Paper Spaces:
Visualizing the Future

by Alex Soojung-Kim Pang

"What was to go on the canvas was not a picture but an event."

(Harold Rosenberg on Action Painting)

Introduction

Futurists may disagree about some things, but we are unanimous in the belief that if our work is to have any impact, it needs to be made comprehensible and actionable. One important vehicle for achieving that goal is workshops with executives or policymakers, in which we explore how high-level trends will affect their industries or companies, and work with them to develop responses to a range of possible futures. Workshops are also valuable research tools in which interdisciplinary or cross-industry groups can outline and explore future trends and disruptions. But how do you organize them to work well? Obviously it's important to have a good process, but events like these need to be seen as much more than opportunities to exchange information or follow a flow chart. Recently, Grove Consultants founder David Sibbet highlighted how the "deep patterns" of visual maps could help organizations think more powerfully about their present and future, and develop cognitive skills that can help them face complex challenges.[1] Historians of science have likewise shown that visual practices play an important role in shaping how scientists work and think.[2] This essay extends the work of Sibbet and science historians, and argues that we need to pay attention to the role materials and spaces play in shaping collaboration and knowledge-production.

We tend to think of space as irrelevant in creative work, or at best indirectly influential: architects may use a mix of open office plans, natural lighting, and bold colors, for example, to create stimulating workspaces. But for workshops, and for the kinds of visual processes that many futurists use, the relationship between space, ideas, and creativity is much more intimate. Ideas are embodied in materials; they become cognitive and physical spaces that literally surround groups; and the process of creating those spaces can promote a sense of group identity and common vision for the future. I use the term "paper spaces" to describe these environments, and to highlight several things. First, we are used to thinking of things made of paper as physical objects whose qualities help shape the experience of reading, but it's useful to pay attention to their spatial and architectural qualities as well. Large visuals aren't just things: they are spaces that possess some of the qualities of desks or offices. Workshops exploit their scale and physicality to promote social activity between workshop participants. In this case,

Alex Soojung-Kim Pang is an associate fellow at the Saïd Business School at Oxford University, and visiting scholar at Stanford University. The ideas expressed here do not reflect the opinions of SBS, and all errors are the author's. Author's address: askpang@future2.org.

An earlier version of this paper was presented at the "1st Workshop on Imagining Business," Said Business School, 26-27 June 2008.

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

the spatiality of paper is fairly self-evident; but, in fact, our interactions with paper, books, and writing all have a spatial quality. Scholars could gain much by analyzing print media using conceptual tools from architecture, design, and human-computer interaction, as well as literary theory and book history.[3]

Second, it warns us against taking too passive or formal a view of visual tools in business, of treating them like paintings on a wall. In the way users interact with them—they are annotated, extended, argued over, and played with—they are more like Legos than landscapes.[4] Both the process of creating maps, and the maps themselves, reflect a set of attitudes about how to understand and prepare for the future, one that emphasizes user involvement, and the need for actors to develop and possess shared visions of the future. (Ironically, there may be more studies of large interactive displays and other digital media, than of the old media they are meant to displace.[5]) Finally, the term "paper spaces" highlights their hybrid, ephemeral quality. They work because they are simultaneously interactive media and workspace, but their lives are brief and easy to overlook: they are designed to support idea- and image-making, but leave little trace of themselves.

To illustrate how paper spaces work, this article draws on my experience organizing or participating in approximately one hundred expert workshops and roadmapping exercises over the last decade. Most of these were conducted at two Silicon Valley-based futures groups: the nonprofit Institute for the Future (IFTF), and Future2, a boutique consultancy. IFTF conducts research on the future of health care, emerging technologies, and global trends. Its local culture is very visually intensive—it spends a great deal of time on information design and high-quality graphics—and it uses group processes both in its research, and in engagements with clients interested in understanding the strategic implications of futures trends.[6] Future2 works primarily with academic institutions, and specializes in mapping the impacts of emerging technologies. Paper spaces are not unique to futures work, nor are the materials futurists use in workshops special. Flip-charts, whiteboards, and other systems for capturing and sharing ideas are common in academic, corporate offices, and industry. But what is notable is how futures workshops take particular advantage of the special qualities of paper spaces to facilitate the creation of collective knowledge about the future, using processes that embody our beliefs about the future. The article begins by describing expert workshops, how they are organized, what they aim to accomplish, and how they work. It then discusses how paper spaces support the creation of knowledge about the future. Finally, it argues that paper spaces are ubiquitous: most of our interactions with texts and other media have a spatial dimension that affects the ways we read, think, and create.

Workshops as Paper Spaces

Expert workshops generally bring together between ten and fifteen people, ranging from academic scientists and engineers, to venture capitalists and entrepreneurs, to extreme athletes and online gamers, to think together about the future. The fundamental challenge with all expert workshops is to create a social situation in which people are encouraged to share their expertise, but also think beyond their normal horizons. To do this, one needs a space that focuses concentration, and serves as a mirror of the collective's work and thinking.

The Process

Expert workshops at IFTF and Future2 share a common structure and rhythm.[7] They normally begin by introducing participants to each other. Because workshops are often designed to be "trading zones" that bring together people from different disciplines and industries, participants often do not know each other: introductions serve to let people discover common interests and con-

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

nections.[8] The group then moves on to a brainstorming session, in which participants are asked to name the factors that they see affecting their business (or scientific discipline, or organization, etc.) over the next five to ten years. Experts are given a few minutes to write down those factors on notes. (Processes that alternate between private and public modes of thinking may encourage greater creativity; having experts sometimes work on their own also raises overall levels of participation.[9]) The facilitator then asks one participant to contribute a note and briefly explain its importance; as they do so, the facilitator puts the note up on a large sheet of paper facing the group. If others have written about similar factors, those are placed on the board with the first note. Once discussion of the trend finishes, a second person offers up a new note, and similar notes are gathered and added. The process is repeated until all the notes are played.

By the end of the session, the board may have 75-100 notes on it, and look fairly chaotic. The group's next challenge is to give the board's notes (and, through the board, their own ideas) some order. There are several ways to do this. The group might organize the notes into thematic clusters, to see which factors or trends are associated, or place them along a timeline, to help clarify when different forces might come into play. Once the notes are organized, experts vote on the factors, identifying which are most important, marginal, or wildcards—events with a low probability but high impact. This map then serves as a foundation for the rest of the day.

In the afternoon, the group is guided through exercises focusing on the trends it has identified as most important. For example, they may divide into several small groups to create scenarios that describe different potential futures made by combinations (or cross-impacts) of trends.[10] (Building on earlier work is not only more efficient, it promotes a greater degree of satisfaction among participants.[11]) At the end of the exercise, the group reassembles, and each group briefly describes their work to the collective. If time remains, the entire group might brainstorm ideas for a strategy that would allow them to respond to any of the scenarios.

How Paper Spaces Work

How do you design a space that supports this process? By combining media, room, facilitator, and process into what Bonnie Nardi and Vicky O'Day call an "information ecology."[12] The key components of this ecology are book-sized Post-It notes; large sheets of paper (often 4' x 8' or longer); and rooms arranged to allow facilitators and participants to move and interact both with the media and each other. These information technologies share several features: they are easy to use, highly flexible, shareable with groups, and can be manipulated by several people simultaneously. To understand how this ecology works, and what makes the different components so important, let's start with the smallest pieces of this ecology, and work our way up.

Notes

When participants are asked to brainstorm ideas, they are given large Post-Its (usually 5" × 7") to write their ideas down on. These notes are inexpensive, easy to use, and easy to edit. Participants can afford to use up lots of notes—and, one hopes, be as generous with their ideas. It makes it easy to toss out their first couple tentative experiments once the really good ideas start to flow. Participants are encouraged to write in very large letters, to make their ideas legible at a distance: this makes them shareable. This also imposes a measure of discipline: it prevents participants from writing more than a few words on a note, and encourages people to be simultaneously profligate in generating ideas, but economical in expressing them. Notes are also easy to handle. They can be put up on a board quickly, which keeps a meeting (and ideas) flowing. Facilitators also don't

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

have to worry about choosing between similar notes: stacking them together provides a quick visual indicator that an idea is popular.

Later, when making chronologies or idea maps, notes can be moved around easily. To paraphrase Bruno Latour, notes are "mutable mobiles."[13] They are mobile in the sense that they can be moved around on the map, which changes their place in a timeline or other organizing structure, or alters their proximity to other notes—sometimes in ways that allow participants to see new connections between different ideas or trends. They are mutable in that their meanings change through the day. Unless the few words on them are a familiar term of art or technical phrase that the group already understands, contributors have to explain to the group what their notes mean. Playing notes, in other words, starts a conversation—about that note, about what it means, and how it fits in a larger scheme of meaning. As groups talk about notes and the trends they describe, they often create additional meanings or discover new implications. As participants move notes from one point on a timeline to another, or from one cluster of ideas to another, they acquire new neighbors and context, which subtly changes their meanings and importance.

In short, notes are cheap, flexible, and eternally tentative.[14] They make ideas shareable, social things, both through the opportunities they create for group discussion and meaning-creation, and in the limits they impose on authors. The fact that notes cannot stand completely on their own—they are signs, not signifiers—means that the course of a day groups change notes' meaning, importance, and place within a larger network of ideas and associations.

Paper

That evolution takes place in the heart of the paper space, the large sheets of paper and templates that groups work with. These sheets of paper are generally four feet tall, and between eight and sixteen feet long, depending on the space available.[15] Large papers like these let individuals hold, examine, and process lots of ideas. They let members of a group work together to build a common vision of the future. And they support the development of complex, multilayered scenarios and threads.

Let's look first at how individuals relate to large sheets of paper. Most people are accustomed to thinking of paper as something we hold, read, then put down or discard. But a wall-sized document reverses the normal relationship between users and information: it makes you stop and think. My sense—which has a little bit of empirical backing from work in the psychology of perception—is that because these large sheets can take up more of a participant's visual field, they can command more attention for longer periods. Large sheets of paper provide room for everything from big ideas to small details. They allow users to store and see a lot of information, and see it all at once. In this respect, large sheets of paper have some of the virtues of the zooming browser.[16] Personal notes only give authors enough room to record key points, and it is impossible to pack as much information into a handout as one can get on a wall. This reflects the fact that under normal circumstances, paying attention to the "big picture" and small details at the same time is difficult: a normal sheet of paper doesn't provide enough space to see both. But in paper spaces, the big picture—the structures or abstractions that give context and meaning to the details—doesn't replace the details; it is built up from them. Abstract ideas emerge by literally moving the details from one place to another, embedding them in new contexts or creating new contexts around them.

Large sheets of paper let everyone in a group see, and contribute, to a conversation at once. Participants have space to build on each other's ideas. An entire group can work at once on large paper. Groups can reorganize or annotate the notes and clusters at the same time—something that would be

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

impossible with regular pieces of paper.[17] Several people can stand in front of an eight-foot long sheet, working together to arrange stickies in new combinations and patterns. This also gives people an excuse to get up and walk around, which keeps participants more energetic and engaged, and lets people see where others (literally) stand on an issue.

Paper spaces, by allowing people to interact with maps, move ideas around, negotiate with others over how trends should be represented and contextualized, turns thinking about the future into a kind of "embodied learning"—as embodied as the future can be, at least. Putting an idea on a map may look like a simple physical act, but it marks a person's contribution to a conversation; it locates that contribution in an emerging picture of the future; and it situates that contribution alongside (or against) others'.[18] I would also draw a gentle parallel to multimodal forms of learning used in dysgraphia and dyslexia education, which often use a combination of "air writing" (drawing the letters with large motions of the arm) and speaking the letters to help fix the association between letter and phoneme in students' minds.[19]

But just as systems like del.icio.us are innovative because they make private knowledge public and shareable, workshops turn thinking about the future into a shared experience in constructing a common vision of the future. This is a type of embodied learning that goes beyond private contemplation of a text, and doesn't stop at creating knowledge by moving ideas around; while workshops build in time for private reflection, their ultimate aim is to create documents that embody the knowledge of an entire group.[20] In the course of this process, what a group learns is a bit like what a sports team learns after practice: not just formal rules for doing things, but knowledge of how to do things together.

Rooms

By providing room for attendees to write, react, and interact with each other, large sheets of paper reach across the gap between media and workspace. Facilitators can also design the physical space to blur this boundary.[21] The basic layout for a paper space is normally U-shaped or curved seating, facing a large sheet of paper. This has several virtues. Normal meeting rooms have fairly clear hierarchies: powerful people sit at the head of the table. A U-shaped or curved table, in contrast, helps decouple seating and social rank, and makes it harder for any individual to become the room's center of attention. In contrast to traditional lecture halls or classrooms, which direct students' attentions toward teachers and away from each other, a U-shaped arrangement gives all the participants clear views of each other, the facilitator, and the main board.

The ideal room also has several bare walls or picture windows, on which one can easily put up maps, papers, and other materials. Once an exercise is concluded, a facilitator moves the final product to a side wall; this makes space for the next exercise, but keeps the previous work in view, available for reference. As the day progresses, the paper space fills with roadmaps, brainstorms, small group scenarios, and other materials: a prolific group will eventually be surrounded by their own work. For a group dealing with a number of topics, in a workshop lasting a couple days, the paper space serves as a memory palace.[22]

Paper spaces thus demonstrate several of the features that Nancy Van Note Chism identified as essential to contemporary creative spaces: flexibility, comfort, sensory stimulation, de-centeredness, and technology support.[23] But paper spaces don't just keep groups focused or stimulated: a paper space is a tangible expression of the work a group has done, and the progress they have made in describing their common future. It is something that every participant can refer to, and feel some ownership over. This is especially valuable for groups that haven't worked together before, and don't already have a strong sense of common purpose. Paper spaces also can help create a

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

shared sense of identity among participants. As sociologists of science might put it, in workshops, knowledge about the future, the social context necessary to interpret it, and a collective sense of ownership of the future are all co-productions.

Finally, it isn't just the paper space, or the notes and writing, that represent the future. The process itself embodies ideas about how to approach the future. Workshops encourage groups to collaborate to create a common vision of the future, to explore and expand the meaning of ideas represented by notes, to see various ways in which the future can be mapped, and to better understand how different possible combinations of trends can yield different futures. The processes involved in using paper, and the special qualities of paper itself conspire to reinforce a vision of the future as contingent, open-ended, subject to human agency, and collectively made. The paper space, in other words, is a microcosm of the future itself: the finished space contains a vision of the future, while the processes we use to help groups generate collective visions also produces intellectual tools that will help them better respond to the future.

Paper as Space

Futures expert workshops are unusual examples of paper spaces, in that it's easy to see how room-sized sheets of paper are spaces. But that is really the only way they are unusual. All of our interactions with paper—or with printed objects more generally—have a spatial dimension that often goes overlooked.

First, the act of reading has an important, but easily-overlooked spatial dimension.[24] Readers' relationships with printed texts are generally defined by the simple fact that they are smaller than they are, and are brought within the reader's own personal space. The fact that many devoted readers have favorite chairs, or tailor their environments to facilitate reading and concentration—a space near a window in a quiet room, say—is a familiar clue to the physicality of reading. The physicality of reading is also visible in the practice of reshaping printed works. Many readers fold newspapers or maps to make them easier to hold. For others, reading is more like a martial art: Charles Darwin, for example, "had 'no respect' for books but 'merely considered them as tools to be worked on,' reading them to pieces or tearing them in half as necessary."[25] Even when spreading books out on a table or desk, reading materials are rarely further than an arm's length away: any further and they become illegible.

But reading is rarely a solitary practice focused on a single text. We treasure that image because of its scarcity, as well as for the pleasure to gives. Most reading—particularly reading that takes place while working—is a mix of visual and physical activity. Readers treat books and manuscripts as spaces in which they can construct meaning: witness the practice of marginal annotation, which is virtually as old as the book itself.[26] As Abigail Sellen and Richard Harper succinctly put it, "When we read, we work our way through a text using both our hands and our eyes."[27] Reading tends to be fragmentary and goal-oriented: knowledge workers often read across multiple texts, or simultaneously read and take notes, edit documents, or write. It's more accurate to say that reading takes place not on a page, but in spaces, as workers spread documents out on desks or tables, review documents with colleagues, or compare figures on paper with readouts on screens. Paper documents are valuable because they support such a wide variety of reading and working practices: the same object can be carried around, read alone, read with colleagues, or presented to superiors.

Other kinds of work mix reading, printed works, and physical activity even more intensively. Doctors use MRIs and X-rays as a guide to patients' bodies. Cooks move between recipes and the contents of pots and pans. Carpenters or electricians comparing blueprints or schematics to

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

buildings and wiring, infantry companies using maps to find a meeting point, and sailors using charts to sail around reefs are all using printed documents as guides to action. Indeed, the presence of printed texts signals that many kinds of work we think of as mere trades or manual labor require much more skill than we realize: fixing a motorcycle, for example, involves as much intellectual labor as physical labor, and is as much a kind of "knowledge work" as, say, data entry.[28]

All this reminds us of the simple fact that reading has a physical and physiological dimension. This is easy to overlook today, when we think of reading mainly as a disembodied interaction with "content" rather than things, but this perspective is perhaps uniquely modern: as Ann Blair and others remind us, Renaissance readers "were distinctly aware of reading as a physical activity," and saw reading as a visceral, emotional activity that involved—and could even threaten—mind, body and soul.[29] Others are beginning to explore the relationship between reading and the body in the modern world: N. Katherine Hayles, for example, argues that new media encourage readers to be cyborgs.[30] I would argue, *pace* Andy Clark and Paul Saenger, that all engagements with media—and especially the compelling experience of losing one's self in a book—have the quality of encouraging readers to meld with media and content. Reading is one of the oldest and most powerful examples of our ability to merge with technologies.[31] Recent neuroscientific research on reading has emphasized the degree to which it succeeds because of the plasticity of the brain, and the mutual influence brains and books have on each other. Stanislas Dehaene argued that "learning to read, and other forms of cultural learning, are only possible if… [the brain's] built-in flexibility can be used to divert brain circuits from their previous uses.… In effect," he contends, "we are able to learn to read because the primate visual system evolved to do a different job that was sufficiently similar to allow it to be 'recycled' into a reading machine."[32] More recently, Maryanne Wolf's *Proust and the Squid* argues that brains and books have a symbiotic relationship: the "brain's design made reading possible, and reading's design changed the brain in multiple, critical, still evolving ways."[33]

Conclusion

My purpose in this paper has been to show how facilitation and meeting technologies can support the production of group knowledge, and in particular how futurists use the special qualities of paper to their advantage. Large sheets of paper and sticky notes may seem hopelessly low-tech, but they have several advantages. They are easy to use. Paper doesn't fail unexpectedly. Everyone knows how to write. Just as important, they are excellent social technologies. They serve as a group memory, make it easier for people to collaborate on tasks, and develop a common vision of the future. Finally, they allow us to turn meeting rooms into collaborative microcosms, surrounding participants with their own ideas.

There are several larger lessons here. Information technologies have a physical and ergonomic dimension defined by the scale of their relationship to the body and group: a large board is a collaborative space, just as a small screen is a private one. Meetings and meeting spaces are themselves information technologies. Further, the success of paper spaces highlights how essential social interactions are to creative work. We are accustomed to think of communications and information technologies as unrivaled enablers of new forms of collaboration and group work. The Internet, we are told, allows groups around the world to work together in real time, access common materials and documents, and even improves the flow of ideas by removing the normal distractions of status and hierarchy. In reality, however, too many information technologies have succeeded only by sacrificing social bonds, weakening real opportunities for collaboration and ne-

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

gotiation. It is ironic that technologies that let people communicate very effectively across thousands of miles actually disrupt communication within a room.[34] But studies from fields as different as the history of the book, human-computer interaction, and neuroscience are beginning to generate insights that help futurists better understand how to think about the relationship between media, spaces, minds, and groups, and to develop the kinds of creative, collaborative spaces that support imaginative but grounded thinking about the future.

"If you are futurists, why do you still use paper in your meetings?" Clients are sometimes mystified why a profession that talks about the death of the book, the obsolescence of print media, and virtual presence still uses old-fashioned technologies like Post-Its, rolls of newsprint, and physical rooms. The concept of paper spaces answers the question by alerting us to the ergonomics and special qualities of paper spaces, their flexibility, their ability to generate formal group knowledge about the future, and their utility in generating an informal sense of group solidarity around that knowledge and the process of making it. One day, we will likely have wall-sized OLED screens that surround groups with digital notes and maps, haptic interfaces that let people move ideas around, and remote conferencing tools that give collaborators in different countries equal access to the same information spaces—in short, technologies that reproduce the special qualities and psychological impact and usability of newsprint and notes. But today, paper is still where the action is.

Notes

1. David Sibbet, "Visual Intelligence: Using the Deep Patterns of Visual Language to Build Cognitive Skills," *Theory Into Practice* 47:2 (2008), 118-127. On the history of graphic facilitation, see Christine Valenza and Jan Adkins, "Understanding Visual Thinking: The History and Future of Graphic Facilitation," *Interactions* (July-August 2009), 38-43.
2. On visual representation in science, see Pang, "Visual Representation and Post-constructivist History of Science," *Historical Studies in the Physical and Biological Sciences* 27 (1997), 139-171; Jennifer Tucker, *Nature Exposed: Photography as Eyewitness in Victorian Science* (Baltimore: Johns Hopkins University Press, 2005); Renzo Baldasso, "The Role of Visual Representation in the Scientific Revolution: A Historiographic Inquiry," *Centaurus* 48:2 (2006), 69–88. On visualization in technology, see Kathryn Harrison, *On Line and on Paper* (MIT Press, 1999).
3. The rich possibilities of working at the intersections of the history of architecture or workspaces, the history of reading, and the history of media are suggested by Jonathan Rose, "Alternative Futures for Library History," *Libraries & Culture* 38:1 (Winter 2003), 50-60.
4. On display practices and user interaction, see Andy Crabtree, Terry Hemmings and Tom Rodden, "The Social Construction of Displays: Coordinate Displays and Ecologically Distributed Networks," in Kenton O'Hara, Mark Perry, Elizabeth Churchill and Daniel Russell, *Public and Situation Displays: Social and Interactional Aspects of Shared Display Technologies* (Berlin: Springer, 2003), 170-190.
5. See for example, Elizabeth D. Mynatt, Elaine M. Huang, Stephen Voida and Blair MacIntyre, "Large displays for knowledge work," in *Public and Situation Displays*, 80-102; Elaine M. Huang, Elizabeth D. Mynatt, Daniel M. Russell and Alison E. Sue, "Secrets to success and fatal flaws: The design of large display groupware," *IEEE Computer Graphics and Applications* 26:1 (January/February 2006), 37-45.
6. Theodore Jay Gordon, "The Methods of Futures Research," *Annals of the American Academy of Political and Social Science* (special issue on The Future: Trends into the Twenty-First Century) 522 (1992), 25-35 is still a good overview of futures methods.
7. For a more general overviews of facilitation and workshops, see Jeff Conklin, *Dialogue Mapping: Building Shared Understanding of Wicked Problems* (Wiley, 2005).

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

8. On "trading zones" in knowledge-production, see Peter Galison, *Image and Logic: A Material Culture of Microphysics* (Chicago: University Of Chicago Press, 1997).
9. There is a substantial literature on the psychology and effectiveness of group versus individual brainstorming: see in particular Adrian Fumham and Tanya Yazdanpanahi, "Personality Differences and Group Versus Individual Brainstorming," *Personality and Individual Differences* 19 (1995), 73-80; Adrian Furnham, "The Brainstorming Myth," *Business Strategy Review* 11:4 (2000), 21-28; Karen Leggett Dugosh, Paul B. Paulus, "Cognitive and social comparison processes in brainstorming," *Journal of Experimental Social Psychology* 41 (2005), 313-320; Bernard Nijstad, Wofgang Stroebe and Hein Lodewijkx, "The illusion of group productivity: A reduction of failures explanation," *European Journal of Social Psychology* 36 (2006), 31-48.
10. The classic work on scenarios remains Peter Schwartz, *The Art of the Long View: Planning for the Future in an Uncertain World* (New York: Currency Doubleday, 1991); another excellent overview is James Ogilvy, *Creating Better Futures: Scenario Planning as a Tool for a Better Tomorrow* (Oxford: Oxford University Press, 2002). On cross-impact analysis, see Theodore Jay Gordon, "Cross-Impact Method," in Jerome C. Glenn (ed.), *Futures Research Methodology* (Washington, D.C.: Millennium Project Of American Council for the United Nations University, 1999).
11. Gert-Jan de Vreede, Robert O. Briggs, Ron van Duin, Bert Enserink, "Athletics in Electronic Brainstorming: Asynchronous Electronic Brainstorming in Very Large Groups," *Proceedings of the 33rd Hawaii International Conference on System Sciences* (2000), 1-11.
12. Bonnie A. Nardi and Vicki L. O'Day, *Information Ecologies: Using Technology with Heart* (Cambridge: MIT Press, 1999), esp. chapter 4.
13. Bruno Latour, "Visualization and cognition: Thinking with eyes and hands," *Knowledge & Society* 6 (1986), 1-40.
14. The material qualities of information devices can have a strong effect on the ways they are used, and the moral economies that develop around them. For example, the *Drosphila* fruit fly is cheap to feed, travels well, and breeds very quickly—qualities that made it an exceptionally valuable subject for early geneticists: see Robert Kohler, *Lords of the Fly: Drosophila Genetics and the Experimental Life* (Chicago: University of Chicago Press, 1994), esp. chaps. 4 and 5.
15. Researchers have found that when working with horizontally-oriented interactive displays, "group members switched more between roles, explored more ideas and had a greater awareness of what each other was doing"; with vertically oriented displays, however, "groups found it more difficult to collaborate around the display": Yvonne Rogers and Siân Lindley, "Collaborating around vertical and horizontal large interactive displays: which way is best?" *Interacting with Computers* 16:6 (December 2004), 1133-1152.
16. On zooming browsers, see Jef Raskin, *The Humane Interface: New Directions for Designing Interactive Systems* (Reading, MA: Addison-Wesley, 2000), esp. chap. 6.
17. In their study of NASA MERBoards, Elaine Huang *et al* note, "Large interactive displays are valuable as interactive support for exploratory tasks for which procedures are ill-defined." Paper spaces likewise serve a similar purpose in brainstorming exercises. Elaine M. Huang, Elizabeth D. Mynatt, and Jay P. Trimble, "Displays in the Wild: Understanding the Dynamics and Evolution of a Display Ecology," *Pervasive Computing* LNCS 3968 (2006), 321-336.
18. My thinking about embodied learning is influenced by Diana L. Gustafson, "Embodied Learning: The Body as an Epistemological Site," in Maralee Mayberry and Ellen Cronan Rose (eds.), *Meeting the Challenge: Innovative Feminist Pedagogies in Action* (New York: Routledge, 1999), 249-274; Jim Horn & Denise Wilburn, "The Embodiment of Learning," *Educational Philosophy and Theory* 37:5 (2005), 745-760; Margaret Somerville and Anne Lloyd, "Codified knowledge and embodied learning: the problem of safety training," *Studies in Continuing Education* 28:3 (November 2006), 279-289.
19. Alan S. Brown, "A Review of Recent Research on

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015

Spelling," *Educational Psychology Review* 2:4 (1990), 365-397.

20. On large displays and the boundaries between public and private knowledge, see Stephanie Wilson, Julia Galliers, and James Fone, "Not all sharing is equal: the impact of a large display on small group collaborative work," *CSCW'06* (November 4–8, 2006), Banff, Alberta, Canada.
21. For those outside the business world, it may seem remarkable, but facilitation is a profession. Facilitators are generally valued for their neutrality (particularly when hired to run meetings dealing with especially complex or contentious subjects), their ability to organize and manage meetings to yield results, and their craft skills (e.g., they ability to read a room, to draw out reticent participants, rein in overbearing ones, etc.). See Michael Wilkinson, *The Secrets of Facilitation: The S.M.A.R.T. Guide to Getting Results With Groups* (San Francisco: Jossey-Bass, 2004); Suzanne Ghais, *Extreme Facilitation: Guiding Groups Through Controversy and Complexity* (San Francisco: Jossey-Bass, 2005).
22. Frances Yates, *The Art of Memory* (Chicago: University of Chicago Press, 1966); Mary Carruthers, *The Book of Memory: A Study of Memory in Medieval Culture* (Cambridge: Cambridge University Press, 1990); Jonathan Spence, *The Memory Palace of Matteo Ricci* (London: Faber and Faber, 1984).
23. Nancy Van Note Chism, "Challenging Traditional Assumptions and Rethinking Learning Spaces," in Diana G. Oblinger, ed., *Learning Spaces* (EDUCAUSE, 2006), 26-27.
24. On the history of reading, see Alberto Manguel, *A History of Reading* (New York: Penguin, 1996); Steven Roger Fischer, *A History of Reading* (Reaktion: 2003); Guglielmo Cavallo, Roger Chartier, Lydia G. Cochrane, eds., *A History of Reading in the West* (Amherst: University of Massachusetts Press, 2003). On the place of the history of reading in the recent historiography of ideas see Anthony Grafton, "The History of Ideas: Precept and Practice, 1950 –2000 and Beyond," *Journal of the History of Ideas* (January 2006), 1-32.
25. Jonathan R. Topham, "A View from the Industrial Age," *Isis* 95 (2004), 431–442, quote on 433.
26. As David Livingstone puts it, "spaces of reading are always… sites of textual hybridity:" Livingstone, "Science, Text and Space: Thoughts on the Geography of Reading," *Transactions of the Institute of British Geographers* 30 (2005), 391–401, quote on 393.
27. Abigail Sellen and Richard Harper, *The Myth of the Paperless Office* (Cambridge: MIT Press, 2001), 101.
28. On labor as knowledge work, see Matthew Crawford, *Shop Class as Soulcraft: An Inquiry Into the Value of Work* (New York: Penguin, 2009);Richard Sennett, *The Craftsman* (New Haven: Yale University Press, 2009).
29. Ann Blair, "An Early Modernist's Perspective," *Isis* 95 (2004): 420-430, quote on 420; see also Michael Schoenfeldt, "Reading Bodies," in Kevin Sharpe and Steven Zwicker (eds.), *Reading, Society and Politics in Early Modern England* (Cambridge: Cambridge University Press, 2004), 215-243; David Bleich, "The Materiality of Reading," *New Literary History* 37:3 (2006), 607-629.
30. N. Katherine Hayles, "Print Is Flat, Code Is Deep: The Importance of Media-Specific Analysis," *Poetics Today* 25:1 (Spring 2004), 67-90, esp. 85-87.
31. Andy Clark, *Natural-Born Cyborgs: Minds, Technologies, and the Future of Human Intelligence* (Oxford: Oxford University Press, 2003); Paul Saenger, *Spaces Between Words* (Stanford: Stanford University Press, 1997).
32. Stanislas Dehaene, "Natural Born Readers," *New Scientist* (July 5, 2003), 30-33.
33. Maryanne Wolf, *Proust and the Squid: The Story and Science of the Reading Brain* (New York: Harper, 2007), quoted in Vikram Johri, "*Proust and the Squid* by Maryanne Wolf," *California Literary Review* (26 September 2007).
34. Attempts to develop computer-mediated group facilitation have been at best partly successful. On the challenges, see S. Pak Yoong and R. Brent Gallupe, "Coherence in face-to-face electronic meetings: A hidden factor in facilitation success," *Group Facilitation* 4 (Spring 2002), 11-20.

Downloaded from wfr.sagepub.com at SUNY BINGHAMTON on March 8, 2015