The Reactive Engine," Ph.D. dissertation, University of Utah, 1969. A comprehensive first-person account of the development of Smalltalk is Kay, A. (1993), "The Early History of Smalltalk," *ACM Sigplan Notices* 28(3). See also two recent publications: Barnes, S. (2007), "Alan Kay: Transforming the Computer into a Communications Medium," *IEEE Annals of the History of Computing* 29(2), April-June; and Maxwell, J. (2007), "Tracing the Dynabook: A

Study of Technocultural Transformations," Ph.D. dissertation, Simon Fraser University, and http://thinkubator.ccsp.sfu.ca/Dynabook/, which provides many links to relevant sources.

A good single source on the Xerox Star is Johnson, J., Roberts, T.L., Verplank, W., Smith, D.C., Irby, C.H., Beard, M., and Mackey, K. (1989*), IEEE Computer* 22(9). Case Study D in Baecker and Buxton (1987) lists almost 40 other sources.

A good journalistic account of the development of the Apple Macintosh is Levy, S. (1994), *Insanely Great: The Life and Times of Macintosh, the Computer that Changed Everything*, Penguin Books. 118 stories about the development of the Macintosh and the people who created it are at http://www.folklore.org/index.py.

PART FIVE: GRAPHIC DESIGN AND INDUSTRIAL DESIGN IN INTERACTION DESIGN

To my knowledge, Aaron Marcus is the first graphic designer to commit himself to a career in interaction design. A pioneering early article applying graphic design expertise to the design of a page layout system is Marcus, A. (1971), "A Prototype Computerized Page-Design System," *Visible Language* V(3), Summer 1971. Aaron began teaching tutorials on the subject in 1980 and established the design firm Aaron Marcus and Associates in 1982. Good interviews with Aaron are found at http://www.informationdesign.org/special/marcus_interview.php and http://www.amanda.com/resources/webword/webword_marcus.html.

An excellent history of Apple covering the development of the Apple II is Malone, M.S. (1999), *Infinite Loop: How Apple, the World's Most Insanely Great Computer Company, Went Insane*, Currency Doubleday. Pages 122-123 discuss the roles of industrial designer Jerry Manock in developing the case for the Apple II and art director Rob Janov in developing a new Apple logo. See also http://apple2history.org/.

Levy (1984), Chapter 6, discusses the roles of Manock and graphic designer Susan Hare in developing the Macintosh. Interesting debates involving Steve Jobs and key designers and developers about whether the Mac should be more like a Beetle, a Ferrari, a Porsche, or a Cuisinart are documented in http://www.folklore.org/StoryView.py?project=Macintosh&story=More_Like_A_Porsche.txt.

Beginning with work on statistical graphics in the mid-'70s, Edward Tufte has emerged as the preeminent information designer, setting standards for elegant design tailored to cognitive tasks such as understanding causality, comparison, and the effects of multiple variables on complex phenomena. A thoughtful and comprehensive interview with Tufte is Zachary, M. and Thrall, C. (2004), "An Interview with Edward Tufte," *Technical Communication* 13(4). See http://www.edwardtufte.com/tufte/ for information about his four beautiful books, including the particularly influential first book, *The Visual Display of Quantitative Information*, 1983, 2001, Graphics Press.

PART SIX: USABILITY TESTING

The extensive usability testing in Star development is described in Bewley, W., Roberts, T., Schroit, D., and Verplank, W. (1983), "Human Factors Testing in the Design of Xerox's 8010 'Star' Office Workstation," *Proc. CHI '83*, 72-77. User testing of the Lisa conducted by Larry Tesler is described in Levy (1994) Chapter 4, and also in http://www.folklore.org/StoryView.py?project=Macintosh&story=Do_It.txt&sortOrder=Sort%20by%20Date&detail=medium&search=user%20testing.

Arguably the most influential industrial research group to develop principles of user-centered, iterative design was IBM Yorktown Heights. Lessons learned were summarized in Gould, J. and Lewis, C. (1985), "Designing for Usability: Design Principles and What Designers Think," *Communications of the ACM* 28(3). See also Gould, J. (1988), "How to Design Usable Systems," Chapter 35 of Helander, M. (Ed.), *Handbook of Human-Computer Interaction*, North-Holland.

Another important group was at DEC, see for example Whiteside, J., Bennett, J., and Holtzblatt, K. (1988), "Usability Engineering: Our Experience and Evolution," Chapter 36 of *Helander.* An excellent overview of the history and practice of usability engineering is Butler, K.A. (1996), "Usability Engineering Turns 10," *interactions*, Jan. 1996.

A seminal vision of an applied information-processing psychology of human-computer interfaces that could reduce the need for usability testing is Card., S.K., Moran, T.P., and Newell, A. (1983), *The Psychology of Human-Computer Interaction*, Erlbaum.

PART SEVEN: UNDERSTANDING WORKPLACE CONTEXT

An excellent review of sociotechnical design, including its origins at the Tavistock Institute founded in London in 1946 and its interactions with developments in Scandinavia, is Mumford, E. (2006), "The Story of Socio-technical Design: Reflections on its Successes, Failures, and Potential," *Information Systems Journal* 16. The Scandinavian approach to the design of computer-based systems is treated in depth in Floyd, C., Mehl, W.-M., Reisin, F.-M., Schmidt, G., and Wolf, G. (1989). "Out of Scandinavia: Alternative Approaches to Software Design and System Development," *Human-Computer Interaction* 4(4). See also Ehn, P. (1988), *Work-oriented Design of Computer Artifacts*, Lawrence Erlbaum, esp. Chapter 11.

Hiltzig (1999), Chapter 14, describes how designers of the Gypsy word processor grounded their work in interviews with editors at the Ginn publishing subsidiary of Xerox. Chapter 21 discusses how the Xerox Systems Science Lab based new office system designs on an understanding of how people do their work. A landmark achievement was the Ph.D. dissertation Suchman, L. (1987), *Plans and Situated Actions: The Problem of Human-Machine Communication*, Cambridge University Press, which applied ethnomethodological methods to the analysis of an expert help system.

PART EIGHT: TOWARDS A RICHER UNDERSTANDING OF THE HISTORY OF HCI

For the Welcome Trust, see http://www.ucl.ac.uk/histmed/. The Computer History Museum's website may be found at http://www.digibarn.com/. Most interesting is the Digibarn Computer Museum, with a website at http://www.digibarn.com/, that describes its "nonmuseum approach" to creating "a kind of 'memory palace' for the nerd-inclined [to] help … piece together the amazing story of the invention of personal computing and Cyberspace."

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Pencils Before Pixels

A Primer in Hand-Generated Sketching

Mark Baskinger
Carnegie Mellon University | mbasking@andrew.cmu.edu

Drawings and sketches can be powerful and persuasive representations of ideas, events, sequences, systems, and objects. As part of a larger collaborative design process, hand drawing can serve as a key method for thinking, reasoning, and exploring opportunities, yet it inherently differs from wire frames and conceptual models. Innately, interaction designers employ a variety of methods for representing ideas and information, both internally in a cognitive sense, and externally in the devices we employ to record, share, and reflect. However, competency in sketching and drawing by hand seems to be diminishing across design disciplines, making it a more highly desired skill in contemporary design practice. In addition, there seems to be an apparent phenomenon of fear when it comes to drawing ideas. For many practicing designers, they have convinced themselves that they can't draw and thus position themselves on the periphery of concept generation. The fact is that we all can draw, and there is a misperception that one has to be the Michelangelo of design drawing to be able to communicate visually. As young children, we had no fear of drawing and putting our work out in the public domain, but as adults, we've grown extremely self-conscious of our abilities and inabilities and now fear being judged. Gaining competence in drawing is similar to becoming a marathon runner; it can't happen overnight. But, like running, most of us can already somewhat do it—we just need to devote the time and energy toward building this skill to become truly versed in it. As a drawing instructor in the School of Design at Carnegie Mellon University, my role is to shape students to become better visual communicators and therefore, better visual thinkers. We always start our creative processes with hand drawing: pencils before pixels. This article will touch upon some of the methods used in the School of Design to present a primer for practicing interaction designers to become better visual thinkers and communicators by employing hand-generated techniques to enrich their creative design processes.

Envisioning, Recording, Sharing, and Reflecting

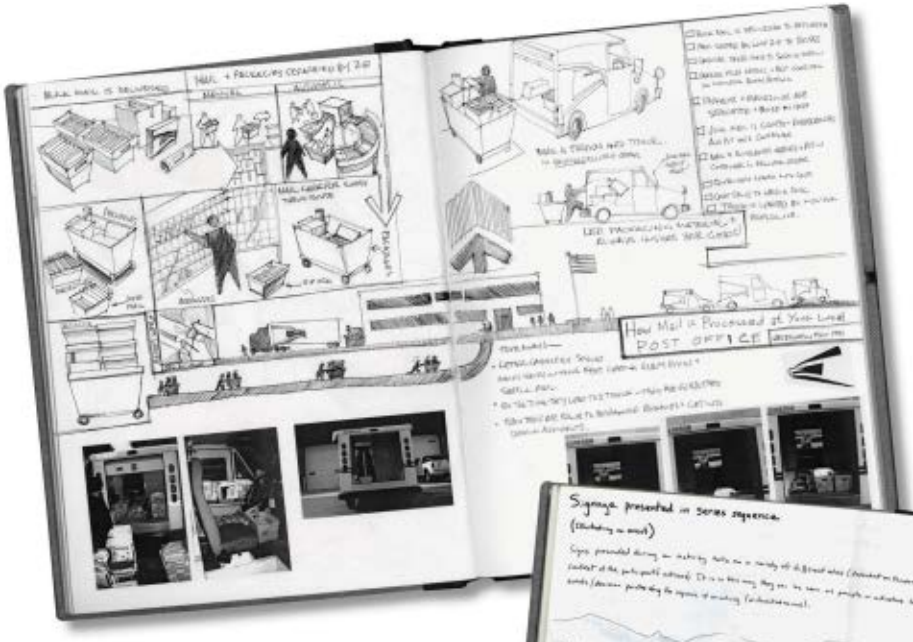
As designers, we enjoy the journey of discovery, in making relationships between intangible ideas/data and the formal elements that make an idea accessible. Initiating the creative process with hand-generated sketches to think through abstract or intangible ideas in various permutations can provide a stronger basis to refine these ideas with digital images, words, pixels, and vectors. By starting with hand-generated "analog" media

► A child's visual interpretation of *Alice in Wonderland*. Children often will draw with any available implement on any available substrate to explore ideas and tell stories. Is it possible to sustain our interest in the world and develop the ability to tell visual stories beyond childhood? (Sketch by Ana Baskinger, age 4)

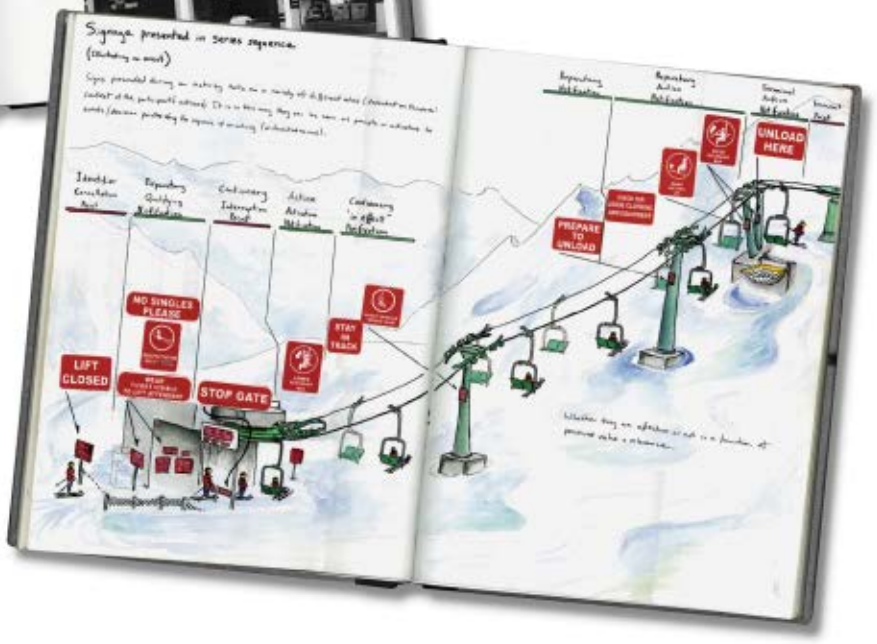
like pencils and pens, we can express ideas in lower fidelity very quickly. The expediency of this process tends to yield visualizations that communicate best to the author/designer but often fail in communicating to others. To better understand the role that drawing can play in the design process, it's best to have fairly simple expectations and goals for hand-drawn activities. Explicit goals for drawing and sketching are 1. to externalize and convey the process of thinking—to transform intangible ideas to tangible information for others; 2. to reveal ideas/relationships, not results; and 3. to engage discussion around the subject/problem as an inclusive activity. The common link to all of design drawing is in constructing a graphic representation in a coherent format, one that speaks to alternative ideas and the evolution of an idea. The images that result from this process serve as vehicles to bring others into the designer's mind to better facilitate conversation and collaboration.

Envisioning ideas and transferring the ideas in your head onto paper can be challenging. The style of drawing, the methods of collecting ideas, and the media used can all vary greatly—thumbnails, Post-its, napkin sketches, and doodles are valid when trying to capture an idea. There is only one rule when drawing to capture ideas: Each idea must be explored from many different perspectives. Too often people try to capture an idea with one solitary sketch that edits the amount of information. Drawing ideas in variations, details, and from multiple viewpoints can enhance communication and enable the author to think more critically about the completeness of an idea as well as to provide reference points to more effectively express each thought.

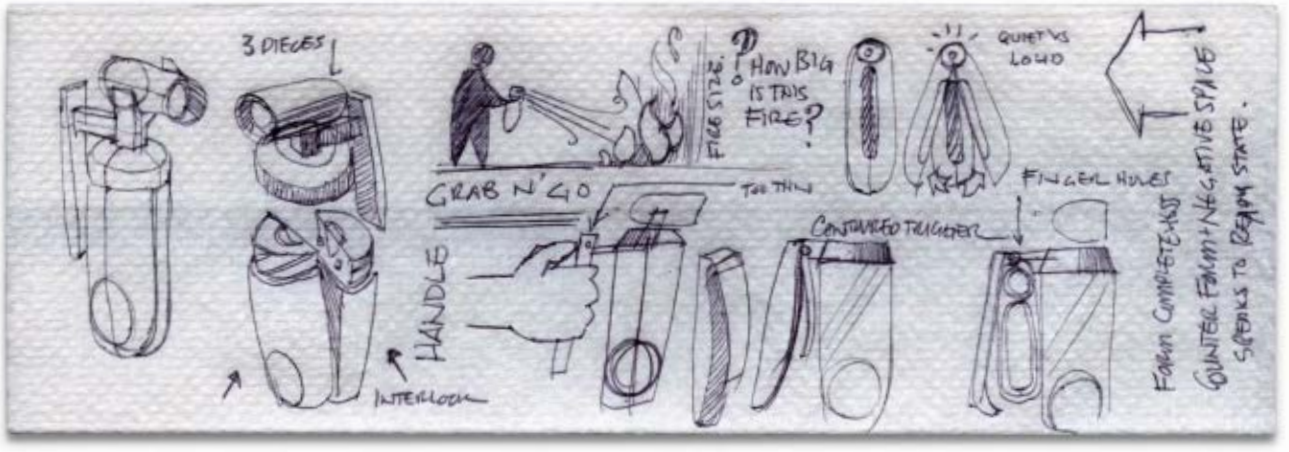
One of the most powerful uses of sketching is to record ideas



► This page of quick visual notes and photographs captures events and sequences during a post-office research visit. These field notes were photocopied and distributed to the design team for recreation of events and discussion. (Sketches by Mark Baskinger)



►A composite sketch of signage system summary generated in context, combining digital photographs of existing signage and a sequential visual timeline of the ski-lift experience. Sketching in context can yield interesting insights and observations and may facilitate conversation with stakeholders. (Drawing and photograph courtesy of William Bardel)



►This napkin sketch for a fire extinguisher concept shows an evolution of ideas through details and actions from many different views recorded during a brief lunch meeting. Note the use of a fine-point pen to draw cleaner and more accurately on this small surface. (Sketch by Mark Baskinger)

for yourself through observation and note taking. The activity of drawing can occur almost anywhere but can be most effective in particular settings. Most designers actively keep sketchbooks or journals to record ideas and thoughts that can be brought back to the studio to build upon. These sketchbooks serve a variety of functions, but most important, they serve as a personal repository of ideas to communicate back to the designer. Collecting ideas in a sketchbook can incorporate digital photography combined with hand drawing and note taking to record ideas and observations. The key with most sketching and drawing is to do it directly in the context in which design implementation would occur. In these settings, your ideas can be inspired by the activities, events, objects, people, and spaces that may have direct implication on the designed artifact or system.

Drawings should not be cherished, nor should they be easily discarded. The reality is that a drawing marks a particular idea in time and represents the viewpoint of the author. Sharing and presenting ideas through drawing in a more formal setting can be very effective, especially if the drawings are seen as negotiable ideas that invite others into the conversation to ask questions and share their ideas as well. Too often are drawings viewed as final artifacts, where in the mind of the author they should be protected (in a frame, perhaps). This tendency can stifle a creative process by bringing finality or concreteness to the presentation of the idea.

Reflecting on your work is key for many reasons. This implies getting some distance and time between you and the work so that you can look at it with a renewed perspective. Regular pinups and sketchbook reviews can be very enlightening. First, regularly going back through your work may reveal competencies or weaknesses in your approach to design drawing. Second, you may notice patterns or commonalities in your work that may indicate an emerging style or vernacular. Since drawing is like handwriting, you can identify the author by his or her sketches. Having a celebrated style in a particular media is not as important as developing a consistent approach to drawing. Competency in drawing your ideas generally reveals consistency in drawing forms, structuring ideas, and effectiveness in communication.

Drawing What You Really Mean: Constructing Stories Through Narrative Sketching

Using visual methods to communicate ideas entails creating a substructure of nonverbal communication. Too often designers make hasty, unrefined drawings that must be laboriously overexplained to colleagues and clients. The very premise of design drawing is to convey thinking, to tell a story to someone else. Therefore, as a visual "story," a sketch must sequentially reveal information across the page in an orderly and scripted fashion. A narrative substructure built into the organization, hierarchy, and composition of the piece will enable the nonverbal story to unfold. Narratives, which provide accounts for telling the story of events, experiences, and ideas, offer concrete touch points for viewers with a sequential format divided into three distinct parts—beginning (to invite the viewer in), middle (to engage the viewer), and end (to provide closure). The viewer should immediately recognize a starting point, a main body of information, and an ending point to provide a comprehensive visual discourse of the concept. Regardless of the particular emphasis, drawn images somehow yield faster access to an idea than words. This, of course, is assuming that the sketch or drawing is clearly organized and communicates well. Visual narratives can take many forms—from a page of loose sketches around a common theme to a highly structured and organized matrix. For interaction designers, visual narratives also include aspects of storyboarding and diagramming.

Within each narrative sketch, there may also be elements given importance through increased size, enhanced color, or fidelity. In storyboards that read sequentially from beginning to end, there is clear termination. However, in loosely

QUICK TIP #1

Media is variable.

A ballpoint pen, no. 2 pencil, or a nylon tip pen are all valid, but each influences the formal qualities of drawings. Try different implements to see which ones feel best in your hand and enable you to draw clean, dark lines. The size of the tip should relate to the scale of your drawing; avoid using broad-tip markers on Post-it-size paper for very small drawings.

► (Top Image) A page of digital alarm clock concept sketches that presents variants of a single theme read from left to right. This sketch presents loose, iterative drawings at the top and more-refined concept renderings at the bottom. (Drawing and photograph by Mark Baskinger and Ki-chol Nam)

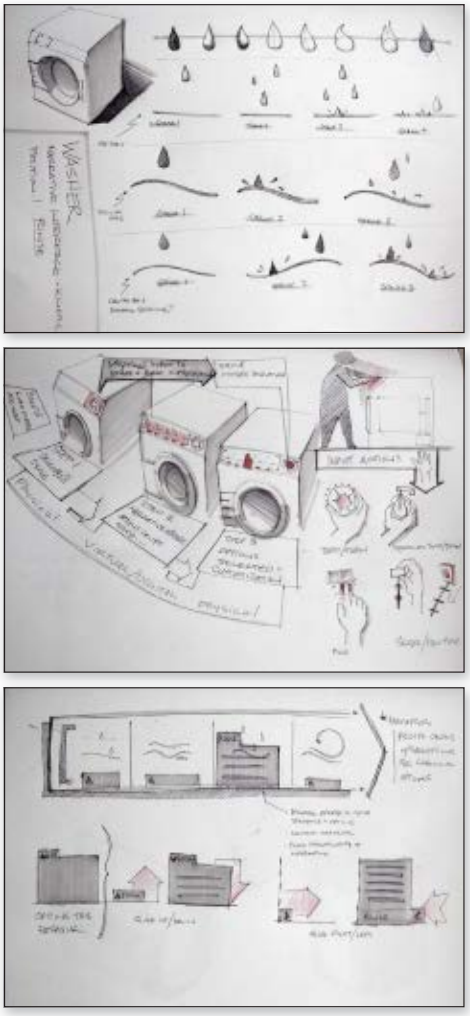
► (Bottom Left) A matrix of form studies for a digital alarm clock formally organized into a matrix that builds from left to right and top to bottom. (Sketch and photograph by Ki-chol Nam)

► (Bottom Right) A page of notational narrative sketches of physical and digital interaction for a digital alarm clock. (Sketch by Mark Baskinger)

structured narrative sketches, the conclusion or ending point is determined by the layout with a clear demonstration that one element on the page is in fact the key concept. A sequential progression of sketches across the image plane or page space will provide cues for orientation as well as indicate some form of conclusion. By structuring parameters for the viewing experience through composition and hierarchy of drawn elements, the body of the work can manifest in a various ways. Again, the ultimate goal is to communicate ideas and thinking to others, so the author must know to whom they are communicating in terms of knowledge of the subject, familiarity with design processes, and visual/aesthetic sensitivity. Understanding both the character of the audience and the format for presentation will keep the narrative focused and succinct.

Anatomy of a Compelling Narrative Sketch

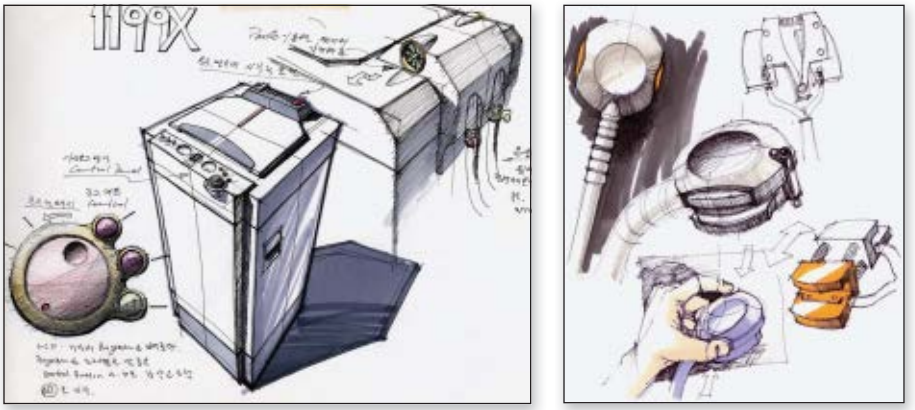
Narrative sketches differ from ordinary sketches in the sense that they are structured to



► A few pages of sketchbook notations for washing machine interaction with digital-interface concept development. (Sketches by Mark Baskinger for GE Appliances, Louisville, KY.)

actively engage the page space to present ideas in a sequential way. Leveraging the way the Western world reads, most visual narratives move from left to right and top to bottom within the page space. They tend to start with the seed of an idea in the upper left and flow diagonally through to the bottom right, clarifying the idea into a refined summary drawing most prominently displayed. Visual narratives can be loosely structured as a composite of drawings occupying the same page or a highly structured matrix. When depicting sequential interaction, a storyboard structure can be particularly useful in communicating key events. Again, storyboards move from left to right and top to bottom but present ideas contained within each bounding cell.

It is essential in all sketching that the images you want the viewer to pay attention to are positioned on the page in a visually accessible way, not obscured by doodles and notation. When teaching sketching and design drawing to young design students, I always emphasize simplicity as a rule. The more simply you can communicate an idea, the better chance you have at effectively reaching the viewer. Sometimes it can be difficult to define what a simple sketch actually is. As a standalone image it may not be possible, but in context of other drawings that communicate the concept, confusing or distracting elements can be identified and subsequently removed. Knowing what you want to communicate and being able to edit out the unimportant, redundant, or confusing information is key.



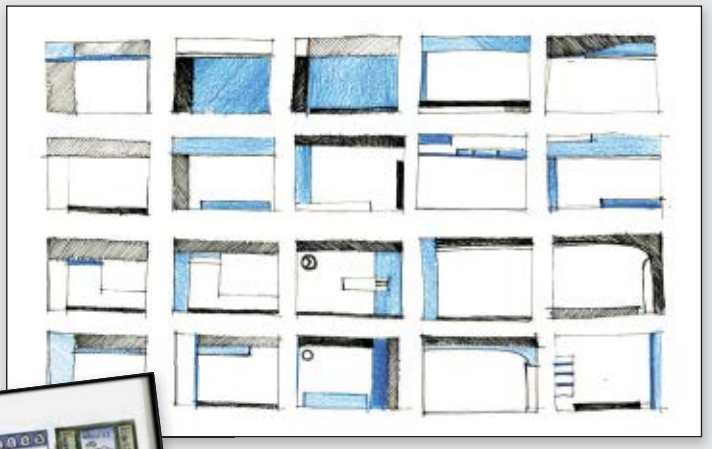
► These product sketches by Ki-chol Nam show an evolution of ideas across the page. They present complete and incomplete thoughts, details, suggestions, and notation as well as more-resolved sketches. Note that the drawings flow across the page space, use limited amounts of color and media, and are visually engaging.

Calling out key information and ideas in the context of a larger drawing can be done in a number of ways. One method is to use scale to establish a hierarchy in communication to differentiate dominant or essential images from subordinate or supportive ones. Another approach is to increase fidelity or resolution of key ideas by using tighter technical control of line, tone, and color. While establishing a hierarchy is necessary to enhance readability and communication, combining too many levels of differentiation (enhanced line work, excessive color, etc.) may yield an overworked or overly complex sketch.

A Quick and Employable Strategy: Moving from Words to Pictures, or from Written Narratives to Visual Narratives

Interaction designers practicing in service design and design for user experience come from a variety of backgrounds and educational training. In conducting design drawing and sketching workshops in a variety of conference and business contexts, I've learned that many interaction designers express their ideas only through written narratives, wire frames (for screen development), and very simplistic doodles. Sketching and visualization are often separated as the work for visual designers or industrial designers, who now find themselves in the world of interaction design because they tend to possess a better skill set for communicating concepts in visual form. Many of the interaction designers I've met express frustration for this apparent divide and believe that if they had these visualization skills,

QUICK TIP #2



Composing drawings and layouts

Generating a series of quick thumbnails can help you to plan various layouts and configurations for screen-based and print design. Key elements can be simplified to rectangles, and supporting text reduced to lines to promote expediency. These thumbnails can then be translated into more-refined drawings or used as a basis to transition into digital sketching and wire frames. (Thumbnail sketches by Mark Baskinger; screen concepts by William Bardel.)

they would better serve their teams. Conference workshops are too brief of an experience to truly acquire drawing skills, and design drawing books generally address only good visual aesthetics—showing eye candy—not the rationale for structuring drawing to organize and express ideas.

To better equip interaction designers who desire the ability to become better communicators, I've developed a series of worksheets (*see page 36*) that can ease the transition from using words to using pictures and help keep sketching on target. Incidentally, the best communication is often a combination of words and images. One of the main issues I've noticed from working with professional designers and design students is that knowing what to draw is really the most difficult part.

To shift verbal and written communication toward a compelling sketch or visual narrative, a coherent plan may help to focus drawing efforts and resolve the dilemma of not knowing exactly what to draw. As interaction designers we are adept at guiding interaction and shaping user experience through designed systems or artifacts and often focus on small events to identify design opportunities. The sample worksheets shown here represent a basic approach to structuring drawings to communicate design research or design intent by simplifying interactions into key points, events and scenarios. Rather than structuring an elaborate storyboard all at once, designers can first list out the critical events for design attention. Next, key components, actions, objects, people, and systems that shape the interaction of each event can be listed to provide a greater sense of context. For example, when looking at how an elder interacts with her dishwasher, or more specifically, how she cleans dishes using a dishwasher, one key event to design for is the pre-rinsing of dishes in the sink and transfer/loading into the appliance. This event comprises the following elements and activities: dishes, soap, sink, dishwasher door, cups, flatware, standing, reaching over, bending, and stooping, among others. Once this list is established, a summary statement can be crafted to inform the drawn component. This statement can then be used as support within the drawn image. An example for this scenario would be: "An elderly woman stands at the sink rinsing off dishes and sequentially places them into the dishwasher by bending and stooping to reach the lower rack. She holds on to the wet porcelain sink for balance because her walker does not fit in the access space when the dishwasher door is fully open." Now that this statement is clarified, a series of thumbnail images can be generated to illustrate the event of pre-rinsing and loading. Thumbnails are smaller, less refined drawings that can be created quickly and easily. Their expediency can enable designers to take multiple viewpoints to best illustrate the relationships of the person-product-system.

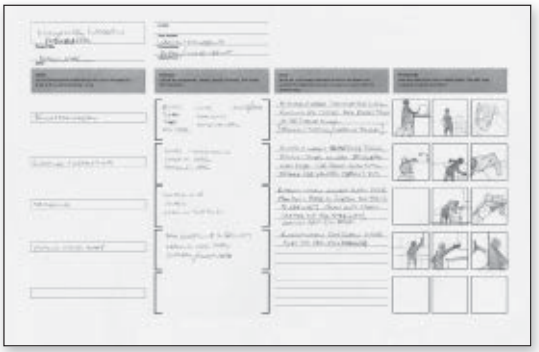
The first worksheet (or series of worksheets) is intended to capture the key events during interaction from many different perspectives using words and images. The second worksheet enables designers to pick the best viewpoint from the thumbnails to illustrate the key events at a larger size incorporating more detail. In the dishwasher example, there are four key events illustrated to demonstrate major physical interaction. Finally, the second worksheet can be adapted for concept development where key events are used to inform design opportunities and concepts. Since the format of these sheets can vary, I encourage designers who are interested in this method to develop their own framework to use sketching combined with written narratives to express their ideas.

An alternative method for

QUICK TIP #3

Adding human elements

Human elements add reality and context to drawings that focus on interaction. Reducing human figures into basic geometries can enable quicker and more symbolic representation.



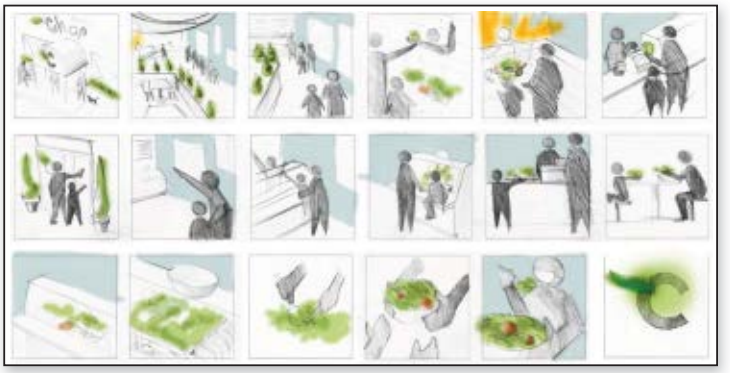
Worksheet 1

Worksheet 2

Worksheet 3

► Dishwasher physical-interaction worksheets. Worksheet 1 identifies key events and design opportunities for interaction and user experience. Worksheet 2 shows an edited selection of sketches for key events. Worksheet 3 illustrates design concepts to address critical issues identified in the previous worksheets. (Sketches by Mark Baskinger)

To download Mark's worksheets as full-size, printable PDF files, please visit: http://interactions.acm.org/content/XV/baskinger.pdf



► Restaurant concept development from various perspectives. Top row, from an overall system/context view; second row, from the human-experience or user-centric view; and third row, from the product-centric view. (Sketches by Mark Baskinger)

using these worksheets is to represent interaction and systems design from many different perspectives. For example, the design of a restaurant experience may require the designer to consider the perspectives of the patrons, the workers, or the products (food) to find opportunities for innovation. In this sense, using worksheets can enable enough individual sketches to construct a matrix or storyboard to communicate these perspectives.

Summary

Design drawing and sketching are an integral component to the development process for many designers. Sketching by hand tends to be very engaging and invites others in for collaboration. It is important to remember that drawing by hand can enable you to think differently about a subject or a design problem and can equip you with greater persuasion and impact during collaboration. Hand-generated drawings can also provide a basis for transitioning into digital sketching in a variety of tools. The expediency and impromptu nature of picking up a pencil and letting ideas flow onto paper can be both powerful and compelling. Developing sketching skills and your own methods to help you to draw more effectively with greater intent is the key. We might not all become white-board heroes, but drawing ideas with confidence and clear intent can serve to clarify, lead, and facilitate collaboration in meaningful ways.

Anne Jackson

ABOUT THE AUTHOR

Mark Baskinger is an assistant professor in the School of Design at Carnegie Mellon University and the co-founder of The Letter Thirteen Design Agency. His work spans across graphic, product, interaction, and environmental design. Mark's research at CMU focuses on how artifacts communicate through their behavior, form language, and context to inform interaction and shape user experience. His work has been featured in design publications and has been exhibited in numerous galleries and museums, including the Museum of Modern Art (New York), I-Space Gallery (Chicago), the Krannert Museum (Champaign, IL), and the Regina Gouger Miller Gallery (Carnegie Mellon University). For a sample of Mark Baskinger's current work, please see: www.letterthirteen.com and www.design.cmu.edu

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The Future of Interaction Design as an Academic Program of Study

Kevin Conlon
Savannah College of Art and Design | kconlon@scad.edu

What is required today to understand the notion of interaction design? Looking at most academic programs, it seems that a loose variety of interdisciplinary study opportunities, vaguely related to each of the facets within the overall discipline, can be thought to provide some sort of cohesive body of knowledge. This is unfortunate, but worse is the common perception that, because of interaction design's breadth, we cannot widen our view in order to synthesize a more cohesive knowledge of the discipline; instead, we rely on this piecemeal approach that serves the parts rather than the whole.

When it comes to interaction design, in general, most colleges and universities think too small. And even more problematic, schools tend to avoid looking at the shifting of the political, economic, environmental, and cultural landscapes. Without necessarily being very intentional or well-informed in their efforts, schools create academic programs without really thinking about what purpose they will ultimately serve. Unintentionally or not, they perpetuate the status quo by not letting their students think very far beyond the margins of current cultural and technological markers.

Schools also tend to buy in to a consumerist model in thinking about how human interactions via technology (like social-networking websites and multifunction devices) shape the experiences and the relationship opportunities between the user and the tool, rather than examining how the user appropriates technology as needed to shape personalized relationships and relationship opportunities with other users. There's a subtle but important distinction in these two points: One humanizes resources and relationships, while the other depletes both.

Ultimately, even if courses and programs designed by conventional standards serve the notion of a future for interaction design by happy accident, they end up being *reactive* instead of *proactive* by following trends instead of anticipating them. Schools need to think bigger by reestablishing their dominance as crucibles for change and encouraging students to think creatively about not only the problems of today, but also tomorrow.

Rejecting the Silo Approach

Because of its newness and breadth, or because of the vested manifold interests from which it draws intellectual resource, or because it requires political skill beyond their comfort level, many academics throw up their hands and give in to the temptation that there is no other way to create a program that moves the discipline of interaction design to a level of prominence that can see a difference in how we think about users, technology, and resources. They tend to fall back on educational models that are familiar because they promise some level of perpetuity and security. While the comfort of the familiar is very reassuring, it is a false promise to a variety of stakeholders, especially the future.

Further, the problem of intellectual domain within typical academic departments defined by subject-matter expertise complicates matters tremendously. In a silo and turf-driven setting, it is not uncommon for the interdisciplinary, piecemeal model to dominate what we are coming to know as interaction design. So it's no surprise that within the typical academic institution, the notion of interaction design is still confused with and within a variety of related academic departments and their subject-matter assignments, depending on which facet of the discipline is being examined.

Some might suspect that this

sort of territorial behavior is deliberate; they might be right. Departments controlling academic content realize the inherent value of the portion that they control, but rather than taking the time to understand the holistic nature of what interaction design is capable of by validating its broader need within an increasingly global community and recruiting the intellectual talent to support it, for a variety of political and budgetary reasons departments often petulantly cling to their piece of the academic pie. The net effect is to minimize the true value of an integrated program of study with a philosophical value of its own. This dilutes the intellectual development of students, the structure of the discipline and the necessary self-reflective criticism that will make such a program not only viable but also essential to the understanding of technology and its humane and rational integration into our daily lives.

Beyond these subject-matter silos, the other challenge that goes into designing an educational program of study, especially a newer field like interaction design, lies in defining the discipline itself. This is never more difficult than when it has to be done in advance of, or in the midst of, arguments about the validity of its anticipated need—or for that matter, in advance of changes to the status quo. Unfortunately, due to both internal and external pressures, the current model of curriculum and academic program development in higher education is one that has become highly standardized, requiring everyone to have advance confidence in the process and the outcomes. This so-called consensus model sounds good theoretically, and it is, for those vested in perpetuating it. However something is lost when institutions fail to be inventive because they are placed in defensive mode which allows academic programming to naturally gravitate toward that which satisfies only the minimum standards and won't solve the problem. In fact, minimum standards are actually counterintuitive to the future-oriented discovery method that is central in moving interaction design (or any discipline) forward.

The politics of change are often revolutionary rather than evolutionary for good reason; those who financially and politically benefit from existing models are loath to embrace new models. Those guarding that status quo are often very threatened by change and tend to feel that they have the most to lose from any influence a change agent may have. But here we are, not only at a collision of old versus new technology, but also old versus new thinking about the notions of finite resources, sustainability, and even social engineering and personal and community responsibility. Of course, this crossroads argument could be used to talk about revisions to many programs of study, not just interaction design. Indeed, the future of man is increasingly in need of more forward-looking curricula within all disciplines to begin to move our societies beyond current models. Given the potentially tectonic shifts that are coming, by failing to do anything new we are simply rearranging deck chairs on the ship when we should be looking toward the horizon to set a new course.

Interactions: Cultural, Social, and Environmental

How do we move beyond this stasis point? The course we set should be directed away from the current dichotomy between what we want (continued consumption) and what we need (continued survival). That dichotomy has never been greater. Because maintaining the

current consumerist binge cannot be sustained, we need to create academic programs that are focused on helping students see what *can be*, instead of leading them to be dependent on what *has been*.

In order to move forward it is time to clearly communicate and leverage the imperatives facing humankind and to frame solutions to these problems through a new way of thinking about designed interactions. Some may offer that technology will provide the answers needed to buy ourselves out of this situation. But to those who look to (or hope for) technology that evolves out of our continued exploitation to solve the problems inherent in our current consumerist model, I'd offer that our most serious environmental challenges are the direct result of the technologies that created the model in the first place. As only one example, new technology in the form of biofuels has been proposed to maintain the continued use of the internal combustion engine. But in so doing, there are troublesome issues surrounding availability of other resources, including land, food, and most concerning, water.

Technologies that create new problems that displace the old problems should not be considered. We should not be robbing Peter to pay Paul. Furthermore, technology as a panacea for every problem also ignores our own need for humanity as a component of the solution. Heidegger's post–World War II observations about technology being a means to an end were never more timely than now. His essay "On the Question of Technology" and his prescient observations on the threat of consumerism resonate even more powerfully today than they did more than 50 years ago, especially as we give up on the idea that technology should serve only as a means to an end. We've instead embraced the notion of technology as an end in itself by grossly accelerating both obsolescence and depreciation in exchange for instant gratification.

As Heidegger put it, in "our sheer preoccupation with technology we do not yet experience the coming to presence of technology." Such a thought does not bode well and warns us of the risk that technology for its own sake will consume us before we know it has happened. Indeed, the current path is without end until there is nothing left to consume but ourselves. There are those who might argue that it's already happened. If so, we will need to back ourselves out of a very deep hole.

Without sounding apocalyptic, the sooner we can push away from the notion that happiness or peace of mind can be bought in the objects that we consume and surround ourselves with, the less painful the transition will be to a more sustainable model. We need to be much more brutally honest with each other about how we, as members of a global community, must shape our future and our lives at all levels, including those most intimate—those that shape our most human and humane interactions.

New Interaction Imperatives

What can be done to transition interaction design to the academic model we need for the future? In order to be deliberate about how we do such a thing, we need to clearly communicate the aforementioned environmental a priori imperatives. Certainly with increasing focus on the problem it will become evident that new models are needed quickly. To that end, those interested in finding solutions must find venues to collaborate for the purpose of fomenting a consistent dialogue that reaches a broad constituency of stakeholders. Providing the places for collaboration and leadership has always been the responsibility of the world's educational systems; having long abdicated that responsibility to the very interests that have perpetuated the current dying model, collaboration and leadership are a responsibility that education needs to take up again.

In order to progress, academics need to further insist on the right to establish new curricular and assessment paradigms rather than blindly follow existing ones. And institutions need to allow these new models the opportunity to develop assessment schema in an independent fashion that encourages innovation and ideation, not dutiful subscription to predetermined outcomes that will only constrain the process. With interaction design, as with most programs that touch on issues associated with old consumer models, the conversation is one that should purposely develop a more thoughtful and strategic use of curriculum to support programs whose students will be able to synthesize solutions in ways that can be measured not only academically and pro-

fessionally, but also in globally responsible ways.

So what should these new, unconstrained outcomes be? That can't be answered here, but perhaps to find an answer it's easier to start by defining what those outcomes should not be. Hearing these criticisms will be difficult to those familiar with or invested in the status quo. To those skeptical that such an awareness of social consciousness is possible within the minds of the next generation, it may be necessary to remind them periodically that it is far less painful to hear and proactively engage new ideas, even if they are occasionally naive, than to be forced to reactively engage the plethora of new threats that are certainly forthcoming.

Wide-Eyed Ideology

A final point: It's time to actively engage students in the conversation. They know that the current didactic structure is, at best, deficient in terms of what it can provide, not just toward their individual futures, but their collective ones as well. At worst, the model is completely self-serving to the generation that created it and perpetuates it. In the field of interaction design, if such a remaking of thinking can be done, it is not, nor will it ever be, done with the extrinsic objects and things that we make. It is not about more object-making; rather, it will be in how we think about our interactions with each other to better support life and its intrinsic qualities.

On a micro level, as those keenly interested in personal interactions and as consumers of technology, many students are painfully aware of the gap between the curriculum on the printed catalog page and the interactions they enjoy in everyday life. On a macro level, students are also painfully aware of the gap between technology and its service to their own lifestyles as they see them extended into the future. Students are very cognizant that thinking needs to turn away from reliance on old consumerist models based on, for one thing, ideas of plentiful energy. Their level of sensitivity to environmental issues is a priority, but other considerations should address the problems with creating new objects for the sake of being new alone. Being technology-centric in design for no reason other than serving the egos of creators and/or users undermines the importance of seeking humane connections with technology so as to have it serve us, rather than the other way around.

Those old dogs in academia should try to look back to their own idealism and optimism about changing the world, even in the face of what will certainly be some difficult decision making and, indeed difficult times. Making a honest commitment to educational change will not only allow for a change in values through the dissemination of new knowledge, but will also produce a generation of students prepared to lead the world in solving the crisis facing, and built by, humanity.

In other words, we need to embrace students' implicit and sometimes anecdotal understandings of the problems we've created, rather than denying that these problems exist or pretending that a technological miracle is waiting just around the next corner. Our encouragement of students' rejection of the status quo, along with their ignorance of the "rules," and what they should not do, may provide them with the motivation to create new solutions and perhaps do what we've long assumed impossible.

ABOUT THE AUTHOR

Kevin Conlon earned his Bachelor of Fine Arts from the University of South Alabama and his Master of Fine Arts from The Ohio State University. He has been a faculty member at the Savannah College of Art and Design since 1996, teaching design, drawing and sculpture, and has served as the college's dean of undergraduate studies since 2004. In addition to his work at the college, Conlon has also served as a professional consultant in the field of architectural restoration, historic foundry work, and new media applications in foundation studies; he has presented workshops and papers at the National Trust for Historic Preservation and the College Art Association. Working as a professional artist for almost 25 years, Conlon has recently completed several commissions. More information about Conlon and his work can be found at http://employeepages.scad.edu/~kconlon/index.htm.

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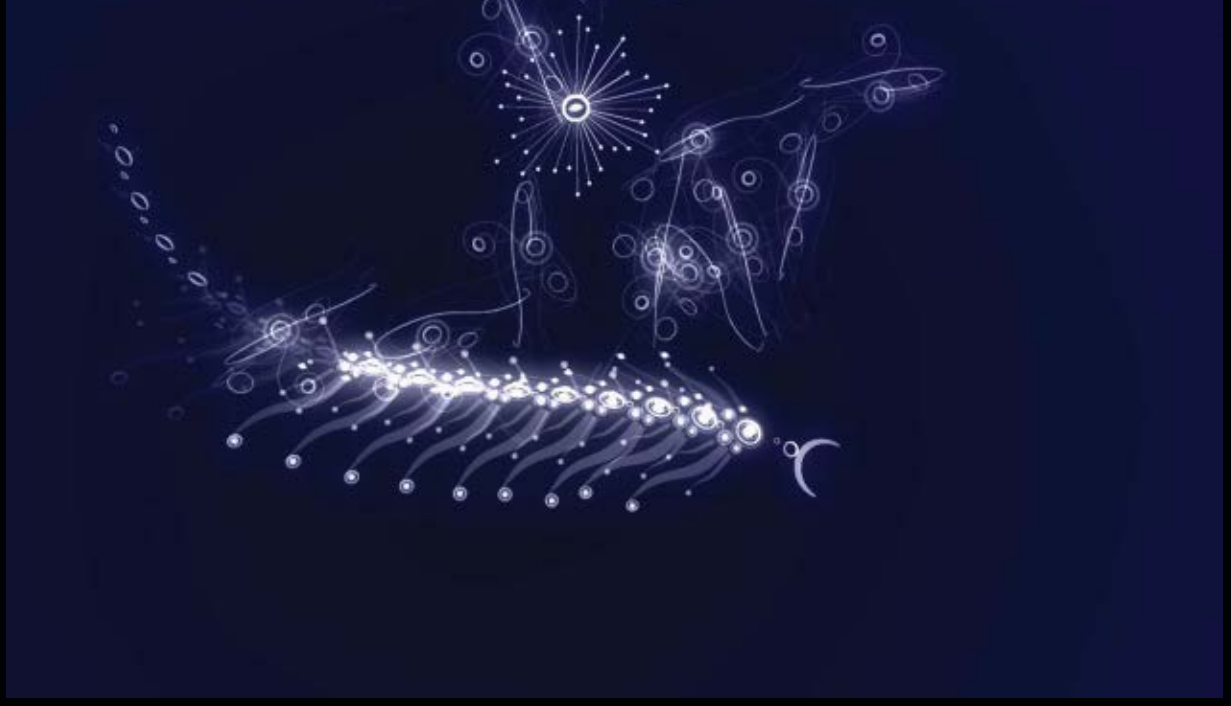

EDITOR
Dennis Wixon
denniswi@microsoft.com

It's my pleasure to introduce a guest columnist this month: Professor Tracy Fullerton of the Interactive Media Division of the USC School of Cinematic Arts. The program is one of the first game-design curriculums in the nation and is already producing promising designers and exciting innovations. —Dennis Wixon

Playcentric Design

Tracy Fullerton
USC School of Cinematic Arts | tfullerton@cinema.usc.edu

"Play has a tendency to be beautiful."
—Johann Huizinga

Game designers create systems that contain opportunities for play. As the quote from Johann Huizinga suggests, play is a beautiful and important part of human culture. Teaching the art of designing satisfying play is a challenging and new discipline. The study of game design is still evolving and as yet is unheralded among the more "serious" arts such as music, dance, literature, or theater. However, experimental programs in this field are being established in some of the most prestigious universities in the world, and these programs seek to produce a new breed of designers—not fans or hackers, engineers, or executives, but *artists of play.*

As a professor of game design, I take this challenge seriously. My goal is to prepare students not merely to work in the game industry of today, but also to be the voices of change and innovation. Whether it is subject-matter innovation, such as "serious games" or gameplay innovation, I encourage my students to ask provocative questions about the nature of games and to set difficult design challenges for themselves.

I teach a process of design that is adapted from best practices in usability and design research. Called "playcentric" design, it involves setting interesting player-experience goals, building a rough paper or digital prototype that attempts to achieve those goals, testing the prototype with players, evaluating the results and integrating feedback, and then doing it again.

While iterative processes are widely used for productivity applications, conventional wisdom has been that game designers know good design when they play it and they don't need anyone telling them how to design good games. That attitude is changing as the industry matures; today's designers realize that they are expected to design for players within a broad range of ages, backgrounds, gender, and skill levels. To do so designers need to be adept at merging the science of usability with the art of play. This merger is the heart of playcentric design.

Back in 1995 I was designing a game for the launch of the Microsoft Network when I had an epiphany about user-centered design. I had come up with the idea for what was, at that time, an entirely new type of game: a casual online game. In the mid '90s the Internet was still only for early adopters, but with the launch of Windows 95 and the promise of millions of new potential players coming online, the plan was to make a suite of easy-to-learn, fun-to-master, multiplayer games. To help us make the games accessible to the nascent Internet audience, Microsoft assigned a

► flOw is a uniquely beautiful PlayStation 3 game that began as a student research project at USC. The design goals were to create player-controlled difficulty adjustment in a relaxing, casual game style.

The Interactive Entertainment Program at the USC School of Cinematic Arts

The project-based curriculum at the USC School of Cinematic Arts offers students an education in design fundamentals, production skills, and leadership in a collaborative, creative environment. The goal of the program is to produce students who have the technical, creative, and critical skills to bring to life the next generation of interactive entertainment.

The "gateway" class for matriculating students is Introduction to Interactive Entertainment, which exposes students to foundational works in game design and gives them critical vocabulary and historical perspective. Additionally, students take introductory cinema courses covering technique, aesthetics, criticism, and social implications of cinema.

The program's beginning game-design course, Game Design Workshop, introduces students to core concepts such as the analysis of game mechanics, defining player-experience goals, brainstorming and ideation, paper prototyping, playtesting, and the iterative design process. Game Design Workshop treats game design not as technical practice, but as a participatory art form and provokes students' imaginations with questions about the nature of games, the process of design, and the aesthetics of play.

The beginning game design course is accompanied by an introductory technology class, Programming for Interactivity. This class takes students from various levels of expertise through an exploration of the basics of programming for games. Students are introduced to object-oriented computer programming and complete several small 2D game prototypes by the end of the semester. Like the complementary design class, Programming for Interactivity teaches technology implementation in support of the player experience.

Intermediate and advanced project classes follow this same structure, bringing design and technology closer together in service of the overall experience. In joint projects at the intermediate level and larger teams at the advanced level, students learn to form successful collaborations, to become articulate and skillful team members, and to earn the right to lead others by gaining the respect of their fellow students.

In addition to these core project classes, students round out their game education by taking elective courses in visual arts, interface design, programming, audio, writing, business and management, experimental hardware, mobile technologies, motion capture, and cultural game studies.

It has become clear to us as we have developed and expanded this program that the future growth of the game industry lies in the expansion of the expressive palette of games. Academic institutions can play a part in this evolution of the medium by understanding that the purpose of an education in games is not to train people to fill the ranks of the game industry—though this may be one effect, as it has been with film studies, for example. The purpose of an education in games is to explore the nature of the medium, to learn by practice and by exposure what its potential might be, and to help students to articulate their own unique ideas in this powerful aesthetic form.

▶ Intermediate students test their game prototypes in the state-of-the-art testing lab at USC. Class projects at all levels of instruction go through multiple playtests over the course of development.

usability expert to the project.

As a young designer, I felt threatened by this. Who was this expert? Did he have the authority to change my game? It was with some trepidation that I first met with Kevin Keeker from the Microsoft user research group. Kevin showed up with a dog-eared copy of the spec, a list of questions, and a heuristic evaluation. He had clearly done his homework. The games were in a very early state, and I was hesitant to put them in front of users yet. Like most designers, I felt that if I could just get all of my ideas implemented, the tests would "go better." Kevin assured me that it was actually better to test early and identify any issues while there was still time to make changes to gameplay. So he created a test plan, and I took the first set of prototypes out to Seattle.

What we found imploded my view of the design process. Things which were completely self-evident to me were lost on the new players. Interface design, clarity of rules, game balance, overall premise—I came back with notes on all of this and more. On the way to the airport, I realized that I wanted to do another set of tests as soon as possible—just as soon as we could implement changes based on this initial feedback. I started thinking about how I might work more tests into the design schedule. What if we started earlier? What if we started with paper models of the gameplay and interface? I had become an addict. I realized that user tests were the way to game-

design nirvana. Before, it had just been me and my idea. Now I was engaged in a dialogue with my players, and with Kevin, who helped me learn how to integrate player feedback with discretion.

Later when I began to teach game design, I remembered that epiphany, and I knew there was no way to explain to my students how important user testing is to the design process—they would have to experience that moment of insight themselves. But I could build it into their training. I could force them to sit behind that glass and watch players try to use their game. I could teach students methodologies for involving players in their design process, creating test scenarios, really listening to feedback, evaluating results, and learning how to productively integrate changes into their designs.

This is exactly what we do in the games programs at USC Interactive Media. At every level of design instruction, playtesting is part of the process. From informal tests of paper prototypes, to more structured tests in our state-of-the-art lab for digital projects, students are taught to embrace player feedback. My hope is to train a generation of designers who use solid, repeatable methodologies in their design process, ones that allow them to take greater risks in their work, expand the boundaries of play, and explore its innate beauty.

ABOUT THE AUTHOR Tracy Fullerton has been a game designer for 15 years, developing projects for companies including Microsoft, Sony, Disney, Intel, MTV, and NBC. Currently, she is co-director of the Electronic Arts Game Innovation Lab at USC, where she has worked on experimental games such as Cloud, flow, and The Night Journey. She is also the author of *Game Design Workshop: A Playcentric Approach to Creating Innovative Games*, a design textbook in use at game programs worldwide whose second edition is scheduled for release in early 2008.

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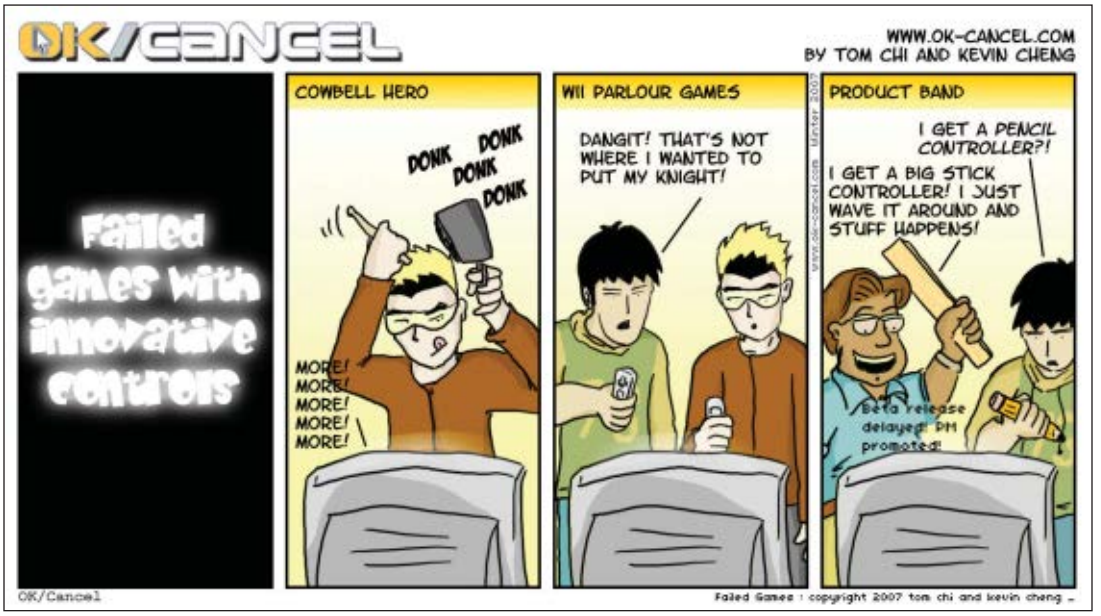

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How I Learned to Stop Worrying and Love the Hackers

Carla Diana
Georgia Institute of Technology | carla@carladiana.com

Designers are a unique breed: We take pride in our flexible attitude and ability to be disciplinary ambassadors, but we are often so easily seduced by process that we can get set in our ways. Though having a strong sense of what "designerly" means is an important aspect of creating professional results, focusing too closely on this definition may prevent us from embracing work that doesn't quite appeal to our sensibilities. The current hacker-inspired DIY movement is an example of this, and this groundswell of activity has become too important to be ignored.

As disciplinary boundaries blur and we approach what forecaster Paul Saffo describes as a "creator's economy" [1], we as designers face an interesting situation where there may actually be more creativity happening around us than there is inside our own offices and studios. This peripheral activity may not be design in a traditional sense (or in a billable sense), but in some ways it actually embodies the exploratory spirit of design better than our own professional practice. Are these emerging hacker-explorers starting to outcreate the creatives?

[1] Saffo, Paul, "Farewell Information, It's a Media Age," December 2005. Saffo.com. http://www.saffo.com/essays/essay_farewellinfo.pdf (Dec 2007)

[2] Davis, Joshua "Dynamic Abstraction." Presentation at the Flash on the Beach conference, Brighton, U.K., November 5, 2007.

In Our Backyard

At a recent design conference, digital illustrator Joshua Davis told a story about going to Japan to speak about the patterns he had recently incorporated into his work [2]. Davis was an American guest lecturer invited specifically to expound upon his appreciation of Japanese graphic motifs. The moral of the story was familiar: It sometimes takes an outsider to point out something that is right under our noses. Though these were the very patterns that appeared on the floors and tile work that his hosts could see every day in or near their own homes, it took an outsider to truly celebrate them.

I had a similar experience when I first moved to San Francisco in 2005. In addition to the Bay Area being a hotbed of geek culture, it was a pivotal time in product-design history—when the confluence of broadband availability, wireless internet access, and ubiquitous screens made the "smart products" that we dreamt up in utopian student projects and hypothetical design scenarios a reality. In my new home I was thrilled to see the roles of artists, designers, and technologists so seamlessly blur into one another through local events and collaborative projects. At the same time, I was stunned to see how little attention my colleagues in the interaction-design world paid to it. In their eyes, I was off to my "funny little meetings" to hang out with the geeks and the hackers and their current curiosities, but I certainly didn't see my collection of extracurricular activities as particularly out of place. In fact, I believed these activities to be must-see examples of design exploration. They were exuberant displays of visionary exercises. They were elegant slices of innovative thought, and they had everything to do with contemporary design practice.

DIY Renaissance

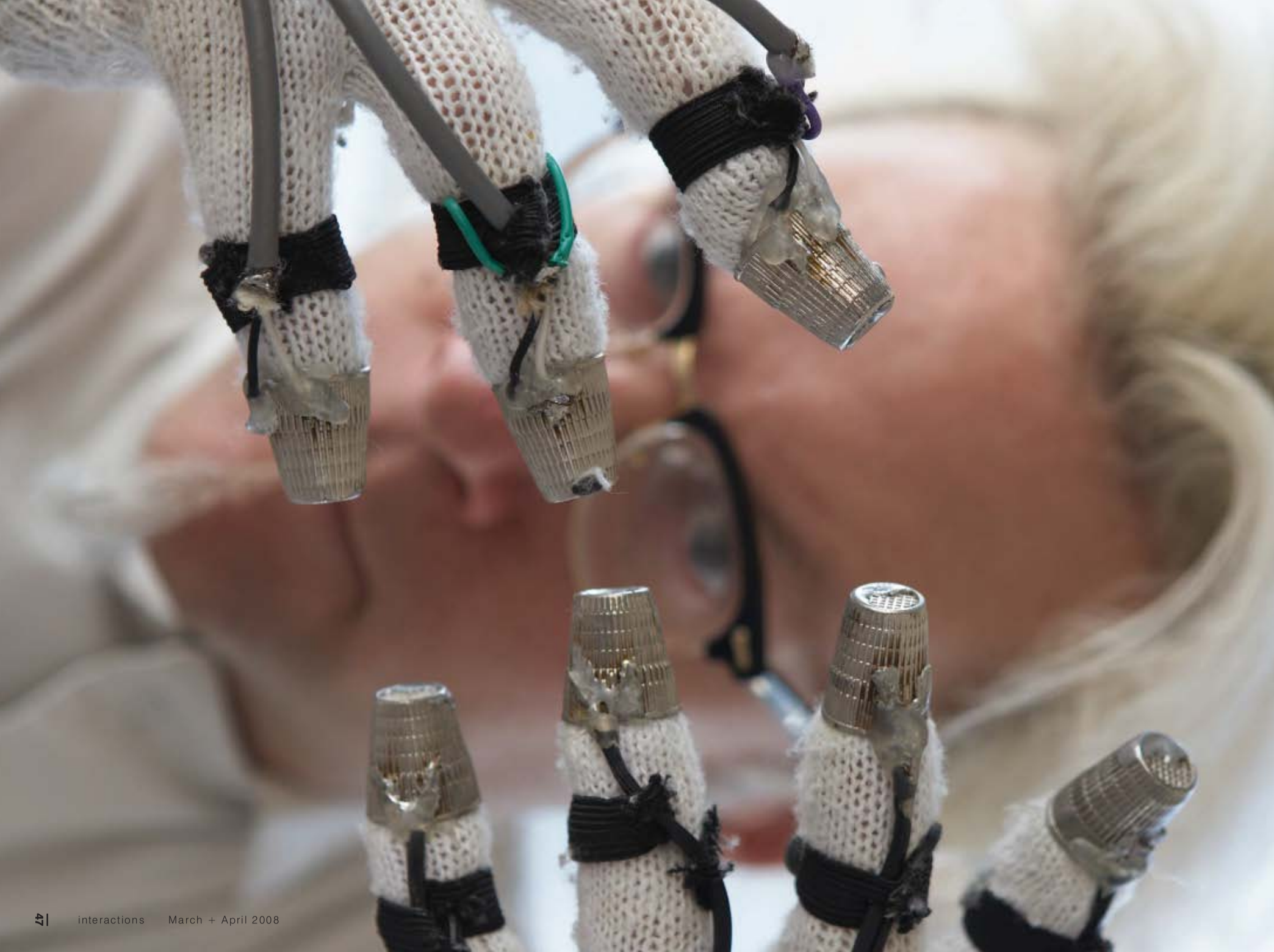
Fast-forward a couple of years, and I can see that there is more awareness among design firms of how hacker-inspired art and technology efforts can provide an excellent playground for inspiration and experiments in cultural change. Nonetheless, there is still a reluctance to seek this inspiration on a regular basis. In the meantime the creative geek/hacker/tinkerer subculture has exploded, and the technological DIY spirit that was once the almost exclusive domain of the Bay Area and elite technology institutions has spread to cities throughout the world.

Resources for Information

"Okay, great," you may say, "so where can I get some?" Well, for

▶ The "Thimbletron" DIY Interactive Gloves by artist Trademark G. were on view at the 2005 Maker Faire in San Mateo, CA.

Brooke Buchanan



►LED "throwies." A DIY portable lighting project organized by the author in Savannah, Georgia, in May 2007, inspired by New York–based Grafitti Research Labs.

starters, DIY publications and community-driven resources take the mystery out of tough technical problems and can inspire new projects. *MAKE* (http://makezine.com) is a monthly magazine published by O'Reilly that seeks to embody the weekend-inventor spirit that once existed in '50s geek classics such as *Popular Mechanics* [3]. Though the projects featured may exist more for the pleasure of their creation than their actual use (they include things like solar-powered music boxes and aerial photography balloons), the spirit of tinkering and experimentation is one that will make you look at a soldering iron in a whole new light.

[3] Dougherty, Dale, "The Making of *MAKE*." Presentation at Dorkbot, San Francisco, Cal. 14 September 2005.

While *MAKE* is slick, tightly edited and published in a number of different formats (including specially packaged collector's series), Instructables (http://www.instructables.com), is the wilder, freer version of this same kind of content that *The Village Voice* credits with being "perhaps the most concrete case to date of the Internet's potential for reshaping our material world... [4]" This Web-based, community-driven repository of how-to documents maintains consistency through its structure of "step-by-step collaboration." The content includes instructions on how to build a CO_2 generator, an electric solar-power system, and motor-driven spiders, to name a few.

[4] Dibbell, Julian, "DIY.org: When a website shows you how to build it, why buy it?" *Village Voice*, 10 March 2006, site specific column.

Access to Tools

All this clear instruction and powerful inspiration is great but won't go beyond entertaining reading without access to tools and space to work. This is where places like Techshop (http://techshop.ws) come in. Techshop is a fully equipped workshop that gives members access to almost every imaginable machine-shop tool such as welding stations, laser cutters, and milling machines. A monthly or yearly membership offers full access to the tools, space, events, and low-cost skills classes and is a natural breeding ground for collaborations and creativity. Currently based in the California Bay Area, it is planning to open in 10 more cities around the U.S.

At the same time, imagine if you could dream up an object and then use all your tools virtually without ever setting foot in a machine shop. It sounds pretty magical, but Ponoko (http://www.ponoko.com) is an online resource that does just that by letting its members design, produce, and sell physical products like jewelry, lamps, or even furniture without ever leaving a browser window. Seriously. Aimed at anyone with access to a vector program like Illustrator or Freehand, the downloadable template kit lets users draw a design, upload it, select materials, and have the parts shipped directly to them. Ponoko will even provide sales and distribution. Though the current focus on laser-cutting techniques means that the forms must be based on flat panels, the service represents a 3D leap off the desktop-publishing page with which we are all so familiar. Currently based in New Zealand, they are actively adding production resources in the U.S.

Events and Happenings

The amount of information about projects, processes, and resources is so immense that it can become overwhelming, but local events offer an opportunity to contextualize the work. Community gatherings combine encouragement, vision, and good old-fashioned schmoozing under one roof on a regular basis. The granddaddy of maker-community events is Dorkbot (http://dorkbot.org/), a monthly show-and-tell club of artists, technologists, and veritable mad scientists. Founded in 2000 by Douglas Repetto in New York City, Dorkbot events now take place in more than 60 cities around the world. Though its main focus is around the self-proclaimed description of "people doing strange things with electricity," its presentations have included everything from gourmet food hackers to bigfoot hunters and something with robot anatomies called "teledildonics." Meetings are locally run and organized by key volunteers, and beverages are often available for a small price, with proceeds going toward future events.

On a much larger scale, Maker's Faire (http://www.makerfaire.com) is the biannual public event that is an extension of the *MAKE* and *CRAFT* magazine community. A spectacular display of contraptions, customizations, and maverick product manufacturing techniques, it will leave you championing the little guy in the marketplace. The Faires take place twice a year in

the California Bay Area and have begun branching out to other cities such as Austin, Texas.

Electronic Prototyping for the Rest of Us

Though electronic systems have become more prevalent in the design of everyday objects, they certainly are not a new phenomenon that would warrant an explosion in creative activity. What has changed is not the existence of electronic components or even ideas in creative technology, but access to tools and resources. Programmable chips, LEDs, and other electronic parts are cheaper than ever before. At the same time, easy-to-use electronics prototyping systems allow designers to quickly mock up physical user interfaces in a way that was, until recently, only accessible to engineers and electronics enthusiasts. Phidgets (http://www.phidgets.com) are a system for interfacing physical inputs with a computer via USB. "Plug and play" sensor kits allow anyone to monitor properties such as temperature, pressure, rotation, and 3D position. Specialized inputs such as touch sliders and RFID readers are also available, and many of the kits also have outputs for controlling physical devices like lights and motors. The boards can be controlled via a number of programming environments, and their incorporation of Flash ActionScript makes it an easy transition for many designers who have never worked with electronics before.

Arduino (http://www.arduino.cc) is an input/output system similar to Phidgets, but it is completely open source and has a strong community following. Created at the Interaction Institute Ivrea in Milan, it has its own programming environment, but like Phidgets, can also be interfaced with many other common programming environments such as Flash ActionScript.

A Screwdriver and a Set of Pliers

While plug and play kits like Phidgets and Arduino offer a powerful approach to experimenting with device behaviors, you can't beat the immediacy of hacking an existing device when its functions will fit the bill for a project at hand. The popularity of electronic gadgets has led manufacturers to offer a plethora of new products that combine several sophisticated capabilities in a small case. Nabaztag is one such gadget. A WiFi-enabled device in the shape of an abstracted toy bunny with glowing lights and motor-controlled ears, it can be set to display user-configured ambient information such as stock market data, weather, or specialized tasks such as notification of when a specified user logs on to IM. Despite the fact that the bunny's creator does not promote the item as "hackable," splinter communities have begun to emerge online to encourage Nabaztag hacking.

Chumby is an ambient device that combines WiFi access with a touchscreen display for viewing content via user-selected "widgets." While not quite as distinctive-looking as the Nabaztag bunny, it redefines the information appliance by embracing the spirit of customization and community-based knowledge exhange. Its makers boast that it is "completely hackable" and actively encourage both hardware and software tinkering with an open source platform. It has two USB ports as well as built-in position sensors (via accelerometers), so the combination of virtual and physical behaviors is endless.

Hacker Culture and You

Though I agree that the temperamental approach of a "rebel artiste," as Luke Kowalski described in his November-December 2007 article for *interactions* [5], can be counterproductive to a design project, there is still a lot to be gleaned from the DIY community. We are in the midst of a tinkerer-maker revolution where everyone from amateur geeks to world-class artists are sharing a common spirit of creative energy. The DIY attitude is one of play, experimentation, and an appreciation for an intellectual landscape of possibility and undefined paths. It is visionary in its ability to maintain its rose-colored viewpoint and look beyond the nuts, bolts, and masking tape to the essence of something new. While it is natural to celebrate this subculture as some curiosity to be lurked at from afar, it may take some effort to embrace and integrate into design practice, but the knowledge gained will be well worth it.

ABOUT THE AUTHOR

Carla Diana (http://www.carladiana.com) is an industrial designer and educator with a diverse background in design, technology and product research. Currently a visiting assistant professor at the Georgia Institute of Technology, she is also cofounder of Spank Design Studio (http://www.spankdesign.com) and is working on a variety of projects from cocktail shakers to emotive robots.

DOI 10.1145/1340961.1340973

[5] Luke Kowalski, "A 'Survivor'-like Designer Reality Show?" *interactions* 14, no. 6 (2007): 20-22.

Empowering Kids to Create and Share Programmable Media

Andrés Monroy-Hernández
MIT Media Lab | andresmh@media.mit.edu

Mitchel Resnick
MIT Media Lab | mres@media.mit.edu

There are now many websites, such as Flickr and YouTube and blogs, which support user-generated content, enabling people to create and share text, graphics, photos, and videos. But for the most part, Web 2.0 does not include interactive content. People interact with Web-based animations and games all the time, but few people can create and share their own interactive content.

The Scratch project [1] from MIT Media Lab aims to change that, making it easy for everyone, especially children and teens, to create and share interactive stories, games, and animations on the Web, in the participatory spirit of Web 2.0. With the Scratch programming environment [2], users snap together graphical programming blocks to control the actions and interactions of rich media content, including photos, graphics, music, and sound. Then they upload their interactive creations to the shared Scratch website, where other members of the Scratch community can interact with the projects on the site and download the original source code to examine or modify the project [3].

The Scratch website offers an alternate model for how children might use the Web as a platform for learning, enabling them to create and share personally meaningful projects, not simply access information. Children create and share Scratch projects as a way to express themselves creatively, much as they would paint a picture or build a castle with LEGO bricks. In the process they not only learn important math and computer science concepts, but they also develop important learning skills: creative thinking, effective communication, critical analysis, systematic experimentation, iterative design, and continual learning. We believe that the ability to produce (not simply interact with) interactive content is a key ingredient to achieving digital literacy and becoming a full participant in the interactive online world.

Learning Through Online Community

The Scratch Online Community makes programming more engaging by turning it into a social activity. Hobbit, a 14-year-old member of the community explains: "When I think about it, recognition for my work is what really drew me into Scratch. Other things played a part, but the feeling that my work would be seen is what really motivated me." The website provides a wide range of entry points for community interactions. Children comment on projects, upload their own projects, and can become involved in existing projects. The site is also a repository of user-generated content that serves as a source of inspiration and appropriable objects for new ideas. Users can connect with each other, forming a social network of creators and collaborators through the use of "friendships," galleries (groups of projects based on a topic), and forums where users can post their questions or interests to be discussed with others.

Inspired by Jenkins's description of the states of participation in fan-fiction communities [4], we put forward the idea that members of user-generated-content communities tend to move in four different roles or states of participation: passive consumption, active consumption, passive production, and active production. In order to build a successful community, it is essential for the sites in question to support and welcome users regardless of which state of participation they fall into. For example, Lave and Wenger argue that "peripheral participation" is a legitimate

[1] Resnick, M., "Sowing the Seeds for a More Creative Society." *Learning & Leading with Technology*, International Society for Technology in Education (ISTE), December 2007.

[2] Resnick, M., Y. Kafai, J. Maeda, J. Maloney, and N. Rusk, "A Networked, Media-Rich Programming Environment to Enhance Technological Fluency at After-School Centers in Economically Disadvantaged Communities." Proposal [funded] to the National Science Foundation, Washington, DC: 2003.

[3] Monroy-Hernández, A., "ScratchR: Sharing user-generated programmable media." Proceedings of the 6th International Conference on Interaction Design and Children, Aalborg, Denmark, 2007.

[4] Jenkins, Henry, *Convergence Culture*. New York: NYU Press, 2006.

[5] Lave, J. and Wenger, E., *Situated Learning: Legitimate Peripheral Participation*, Cambridge: Cambridge University Press, 1991.

form of engagement [5]. These roles/states are the core of most user-generated-content sites, and the Scratch community addresses them in a relevant way for the specific audience and type of content.

- ***Passive consumer.*** Online communities often refer to these people as lurkers. In this state, people assess the community to understand their values and ideas. In the case of Scratch, this involves the act of browsing the different categories and interacting with Scratch projects that other people have created. While this is the most passive state, the passive consumer alters the system simply by viewing because the number of views is counted and presented publicly.
- ***Active consumer.*** An active consumer participates in the community by providing metadata. Active Scratch consumers contribute their ideas by commenting, tagging, and rating projects.
- ***Passive producer.*** In this state, users create projects, sometimes inspired by other projects they have seen in the community, but do not necessarily feel compelled or ready to share them to the community.
- ***Active producer.*** An active producer not only consumes but also contributes to the repository of projects. This person gives feedback to other people's projects, gets inspired, and also provides inspiration. An analysis of the usage of the website showed that the number of projects a user creates is correlated with the level of activity by that user on projects created by others. That is, there is a correlation between the number of projects a user creates and the number of a) comments posted on other people's projects, b) views on others' projects, c) projects marked as favorites, d) projects marked as "I love it!," and e) projects downloaded. Smaller correlations were found in regard to tags. Other people often recognize these active producers' level of involvement. Members in this state feel invested in the community—it is one of the most important assets of the Scratch online community.

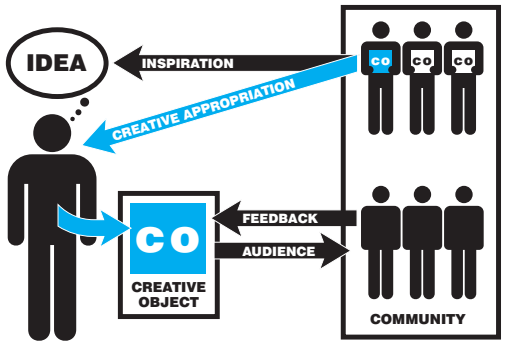
Sharing and Collaboration

We use the term "creative appropriation" to refer to the utilization of someone else's creative work in the making of a new one. Professional programmers are very familiar with this concept, as a great deal of their work is based on programs and algorithms created by others. With Scratch, we wanted to introduce children and teens to this approach, because learning in the context of a community is not only more convenient, but is also more rewarding and engaging.

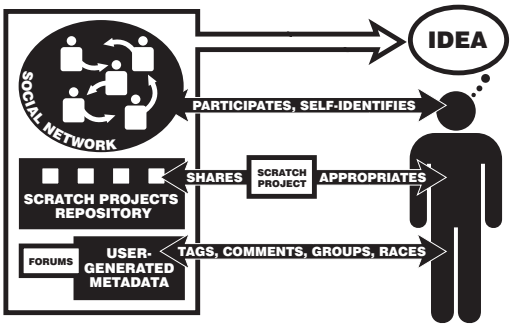
One of the main goals of the Scratch online community is to foster the idea of learning from each other by building on other people's ideas or projects. This is one of the reasons why it is always possible for a member of the community to download the source code of any project. Additionally, users of the community often create their projects after being inspired by other projects they see. In this type of creative appropriation, no code or media is reused; instead, it is the idea or concept that is appropriated to create a new project. This type of appropriation often leads to the emergence of trends

▶ People can interact with projects displayed on the Scratch website.

▶ The Scratch website highlights projects contributed by the user community.



►Scratch users build on one another's projects through "creative appropriation."



►Scratch users contribute to (and learn from) the online community in many ways.

in the community. One of these trends was started by an interactive "dress up" project created by an 11-year-old girl from South Africa. The project was a digital version of a traditional paper doll: The viewer could choose the skin color, hair, and clothing of the doll. Projects tagged as "dress up" are so popular that they often go to the "Top Viewed" section of the front page with hundreds if not thousands of views. To date, there are more than 150 projects tagged as "dress up." Ranging from a project about dressing up a hero to dressing up a famous TV star and original characters, "dress up" projects are as diverse as their creators.

The Scratch website serves as a repository of code and ideas that can be creatively appropriated to spawn new ideas and new projects. The Scratch website and the Scratch desktop environment make it very easy for this to happen. Fifteen percent of all of the 23,394 projects shared (as of August 14, 2007) were remixes of other projects. Of those, the types of changes made ranged from simple changes to images and sounds, to modifications of the actual programming code.

Every time a project gets shared on the Scratch website, the Scratch desktop application adds information about who shared the project and when. This information is used to automatically connect projects that are based on others. When a project is a remix of another, it displays a link to the original project, giving credit to the creator whose work has been remixed. Several members of the community have posted messages in the online forums expressing their concern about others "copying" their work. This controversy has provided an opportunity to discuss important ideas and differences between plagiarism and sharing.

Mesh Inc.

One of the early and ongoing collaborative efforts on the Scratch online community started when a 15-year-old girl from the U.K., screen name BeeBop, created a series of projects with animated sprites and encouraged others to use them in their projects. "You can take any of these to use in your own project, or you can post a comment saying what you want and I can make it for you," BeeBop explained. The same day, a 10-year-old girl, using the name MusicalMoon, wrote a comment saying that she liked BeeBop's animations and asking if BeeBop could create a project with "a mountain background from a bird's-eye view" for use in one of her own projects. MusicalMoon also asked BeeBop to submit the project to Mesh Inc., a "miniature company" that MusicalMoon had created to produce "top quality games" in Scratch. MusicalMoon explained that "all you do is simply send in a project, I will review it back in the Mesh gallery, and, then, if it's good enough, I will grant you a member of Mesh_Inc.!" MusicalMoon and BeeBop continued their exchanges and created an initial version of a collaborative project.

A few days later, Hobbit, the 14-year-old boy from New Jersey, discovered the Mesh Inc. gallery and offered his services: "I'm a fairly good programmer, and I could help with de-bugging and stuff." MusicalMoon asked Hobbit

if he could solve a problem with a particular Mesh Inc. project: "I can't make characters jump so you're up." A day later Hobbit fixed the game and posted: "This is the new updated version, so now he can jump on the snow." MusicalMoon replied "gr8 job, Hobbit! I'll take this and carry on from here." Meanwhile, Hobbit decided to put his blogging skills to use and created a blog for Mesh Inc. where each of Mesh Inc.'s members is listed with their corresponding positions. MusicalMoon was selected as the "chairlady." Later, an 11-year-old boy from Ireland calling himself Marty was added to the Mesh staff as the expert in "scrolling backgrounds."

As others witnessed these interactions happening, Mesh Inc. got a lot of recognition in the community and many people started to "audition" for Mesh Inc. BlueRiver, a 12-year-old girl from Russia, now leads the "character design" and "sound operations" along with GreenDinosaur, a 10-year-old boy from the U.S., who holds the title of "story writer." Other Scratch community members, inspired by Mesh Inc, have created their own similar companies.

Acknowledgements

Scratch and the Scratch website have been developed by the Lifelong Kindergarten Group at the MIT Media Lab. The core development team includes: John Maloney, Natalie Rusk, Evelyn Eastmond, Tammy Stern, Amon Millner, Jay Silver, Han Xu, Eric Rosenbaum, Karen Brennan, Brian Silverman, and the authors. Special thanks to Ubong Ukoh, Kemie Guaida, Lis Sylvan, Chris Garrity, Lance Vikaros, and Chris Spence for their contributions to the Scratch website and online community. Yasmin Kafai, Kylie Peppler, Grace Chiu, and others at UCLA Graduate School of Education and Information Studies collaborated on the development of Scratch. All screen names in this article are pseudonyms. This material is based upon work supported by the National Science Foundation under Grant No. ITR-0325828. The Scratch project has also received financial support from the Intel Foundation, the LEGO Company, and MIT Media Lab consortia.

ABOUT THE AUTHORS

Andrés Monroy-Hernández, Ph.D. student and Samsung Fellow at the MIT Media Lab, has conceptualized and led the development of the Scratch online community. Andrés is interested in the development of social software that fosters creative and collaborative learning experiences. He has worked in the software industry and at the Los Alamos National Laboratory. He received a B.S. in electronic systems engineering from the Tecnológico de Monterrey in Mexico.

Mitchel Resnick, professor of learning research at the MIT Media Lab, explores how new technologies can engage children and teens in creative learning experiences. His Lifelong Kindergarten research group has developed many innovative educational technologies, including Scratch and the "programmable bricks" that were the basis for the LEGO MindStorms and PicoCricket robotics kits. Resnick cofounded the Computer Clubhouse project, an international network of after-school learning centers for youth from low-income communities, with more than 100 sites in 20 countries. Resnick earned a B.S. in physics from Princeton and an M.S. and Ph.D. in computer science from MIT. He is the author or coauthor of several books, including *Turtles, Termites, and Traffic Jams*.

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Usage Statistics

The Scratch Online Community was beta released on March 4, 2007. The community started with only the 20 participants who were involved in a Scratch workshop. On the morning of May 14, 2007, the website was officially launched. Several news outlets and social news websites featured the Scratch website on their front pages. In a matter of hours the server and the website could not handle the traffic and the website went down several times.

As of December 9, 2007:

- the site has received 10,373,606 page views
- there have been 1,708,857 sessions
- the site was visited by 1,176,042 unique visitors
- 56,352 projects have been shared
- 915,489 scripts have been created
- 317,142 sprites have been created
- 53,639 members have registered
- 10,743 individuals have contributed content
- 181,230 comments have been posted on projects, galleries, and forums

While the majority of the users come from the United States, London is the city that generates the most number of visits. Visitors to the site come from 213 different countries, mainly from the U.S., U.K., Canada, Australia, Japan, Germany, Brazil, Spain, France, and India.

An analysis of usage data during the first five months showed that users are primarily age 8 to 17, with a peak at age 12. A good number of users are adult computer hobbyists and educators that create projects in Scratch, even though a lot of them know other professional programming languages. Some members of the community have emerged as mentors that help the beginners and provide advice.

Data also shows that age is not indicative of engagement. No correlation was found between age and number of projects, $r = .108$, $p < .001$. Also, surprisingly, no correlation was found between the number of posts on the text-based forums and age either, $r = -.016$, $p = .007$. Even starting new threads on the forums is not correlated to age, $r = -.016$, $p = .006$. Age was also not an indicator of the number of friends, $r = .065$, $p < .000$.

While 70 percent of users are male, no correlation was found between gender and the number of projects, $r = .001$, $p = .923$. This indicates that even though the majority of users are male, the females are as engaged in creating projects as the males. As we continue our work on Scratch, one main goal is to achieve broader participation across gender.

UIGarden.net: A Cross-cultural Review

Neema Moraveji
Stanford University | neema@moraveji.org

Zhengjie Liu
Dalian Maritime University | liuzhj@dlmu.edu.cn

How many mobile phones does the average South Korean have? What is the rage among Chinese websites designed for young people? Do we need to design different products for different cultures, or simply localize our existing line?

Everyone in the HCI community faces the barrage of information heralding the implications of globalization on designers and researchers. At the same time, Chinese designers attempt to assimilate Western thinking into the design of local products. uiGarden (http://www.uigarden.net), a Chinese-operated webzine, was developed to address these two needs, as proclaimed in their mission statement:

• Bring the newest Western research and development to China.

• Become a bridge [for] the Western [HCI] community [to understand] Eastern culture.

Founder Christina Li says that her goal, beyond the mission statement, "is very straightforward: When people think about usability and user-experience design in China, I want the first word that comes into their mind to be uiGarden." Li started the site in 2004. She says for the month of November 2007, "we had more than 31,000 page views in total, and on average more than 500 unique visitors every day. Visitors came from 105 countries around the world. About 56 percent of them came from China, 18 percent from the U.S. and the UK, and 26 percent from the rest of the world. Most of them are UX practitioners or students." uiGarden clearly has an audience in China.

Each month uiGarden publishes Chinese and English versions of a few well-chosen articles, usually written by Westerners or Chinese-Americans. These are either original articles for uiGarden or are reprinted from appropriate journals or conference proceedings such as CHI or DUX. These are not just cursory blog posts commenting on the latest trend or cultural difference in using technology; they are thoughtful pieces on myriad topics of interest to the audience. The topics and articles selected reflect the newest development in usability and UI design and provide new thoughts and concepts. The articles help Chinese readers to broaden their view and to be aware of trends in this field. The content is easy to read, with many examples from daily life, which help readers gain a better understanding of the concepts.

Examples of recent uiGarden articles include:

• "The Gap Between 25 Seconds and 5 Seconds"—a comparison of the design of a Chinese-brand air-conditioning unit to its Japanese cousin shows the evolving nature of usability in Chinese products.

• "Meaning of Chopsticks in Asia"—a discussion on the intricacies of chopsticks in Asia, and how these relate to cultural values and norms.

• "Design for Emotion: Ready for the Next Decade?"—an article on emotive product design showing how Chinese porcelain has evolved certain emotive characteristics.

• "Global Market, Global Emotion, Global Design?"—a discussion of attempts to identify a "global experience" and designing "global" products suggesting that, until context is sufficiently shared (through media, movies, virtual worlds, and so on), the "global experience" will remain elusive.

For Chinese readers, uiGarden provides an opportunity to read articles in their native language, gleaning greater and subtler meaning than if read in English. For Western readers, uiGarden is useful in that it acts as a highly targeted publication whose readers might be pleasantly

EDITOR
Fred Sampson
wfreds@acm.org

surprised to find pieces typically unavailable in other publications—that is, by Chinese designers. But content primarily benefits Chinese readers. Virtual China (http://virtual-china.org) is a related blog that attempts to dissect Chinese digital culture for Western readers in a non-journal format. By soliciting more Asian authors for articles UIGarden's value would enhance greatly. Because of the easy knowledge transfer and points raised for discussion in user comments, a good place to start would be case studies.

The editors of uiGarden acknowledge that as the field of user-experience design changes, so too will the site. As uiGarden grows, Li says, "we plan to have more original content, that is, articles not published elsewhere, and more articles from Chinese authors. We also plan to improve our categories and to have special columns on popular topics." uiGarden might be the only site where people can find a reasonably large collection of Chinese translations of relevant articles from English. This makes uiGarden popular among Chinese usability practitioners. The translation seems of good quality, and in most cases, even the subtle, deep meaning of the article seems to translate well. However, just as with any translations, whether this kind of meaning transfers well, the holistic knowledge transfer depends on the reader's knowledge and experience level on the topics. What the readers really get from the articles, especially those deeper meanings, varies from reader to reader.

Western readers hoping to gain some understanding of their counterparts across the globe might be disappointed with uiGarden, but not because of the content itself. Chinese and English versions of the articles are separated into two pages on the site. When conversations or comments do arise (not always), Chinese users discuss articles in Chinese, while Westerners debate in English. Reader comments on articles and posts in the forum are segregated and not translated. This means a key opportunity, to bridge conversations between Eastern and Western HCI practitioners, is missed.

Readers want to see more communication between Chinese and Western participants. If an article and its related comments in English could appear in parallel with its counterpart in Chinese, it might encourage more conversations and better achieve the objective of becoming "a bridge [for]

▶ A recent issue of UIGarden in English and Chinese.

the Western [HCI] community [to understand] Eastern culture."

The numbers in the forum should please uiGarden's intended readers: 4,906 posts in 814 Chinese threads, and 950 posts in 357 English threads. The English-language forum does not provide much value, so the Western reader is left salivating over the potentially juicy debates going on in the Chinese forum. Translating user comments and putting them on both versions of the article would be a welcomed feature for a cross-cultural publication, a goal that is tantalizingly close and would set uiGarden apart.

The Chinese are fiercely proud and highly informed of their culture and history. There is a simple reason why news topics and forums in China are so popular: The Chinese love to discuss China. Many of these comments and opinions on uiGarden, rich with cultural nuances, are commonly hidden from Western readers because they come in the form of casual comments in the thousands of Chinese forums and blogs. uiGarden is one resource that has the potential of appealing to Western readers, while providing Eastern readers with a reason to come back. If the site's editors can include more articles from Asian authors and make user commentary transparent across the site, uiGarden will be poised to enhance cross-cultural communication among HCI practitioners, ultimately leading to a harmonious partnership, not competition, between both groups.

ABOUT THE AUTHORS Neema Moraveji studies the design of education technology while pursuing his Ph.D. at Stanford University. Before that, he was an HCI researcher with Microsoft Research Asia in Beijing for two years. Before that, he studied at Carnegie Mellon University's HCI Institute. And before that, he studied at the University of Maryland's HCI Lab. Before that, things are fuzzy, but he remembers scores of trips to local fruit markets in countries around the world.

Zhengjie Liu is founder and director of the Sino-European Usability Center (SEUC) (www.usabilitychina.com), professor of HCI at Dalian Maritime University in China, and co-founder and co-chair of ACM SIGCHI China. He is one of the pioneers in HCI and usability in China since the early 1990s. He provides consultancy to industries and conducts research funded by the public funds from the European Union and China.

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EDITOR
Hugh Dubberly
hugh@dubberly.com

The Analysis-Synthesis Bridge Model

Hugh Dubberly
Dubberly Design Office | hugh@dubberly.com

Shelley Evenson
Carnegie Mellon University | evenson@andrew.cmu.edu

Rick Robinson
Design Continuum | rrobinson@dcontinuum.com

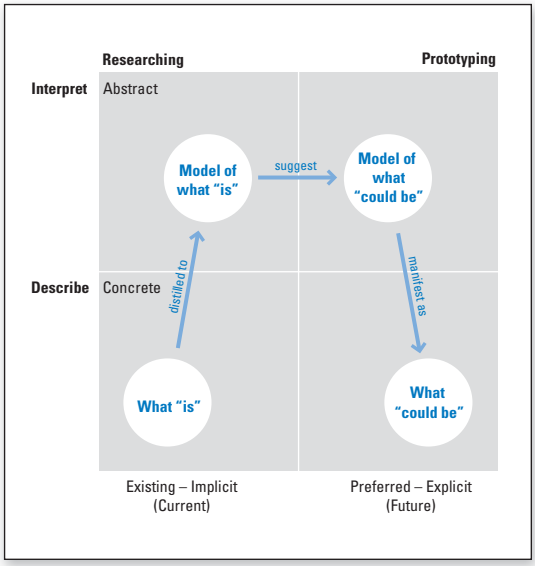
The simplest way to describe the design process is to divide it into two phases: analysis and synthesis. Or preparation and inspiration. But those descriptions miss a crucial element—the connection between the two, the active move from one state to another, the transition or transformation that is at the heart of designing. How do designers move from analysis to synthesis? From problem to solution? From current situation to preferred future? From research to concept? From constituent needs to proposed response? From context to form?

How do designers bridge the gap?

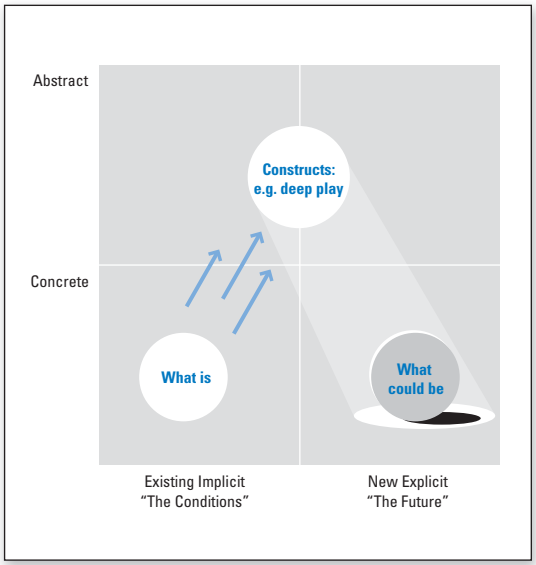
The bridge model illustrates one way of thinking about the path from analysis to synthesis—the way in which the use of models to frame research results acts as a basis for framing possible futures. It says something more than "then the other thing happens." It shows how designers and researchers move up through a level of analysis in order to move forward through time to the next desired state. And models act as the vehicle for that move.

The bridge model is organized as a two-by-two matrix. The left column represents analysis (the problem, current situation, research, constituent needs, context). The right column represents synthesis (the solution, preferred future, concept, proposed response, form). The bottom row represents the concrete world we inhabit or could inhabit. The top row represents abstractions, models of what is or what could be, which we imagine and share with others.

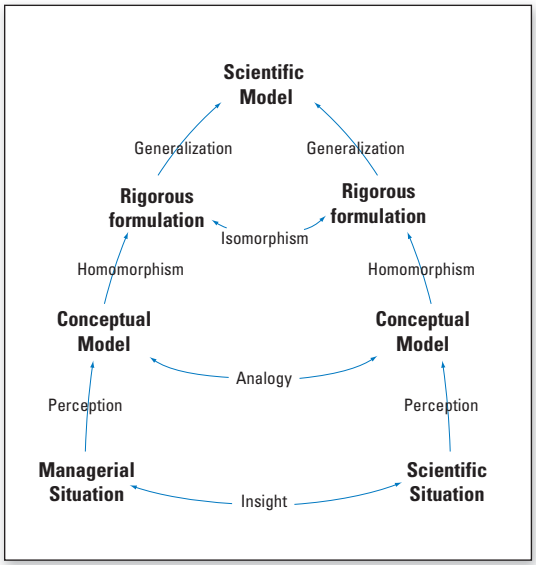
Ideally, the design process begins in the lower-left quadrant with observation and investigation—an inventory (or description) of the current situation. As the process moves forward, it moves to the upper-left quadrant. We make sense of research by analysis, filtering data we collect to highlight points we decide are important or using tools we're comfortable with to sort, prioritize, and order. We frame the current situation, but move out of the strictly concrete. We define the problem. We interpret. Analysis begins as thoughtful reflection on the present and contin-



▶ Analysis-synthesis bridge model



▶ Robinson model



▶ Beer model (Reproduced with permission)

ues as conversation with the possible. Crucial for progress is documenting and visualizing our analysis, making it possible for us to come back to it, making it possible to imagine alternatives, making it possible ultimately to discuss and agree with others on our framing and definition. We might write down a list of findings or a statement defining the problem. Better still is writing a story. A story describes actors and actions; it suggests relationships, which we may represent in visual form. A story of what happens suggests a model of what is—an interpretation of our research. The process of coming to a shared representation externalizes individual thinking and helps build trust across disciplines and stakeholders.

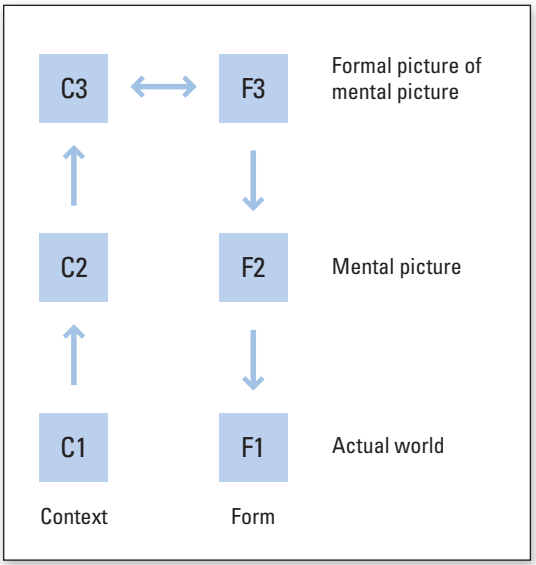
Having agreed on a model of what is (framed the current situation, defined the problem) then the other side of the coin (the preferred future, the solution) is implied. An interpretation provides "a description of the everyday in such a way as to see how it might be different, better, or new [1]." We can devise stories about what could happen. We can model alternatives in relation to our first model. In doing so, we've moved to the upper-right quadrant, to the use and development of models of what could be. It is in the realm of abstraction—by thinking with models—that we bridge the gap between analysis and synthesis.

These models are hypotheses, speculations, imagined alternatives to the concrete we started with, but they are still abstract themselves. It is easy to "play" with models at this point, to test and explore. But design requires that the work return to the concrete, that we make things real, realize our models as prototypes or even finished form. This is the lower-right quadrant.

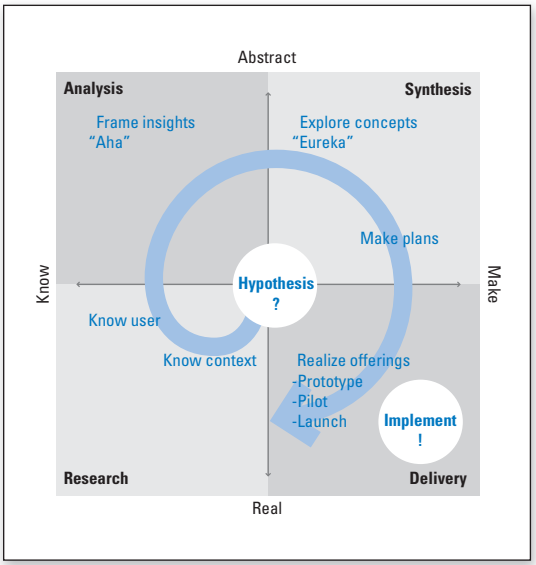
Of course, results improve with iteration. Submitting the new prototype to testing, further observation and investigation, continuing around the quadrants, we learn and refine our work.

The bridge model has several antecedents and variations.

The bridge model grew out of personal discussions over the past few years. Rick Robinson (one of this article's co-authors) has written about "the space in between" research and concept. He has described anthropologist Clifford Geertz's essay, "Deep Play: Notes on the Balinese Cockfight," as an example of abstracting a model from research, and one that parallels strongly the moves that other forms of research and design make in moving from description through interpretation to application. "[The construct of] Deep Play becomes a lens through which Geertz can show what's important about the Balinese cockfight, and his colleagues can understand important underlying factors in something like fan riots at soccer matches [1]."



▶ Alexander model (Reprinted by permission of the publisher)



▶ Kumar innovation model

Writing about the relationship of science to management, Stafford Beer presented a more elaborate model of the move from cases to consensus, from particular to general. He points out that several levels of models are involved [2].

At the beginning of his career, Christopher Alexander described a six-part model. It differs from the bridge model in two important respects. First, Alexander explicitly separates the mental picture (model) from a formal picture of the mental picture (a representation of the model). Second, his notion of a model (at that time at least) was highly mathematical [3].

Vijay Kumar has proposed a model of the innovation process [4]. He frames it as a two-by-two matrix moving from research, to "Framing Insights," "Exploring Concepts," and "Making Plans." He notes, "'Framing Insights' are primarily about descriptive modeling, creating abstract mental pictures about the patterns that we recognize about reality. 'Exploring Concepts' and 'Making Plans' are about prescriptive modeling." Where the bridge model forefronts the role of models, Kumar's model forefronts steps that make use of modeling. He recently published a wonderful poster that maps the steps in the "innovation process" to a series of methods.

During the process of writing this article, *interactions* co-editor Richard Anderson pointed out the Kaiser/IDEO model of the innovation process. Christi Zuber reports that Kaiser Permanente's Innovation Center (working with IDEO) developed this model in 2004 as part of an innovation toolkit created for use inside Kaiser. This model is similar to Kumar's model, but the Kaiser model emphasizes storytelling and brainstorming as key methods.

Responding to questions about the origin of the Kaiser/IDEO model, Jane Fulton Suri supplied a recent model of the process of moving from synthesis to strategy. It shares the same basic structure as the Robinson model, though here synthesis (depicted as the right column in other models) is depicted as the left column. The framing of models as a link between patterns and principles is a useful addition [5].

While practitioners and educators increasingly make use of models, few forefront the role of modeling in public summaries of their work processes. Glossing over modeling can limit design to the world of form-making and misses an opportunity to push toward interaction and experience. We see modeling becoming an integral part of practice, especially in designing software, services, and other complex systems.

The bridge model makes explicit the role of modeling in the design process. Explicit modeling is useful in at least two ways. First, it accelerates

[1] Robinson, R. "Locating the Work: The Spaces Between", in *Everyday Matters*, unpublished manuscript, 2005.

[2] Beer, S. *Decision and Control: The Meaning of Operational Research and Management Cybernetics*. New York: John Wiley & Sons, 1966.

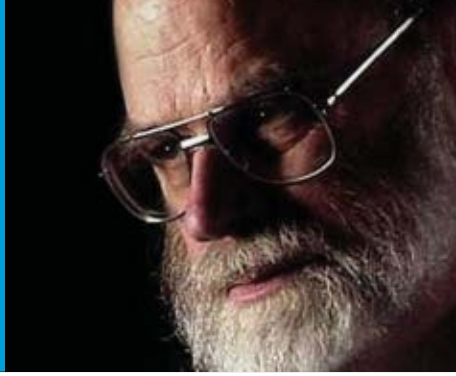
[3] Alexander, C. *Notes on the Synthesis of Form*. Cambridge, MA: Harvard University Press, 1964.

[4] Kumar, V. "Design Innovation Process." Presentation at the About, With and For Conference, Illinois Institute of Technology/ Institute of Design, Chicago, 2003.

[5] Fulton Suri, J. and Gibbs Howard, S. "Going Deeper, Seeing Further." Advertising: What's Next? Conference, San Francisco, December 2006.

Tribute to Honor Jim Gray

May 31, 2008
University of California, Berkeley



A Tribute Honoring Jim Gray:
Legendary computer science pioneer, known for his groundbreaking work as a programmer, database expert, engineer, and his caring contributions as a teacher and mentor.

General Session

Zellerbach Hall, UCB
9:00am – 10:30am

Speakers:

Shankar Sastry
Joe Hellerstein
Pauline Boss
Mike Olson
Paula Hawthorn
Mike Harrison
Pat Helland
Ed Lazowska
Mike Stonebraker
David Vaskevitch
Rick Rashid
Stuart Russell

All are welcome.
Registration is not required.

Technical Session

Wheeler Hall, UCB
Please see website for session times.

Presenters:

Bruce Lindsay
John Nauman
David DeWitt
Gordon Bell
Andreas Reuter
Tom Barclay
Alex Szalay
Curtis Wong
Ed Saade
Jim Bellingham

All are welcome.
Registration is required, see below.

Technical Session registration and additional information:

http://www.eecs.berkeley.edu/ipro/jimgraytribute

the design process by encouraging team members to understand and agree on the elements of a system and how those elements interact with each other and their environment. Second, by making the elements and their interactions visible, it reduces the likelihood of overlooking differences in point of view, which might otherwise eventually derail a project.

Explicit modeling also helps scale the design process. It enables designers to develop larger and more complex systems and makes the process of working with larger and more complex organizations easier. Discussing the role of modeling in design also invites comparison and interaction with other disciplines that use models. Ideally, practitioners that use models may, over time, be able to see patterns across their models that will advance the practice of design.

ABOUT THE AUTHORS Hugh Dubberly manages a consultancy focused on making services and software easier to use through interaction design and information design. As vice president he was responsible for design and production of Netscape's Web services. He was at Apple for 10 years, where he managed graphic design and corporate identity and co-created the *Knowledge Navigator* series of videos. Dubberly also founded an interactive media department at Art Center and has taught at San Jose State, IIT/ID, and Stanford.

Rick Robinson is vice president for practice innovation at Design Continuum in Boston. As chief experience officer (or CXO) at Sapient, Rick oversaw the development of innovative research approaches for understanding human interaction with products, environments, communications, services, and technologies. Before joining Sapient, he founded E-Lab, a user research laboratory. An interdisciplinary social scientist, Robinson received his Ph.D. from the Committee of Human Development at the University of Chicago.

Shelley Evenson is an associate professor in the School of Design at Carnegie Mellon University, where teaches graduate and undergraduate courses in interaction design. She is a voting faculty member in the Human-Computer Interaction Institute (HCII). She is the director of graduate studies in design and for the joint master's program in HCI between Carnegie Mellon and the University of Madeira. Shelley brings more than 20 years of experience in multidisciplinary consulting practices to the school. She is a frequent speaker at design conferences and conducts design strategy workshops with large and small corporations. Shelley also works with graduate students from the school of design to host the international Emergence Conference in service design. Her current interests include design languages and strategy, organizational interfaces, what lies beyond human-centered design, and design for service.

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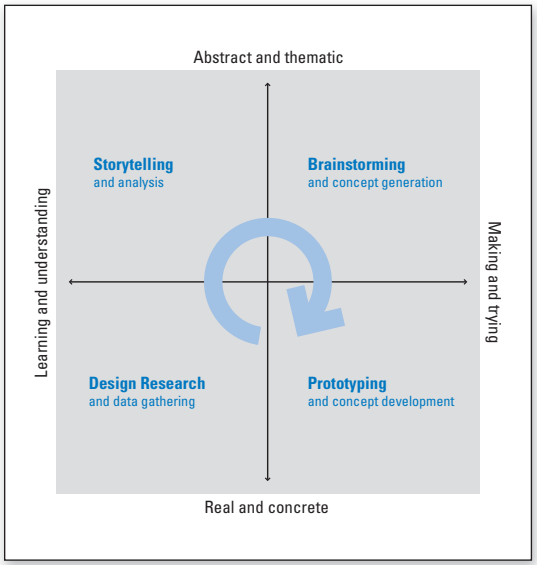
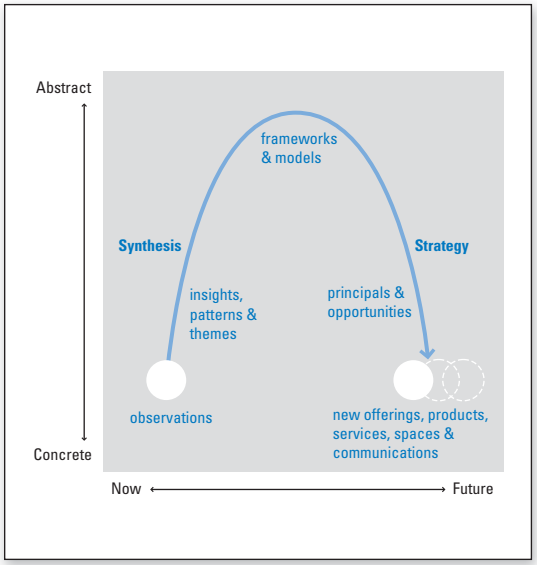


▶ Kaiser/IDEO model



▶ Suri/IDEO second model

An Ode to TomTom: Sweet Spots and Baroque Phases of Interactive Technology Lifecycles

Jan Borchers
RWTH Aachen University | borchers@cs.rwth-aachen.de

A few months ago my sweetheart said one of those things that would make any geek start drooling: "I hate getting lost each time I drive into Cologne. Can't we get a TomTom?" I love getting a free ticket to spend obscene amounts of cash on a gadget, without all the weak, post-hoc rationalizing of why it's so useful, which is usually met with something between fury and pity, depending on its price tag, size, number of cables, and overall potential for destroying your living room's visual appearance. But I digress.

For those of you who have been living under a gadget-proof rock for the past few years, a TomTom (mine is a GO 910) is a GPS car-navigation system made by the current market leader of the same name. You stick it to your windshield with a suction cup, tap in your destination address, and off you go, hopefully in the right direction.

It has also become the technology to most profoundly influence my everyday life since my first DSL flat rate in 2001. And that's despite not being a regular driver—or maybe just because of that.

Now, I will admit that I got my first mapping-software fix back in '97, when a little-known Dutch software company called Palmtop had just released *EnRoute*, a route-planning application for my favorite personal computing device of all time, the Psion Series 5 PDA.

But back then, of course, there was no live navigation support. GPS devices were still something supremely geeky, and well beyond the purchasing power of your ordinary computer-science grad student (i.e., me). Geocaching had not even been invented.

Also, in all honesty, only geeks had PDAs back then, so this was definitely not yet affecting the public at large. But we, the bold and fearless early adopters, could explore this strangely empowering new world of geographical information literally at our fingertips. While I hardly used it for the demanding task of live, in-car navigation, it became indispensable to quickly estimate driving times when planning trips, or to simply hide my deep geographical ignorance in a conversation on, say, the wonderful architecture of Barcelona, by discreetly checking which country that was in again.

While it did become possible later to attach a GPS to your PDA (until you realized that multiple loose devices, power adapters, and 200 feet of cable around your dashboard weren't exactly safe, and that setting up took longer than most actual trips), it wasn't until around 2004 that Palmtop—now renamed TomTom!—and others started selling all-in-one devices, and live navigation support became a realistic option for the average consumer.

Boy, what a difference. Instead of having to map out each new trip in advance; write down or print out those instructions that as soon as you hit the road you realize are conveniently still sitting on the kitchen table; have your codriver call a friend for instructions on a bad cell phone connection, which he'd then repeat back to you while you're nervously peeking at each new street sign because it *could* just be the one where you had to make a right (or was it left?)—in short, instead of this constant sense of sublime (or not so sublime, depending on the nature of your fellow

passengers) tension while driving, you could now focus on traffic and your environment knowing your TomTom would alert you to each turn in time. Even male drivers have been reported to now occasionally have a few brain cycles left to follow what everybody else in the car is chatting about. In other words, here's a complete revolution of your emotional experience of driving somewhere unfamiliar.

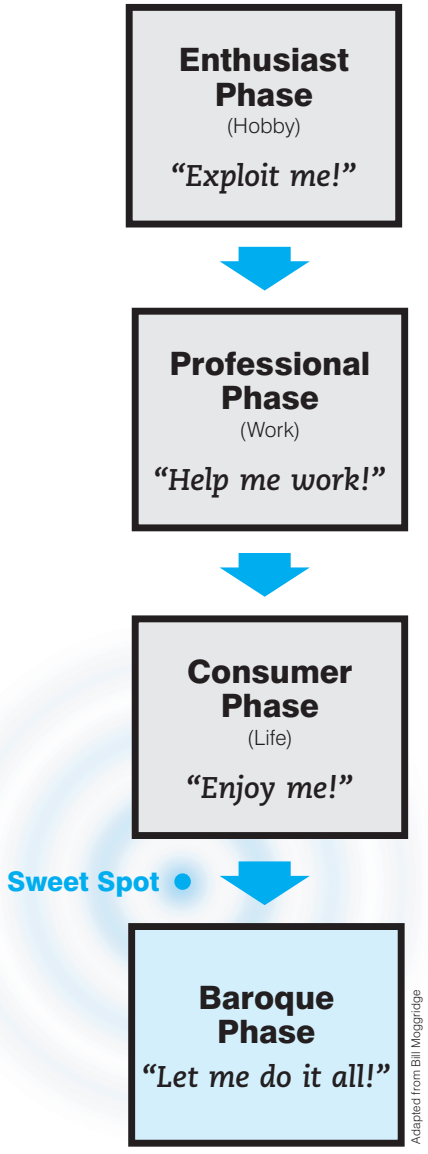
Its real potential unfolded for me, though, when we recently moved to San Diego. It's hard to imagine the stress this saves you driving around an unknown city in a different country. It also quickly becomes hard to remember how much of a hassle it all was before. In fact, TomTom offers special computer voices with "I *told* you we should have taken that exit"-style instructions, should you miss that part of the classic driving experience.

Of course there are still plenty of usability problems that make you scratch your head, wondering just what the designers were thinking. City or street names are listed so close below each other that you keep selecting wrong ones—Fitts' law at work. I also got a furious call when my sweetheart first tried using it: Köln (Cologne) wasn't in the city list. It turned out TomTom had left out German umlauts from their onscreen keyboards, but forgot to include the standard transcriptions in their search algorithms; unable to type *Köln*, she'd entered *Koeln*, but the system was expecting *Koln*, not even listing the city as a close match otherwise. Dudes, localization.

Oh, and turning it on is a nightmare. Pressing the tiny, half-sunken power button briefly is happily ignored, but keep pressing it a couple times at the wrong moment and it won't turn on at all. Protecting against inadvertent operation is fine, but have these people ever heard of the inherent evil of time-based interactions, or of at least providing appropriate feedback when they're unavoidable? A short "Thank you, starting up, you can let go now" beep would have done the trick. But then again, no one with the slightest case of arthritis in their fingers will ever be able to press that button, so with our aging population the company will soon run out of customers anyway.

But I'm sure these issues will be fixed. My point is that TomTom has crossed—no, jumped across—the "threshold of indignation," as Paul Saffo put it in Terry Winograd's great book, *Bringing Design to Software*. The usefulness of the device by far outweighs the

Courtesy of TomTom



▶ The phases of technology adoption.

remaining awkwardness for a wide range of users and their daily tasks.

Obviously, the entire user experience counts here. You can actually go and buy this thing in a department store today, stick it to your windshield, turn it on, and after making a few obvious(!) choices, enter your first destination and be on your way. This is careful design. Some companies, such as TomTom and Apple, get how important this "first-encounter usability" is, from just the right software default settings, to physical device design, to the printed quickstart, to the design of the packaging. It's no coincidence that for a brief, innocent period, Googling "iPhone porn" actually led to slideshows of devoted users unpacking their new gadget.

So what can we learn from the TomTom story? At some point the mix of features, technical feasibility, and task-centered product, software, and user-interface design came together to shape a product that could make such a radical difference to people's lives that its popularity skyrocketed. Of course this takes years of market research and iterative product development, but it creates a qualitatively new product genre that brings an unprecedented and realistic promise to the market and fulfills it. I call this moment the "sweet-spot" phase.

A telltale sign that a product has reached this stage is that people get its usefulness within 15 seconds of explanation, even though they may not know the technology yet (or even understand it afterward). Non-geeks start telling *you* about this new thing and begin to evangelize others about it.

Another sweet-spot indicator is that social behavior around the associated tasks changes. These days, when someone gives me driving directions—a sales clerk on the phone, or a friend inviting me to his house—I find myself politely cutting them short, just asking them for their street address, which I then write down and later type into my TomTom.

Clearly, using these devices also has questionable consequences. For one, we quickly begin to rely on them. Usually, after going to a new destination with my TomTom, I still can't go there on my own: There was no need to memorize the route. A more subtle effect is the potential loss of a mental area map—with a TomTom, you never care to develop a picture of your city as a whole in your head. Will people forget how to describe the way to their home to others? Will real-estate owners bribe TomTom to direct traffic away from their upscale properties? Studying these effects will keep us busy for some time. But even such potentially adverse consequences show the fundamental change that a specific technology can bring about.

Now the bad news: Feature development doesn't stop at its sweet spot. Beyond the idea of providing reliable, easy-to-use directions, TomTom has since added an MP3 player, live updates through the wireless network, connections to "Buddies" (the use of which has escaped me so far), cooperative street updates, photo slide shows (I'm not kidding), and a stream of other features. Some

of these are actually useful, but the original TomTom was the sweet spot.

David Liddle, design lead for the world's first commercially available GUI computer, explains his theory of technology adoption in Bill Moggridge's wonderful book, *Designing Interfaces*. He postulates a first, enthusiast phase exploiting the new technology, a second, professional phase putting it to use to get work done, and a third, consumer phase when it becomes available enough for people to enjoy.

I think we should add a fourth stage to this otherwise excellent model: the "baroque phase," in which the successful new consumer product genre is then embellished with secondary features that often already existed before but are now integrated into the new product.

This phase obeys the terrible law of feature creep. Consumers, having experienced the wonderful new possibilities of the initial sweet-spot device, are hoping that subsequent products in this new genre will have an equally revolutionary and additional positive impact on their everyday lives—which of course they don't, as they're just incremental improvements—and so buy new models because of their added features. The resulting featuritis, prevalent in software, is spreading to consumer devices as they are increasingly software-controlled. (Shopping for a new toaster, I recently encountered a model that would assist me in my complex toasting tasks with an informational LCD screen. Please?)

At first sight the sweet spot and the baroque phase seem hard to tell apart: Both give the user new features, just at different levels of originality. But there's an easy test: Sweet-spot products make your life *simpler*, baroque ones *more complex*. Sweet-spot products support you in a new way, making a previously difficult or awkward task change fundamentally. Learn just a few new things, and you get an almost magical boost in productivity, simplifying your everyday life. Baroque products just tweak existing processes, trying to make them more efficient in some situations but often complicating other tasks (and sometimes the most frequent ones—think microwave ovens). And to use them, you often need to learn a fair amount of new interaction concepts, operations, and other lingo.

Let's look at some products I consider worthy of a sweet-spot award, and some technologies way in their baroque phase.

Cell phones hit their sweet spot in the mid-'90s: pocketable handsets, with several days of standby and calling charges that didn't ruin the average consumer anymore. What a change! Within years, people moved from carefully planning their evening out to "call us when you're ready; we'll tell you what bar we ended up in." Agreeing when and where to meet, which often failed before, leading to heated arguments over whose fault it was ("But I was looking for *you!*"), was replaced by the stress-free model of just calling if something came up, no matter where everybody was. The list goes on.

Today cell phones have moved

HCI research should focus more on preparing—and industry on creating—new sweet-spot devices, rather than wasting time on baroque extensions of existing paradigms.

squarely into their baroque stage. In a 2007 study we did for Germany's largest mobile-technology consumer magazine, *connect*, virtually all models we tested gave users problems with even the most basic and essential tasks: turn on, mute ringer, call number. Being able to browse the Web, take pictures, watch or record movies wherever you are is great, mind you, but it has overloaded the sweet-spot product and interaction design of the traditional mobile phone beyond recovery.

The only way out was to radically rethink the product. Apple's iPhone did that to a degree, removing the keyboard and its dead-end soft-key concept and introducing multitouch to more directly interact with what's on screen. It was far from perfect, but mobile browsing became good enough to become useful, giving you the tingling feeling of a new sweet-spot candidate.

Or take home internet access. After listening to our chirping modems for years, it was DSL's unlimited-time, unlimited-volume flat rate that changed how we thought about the Internet: Suddenly it was free to access the Net after paying a fixed monthly fee. Getting movie showtimes, driving instructions, or just a recipe for cranberry sauce became a snap. And flat rates made our systems always-on, with no dial-in delays. Since then providers have tried to integrate DSL, landline, cable, and cell phone contracts, leading to a maze of options with some further savings but no impact anywhere near that of the flat-rate DSL effect.

Occasionally, consumers will go as far as backpedaling to find the sweet spot again. My last microwaves were all of the one-dial-for-time, one-dial-for-power, go-*bing*-at-the-end variety, and I can't be alone, judging from what's in stores. On my Sony-Ericsson T630 phone, I quickly replaced the default, distracting, low-contrast ColorBombs theme with a simple black and white one that let me focus on the important stuff.

The desktop metaphor had its sweet spot with the release of the Xerox Star and Apple Macintosh between 1981 and 1984. Since then its basic idea has remained unchanged, as is often lamented, and only small improvements and secondary features have made it onto our screens. Smaller sweet spots were reached within that metaphor (full-text search or Apple's Time Machine backup come to mind), but most new, more colorful and feature-rich systems fall into the baroque phase. Sometimes I fantasize about a system that returns the desktop metaphor to its sweet spot (not that that would be very useful today), or that finds the right revolutionary approach to kick the desktop metaphor out the door.

Other examples include the original iPod, or the affordable consumer digital camera with enough resolution for standard-size prints, letting you take, immediately check, and delete shots for free. TiVos changed TV viewing habits fundamentally, and personally, I would include iChat AV, for letting me show our new kitchen to my mom some years ago, walking around with a laptop and iSight camera (okay, still geeky).

So what gives? For consumer experiences, HCI research should focus more on preparing—and industry on creating—new sweet-spot devices, rather than wasting time on baroque extensions of existing paradigms. To make history, look for that sweet spot providing the broad public with a device/application/service to which they had no usable, affordable access before.

This, by the way, is also why HCI is key to innovative products. Sweet-spot solutions are task-centered in an unprecedented way; they are uncluttered, simple, and elegant.

The other day, after Googling another nearby store on my iPhone, because the one where we were didn't have what we wanted, my sweetheart said, "You know, it's really incredible how useful this iPhone is." Now excuse me while I go and drool some more.


Peter Winandy

ABOUT THE AUTHOR

Jan Borchers is a professor of computer science at RWTH Aachen University in Germany, where he heads the Media Computing Group, studying interaction with audio and video streams, mobile devices, and ubicomp environments. He has currently deserted his students for a sabbatical at UC San Diego to write random rants like this. He's not getting paid for this article by TomTom, Apple, or Psion, although he will happily provide them with his banking details should they feel obliged to change that. He can be found at http://hci.rwth-aachen.de.

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What Robotics Can Learn from HCI

Aaron Powers
iRobot | apowers@irobot.com

As the robotics field grows and becomes competitive, robotics companies are beginning to inject user-centered design methods into their processes. Applying HRI methods to industrial and commercial products introduces new challenges and a focus on cheap, proven methods. The specialty of human-robot interaction (HRI) is a growing group of roboticists, social scientists, and designers, but the field of industrial practitioners is still small. Robotics has yet to reach the transition point that Don Norman talks about in *The Invisible Computer*, where the level of performance exceeds users' needs [1]. For that reason, the robotics industry to this point has focused on technology rather than user experience. As we see robots become ubiquitous consumer products, that focus is starting to change.

At iRobot we have one practitioner of HRI (that's me). iRobot has begun the transition from a technology-centered company to a user-centered company, as we grow from research robots toward commercial products. As we focus more on product development, we transform many research methods from the HCI and HRI fields into practice. Additionally, robotics companies provide a good opportunity to put HCI principles into practice. Because robotics companies like iRobot are growing quickly and shifting toward commercial products, the field is too new to have an ingrained process. HRI can become the framework for development of commercial robots.

Ethnography is the most popular investigative method being adopted in commercial HRI. Detailed ethnography studies helped iRobot learn about the culture of the PackBot users in the military and about the homes and cleaning patterns of Roomba owners. The open-ended approach of ethnography allows a series of short studies to explore varied topics and build a baseline of knowledge. Interacting with a humanlike robot is, in some ways, like the intersection of a new culture into an old one, making ethnography an excellent method of research and evaluation. For example, you may have seen a Roomba push an empty trash can around the room or catch computer cables as it vacuumed. Environment and context can be crucial factors in the success of a robot, and the ethnographic method is effective at discovering their influence.

Certainly, we run experiments in industrial HRI, but running formal experimentation is rare. It is much more common that we need quick, effective, "discount" techniques because projects or decisions are often on a tight deadline. Just as "discount" techniques have garnered widespread commercial use in the usability domain, they are needed in HRI as well.

To understand what principles of HCI will have the most impact in HRI, iRobot ran a series of systematic evaluations of several of iRobot's teleoperated robots, which are driven by remote control. iRobot has several teleoperated robots, such as the PackBot, the R-Gator, and the recently announced ConnectR. To study teleoperation, we collected many hours of observations and documented more than 700 one-line "stories" from the observations. For example, users commented that powering the robot through remote control was difficult because their vision was limited. The video stream that users use to drive the robot had a low frame rate and lagged by less than a second. We're using these stories to identify issues and prototype new ideas. By watching the videos, we noticed that when a team is working with a robot, they would often point where they were going to before they would drive there. So we prototyped a laser-pointer robot—operators use the laser pointer to put a dot on the ground in front

[1] Norman, D. *The Invisible Computer*, Cambridge, MA: MIT Press , 1998.

of the robot, and the robot will drive forward toward the dot.

We organized the large list of "stories" into several areas, and we found four key areas where there are many challenges in HRI—these are the areas that we will focus on improving for next-generation HRI.

Situational Awareness. Especially during teleoperation, users need to know the internal states of the robot, the robot's position in the environment, and the environment. For example, good cameras help users understand the robot's position and state.

Robot Control and Movement. Robots are capable of complex movements, and it is important to be able to clearly and effectively command the robot to do what you want it to do. For example, controls to drive the robot and move its arm need to be flexible enough to complete the task, while remaining accessible for human operators.

Controller/UI. Teleoperated robots follow a client/server model in which the controller interface is a client that can operate independently of the robot. This area has many of its own challenges, like ergonomics, because the operator is working separately from the robot itself.

Communications. Communications between the controller and the robot create limits on the robot's behavior, such as how far away you can send the robot.

Using these stories as a basis for our future work, we've looked at HCI and HRI theories and defined a list of key HCI/HRI principles to focus on. This list of "heuristics" was developed from three core sources: Jakob Nielsen's classic list of usability heuristics [2], Ben Schneiderman's core principles [3], and Jean Scholtz's methods for evaluation of intelligent systems [4]. Certainly, this is an untested, initial list—there is room for research in this area.

Many of these principles are not unique to HRI, but their relative value of weighting is slightly different from other HCI communities. During our evaluations, we found the most space for improvement in the areas of "required information should be present and clear," "prevent errors if possible, if not, help users diagnose and recover," and "use metaphors and language the users already know." That's why these three are on the top of the list.

Sholtz's work on intelligent systems adds a new spin to some of these universal HCI principles in the context of HRI.

"Design should be aesthetic and minimalist" has been the most important interaction design principle used in iRobot's projects intended for use in homes, like the Roomba. Since Roomba is a consumer product, a simple user interface keeps the cost of the robot down while keeping its operation simple. As the product matures, the Roomba team is taking on a broader ethnographic approach, including more in-home studies.

Sholtz also suggests that HRI developers *"make the architecture scalable"* and *"support evolution of platforms,"* because robotics is still an immature medium and the robots are often required to do much more than they were designed for. In short, if you don't make it easy for the system to grow, it will be outdated very soon.

[2] Nielsen, J. and R.L. Mack eds., *Heuristic evaluation, Usability Inspection Methods*, New York: John Wiley & Sons, 1994. Available at http://www.useit.com/jakob/inspectbook.html

[3] Shneiderman, B. *Designing the User Interface: Strategies for Effective Human-Computer Interaction*, Boston: Addison Wesley, 1997. Available at http://www.cs.umd.edu/hcil/pubs/books/dtui.shtml

[4] Scholtz, J. "Evaluation Methods for Human-System Performance of Intelligent Systems," Proceedings of the 2002 Performance Metrics for Intelligent Systems Workshop (PerMIS), Gaithersburg, MD, 2002. Available at http://www.isd.cme.nist.gov/research_areas/research_engineering/Performance_Metrics/PerMIS_2002_Proceedings/Scholtz.pdf

[5] Jenson, Scott, *The Simplicity Shift*, Cambridge University Press, 2002.

KEY PRINCIPLES BEING APPLIED TO HRI	SOURCES
Required information should be present and clear	Sholtz, Nielsen, Schneiderman (modified)
Prevent errors if possible, if not, help users diagnose and recover	Nielsen, Schneiderman
Use metaphors and language the users already know	Sholtz, Nielsen (modified)
Make it efficient to use	Sholtz, Nielsen, Schneiderman
Design should be aesthetic and minimalist	Jenson [5], Nielsen
Make the architecture scalable and support evolution of platforms	Sholtz
Simplify tasks through autonomy	(new)
Allow precise control	(new)
Create a positive brand image	(new)
Strive for a natural human-human interaction	(new)

"Simplify tasks through autonomy." The fewer tasks the user is required to assist with, the more he can focus on high-level planning of his task. As mentioned earlier, it is simpler to drive the robot to a location by pointing with a laser pointer than navigating the robot to the location by remote control. Similarly, to simplify telemanipulation, where users control each joint of the robot arm, we are testing haptic interfaces that will automatically adjust the joints of the robot to move the robot's arm into the desired place.

"Allow precise control." Although it is important to use autonomy to simplify things, the robot still must be able to accomplish difficult and complex tasks. Designers can't predict all the tasks or uses of a commercial robot, once it is in the hands of the user. For example, when teleoperating a robot like the PackBot for Explosive Ordnance Disposal, the user may need to be very careful or complete an action in a specific way when using the robot's arm to manipulate objects. There are many things that robots do not know, and so it is often important that users have the capability to exert precise control over the robot and its arm.

At iRobot, the ninth principle, *"create a positive brand image,"* is crucial because we're focusing on industry and commercial usage. If branding and name recognition become part of a robot, we can expect brand to influence users' perceptions of robots, and their perceptions of the robots may change how they interact with one.

"Strive for a natural human-human interaction." People work in the physical world, and so interfaces that also work in the physical world are the most effective, the simplest, and the most natural. If you work with robots as your teammates, you want to be able to talk to them and gesture to them just like you would to another person—you don't want to drop your task and pick up a laptop. We have begun several small projects allowing users to gesture or speak to robots and to allow users to give commands without using any additional hardware. While general-purpose gestural interfaces are a long way off, we consider other ways to reduce interface burden on users who are multitasking such as using head-mounted displays and familiar gaming controllers (similar to the Playstation 2 controller).

As robots become more complex and as markets become more competitive, the robotics industry is sure to see a growth in its need for HCI and HRI specialists. Similarly, HRI techniques must be expanded and improved to be relevant and useful in the commercial development space. Robots are quickly becoming a staple in many homes around the world, and they open up a whole new world of possibilities for interaction design.

ABOUT THE AUTHOR
Aaron Powers is the lead human-robot interaction researcher at iRobot, Corp. iRobot is known for its commercial successes both with the Roomba line of robotic vacuum cleaners and the PackBot line of military robots.

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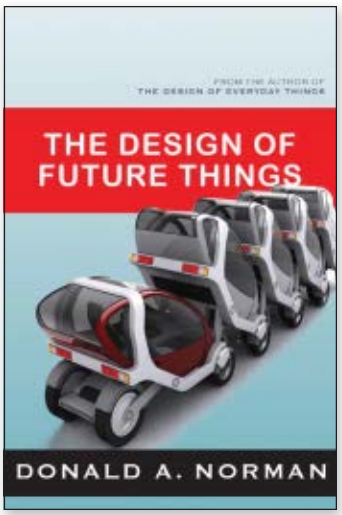

The Design of Future Things

Don Norman
Basic Books, 2007
ISBN 978-0-465-00227-6
$27.50

Reviewed by Gerard Torenvliet
Esterline CMC Electronics |
Gerard.Torenvliet@CMCElectronics.ca

When I was in university studying human-computer interaction, the first paper that I ever wrote was a review of automation issues in the design of aircraft cockpits. One author cited was Don Norman, then a cognitive psychologist at the University of California, San Diego (he is now at Northwestern University). While other researchers were arguing that development had to be slowed because automation had come too far, too fast, Norman instead argued that most problems with automation had arisen because the field hadn't progressed far enough. He thought that the advanced automation of the day was unable to provide the rich and nuanced feedback required for it to be a true partner with pilots in the cockpit. This argument made sense to me, but at the time I concluded that Norman's perspective would be difficult to apply as of the early 1990s. As my freshman pen put it, "Norman's solutions lie in the future."

Fourteen years later Norman and I are still in a dialogue about automation. I now make a living thinking about how to design work support (which includes automation) for pilots, and he's making a living thinking about the future. When I heard that Norman was releasing a book to help everyday people understand and demand more of the increasingly automated technology that the future will offer, my interest was piqued. I wanted to see if Norman would be able to do for the design of future things what he so successfully did for the design of everyday things in his 1998 book of the same name. In *The Design of Everyday Things*, he helped to make complex topics in cognitive psychology and product design accessible to the general reader, while at the same time prompting specialists to see connections they may not have noticed before. Would Norman's secret sauce be strong enough to do the same for the challenging issues involved in the design and use of advanced automation and intelligent machines?

Norman starts his investigation of the design of future things by taking a frank look at the advanced technologies that already surround us. He admires the ways in which technology has helped to improve our lives, while at the same time giving the reader eyes to see the limitations of these same technologies more clearly. Instead of griping about supposed "bad design" (a strange expertise possessed by design experts), Norman's tone is supportive; he points out problems only to make the reader a part of the solution. The emergent thesis is that humans and technology are doomed to be locked in a bad marriage until we come to terms with the fundamental and unchangeable limitations of our relationship. Technologists aspire to create a dialogue between humans and machines, but a prerequisite for dialogue is a common understanding of context. Norman thinks that machines will never be able to develop an understanding of context anywhere as deep, broad, and flexible as humans, nor do they have rich enough means of communication. So our marriage is one with monologues from the machine being met by monologues from us. Dialogue will never result, because two monologues don't equal a dialogue.

Without dialogue between us and our machines, it often feels as if they control us. Norman argues that this is a natural consequence of machines being weak. Their weakness means that they lack

EDITOR
Fred Sampson
wfreds@acm.org

flexibility, and this forces us into conforming to their one best way of doing things. The more powerful a machine is, the more it is able to conform to humans, allowing humans to set the terms the relationship, to be in control. So the diagnosis is clear: Because even future things will lack the power to establish an effective dialogue with us, the promise of technology will always be accompanied by problems, and we humans will feel—to a lesser or greater extent—out of control.

Even though Norman doesn't believe that a cure is possible (or even desirable—just review *2001: A Space Odyssey* to see why the cure might be worse than the disease), he believes that things could be much better than they are today. If the design of new technologies were informed by technology's fundamental limitations, the effects of many of those limitations could be mitigated, and even turned to good. Norman's overall design thesis is that designs need to become more "natural," where natural means a move away from the binary and discrete realm of computer logic to the rich and dynamic realm of human experiences. For example, while the electronic kettle circa 2008 might signal boiling water via a beep or a click, the good old-fashioned steam kettle circa 1850 signals boiling water via a whistle that builds from low and quiet to high and piercing. Norman doesn't want us to throw out digital technology in exchange for steam, but in a world where everything beeps he'd like to see designers experiment with a richer palette of sounds[1].

To be sure, kettles are simple. That's why they're just a building block of Norman's design ideal, an ideal that allows for a natural symbiosis between human and machine. The best expression of this is the horse and rider, a system in which the delegation of authority and the communication of risk between horse and rider is natural and almost effortless. This ideal is lofty, but not too lofty: Norman shows how research into the horse and rider is changing the way designers today are thinking about the car of tomorrow.

One surprising thing about this book is that while it speaks to many current research issues in the realm of automation design (including inappropriate trust, skill-shift and loss, behavioral compensation, etc.), it isn't bullish about automation. Instead of automated systems whose design metaphor is taking over for humans, Norman argues for augmentative systems whose design metaphor is amplifying the capabilities and efforts of humans. These systems already have a strong track record, from recommender systems on shopping sites to co-bots that are used in industrial settings to help operators move items in a warehouse, and they show promise for much more. Norman doesn't discard automation as a design option, but clearly feels that augmentative technologies are closer to his ideal of symbiosis, and so have strong potential for application to the design of everyday things.

This focus on everyday things is perhaps the greatest strength of Norman's new book. Even though he discusses a lot of whiz-bang technology, it never seduces him. His clear interest is in providing better, simpler—yet more powerful—technologies to help people get from place to place, families to work together, and friends to share experiences. He follows through with useful (but high-level) design guidance that is applicable even today. Thankfully, even though this isn't an academic book, Norman is faithful to the academic literature. Sure, some will complain that a point has been missed, or a paper hasn't been cited—and they might be right—but that's missing the point. The contribution of this book comes from the way that Norman brings together such a broad range of research and insight into a reasonably unified structure, all written and packaged to be accessible to a general audience. In contrast to those journal papers he might not have cited, this book might actually get read, and might help everyday people to demand a future where instead of technology requiring respect, technology will instead respect its users.

And at the end of the day, I was comforted to see the lowly steam kettle feature prominently in a book about future things. No matter what the future has in store, it's good to know that one of its foremost prognosticators will always be grounded by making tea the old-fashioned way. Revisiting my freshman thoughts after reading this book, I can happily report that some of Norman's solutions lie not in the future, but in the past.

[1] As an aside, moving beyond the beep can also make technologies more accessible. Most of us with adult hearing can localize sounds, so the beep of the coffee maker can be easily distinguished from the beep of the washing machine or the timer by location. If you are deaf in one ear (like my son) or wear a hearing aid (like my grandmother), localizing sound is much more difficult, and use of a richer, more natural palette of sounds would make life just a little bit easier.

ABOUT THE AUTHOR Gerard Torenvliet is a senior human factors engineer at Esterline|CMC Electronics, where he divides his time between applied research contracts and product design for customers in civil and military aviation, as well as research institutes.

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Designed to Include

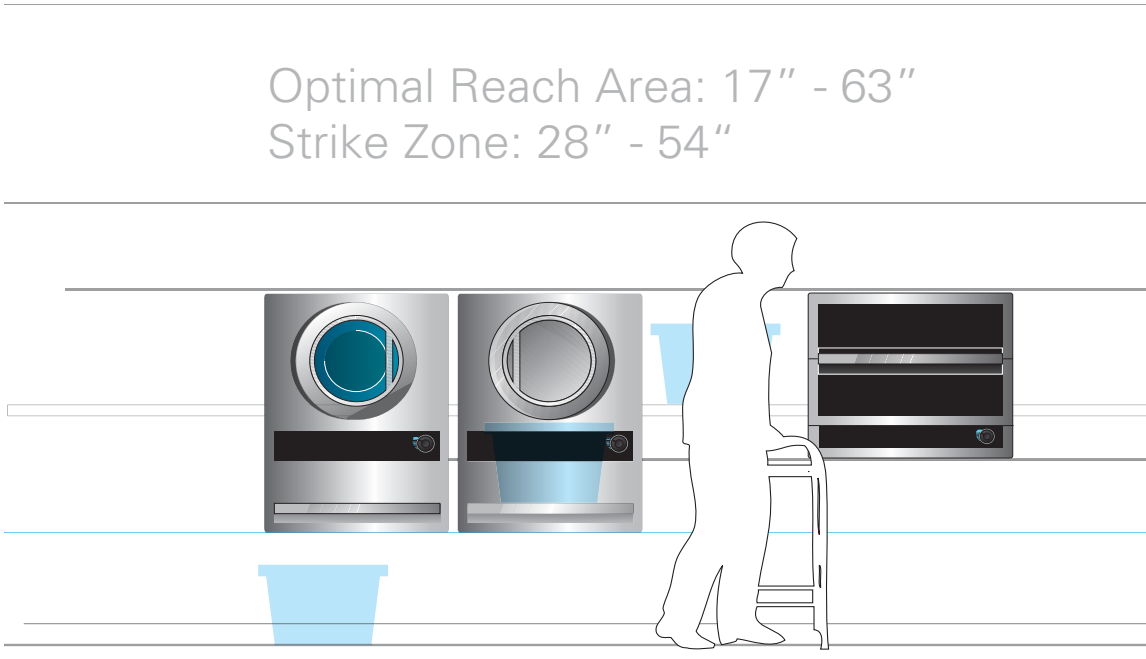
Mark Baskinger
Carnegie Mellon University | mbasking@andrew.cmu.edu

With the baby-boomer population approaching mature adulthood, there is an increasing buzz about universal design for everyday objects. The year 2014 is very significant, as the last baby boomer will turn 50, with the upper tier of this generation turning 68. So many companies are actively pursuing new product-development initiatives that appeal to broad audiences and specifically address the multitude of issues we may experience with aging. Through these inclusive strategies, we may find an increasing array of products that are easy to use, understandable, functional, and relevant. If companies are successful, we may no longer see the stigmatizing, clinical, overly techno-mechanical product forms that speak to the disabilities of elders and special-needs populations. Instead, we may find accessible, inviting, attractive forms that transparently imbed assistive features and prove to be widely accepted.

As a designer who started in communication (graphic) design and branched out into industrial (product) design through graduate studies and professional work, I view all designed artifacts as embodiments of communication that act as catalysts to enhance human experiences with systems, environments, ideas, information, and with each other. It is in this space that I find a very exciting future for product forms that are useful, usable, and desirable, but also intuitive, informative, and inclusive. In this forum, I will introduce three recent research projects that touch upon some inclusive design strategies.

Inclusive Futures: The GE "Autonomy" Project

The ubiquity of major appliances affords an opportunity for a socially responsive change in thinking to address issues of design usability for the aging population. By focusing on the abilities of various populations rather than the disabilities that make them different, an inclusive



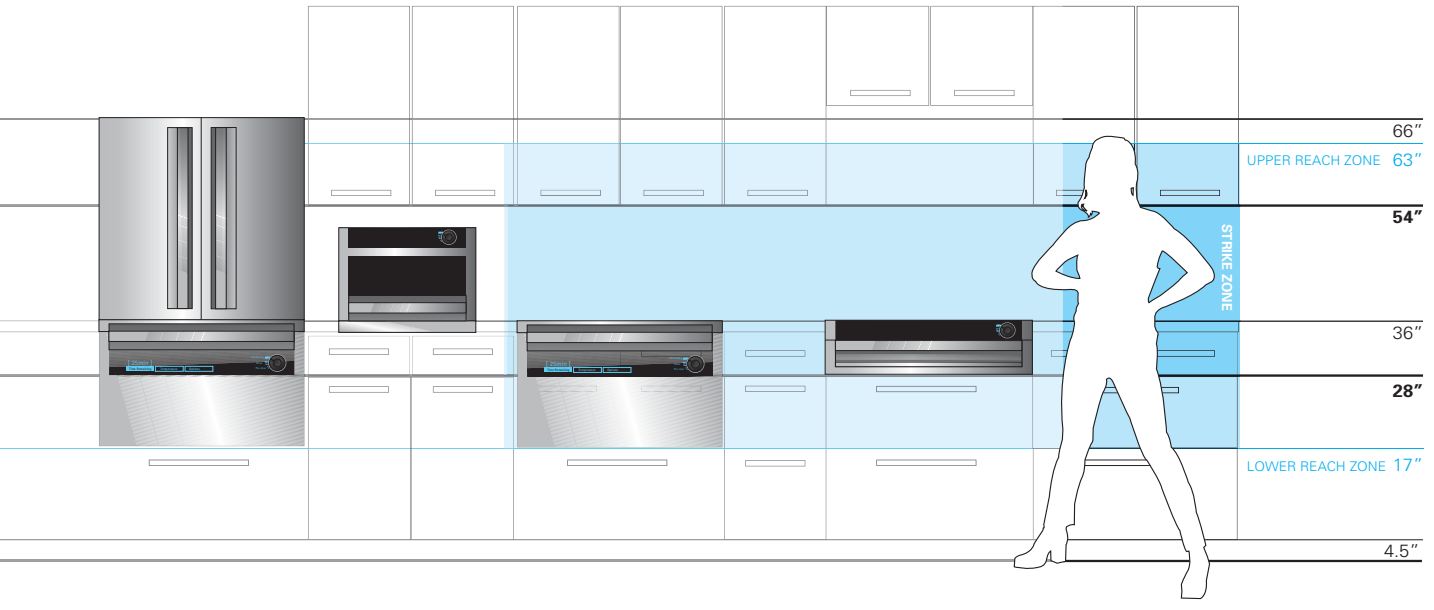
▶The Strikezone concept defines an optimal vertical workspace to place most activity and interaction within a range that limits excessive bending and reaching for most adults.

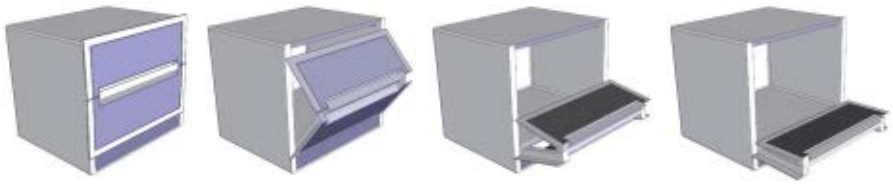
EDITOR
Allison Druin
allisond@umiacs.umd.edu

strategy can be developed to generate broader appeal. At Carnegie Mellon's School of Design, we recently concluded a two-year research project with GE Appliances in Lousiville, KY, that explored the attributes of current and emerging elder populations to identify opportunities to promote sustained autonomous living. What we (re)learned in the process was that most of the advantages designed to empower elders actually increased usability and appealled to a much broader audience. As noted educator and author James Pirkl describes, this is a transgenerational approach. Through our various research methods aimed at better understanding aging from an elder's point of view, we learned that elders expressed views on features, complexity, and materials that were similar to those of much younger consumers (identified as first-time appliance buyers). So our strategy was to focus on the form language, behavior, and interaction with appliances to serve as a primer for GE designers to use as underpinnings for enhancements across their product lines. Creating a new "geriatric" line of appliances would be demeaning—no one wants to be told they're old—but establishing new interactions that would empower elders, yet appeal to a wider audience, made a lot of sense.

Working within existing kitchen-cabinet standards, we developed the StrikeZone concept, which defines a "right-size" approach and situates appliances in the kitchen at optimal locations for reach, access, and movement. This more advantageous configuration promotes greater access into and around each appliance and was determined by establishing a relationship of the user's physical interaction and movement with each primary cooking/cleaning activity, as well as the relationship of the appliance form in situ within the kitchen space. The appliance forms were designed to express behavior and capabilities in simple and intuitive ways. Through observation and anecdotes, we learned that there are common human experiences with appliances; the risk is the same when reaching into a hot oven, and everyone bangs their shins on the dishwasher door. Focusing on design solutions from the elder perspective enabled a more conscious focus on enabling features that would address risk and hazardous scenarios that translated to a broader audience.

Establishing a common visual interface across all products (microwave, dishwasher, fridge, oven, cooktop, laundry pair) was incredibly important in promoting user confidence through consistent visual language and feedback. A combination of analog and digital display serves as the basis for establishing a narrative interface that





▶ The Wall Oven's split-folding door enables hot surfaces to mate and minimize reach-over length. This can reduce accidental burns and provide a surface at counter line for sliding out hot cookware.

graphically illustrates the past, current, and future states of each appliance. For instance, in the washing machine interface example shown here, the various steps of a heavy load sequence are revealed with demarkation of current status. Compared with current radial dial interfaces with lots of small text and confusing terminology, a pictographic display supported by simple, readable text can easily communicate a range of information—What can I do with this appliance? What is the appliance doing now? What is it going to do next? What did it just do? What must I do now? What did I just do? What must I do next?

Currently, the research generated in the scope of the GE Autonomy project is being used as guidelines and criteria for new product development and product updating across their brands.

Inclusive Utility and Safety

One of the major qualities of universal design is the visual language of product forms and how product forms are structured to embody and communicate information. Through visual form, language products can inform interaction, encourage behaviors, and shape user experience. In risky or potentially dangerous situations, product impact is amplified; designed artifacts must clarify and present information in easily accessible and intuitive ways. In certain devices, tools, and product systems, the need for simplicity and clarity is explicit. So why do we have so many products that fail us in this respect? As part of a study on packaging and poisoning for elders, I found that the current prescription medicine bottle is problematic for a lot of people beyond the elder population. Declining eyesight, low-light scenarios, and the frequency of taking multiple medications—common for many elders—greatly complicate an already risky scenario. There is a complete disconnect between the bottle form and the labeling system to encourage safe practice and compliance. Therefore, establishing hierarchies of information in many forms may empower elders (and us all) to index medications easily, store them appropriately, and so on.

▶ Product forms inherently must express state and usage through their behavior and form to provide adequate feedback. In the medicine-bottle concept here, the squared form demonstrates that when the bottle is not securely closed, the corners will not align. In addition, the squared form fits the natural angles of the hand to provide better leverage for grasping and opening. (Designed by Mark Baskinger, May 2000.)

Relying on pictures alone can be problematic as well. In the case of a medicine bottle, fire extinguisher, or other potentially life-implicating products, synergy must exist between physical form, graphic imaging, and textual communication. In scenarios where ailments like arthritis and glaucoma prevent people from using products appropriately, hazardous scenarios can arise. Whose fault is it when an elder takes the wrong dosage of medication, or when the bottle rolls out of the medicine cabinet, spilling pills down the drain? Where does responsibility lie when the grandkids get access to the pills that grandma stores on the kitchen table?

These are not issues associated only with aging; they relate to us all.

Inclusive Design for Kids

In my experience as a parent, the only time I can

Julia Frederking and Michael Cruz

▶ Lila digital artboard

safely turn my back on my kids (ages six and two) for a few minutes is when they are drawing at the kitchen table. When they play independently, I find they tend to get themselves into trouble. Because of their very different interests (my daughter loves dinosaurs, and my son plays only with trucks), they don't often engage in collaborative play. But when they do, it is short lived because they're at very different physical, cognitive, and emotional levels. This premise sparked a research project in 2005, between Carnegie Mellon School of Design and the d.search-labs at Technische Universiteit Eindhoven (Netherlands).

Our strategy was to develop a system that would engage children of varying ages within a localized play space to give parents a bit of a "breather." What emerged from the project was a prototype called "Lila," a digital art board comprising a digital touch screen and digital pegboard to provide two primary sources for input to encourage collaborative or inclusive play. The initial idea was to combine a digital interface with a separate physical interface to engage children of varying ages, as in the case of my two kids.

With Lila, children can draw pictures in a free-form style using their fingers and easily combine the drawings with animations that are generated through the use of the pegboard. Both children can generate visualizations to construct a shared story or image. The Lila system includes a projector mounted in the back of the vertical digital component to show their creations at a larger scale. Once something is projected, the children can enter that space to play and act—taking them from screen-based play back into the real world. The illustrations then serve as the backdrop to further play and provide the children an opportunity to move between physical and virtual worlds to create scenarios.

Summary

Inclusive design, universal design, assistive design, and transgenerational design are not new, but they've historically been seen as specializations. As our population ages, we may find more opportunities to mainstream inclusive strategies into product development. The key to the success of an inclusive future lies in designing for shared abilities with a keen transparency of assistive features that address human deficiencies. The visual language of product forms, systems, and technologies will have an increasingly critical role in making artifacts engaging, appropriate, and empowering.

Anne Jackson

ABOUT THE AUTHOR Mark Baskinger is an assistant professor in the School of Design at Carnegie Mellon University and the co-founder of The Letter Thirteen Design Agency. His work spans across graphic, product, interaction, and environmental design. Mark's research at CMU focuses on how artifacts communicate through their behavior, form language, and context to inform interaction and shape user experience. His work has been featured in design publications, and has been exhibited in numerous galleries and museums, including the Museum of Modern Art (New York), I-Space Gallery (Chicago), the Krannert Museum (Champaign, IL), and the Regina Gouger Miller Gallery (Carnegie Mellon University). For a sample of Mark Baskinger's current work, please see: www.letterthirteen.com and www.design.cmu.edu

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Raising a Billion Voices

Sheetal K. Agarwal
IBM India Research Laboratory (New Delhi) | sheetaga@in.ibm.com

Arun Kumar
IBM India Research Laboratory (New Delhi) | kkarun@in.ibm.com

Sougata Mukherjea
IBM India Research Laboratory (New Delhi) | smukherj@in.ibm.com

Amit A. Nanavati
IBM India Research Laboratory (New Delhi) | namit@in.ibm.com

Nitendra Rajput
IBM India Research Laboratory (New Delhi) | rnitendra@in.ibm.com

Almost a year back, we started working on an exploratory research project Pyr.mea.IT [1]. "The bottom of the pyramid is the largest but poorest socio-economic group. In global terms, this is the four billion people who live on less than $2 per day, typically in developing countries [2]". Since almost all of our research in computer science and information technology has until recently focused on the top of the pyramid, we thought it might be a good idea for us to get at least somewhat acquainted with our end users. All of the authors have lived and grown up in India, so we have a reasonable understanding of the people around us, or so we thought. We conducted some initial surveys, in about 10 cities and towns in India, with fruit sellers, milk-delivery men, auto rickshaw drivers, plumbers, and the like, to get a firsthand idea of the way technology, not just IT, impacts their lives and their level of comfort in using it.

Two things, seemingly contradictory, are inescapable in today's India: the lack of literacy and the penetration of mobile phones. While the former has been around for years, the latter is a recent phenomenon. Even people whose monthly salary is one-fifth the cost of a mobile phone are carrying one around with them (the mobile is shared with the family). One milkman we talked to does not use the address book to store and retrieve numbers! He dials the number every time. Another young man plays games on his, although he cannot read or write. Invariably, all the folks surveyed use the mobile phone to talk and stay connected with family and clients. Although sending a text message is often cheaper than making a phone call, lack of literacy makes that a nonexistent option for most of these people. Somewhat interestingly, it is also true that many educated people in India do not use the mobile except for talking. One thing becomes clear: Services relevant to various sections of the society are either nonexistent or the interface is practically unusable.

Until as recently as four to five years ago, mobile phones were still expensive, and getting a landline phone connection was complicated. Many of the plumbers, electricians, and carpenters come to the city from neighboring towns and villages and stay with friends and relatives, so address verification becomes an issue, and it could take several months to get a connection. The processes were slow, and there was no competition for the telecom company. As a result, freelance plumbers, electricians, and carpenters used to associate themselves with an electrical shop or a hardware store to find job assignments. People typically call up these shops for such services, and the shopkeeper sends the workers on assignments and collects a fee from them. The falling price of the mobile phone has changed this

EDITOR
Gary Marsden
ugaz@acm.org

►Creating/accessing a Voicesite: Scene from a village in India.

system. The workers can now buy a prepaid connection over the counter, thereby gaining independence from the shopkeepers. They get assignments by word-of-mouth and through inexpensive advertisements in the local yellow pages.

In almost all developing countries around the world, Internet penetration is much lower than that of the mobile phone, and the rate of increase of mobile-phone penetration far exceeds that of the Internet. This fact, coupled with the obvious preference of speech interfaces over textual ones, led us to the vision of the Telecom Web [3, 4]. The Telecom Web is a worldwide network of Voicesites, just as the World Wide Web is a network of websites. A Voicesite is a voice-driven application that consists of voice pages (say, VoiceXML files) that are hosted in the telecom infrastructure.

The Telecom Web exists and operates on the telephony network. People browse Voicesites by talking with them, traverse from one Voicesite to another via VoiLinks, and even conduct transactions over voice. The Telecom Web figure shows several Voicesites connected to each other via VoiLinks, which make it possible to move from one Voicesite to another by uttering commands or keywords. This introduces a "browsing-by-talking" experience that includes the possibility of supporting "back buttons" ("go to the previous Voicesite"), bookmarks, etc. The Voicesites can be identified by phone numbers playing the role of URLs. When one traverses a VoiLink to go from one Voicesite to another, this is more than a simple call transfer—the context of the conversation also needs to be transferred along with the call [4].

A common objection to the general acceptance of such an approach is the frustrating experience we've had so far in using voice applications. However, we believe that there is a reason for cautious optimism: In already developed regions, alternatives to voice have been available, and so expectations are different. For our targets, this will enable them to do things they have never been able to do, and by starting out with small applications [5], we might find the right way to use voice. Just as the proliferation of the World Wide Web hinged upon the simplicity of creating a website (HTML), so will the proliferation of the Telecom Web depend upon the ease of creation of Voicesites. We have built a system called VoiGen [6], which lets you create your Voicesite just by making a phone call.

For these micro-business freelancers, a missed call is missed revenue. Now, suppose our freelancers could have their Voicesites—this would mean an online presence for them. What if a potential client could reach a plumber's Voicesite and schedule an appointment with him? We created a template for a plumber, which included questions such as "Enter your welcome message," "What are your working hours," and "Would you like to mention references for your work?" The plumber's answers are recorded by VoiGen and used to create a Voicesite so that when a potential client calls up the plumber, he hears the plumber's voice taking the client through various possible interactions with the Voicesite. The system can be set up such that when the plumber is unable to pick up the call, the call is redirected to his Voicesite, or alternatively, all calls first get directed to the Voicesite, and you are connected to the plumber only if you need to speak with him. VoiGen becomes the equivalent of a "talking HTML editor" for creating a Voicesite.

Just to try this with real targets, we sampled 12 freelancers in South Delhi. None of them had ever interacted with an IVR before, let alone browsed the Internet. We explained the whole idea of having a Voicesite to them, and also the mechanism of creating one. Ten out of those 12 were able to create their Voicesite in under four minutes (this includes the time it took us to explain things), which means that the concept of a Voicesite and the user interface to create it were reasonably compelling and intuitive. Two of them could not: The very first interaction was in a noisy environment, and the user did not have the patience to repeat what he was supposed to say. To reduce noise, the interaction venue was shifted to a car. Another one failed to create his Voicesite because he thought he was interacting with a human at the other end and assumed that free speech would work.

In several parts of the world where Internet access is deep and literacy is not an issue, the World Wide Web suffices. There are several ongoing efforts to make the Web accessible over voice; the notion of a Telecom Web in such regions is superfluous. And yet in regions where the telephony (largely mobile) penetration is far higher, and rising faster than Internet penetration, the

Telecom Web has a major role to play: online presence, information, and commerce for everyone. For better impact, the two webs will have to leverage each other. It should become possible for the websites to be accessible from the Telecom Web, and the Voicesites to be accessible from the World Wide Web. Excuse me, I hear my Voicesite calling!

ABOUT THE AUTHORS Sheetal Agarwal is a technical staff member at IBM India Research Lab. She did her master's in computer science at the University of Maryland, Baltimore County. Her research interests include pervasive and ubiquitous computing, mobile applications, and, more recently, information and communication technologies for emerging economies.

Arun Kumar is a research staff member at IBM Research, India. He obtained a master's degree in computer science engineering in 1999 and is currently pursuing a Ph.D. from IIT Madras, India. He served on the program committee for ACM SAC 2008 and 2007 and has been published in reputed international conferences and journals. His research interests include ICT for developing regions, service oriented computing, object oriented programming, semantic Web services, and distributed systems.

Sougata Mukherjea is a research staff member and manager of the Telecom Research Innovation Center at the IBM India Research Lab. He received his bachelor's from Jadavpur University, Calcutta, a master's from Northeastern University, and a Ph.D. from Georgia Institute of Technology (all in computer science). Before IBM, he held research and software architect positions at NEC USA, Inktomi, and BEA Systems. His research interests include middleware technologies and its applications to telecom, data analysis, information retrieval, and visualization.

Amit Anil Nanavati is a research staff member at IBM India Research Lab. He has a Ph.D. in computer science from Louisiana State University. Prior to IBM Research, he worked for Netscape Communications. His recent research focus has been on telecom solutions, especially for emerging economies. He is also interested in applications of graph theory in various domains. Before completing his Ph.D., he spent a summer at the Jet Propulsion Laboratory, Caltech, NASA.

Nitendra Rajput has been working as a researcher at the IBM India Research Lab, New Delhi since March 1998. His areas of interest include speech processing, image processing, and dialog management. He has done projects on audio-visual speech recognition, Hindi speech recognition, and conversational systems for pervasive devices. His current work involves application of speech technology interfaces for developing countries. Prior to joining IBM Research, he completed master's from IIT Bombay in communications.

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INTERACTIONS CAFE

(continued from page 80)

it becomes thoughtful only when it stops being objective.

I've recently had a number of conversations with professional designers who are all, generally, coming to the same set of conclusions: User research is much, much less important than "worldly research," or "human research." Instead of researching for a specific project, they find more value in forcing themselves to constantly observe, consider, and question the everyday world around them.

Richard: In this issue Hugh Dubberly and colleagues argue for creating explicit models so as to not gloss over the synthesis you reference. And I agree that such synthesis too often gets short shrift.

However, I don't reject the value of applying some form of the concept of "correctness" to such synthesis, in consideration of its goals and the context in which it is performed. And while I agree that ongoing "worldly research" is of great value, I urge designers not to mistake the inadequacy of such synthesis for the unimportance of the focused research that feeds or should feed it.

Design itself isn't magic. It can be taught; it can be learned. It might resist understanding and, hence, prompt fear and marginalization among many. But it comprises, in part, the development and consideration of rationale.

I don't think the work of Tom Moran years ago on design rationale was so completely divorced from the nature of design and abductive thinking. And as Bill Buxton describes in his 2007 book, *Sketching User Experiences: Getting the Design Right and the Right Design*, being explicit about design rationale helps guide the design process away from decision by bullying or seniority and makes it easier and safer to determine whether a design decision should be changed after something new happens or is learned.

In short, what I'm saying is that—borrowing terminology from Jan Borchers—designers need to seek out "the sweet spot" between emotion and logic in order to reach "the sweet spot" in design and in influence within a business.

—Richard Anderson and Jon Kolko

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On Logic, Research, Design Synthesis…

Jon: A core theme of this issue of *interactions* has been the relationship between interaction design and education: how to teach it, how to learn it, and how to live it. As a designer, I'm obviously biased toward design education, as I see design as a core tenet of life, akin to reading and writing. Design has often been characterized as "dreaming" or "problem solving," both of which I consider underpinnings of human life. At the same time, I see the value in logic and pragmatism, and I'm often challenged professionally to "prove it" or "back it up with a sound, logical argument." Do you think future generations of professionals in the interaction world will have to walk the line between Art (emotion) and Science (logic), or will Design with a capital D finally have its time to shine?

Richard: Can design truly shine without addressing both emotion and logic? Was a need to walk the line between art and science responsible for all the messes described in the first section of this issue, or is the culprit better described as an improper balance?

Roger Martin, whom we referenced in our first Interactions Cafe discussion, has written about how the predominant thinking in business—analytical thinking—is hostile to design, and how that needs to change. But he doesn't argue that analytical thinking has no place.

Perhaps you can't "prove it." Perhaps you shouldn't be expected to "prove it." But is it wrong to expect to develop and use and provide rationale that can be subjected to some form of critique throughout and after the design process?

Is Tracy Fullerton wrong in teaching and emphasizing the importance of playtesting in her interactive entertainment program at the USC School of Cinematic Arts? Was Mark Baskinger wrong to observe the elderly and kids in his

inclusive design projects? Doesn't such research contribute to a kind of "logical argument" that is essential?

Jon: I wonder if the word "rationale" should even be part of the designer's language. A great deal of the abductive thinking Roger Martin describes is the "logic" of what might be. This isn't logic at all: I think Roger is smart enough to realize his audience won't respond well if he were to call it "the magic of what might be."

The research Fullerton describes, and Baskinger conducts, is absolutely worthless without some form of generative and interpretative synthesis, and this synthesis isn't logical. It's sometimes appropriate, or comprehensive, or rigorous, or even repeatable, but the notion of there being a "correctness" to design synthesis is far-fetched at best. This phase of synthesis is being publicly glossed over, as design firms pander to businesses looking to get ahead: "Do a little research, and—bam!—innovative products! Design thinking in action!" User research is wonderful, but it isn't Design thinking at all;

(continued on page 79)

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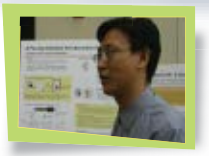
May 29-30, 2008



Symposium
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The International Children's Digital Library goes to Mongolia

Improving Readability of Online Books

Accurately Transcribing Text with Armies of Inaccurate Volunteers

ebooks

SESSION II: Diverse Users

e-Health Literacy & Older Adults

Children's Self-Conception of Culture through Technology

Constructing Knowledge in a Public Forum: Student Projects in Wikipedia

Educational Simulation and Information Ethics

Community Response Grids: For Campus and Beyond

SESSION III: Understanding Information

Temporal Queries on Electronic Health Records

Network Visualization: Successful Case Studies

Understanding Social Networks

Visualizations for Searching and Exploring Document Collections

Cloud Computing: Web-scale Information Processing with MapReduce

DEMONSTRATIONS

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WORKSHOPS

e-Health Literacy & Older Adults

Value Sensitive Design & Digital Libraries

Temporal Search in Electronic Health Records

Keynote Panel
25 years of HCI - 25 years of HCIL

PANELISTS

Richard Anderson, Editor-in-Chief, Interactions Magazine

Ken Perlin, Founding Director & Professor, NYU Media Research Lab

Clare-Marie Karat, Research Staff, Policy Technologies Dept., IBM TJ Watson Research Center

PANEL MODERATOR

Allison Druin, Director, HCIL

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