

Get **REAL**

The Need for Effective Design Research

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Designers use intuition in order to envision possibilities. In that strength also lies a weakness: a disinclination to account for what exists in reality. That prevents design from evolving into the powerful role that it could otherwise be. Learning about reality requires the tools that are necessary to perform research such as theory and methods. Research tools are essential in order to support an opinion or position, to build design solutions in technically challenging application areas, or to advance design as a leadership role instead of a support role. Better understanding and use of research would enable the designer to evolve from craft-bound artisan toward professional. This essay addresses recent influences on design practice, the opportunity for design to evolve in a professional direction and the methods that will support that evolution.

DESIGN PRACTICE

Herbert Simon (1998:4, 111–4) contends that “the engineer, and more generally the designer, is concerned with the way things ought to be—how they ought to be in order to attain goals and to function.” For Simon, the designer takes action to “change existing situations into preferred ones” by “devising artifacts to attain those goals.” The term “designer” represents the disciplines that work to create and develop new systems and products for human use. Traditionally, that includes architects and space planners, urban planners, product (industrial) designers, communication (graphic, information) designers and environmental designers. In recent decades, software interface designers and software architects and fashion and interior designers who deal with functional issues have assumed a design role.

Addressing each one of these design disciplines would result in a book, not an essay. Instead, this essay will use one discipline as an example: communication design. The role of

communication design stems from the human need to negotiate between our inner self and the outer (natural) environment. (Simon, 1996:5–6) It is a natural extension of the human need to make sense of the world. In this context, communication design is the practice of visualization in order to inform and/or persuade. The communications designer detects and demonstrates patterns, making the implicit or abstract evident. Table 1 summarizes the kinds of knowledge that comprise communication design. The examples that it contains are not intended to be exhaustive. Rather, they demonstrate the relationships among theory, knowledge and skill.

Philosophy

Philosophy informs design practice by framing views of reality and the human role in it. Semiotics, the understanding of reality through perceptions, is one of many philosophical approaches. Designers structure properties in order to send messages, using hierarchies

(taxonomies) in order to organize them into purposeful wholes.

Social Sciences

Anthropology and sociology provide theories of culture and society. Methods such as fieldwork make it possible for the designer to learn about both through observation.

Human Factors

Designers rely on human factors knowledge about human limits and abilities, primarily in visual sensation and perception and in cognition (e.g., learning, decision-making and memory). Designers can employ methods such as flow analysis to decompose, analyze and experiment with new models of complex environments.

Design

As there is no current body of knowledge that represents design theory, the theory section in the design column contains no examples. Designers use visualization as a means to embody possibilities by creating physical models.

Management

Through management, the designer leads project teams that include vendors who can be monitored through quality assurance and control methods in order to achieve optimal results. The designer also relies on management skills to develop business relationships and to compete.

As an applied artist, the designer accepts the responsibility for solutions to work, but on what basis? The norms of a discipline are developed and taught through education. Design's apprenticeship tradition relies on formal or informal mentoring programs among groups in order to "become proficient in standard techniques that involve motor-physical coordination" (Byrne and Sands 2002: unpagged). As a result, design education does not provide students with theories, methods or the tools to collect, analyze, interpret or apply data. Donald Norman (2002:41) contends that many designers and design schools cannot distinguish prettiness from usefulness and as a result practice 'facade design' to 'make things pleasant.'

Design has been assimilated into university curricula comparatively recently through a variety of routes that include art programs, architecture schools and technical colleges. This has led to the 'strange ground' of design being "anchored in a range of trades or vocations or

Communication Design Knowledge

Communication design is comprised of four knowledge areas: philosophy, human factors, design and management. The examples that are shown are not intended to be exhaustive. Rather, they demonstrate the relationships among theory, knowledge and skill. Of the four knowledge areas, only design lacks theories to drive its methods and skills. The practice of design research will be one of the factors that enables design theory to evolve by creating what (Byrne 2001: unpagged) calls “generalizable, publicly examinable forms of knowledge about design...”

	Theory	Method	Skill
Philosophy	semiotics	taxonomic development	organization
Human Factors	perception, cognition	flow analysis	experimentation
Social Sciences	culture, society	field work	observation
Design		ideation	visualization
Management	leadership	quality assurance, quality control	planning, outcome assessment

TABLE 1
Communication
Design
Knowledge

crafts” while simultaneously being a “contemporary field growing within the university” (Friedman, 2000:8). Because of this brief tenure in academia, disagreement reigns “on whether the practice of design constitutes a trade, a vocation, an art, or a discipline” (Friedman 2002a:unpaged). Evidence indicates that “scientists problem solve by analysis whereas designers problem solve by synthesis; scientists use ‘problem-focused strategies’ and designers use ‘solution focused strategies’” (Cross 2000:24). Managers and technical practitioners such as engineers rely on data to make such decisions. Designers, on the other hand, tend to use subjective judgment in order to determine success. Professional design presentations tend to describe case studies instead of objective principles that can be used in order to improve design practice. These traits have led other technical disciplines to perceive designers as creative artisans, but hardly as professionals.

The basis for communication design to add value has changed in the past twenty years. New electronic media have also popularized the skills that designers once considered their exclusive turf. Personal computers now enable any individual who has the right software to create the products of visual design. Design’s traditional claim to form giving has now become a commodity and no longer serves as the standard for success in design. Emphasis has shifted to other issues. For example, Edward Tufte (2001) sets the standard of web page success at whether the layout

has eighty percent or more content, not on its visual form.

More complex concepts such as interactive software require designers to cultivate the ability to analyze a problem, to develop a solution direction and to evaluate how well the solution solves the problem. Nemeth (2003) accounts for impediments to problem solving that all disciplines face, both as individuals (failure and lack of expertise, fixation, set and motivation, confirmation bias, availability and conjunction) and organizations (role in the project, culture, characteristics of problems, events, installed base of product and resources).

Design practice is also hemmed-in by practical constraints.

> Time is allotted according to what is cost-effective, not according to the character and scope of a problem. If there is money, research can be done. If the money is inadequate for research it is not performed, however important the questions are.

> Designers respond to client guidance.

A talented designer will challenge client conditions but will rarely run counter to them. Client guidance is subject to competitive pressures. As a result, design activity tends to be market-driven. The challenge for the conscientious designer is to perform research at a level that is appropriate to the problem, yet to still fit within client and commercial constraints.

> Designers are rewarded more for performance that is related to form and style rather than substance. This leads design attention away from significant problems, which are often complex and require a substantial amount of time and patience to understand them.

Design must change or risk being co-opted by other disciplines. How can design practice evolve into the role that new media and opportunities call for? How will communication design add value?

NEEDED CHANGE

As a practice, design can be assessed along five considerations: language, process, role, applications and tools.

Language

Those who insist that design deserves to be a peer among other professions such as medicine and law have it backwards. A discipline does not

become valued through its own practitioners' insistence. Rather, it becomes valued by others who find that it meets needs that other practices do not offer, or do not offer as well. The value of a discipline needs to be expressed in terms that others can understand. Among Howard Gardner's (1983: 60–235) seven intelligences, designers tend to rely on spatial intelligence.

However, other technical staff members tend to rely on logical-mathematical intelligence and management favors linguistic and logical-mathematical intelligences.

Design practitioners need to learn verbal and the numerical languages in order to speak the language of other professions and to demonstrate the value of design. Both design and engineering practitioners need to cultivate verbal language in order to demonstrate the meaning and use of their analyses and solutions.

Process

Each design discipline uses objective knowledge in combination with subjective intuition in order to engage and solve a problem. The amount and depth of that objective knowledge can be insufficient to understand the problem. Design's heuristic solution-based approach may be the best way to approach ill-defined problems. However, seeing what might work is not enough to form the basis for a profession. Design practice will need to cultivate an aptitude for thorough, objective inquiry as well.

Role

The separation of activities in research and development is blurred when the designer in a sole practice or small group is required to take on additional roles such as human factors/ergonomic specialist. This does not make the designer an ergonomist, any more than it makes an ergonomist who builds a mock-up a designer. What it does require is that the designer become as capable with investigation and evaluation as with visualization.

Applications

Traditionally, those who were known as graphic designers have created informational products such as books, posters, handbills, packaging and signage. They also developed insignia, logotypes and programs for organizational identity. More recently, graphic

design has become known as communication design as electronic applications including computer software user interfaces, compact disks (CD) and the Worldwide Web have opened new opportunities. Control interfaces for appliances and equipment also present opportunities. Their creation requires an understanding of user behavior and original problem solving that have previously been the province of other disciplines such as the social sciences. Designers need substantial knowledge about human performance, particularly in the realm of perception and cognition, to meet the challenge that these new media present.

Tools

A Harvard Business School (Harvard Business Review 1994:10) study found that "Despite the billions spent on research, development and marketing, the failure rate of high tech products is staggering." Among high technology products, interactive information systems have existed for decades and designers have participated in

their development. Has this design attention resulted in better systems?

Apparently not. Instead of improving work practices, many information systems that were meant to improve on manual processes have actually impoverished them. For example, McGovern and Norton (2001) contend that most web sites overlook essential considerations such as usability and legibility in a mistaken zest for freedom of content. As a further example, the United Kingdom National Health Service's Value-Added Medical Products (VAMP) is one among many information systems that have failed in recent years. Information systems are not the only instance.

There appear to be three reasons for the demise. The first reason is designers' disregard for those whom they studied, treating "the general practitioner, the user, as a judgmental, or cultural, dope." Second, designers pay only ' cursory attention to circumstances.' Human-computer interface (HCI) designers 'misconceive the user' by oversimplifying what actually occurs in the daily work environment (Heath and Luff 2000: 10–11,59). Third, the mental models and methods they use are not suited to understand the complexity and sophistication of collaborative work.

Sociologist Lucy Suchman (1987:178–89, 2001: unpagged) agrees, criticizing the traditional notion that people act in predetermined goal-directed

ways. Human behavior is far more complex, sophisticated, nuanced and fluid than designers understand. Systems that are intended for human use should reflect human sophistication and complexity. This requires models of design thought that are sophisticated and sensitive enough to understand human behavior. Other fields have already taken up this cause. For example, sociologists have recently developed workplace studies as a way to better observe and understand human behavior and to ensure that design is grounded in reality.

The transition to better design research starts with understanding what separates practice from profession and the role that research plays.

PROFESSION VERSUS TRADE

It is not unusual to hear designers and design students express a desire for their role to be considered as a profession (apparently presuming that a professional is held in higher

esteem and earns more). What makes a trade different from a profession? By contrast with Byrne and Sands' earlier definition of a trade, the learned professions such as medicine, law, business and engineering are grounded in what Donald Schön (1983:21–4, 308–25) calls “systematic fundamental knowledge, of which scientific knowledge is the prototype.” Schön considers the knowledge of a profession to be “specialized, firmly bounded, scientific, and standardized.” So, design currently falls short of Schön's definition of profession. However, Schön does offer four approaches for practitioners who are not bound in science to function at the professional level: frame analysis, repertoire building research, research on fundamental methods of inquiry and overarching theories and research on the process of reflection in action. Each offers a way to think about design thinking: an epistemology of reflective practice. For each of these four approaches, Schön contends that “reflective research requires a partnership of practitioner-researchers and researcher-practitioners.” How can design develop the researcher half of these two dyads? Design research offers a promising direction.

DESIGN RESEARCH

“Research is a systematic investigation (including development, testing and evaluation) designed to discover or contribute to a body of general knowledge” (National Institutes of Health 2002). Through inquiry the researcher seeks to learn about reality, which does not yield answers easily (Blumer 1969:22–3). Research

can be basic (a search for general principles), applied (adapting general findings to classes of problems) or clinical (related to specific cases). Most design research is clinical, because time and budget allow for little else (Friedman 2000:18).

There is no single best way to do design research. Instead, it takes a range of research approaches to learn what one needs to know about reality. For example, some rely on focus groups. Others consider ethnographic studies to be the sum of design research. Heath and Luff (2000:246) are among many authors who disagree, countering that the relationship between ethnographic studies and design ‘remains problematic’ due to significant differences between the agendas, philosophies, thought processes and methods of naturalistic researchers and of designers.

Design research methods are not design methods. Design methods are procedures that are used to assist idea generation. For example, morphological analysis is a design method that is used to combine vari-

ous options into solution possibilities. By contrast, design research is a deliberate process of inquiry in order to discover and interpret new knowledge. To conduct that inquiry the designer needs to use methods in order to collect, to interpret and to apply knowledge on human performance as well as to understand how artifacts effect performance. Design research, then, is the means to combine both design visualization and methodical inquiry throughout the concept development process.

Nemeth (2003) inventories five groups of methods that designers can use to ground their work in reality: analysis, design guidance, evaluation, self-reporting and simple experimentation.

- > Analysis methods are used to collect information on the problem as it is given in order to create a new grasp of the problem as it is understood.
- > Design Guidance methods are used to translate knowledge that was garnered during analysis in order to model existing conditions or prospective concepts.
- > Through Evaluation methods, the designer can assess circumstances that already exist or solutions that are under development. Usability assessment is a popular means to evaluate new concept simulations.

- > Questionnaires and interviews can be used to elicit qualitative responses of individuals or groups to current conditions or proposed concepts.
- > Experimentation is the infrequent but sometimes necessary practice of creating and controlling circumstances to collect specific kinds of information in order to determine cause and effect.

Figure 1 shows how design research methods can be used to investigate and evaluate in parallel with design methods. The interaction between analysis and synthesis occurs from initial analysis, through prototype development, to final solution model, to finished product, then implementation and use. As the process unfolds, new knowledge and new methods are used to develop a notion into a concept and then into an artifact. Investigation provides the basis to develop a design direction at each stage as a concept evolves. It informs design problem definition and ideation. Evaluation provides the means to determine the fit between the concept and the real

world at each stage of evolution. It informs design implementation and idea selection.

Exploration

During exploration, both the problem and its solution are unknown. Analysis methods such as Analysis of Similar Systems enable the investigator to assess how others have approached the problem. Workplace studies can be used to understand how individuals and teams have crafted the circumstances of their work environment. Exploratory usability assessment can be used to discover how subjects respond to concepts.

Definition, verification

During definition the problem is known but the solution is not. Usability assessment can be used to find out how subjects' performance is effected by using a new concept. During verification, a solution has been created but the means of production are yet to be specified. During verification, validation usability assessment can be used to collect data on subjects using pre-release versions of a product (Rubin 1994). In both stages, analysis methods such as Workload Assessment can be employed to learn how those who are using a product can handle the work that they need to accomplish.

Use of these methods opens the way to ground design work in reality. For those who already work in interdisciplinary teams that perform rigorous research, some of these steps will sound familiar.

Develop an original line of inquiry

Identify the problem and components. Define it in a broader context outside of the specific case. Choose the appropriate methods to answer pertinent questions. Qualify and explain the methods' strengths, limitations and value in the research.

Account for the work of others

Thoroughly review and analyze publications by others in design and other fields who have already done work in an area of interest. Determine what has already been accomplished and what work would break new ground.

Develop prospective solution models

Create study models in order to simulate new concepts.

The Design Research Process

The research and development process follows a pattern regardless of application area. Traditionally, designers have used visualization techniques at each stage of concept development to envision possibilities. Designers also rely on both investigation and evaluation in order to create concepts. Incorporation of both into design practice holds the promise for a number of benefits. It could improve the designer's grasp of actual problems, verify how well human subjects perform using solution concepts, and build a stronger position for design as a practice. (Source: Adapted from Nemeth, in press)

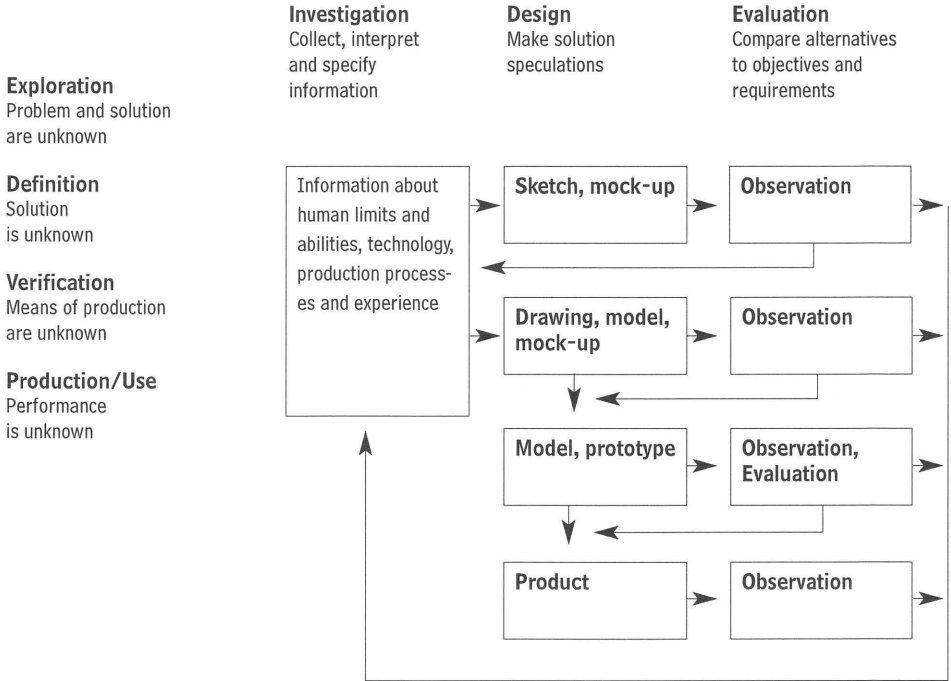


FIGURE 1
The Design
Research Process

Collect original observations and data

Observe human subjects who are performing activities that are part of the problem under study. Spend enough time and effort to understand and reliably analyze what is observed. Explore the use of early concept models with human subjects. Use more than one method such as usability assessment, activity analysis and interviews in order to understand how the subjects perceive and use the artifacts.

Analyze and interpret findings

Focus on the information that observations reveal. Spend time with the results to ensure that important aspects of what is observed are not overlooked. Extract patterns on important areas such as activity or attitudes and determine how typical they are. Relate the findings to the broader context outside of the specific case.

Assess one's own success and failure

Account for what was learned. Describe the limits of the work that was performed and what did not succeed. Identify changes that might compensate for shortcomings in the concept or in the research approach.

Serve as a critic of one's own practice

Turn a critical eye on what did and did not work and translate it into a narrative account. Reflect on what went wrong as well as right.

Publish results in a public forum for review and replication

Product concepts may be proprietary. However, methods and insights into

their use are not. Commit conclusions to paper in order to capture what did and did not meet project goals. Publishing such discussions for other designers and researchers to review expands the wisdom of the field and enables the design community to progress.

Here is an example of how a project in communication design would follow such an approach.

COMMUNICATIONS DESIGN

EXAMPLE: HEALTH CARE

The role of information in health care provides an example of the use of design research methods.

The adverse drug reaction (ADR), which is 'any undesirable effect produced by a drug,' is one of five major threats to patient safety. ADR's have a number of causes. Chief among them are physicians' inadequate knowledge of medications, care providers' incorrect provision of medications and patient non-compliance. Improved information that is organized and presented effectively at the right time may significantly reduce the potential for errors that bring about ADR's. That is because "a relatively high percentage of errors occurs at the time of drug administration..." (Sharpe and Faden, 1998:175–89).

The requirements deal with information and human performance, so the problem is squarely in the realm of communication design. The designer cannot know what information to include, who to inform or what the optimal medium or timing might be unless he or she does the research that is necessary to guide the design process.

What kind of design activity would address such a circumstance? The following actions and questions that can be answered through research suggest an effective approach.

1. Determine actual issues

Review regulatory agency standards and professional practice guidelines in order to determine the terms and information that are required. Read recent papers in journals and proceedings that deal with medications compliance and patient safety issues. Review previous reports of ADR's in which labels or product information were identified as a cause.

2. Quantify user performance using critical incident data

Develop a line of inquiry to direct research. What are the current aspects of performance related to such labels? Do technicians and users correctly understand what the labels mean? How long does it take for subjects to read and understand the information? What information needs does the label meet or fail to meet at first dosage or during subsequent use? What medication errors occur?

3. Controlled observation of users

Develop a sense of the issues from the data.

Rather than simply conduct focus groups, recruit a representative sample (in number and composition) of those who use the current labels. Observe pharmacy staff and patients in order to understand actual use issues. How do care providers select, interpret labels? How do users understand the information that is shown on the labels?

4. Create new artifacts

Research (Cheatham and Wogalter 2002:5–6) indicates that patients tend to discard over-the-counter medications packaging. Consider how staff and patients use information to make medications decisions.

Consider alternatives to printed material that could provide different kinds of related information about the medications. As some kind of label will be necessary, develop new label models that reflect the findings obtained during the previous steps. Base the new approaches on the requirements of regulatory standards, legibility and care provider and patient ability to accurately understand the information.

5. Controlled observation using new labels

Observe a representative population using the new artifacts. Conduct a usability study in order to detect errors as well as success.

6. Assess results of observation, comparison

Use the data on staff and patient performance to draw conclusions about the effectiveness of the new approach. The results that were obtained by using the new label must show improvement over the previous approach in order to justify its adoption.

7. Communicate results to key audiences

Capture the lessons learned regarding user performance using the original and proposed approaches. Convey the conclusions, substantiated by the evidence, to the project client. Convey lessons learned about the design process to others in the research and development community via professional writing.

Many applications, not just those that are technical, will benefit from this approach. In fact, for any product to be 'truly beautiful, wondrous and pleasurable' Norman (2002:42) asserts that it 'has to fulfill a useful function, work well, and be useable and understandable.'

THE FUTURE OF DESIGN RESEARCH

Work by authors such as Senge (1999: 247–50, 287–90, 328–34, 371–80, 425–34, 496–500), Conner (1992:70–8) and Kotter (1996:25–36) demonstrate that change will need to occur on more than one level for design research to evolve.

Organization

Design organizations can begin to recognize well-researched design. Design competitions can include categories for projects that demonstrate the effective use of design research.

Organizations already exist to promote effective

design research. For example, the Design Research Society, based in the United Kingdom, operates a web site <www.drs.org.uk>, a LISTSERV and monthly e-mail newsletter. It also produces the journal *Design Studies* and sponsors other research-related activities. Members are drawn from diverse backgrounds, from within and outside of the traditional areas of design.

Design can benefit from methods and theories that have been developed in other fields. Other disciplines can also benefit from design thought.

That migration of ideas relies on reading and publication in professional journals. In addition to *Design Studies*, other design-related journals provide a resource for thinking about design issues including research: *Design Issues*, *Design Journal*, *Design Methods and Theories*, *Design Science and Technology*, *the Journal of Design History*, *the Journal of Design Management*, *Korean Journal of Design Research*, *the Scandinavian Journal of Design History*, *the Journal of Design Communication*, *Visible Language and Art Design and Communication in Higher Education*.

Client

Allowing for some portion of budgets to be devoted to research would improve

the likelihood that design concepts are grounded in reality.

Design departments/offices

Including design research in proposals will demonstrate the link between reality and concept. Allowing for staff to learn new approaches will encourage research.

Practitioner

Ultimately, it is the designer who must commit to this new design role. Educational institutions that include such an approach in their design curriculum will create a community of practitioners who have the values and tools that will be needed to realize it. Byrne (2001:unpaged) acknowledges that design is rooted in reflexive and interpretive modes of discovery. "The issue, therefore, is whether future designers will ALSO [author's emphasis] be taught how to create generalizable, publicly examinable forms of knowledge about design and to use it to design."

Such initiatives would lead the way to a new future for design practice. What is the risk if such change does not occur? Clients will not allow continued information systems failures such as those that Heath and Luff (2000) describe. Other disciplines that can perform research will change to assume the design role if designers choose to abdicate it.

CONCLUSION

This essay has reviewed recent influences on design practice, indicated an opportunity for design to evolve in a professional direction and presented methods that will support that evolution.

Research will enable designers to get real, by taking account of what exists in reality. The combination of investigation and evaluation with intuitive foresight can bring about significant benefits:

- > Concepts that are well founded and actually do improve human performance.
 - > Improved rigor and validity, enabling the designer to support an opinion or position.
- > An increase in the value of design, particularly in technically challenging applications.
- > Designers performing in a leadership role instead of a support role, sharing results and reflections on practice in order to build knowledge about design among designers.

This combination of reality with intuitive ability holds the promise to build the power and impact of design practice.

Acknowledgement

The author wishes to thank Ken Friedman, Ph.D. of the Norwegian School of Management for his generous assistance in reviewing preliminary drafts of this article and providing resources and insightful comments.

References

- Blumer, H. 1969. *Symbolic Interactionism*. Berkeley, CA: University of California Press.
- Byrne, B. 2001. Will Design Research Go Beyond Non-Reflexive Modes of Inquiry? E-mail. 9 September.
- Byrne, B. and E.Sands. In press. Designing Collaborative Corporate Cultures. In Bryan, B. and S.E. Squires, editors. *Creating Breakthrough Ideas: The Collaboration of Anthropologists and Designers in the Product Development Industry*. Westport, CT: Greenwood Publishing Group.
- Cheatham, D.B. and M.S. Wogalter. 2002. Consumer Over-the-Counter (OTC) Medication Behavior: The Likelihood of Reading Labels and Packaging. Raleigh, NC: North Carolina State University, monograph.
- Conner, D. 1992. *Managing at the Speed of Change*. New York, NY: Random House/Villard Books.
- Cross, N. 2000. *Engineering Design Methods*. Chichester, UK: John Wiley & Sons.
- Friedman, K. 2000. Creating Design Knowledge: From Research Into Practice. *IDATER 2000*. Loughborough, UK: Loughborough University.
- Friedman, K. 2002a. Towards an Integrative Design Discipline. In Byrne, B. and S. Squires, editors. *Creating Breakthrough Ideas: The Collaboration of Anthropologists and Designers in the Product Development Industry*. Westport, CT: Greenwood Publishing Company.
- Friedman, K. 2002b. Notes and Comments on Your Article. E-mail. 2 March.
- Gardner, H. 1983. *Frames of Thinking: The Theory of Multiple Intelligences*. New York, NY: Basic Books.
- Harvard Business Review*. 1994. Product Development: Empathic Design Helps Understand Users Better. March/April.
- Heath, C. and Luff, P. 2000. *Technology in Action*. New York: NY: Cambridge University Press.
- Kotter, J. 1996. *Leading Change*. Boston, MA: Harvard Business School Press.
- McGovern, G. and R. Norton. 2001. *Content Critical. Gaining Competitive Advantage Through High-Quality Web Content*. London, UK: Financial Times Prentice Hall.
- National Institutes of Health. 2002. <www.nih.gov> Accessed 23 February.
- Nemeth, C. (in press). *Human Factors Methods for Design*. London, UK: Taylor and Francis.
- Norman, D. 2002. Emotion and Design. *Interactions. Association of Computing Machinery*. July–August. 36–42.
- Rubin, J. 1994. *Handbook of Usability Testing*. New York, NY: John Wiley & Sons.
- Schön, D. 1983. *The Reflective Practitioner*. New York, NY: Basic Books.
- Sharpe, V. and A. Faden. 1998. *Medical Harm*. New York, NY: Cambridge University Press.
- Senge, P. 1999. *The Dance of Change: The Challenges of Sustaining Momentum in Learning Organizations*. New York, NY: Doubleday.
- Simon, H. 1996. *The Sciences of the Artificial*. Cambridge, MA: MIT Press.
- Suchman, L. 1987. *Plans and Situated Actions*. New York, NY: Cambridge University Press.
- Suchman, L. 2001. *Human-Machine Reconsidered*. Department of Sociology. Lancaster University. <www.comp.lancs.uk/sociology/oct0401s.html> (accessed 29 December 2001).
- Tufts, E. 2001. Chicago Humanities Festival Lecture Series. The Art Institute of Chicago. Chicago. November 4.

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