Dimensions of Participation in Simon's Design

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This paper was originally presented at "Les Sciences de la Conception (Science of Design), The International Conference in Honour of Herbert Simon," organized by Jacques Perrin, and convened in Lyon on March 15–16, 2002.

1 Introduction

Herbert Simon's book *The Sciences of the Artificial* played a huge role in reinvigorating and redirecting scientific interest in design, both as an area for interdisciplinary research and as a focus for higher education, particularly in professional schools. Simon could not have anticipated every theme that would emerge in what he dramatically and optimistically called the "science of design." But it is remarkable how many touchstones he managed to fit into one small book.

In this paper, I revisit *The Sciences of the Artificial* as a means of elaborating *participatory design,* a term that refers to a large collection of attitudes and techniques predicated on the concept that the people who ultimately will use a designed artifact are entitled to have a voice in determining how the artifact is designed. Participatory design is a major, orienting position in contemporary debates about design methods.[1] In my own areas of research—human-computer interaction and computer-supported cooperative work, it has transformed thinking about the role of users in the software development process.

Simon never mentions participatory design as such in his book. However, he expresses sympathy with its central concept. In the first edition (1969), on page 75, he writes: "We have usually thought of city planning as a means whereby the planner's creative activity could build a system that would satisfy the needs of a populace. Perhaps we should think of city planning as a valuable creative activity in which many members of a community can have the opportunity of participating—if we have the wits to organize the process that way." In the second edition (1981), he added chapter 6 "Social Planning: Designing the Evolving Artifact," which includes many further statements pertinent to the concept of participatory design.[2]

My interest in this paper is to re-examine *The Sciences of the Artificial* in order to dissect several dimensions of participation. Participatory design is a high-level feature of design methods that can be implemented in a myriad of ways. It is not a single and integral design method. I consider the following dimensions: domains of human activity, roles of stakeholders in a design, types of shared design representations, the scope and duration of participatory interactions, and the relation-

1 *Computers and Democracy: A Scandinavian Challenge,* G. Bjerknes, P. Ehn, and M. Kyng, eds. (Avebury: Brookfield, 1987); J.M. Carroll, G. Chin, M.B. Rosson, and D.C. Neale, "The Development of Cooperation: Five Years of Participatory Design in the Virtual School" in *DIS'2000: Designing Interactive Systems,* D. Boyarski and W. Kellogg, eds. (August 17–19, 2000, New York, Association for Computing Machinery): 239–251; M.J. Muller, J.H. Haslwanter, and T. Dayton, "Participatory Practices in the Software Lifecycle" in *Handbook of Human-Computer Interaction,* M. Helander, T.K. Landauer & P. Prabhu, eds. (Amsterdam: Elsevier, second edition, 1997), 255–297; E. Mumford, and D. Henshall, *A Participative Approach to Computer Systems Design* (London: Associated Business Press, 1979); and *Participatory Design: Principles and Practices,* D. Schuler and A. Namioka, eds. (Hillsdale, New Jersey: Erlbaum, 1993).

2 H.A. Simon, *The Sciences of the Artificial* (Cambridge, MA: MIT Press, 1969/1981/1996 editions).

ship of users to design activity with respect to changes in their knowledge and skill. I believe these dimensions have important implications for some of the fundamental issues that have been raised regarding the effectiveness of participatory design methods.

2 Design as a Touchstone for Human Activity

In *The Sciences of the Artificial,* Simon characterizes design as central to what humans are and what they do. Humans control the natural world by creating the artificial world, that is, by designing tools and artifacts, including buildings, social institutions, and symbol systems. Simon was writing in the context of the design methods movement of the 1960s,[3] and his thinking reflects that confident view of design as a touchstone for human endeavor. However, Simon's work was distinctive in its analytic emphasis on design cognition and design education.[4] That the book was originally offered to the scholarly community as the Karl Taylor Compton lectures, that Simon subsequently won the Nobel prize in 1978, and that, ultimately, three editions were published probably also contributed to the status this book as a classic.

In the first edition, written in the late 1960s, Simon expressed his perplexity and concern that design was out of favor in professional schools, such as medical schools and engineering schools. He observed that, throughout most of the twentieth century, professional schools sought to increase their academic respectability by embracing natural science, and de-emphasizing design. Professional schools wanted to be seen as intellectually substantive within a rubric of "applied science." Design was associated with crafts, with construction work, and with merely carrying out cookbook instructions. This trivial view of design, and the conflict in values that it evoked, caused a schism between academic programs and the professions that is still widely evident. The first edition of *The Sciences of the Artificial* helped to catalyze a rethinking of the place of design in professional schools, resulting in massive curricular revision during the latter 1970s and subsequently.

It is important to understand this context in reading Simon. Much of the discussion in his book explores and proposes a substantial interdisciplinary foundation for a science of design. Simon specifically focuses on cognitive psychology, economics, social policy and planning, logic, statistics, and simulation. However, he never states that this is the full extent of the foundation he imagined. And, indeed, the foundation for his science of design became broader as he revised his work for later editions. For example, in the second edition, he added a chapter on social policy and planning.

I emphasize Simon's interdisciplinary vision of the science of design because it is possible to read *The Sciences of the Artificial* far more narrowly, as emphasizing the principle of hierarchical decomposition as a sort of panacea for managing problem complexity. The book actually ends with this as its conclusion (p. 216): "My thesis

3 J.C. Jones, *Design Methods: Seeds of Human Futures* (New York: John Wiley & Sons, 1970).

4 *Design Knowing and Learning: Cognition in Design Education,* C. Eastman, M. McCracken, and W. Newstetter, eds. (Amsterdam: Elsevier, 2001).

has been that one path to the construction of a nontrivial theory of complex systems is by way of a theory of hierarchy." (Note that, unless otherwise indicated, page numbers refer to the third edition of *The Sciences of the Artificial,* published in 1996). Throughout his career, Simon characterized hierarchy as the lynchpin of what he called the architecture of complexity. And clearly hierarchy, and hierarchical decomposition, is an elementary and pervasive technique in design, and in all complex problem solving. In the 1960s, hierarchy played a major role in orienting the "new design methods."[5] Examples include issue-based information systems,[6] structured programming,[7] systematic instruction,[8] and the software development waterfall.[9]

Since the 1970s, the risks and limitations of hierarchical decomposition have become more evident. For example, Brooks's[10] concept of emergent requirements showed that the design of complex systems always has to be iterative; that the initial decomposition is more or less always wrong. Alexander et al. showed that many important design abstractions derive from concrete patterns of use and myriad specific domain details—precisely the sorts of considerations ignored by hierarchical decomposition.[11] I have reviewed these issues elsewhere.[12] In this essay, I will regard Simon's broad vision of a science of design as the primary contribution of *The Science of the Artificial,* and his emphasis on hierarchy as merely one facet and one technique within this larger vision.

3 Social Aspects of Design

As he revised his book, Simon broadened his interdisciplinary vision of the science of design. In the second and third editions, he added a chapter entitled "Social Planning: Designing the Evolving Artifact," considering design as a social activity in several different senses. First, he discussed social plans and policies *as designs.* He considered the Marshall Plan and the U.S. Constitution as specifications for organizational designs. These designs are not mere blueprints, as are some of the key examples elsewhere in the book (clocks and houses), but starting points for living systems that grow and evolve over time— systems whose structure and consequences cannot be anticipated at the time of their design.

Expanding the scope of *The Sciences of the Artificial* to encompass the design of social systems enriched the whole analysis. Thus, in considering the design of the urban renewal plans for the City of Pittsburgh, Simon suggests we must give up the idea of designing with fixed goals (pp. 162–167). He argues that the role of design goals is to evoke and focus activity which results in the identification of further design goals—including goals that are substantially inconsistent with the starting goals. This is clearly how design often works,[13] but it is a very significant enrichment of the view that hierarchical decomposition is the key to managing complexity. Yet Simon espoused a pretty strongly non-deterministic view (p. 163): "It is ... beside the point to ask whether the later stages of the development

5 J.C. Jones, *Design Methods: Seeds of Human Futures.*

6 H. Rittel and M. Weber, "Dilemmas in a General Theory of Planning," *Policy Science* 4 (1973): 155–169.

7 E.W. Dijkstra, "Goto Statement Considered Harmful," *Communications of the ACM* 11:3 (1968): 147–148.

8 R.M. Gagne and L.J. Briggs, *Principles of Instructional Design* (New York: Holt, Rinehart and Winston, 1979).

9 W.W. Royce, "Managing the Development of Large Software Systems: Concepts and Techniques," *Proceedings of Western Electric Show and Convention, WESTCON, Los Angeles* (1970): (A/1)1–(A/1)9 (Reprinted in *Proceedings of the 11th International Conference on Software Engineering, Pittsburgh, May 1989*): 328–338.

10 F. Brooks, *The Mythical Man-Month: Essays on Software Engineering* (Reading, MA: Addison-Wesley, Anniversary Edition, 1995, originally 1975).

11 C.A. Alexander, S. Ishikawa, M. Silverstein, M. Jacobson, I. Fiksdahl-King, and S. Angel, *A Pattern Language: Towns, Buildings, Construction* (New York: Cambridge University Press, 1977).

12 J.M. Carroll, *Making Use: Scenario-Based Design of Human-Computer Interactions* (Cambridge, MA: MIT Press, 2000).

13 F. Brooks, *The Mythical Man-Month: Essays on Software Engineering.*

were consistent with the initial one—whether the original designs were realized. Each step in the implementation created a new situation; and the new situation provided a starting point for fresh design activity."

A second sense in which Simon considered design as social activity is that he emphasized the social impacts of all design, and the social responsibilities of designers. One of his examples is a design episode of a genre that has become quite popular in human-computer interaction and computer-supported cooperative work (pp. 143–144): The U.S. State Department at one point replaced teletypes with line printers specifically to alleviate bottlenecks caused by queued messages. The effects of this organizational design innovation were surprisingly negative; officers at country desks were immediately overwhelmed with the volume of communications that were now so efficiently printed for them. Bad designs often are found to have addressed spurious bottlenecks in organizations, or bottlenecks that cannot be adequately understood in isolation from other organizational structures and processes.

Simon argued that designers always must be concerned with consequences *beyond* the client's directly articulated concerns. Thus, psychiatrists must be concerned with family impacts, and engineers must be concerned with environmental impacts. Construing design problems with sufficient scope to include the likely side-effects is a challenge in all design work. Simon saw it as becoming keener in contemporary design endeavors (p. 150): "The traditional definition of the professional's role is highly compatible with bounded rationality, which is most comfortable with problems having clear-cut and limited goals. But as knowledge grows, the role of the professional comes under questioning. Developments in technology give professionals the power to produce larger and broader effects at the same time that they become clearly aware of the remote consequences of their prescriptions."

The third sense in which Simon considered social aspects of design is that he characterized design as a modern lingua franca for people. He characterized the science of design as "a core discipline for every liberally educated person" (p. 137), and claimed that design is a part of every profession, and provides a common framework for professionals to attack the modern tendency to fragment into cultures of specialization. He gives the example of a tone-deaf engineer and a mathematically ignorant composer: "I am suggesting ... that they *can* carry on ... a conversation about design, can begin to perceive the common creative activity in which they are both engaged, can begin to share their experiences of the creative, professional design process."

Simon's consideration of social aspects of design significantly broadens the vision of the science of design in *The Sciences of the Artificial.* But it raises many questions. How could the urban renewal of Pittsburgh have been organized to capitalize on the fact that there were no final goals? How could the State Department have designed a better technology enhancement for their employees? How can psychiatrists act as family counselors in designing courses of treatment? What are the consequences of the conversation about design between the engineer and the composer?

Simon's consideration of design is concerned chiefly with foundations. He is concerned with explaining what design is, with respect to ideas about science, engineering, and human nature. His point of view throughout is that of the outside analyst, not the designer. The discourse in his book takes place at a higher level than that of actual design practices or case studies. This makes the book inspirational, but also incomplete. It is useful to rearticulate many of Simon's themes at a finer level; to ask how aspects of his vision can become concrete in design practice. Participatory design is a case in point.

4 Participation in Design

Participatory design—also called cooperative design[14]—is the direct inclusion of users within a development team, such that they actively help in setting design goals and planning prototypes. It contrasts with still-standard development methods in which user input is sought only after initial concepts, visions, and prototypes exist; and is obtained through rather narrow communication channels, such as requirements interviews. Participatory design approaches were pioneered, and have been widely employed, in Europe since the 1970s, and now consist of a well-articulated and differentiated set of engineering methods in use worldwide.[15]

When Simon wrote the first edition of *The Sciences of the Artificial*, participatory design was not a developed perspective. A lot of the early work we now see as the foundation of participatory design—socio-technical design,[16] soft systems,[17] and cooperation with the labor movement[18]—was underway by the late 1960s. However, these initiatives were not coordinated and not widely recognized. Almost thirty years later, when Simon prepared the third edition,[19] participatory design was a major perspective in many design communities. There is no direct discussion of participatory design in *The Sciences of the Artificial*, but there are some clear hints of Simon's sympathies, as in the passage from the first edition quoted in section 1 above.

As he revised his book, Simon slightly elaborated his views about user participation. He writes (p. 153), "The members of an organization or a society for whom plans are made are not passive instruments, but are themselves designers who are seeking to use the system to further their own goals." In this statement, he sees the ultimate stakeholders— often called "users"—as ipso facto designers, ineluctably designing their own use of the system. Simon conceived of the relationship between the official designers and the end-user

14 M. Kyng, "Creating Contexts for Design," *Scenario-Based Design: Envisioning Work and Technology in System Development,* J.M. Carroll, ed. (New York: John Wiley & Sons, 1995), 85–107.

15 *Design at Work: Cooperative Design of Computer Systems,* J. Greenbaum and M. Kyng, eds. (Hillsdale, NJ: Erlbaum, 1991); M.J. Muller, J.H. Haslwanter, and T. Dayton, "Participatory Practices in the Software Lifecycle" in *Handbook of Human-Computer Interaction*; *Participatory Design: Principles and Practices,* D. Schuler and A. Namioka, eds.

16 E. Mumford, and D. Henshall, *A Participative Approach to Computer Systems Design.*

17 P.B. Checkland, *Systems Thinking, Systems Practice* (New York: John Wiley, 1981).

18 *Computers and Democracy: A Scandinavian Challenge,* G. Bjerknes, P. Ehn, and M. Kyng, eds.

19 H.A. Simon, *The Sciences of the Artificial.*

designers game-theoretically: designers make a move in their system design, and members of the end-user organization make a countermove in the design of their use (pp. 153–154).

This excerpt displays again Simon's tendency to see relationships in terms of the underlying logic, but not the social dynamics. Thus, game theory unavoidably tends to analyze social interactions as asynchronous transactions, indeed with rather stodgy turn taking. Simon's analysis is, of course, compatible with cooperative games in which all stakeholders in a design work towards common objectives. But it is not compatible with collaborative "games" in which the participants work together to design each move. This alternative view of social games is clearly espoused in ethnomethodological analysis of interactions.[20]

Participatory design motivates specific elaborations in the foundations of the science of design, and in curricula for educating designers. Most critically, it emphasizes that designers must deeply understand the human activity systems that will be affected by their designs. Doing this involves identifying all stakeholders in a design—every type of person that can be affected and the manner in which they can be affected. If end-users are to play a significant and continuing role in design, it is crucial to make design activity intelligible to all stakeholders. One of the most powerful tools for "designing without final goals" is to ensure that all stakeholders understand the initial design goals. The processes of participatory design are far more complex than the simple image of a designer sketching at the bench. Design work incorporates the full range of human social interactions. Perhaps the most important dynamic in design is human development: Simon emphasized the potential breadth of evolutionary change evoked by social designs, but a complementary point is how deep the consequences of design work can be for individuals. Once the engineer and the composer talk about design, neither can be the same again.

5 Understanding Human Activity

Simon's game-theoretic concept for understanding the interaction between designers and users is transactional. He countenances an active role for users in design, but *only after* the designers have made the first move. The game-theoretic view suggests the metaphor of chess openings, namely, that the initial design move is drawn from a standard body of design knowledge, and after that interesting and creative things begin to occur. Through the past two decades, conceptions of the end-user's role in design have moved from this "half-duplex" style of interaction to a fully interactive concept in which end-users are involved in the earliest planning stages and throughout. These innovations in design methods are motivated by the need to accommodate, indeed to capitalize from, the variety in human activity.

20 L. Suchman, *Plans and Situated Action: The Problem of Human-Machine Communication* (New York: Cambridge University Press, 1987); H. Sacks, E.A. Schegloff, and G. Jefferson, "The Simplest Systematics for the Organization of Turn-Taking for Conversation," *Language* 50 (1974): 696–735.

As Simon noted, people organize their activities through divisions of labor and collaborative dependencies to allow themselves to perform tasks more extensive and complex than any individual could accomplish. These social structures and processes often are spontaneous, even ad hoc. They not isomorphic with management structures, they are not readily understood without direct guidance from the participants themselves, and they determine the potential effectiveness of design interventions. In the past decade, many studies of technology innovation have documented how designers regularly misinterpret, or fail to notice, critical issues in the social organization of the activities they are trying to redesign—and the wasteful and embarrassing consequences for their designs.[21]

To effectively redesign human activities, designers need a deep understanding of these activities. School teachers do not collaborate like engineers, because the culture of teaching, the status and management of teachers, and the work objectives of teaching all are different from those of engineers. Effective designs to support teachers would be different from effective designs for engineers. Moreover, design collaborations with teachers would be different than design collaborations with engineers. Each work culture has a preunderstanding of what collaboration is like, and its own practical constraints on carrying out a collaboration.

In his city planning example, Simon noted that users relate to new designs creatively as a means to furthering their own ends, but users also frequently have the discretion to accept or reject designs according to whether they believe those designs meet their needs and expectations. This point often is made by citing the use (and nonuse) of information technology by managers: When business executives are disappointed with technology, they delegate it to underlings. Thus, PCs in the 1980s had relatively little effect on executives. However, the same pattern can be observed whenever workers have ultimate control over their use of technology. Consider school teachers. The isolation and discretion of the teacher's work environment requires that technology for classroom use be highly appropriate and reliable. Yet it generally is assumed that teachers are to be *trained* on new technologies, not asked to *define* what those technologies should be. From the teacher's standpoint, classroom technology often is itself the problem, not the solution. This culture of technology development in the schools has been singularly ineffective—film and radio in the 1920s, television in the 1950s, computer-assisted instruction in the 1980s, among others, have been notable failures.[22]

Dimensions such as collaborative workflow dependencies and worker discretion modulate the implementation of participatory design. All human activity is collaborative, but the structures and processes of each design context are somewhat unique, both with respect to design requirements and the approaches to identifying those requirements. When potential users have substantial discre-

21 G. Button, "Studies of Work in HCI" in *Toward a Multidisciplinary Science of Human-Computer Interaction*, J.M. Carroll, ed. (San Francisco: Morgan-Kaufmann, 2002); J. Blomberg, L.A. Suchman, and R. Trigg, "Reflections on a Work-Oriented Design Practice," *Human Computer Interaction* 11 (1996): 237–265.

22 D. Tyack and L. Cuban, *Tinkering Toward Utopia: A Century of Public School Reform* (Cambridge, MA: Harvard University Press, 1995); and S. Hodas, "Technology Refusal and the Organizational Culture of Schools," *Educational Policy Analysis Archives* 1:10 (September 14, 1993).

tion, and as the example of school teacher shows, discretion in this sense is not correlated with organizational power. Thus, understanding how and when to involve them is critical and unique. In particular, involving them late in the design game may concede the game.

6 Identifying All Stakeholders

In considering the relationship between client and designer, Simon emphasized that designers must consider the consequences of a design beyond what the client specifies or even cares about, and that a designer has the obligation to act as a teacher, and not merely an implementer (p. 151). He says that society always is a client in design, but that society is itself multifaceted and replete with conflicting goals and values (p. 153).

How can this work as a design method? One way is to enumerate the categories of persons who have a stake in a design. Consider the design of a community-information Web site. Many groups throughout the community have stakes: members of the local government (mayor, town supervisors, etc.), members of civic groups (church congregations, parent-teacher associations, service organizations); special groups such as children, parents, underemployed persons, and the elderly (who might have special areas of interest with respect to the total information/service space in the system); representatives of commercial organizations that want to advertise to the community; frequent (daily) community users of the information and services (who might want profiles or other support for customized views of information and functions); infrequent community users of the information and services (who might want simplified views); and system administrators (employees of the town or municipal government who maintain the core information and function).

One way to implement Simon's broadened notion of designer responsibilities and of society as a client is to adopt the concepts and methods of soft systems,[23] in which stakeholder analysis is a key step in design. This method helps to characterize important differences between different design contexts. The community information system is an example of a direct democracy implementation of participatory design. All residents are stakeholders and, in principle, all can represent their interests in design decisions. In practice, of course, some groups, such as children or minorities, may be disenfranchised, but enumerating stakeholder groups and analyzing their respective stakes at least provides a program for addressing such deficiencies.

Another interesting implementation of participatory design is representative democracy. In some design contexts, there are just too many end-users for everyone to participate directly. In such contexts, there has to be a scheme to designate representative users. In some cases,[24] these representatives may have been designated by the workers' union, though one could argue that union

23 P.B. Checkland, *Systems Thinking, Systems Practice.*

24 S. Bødker, P. Ehn, J. Kammersgaard, M. Kyng, and Y. Sundblad, "A Utopian Experience" in *Computers and Democracy: A Scandinavian Challenge,* G. Bjerknes, P. Ehn, and M. Kyng, eds. (Brookfield, VT: Avebury, 1987), 251–278.

leaders are not representative members. Union leaders often are full-time representatives, proxies who do not themselves have the same stake as those they represent. Another approach is statistical sampling, but this is also complex. Random samples of potential users may be socially incoherent collections of people who will fail to represent important synergies and bottlenecks of the activity.

7 Intelligibility of Design Representations

Meaningful user participation in design requires that the discourse constituting the design work be accessible to all stakeholders. This requirement runs directly counter to many aspects of professional culture, such as jargon and formal modeling. These are definitely issues in the design of software systems and applications: Software engineering has a strong tradition of gratuitous terminology and formalism. Indeed, software and systems engineering, as academic disciplines, still manifest the traditional flaws that Simon criticized in his first edition. Research in these areas often seeks to produce elegant mathematical structures, but is poorly integrated with real design work. But even when software engineers are effectively engaged with the task of producing good software, much of what they discuss in their design work is unintelligible to users. The design representations employed by software engineers are incomplete precisely with respect to critical non-designer concerns. Thus, software design representations focus on describing functions and control, but do not describe user performance and experience, application workflow, or the social and organization context in which systems are used. Thus, users often describe current technology and envision future systems in a language equally unintelligible to software engineers.

The non-triviality of this "gap" between the worldview of the software designer and the worldview of the potential user of the software is one of the motivations for participatory design. Bringing the two groups and two worldviews into conjunction is a step towards bridging the gap. Ideally, these encounters are like the conversation between Simon's composer and engineer. But the lingua franca of design itself needs an implementation: Designers, users, and other stakeholders need representations of software and activity intelligible to all and rich enough to represent the concerns of all.

The last decade of participatory design research has produced many proposals for such design representations. Many of these approaches essentially implement a user interface design at the earliest stage of system development: Designers can show concretely what they have in mind, rather than specifying it mathematically, and other stakeholders can react and critique what they can actually see and manipulate.[25] A slightly more abstract approach is scenario-based design in which system functionality and the experience of using that functionality are described in narrative episodes of user interaction.[26] Because all stakeholders are able to create stories of

25 *Design at Work: Cooperative Design of Computer Systems*, J. Greenbaum and M. Kyng, eds.

26 J.M. Carroll, *Making Use: Scenario-Based Design of Human-Computer Interactions.*

envisioned user experiences, scenario-based design allows non-designers to participate as creators as well as critics. Scenario-based design representations have been assimilated into a wide range of system development activities.

Simon's discussion of design representation (p. 131 f.) focuses mostly on how properties of a representation facilitate solution in the narrow sense of a single designer working at the bench. He loved the experiments on games such as number scrabble that showed the superiority of conceptually distinct, but logically identical, representations.

In the second edition, Simon's thinking about representations seems different. He suggested that *organizations* could be considered design representations (pp. 141–143), using the example of the Economic Cooperation Administration (ECA), the entity that implemented the Marshall Plan in 1948. At the outset, there were at least six distinct, and contradictory, conceptions of what this agency should do. There was considerable debate, but no obvious way to resolve the debate. Simon observes (p. 143), "What was needed was not so much a 'correct' conceptualization as one that would facilitate action rather than paralyze it. The organization of ECA, as it evolved, provided a common problem representation within which all could work." As the ECA proceeded, one of the six original concepts, based on specific aid to achieve balance of trade, prevailed, and later evolved into the Common Market. Many uses of prototypes in participatory design are compatible with this suggestion. Prototypes provide an evolving framework for exploring design options, and gradually focusing on a final solution.

Simon suggested that a key desideratum for a design representation is that it identifies limiting resources. His example is the U.S. State Department's misanalysis of printer bottlenecks. Indeed, Simon was ahead of his time in emphasizing that the key bottleneck in information systems frequently is limited human attention resources for processing information, rather than limited access to information. The representation of tradeoffs in a design space has been found to be an effective participatory design activity.[27]

He also provides an interesting, broadened perspective on the use of simulation models (pp. 144–146), suggesting that for very complex problems (such as understanding the effect of automobile emissions on the environment) it might be "preposterous," in his word, but still useful to develop simulation models. The actual numbers that are manipulated may not be credible, but the models illustrate a conceptual scheme that can provide useful guidance. Indeed, Simon emphasized that this use of models without numbers can be particularly useful in trying to structure complex problems that require coordination of many disciplines (pp. 145–146). This is an interesting proposal as to how quantitative models can make design representations more broadly intelligible.

27 J.M. Carroll, M.B. Rosson, G. Chin, and J. Koenemann, J., "Requirements Development in Scenario-Based Design," *IEEE Transactions on Software Engineering* 24:12 (1998): 1–15.

8 The Dynamics of Design

Participation in design is not a single, homogeneous activity. People can participate in a design activity by creating envisionment scenarios of what using a new sort of group-support system might be like, or what work might be like using a new sort of group-support system. They can participate by elaborating someone else's scenario. They can demonstrate a prototype user interface, play the role of user in a walkthrough of a prototype, or discuss the walkthrough demonstration of a prototype. People can collaborate for a hour, for a day, for a week, or for several years. They can see their own role in the collaboration in a variety of ways, for example, a user-participant could see him or herself as being a consultant, a user representative, the domain expert, a requirements specialist, a user interface designer, or as the lead designer.

At a deeper level of collaborative dynamics, participants can offer a variety of social support to the design process. They can provide leadership, seek support from others, negotiate meanings, compromise and facilitate compromise in cases of conflict, secure and/or share power, and reconstruct and rationalize decisions and other outcomes. The various participatory actions people take, the roles they play, and the social relationships they create and rely upon describe a space of possibilities for participatory design. One way to elaborate participatory design is to map this space, enumerating the different implementations of participatory design and the characteristics of each.[28]

An illustration of the range of interactions that comprise participatory design is the contrast among the Scandinavian UTOPIA project,[29] Muller's PICTIVE (Plastic Interface for Collaborative Technology Initiatives through Video Exploration) method,[30] Blomberg, Suchman, and Trigg's technology mediator approach,[31] and Carroll, Chin, Rosson, and Neale's case study of long-term cooperation.[32] The UTOPIA project was an important early study of participatory design of information technology. It addressed the introduction of workstation-based document processing into the print industry. The project demonstrated the feasibility and utility of articulating workplace activity and worker preferences as part of the process of technology development and deployment. Worker participation in this process was mediated by labor union representatives, and carried out in a strongly political context. The study can be seen as part of a broader social initiative to secure workers' rights to help determine the information technology of their workplace.

PICTIVE involves designers and users in joint exercises in which they propose and discuss layout and control options for user interface display objects—windows, buttons, menus—by manipulating bits of papers (photographs of display objects, Post-its, and so forth). PICTIVE sessions typically last less than an hour. The goal is to engage users and designers in a shared activity that is fun, and

28 M.J. Muller, J.H. Haslwanter, and T. Dayton, "Participatory Practices in the Software Lifecycle"; and *Participatory Design: Principles and Practices*, D. Schuler and A. Namioka, eds.

29 S. Bødker, P. Ehn, J. Kammersgaard, M. Kyng, and Y. Sundblad, "A Utopian Experience."

30 M.J. Muller, "Retrospective on a Year of Participatory Design Using the PICTIVE Technique," *Proceedings of CHI'92: Conference on Human Factors in Computing Systems* (New York: ACM, 1992), 455–462.

31 J. Blomberg, L.A. Suchman, and R. Trigg, "Reflections on a Work-Oriented Design Practice."

32 J.M. Carroll, G. Chin, M.B. Rosson, and D.C. Neale, "The Development of Cooperation: Five Years of Participatory Design in the Virtual School."

that generates a lot of design ideas and insights into how users interpret displays and controls. This method evokes Simon's observation (p. 164) that design is a pleasurable activity, and that we should think of it in part as an end in itself. Deep issues of workflow and job design generally do not arise in a PICTIVE session, but important usability problems can be identified and addressed before any software design or implementation has occurred.

Blomberg, Suchman, and Trigg developed the role of technology mediator. They were working for a company developing retrieval systems for text and image collections. They worked directly with all customer stakeholders to understand the how the workplace functioned, and later, to support and learn from the introduction of prototypes. On the other side, they collaborated with the developers to make the workplace and the work more visible to them.

In our virtual school project, my collaborators and I were the system developers, but we made a long-term commitment to work with a group of school teachers to address the chronic issues of "technology refusal." [33] In this case, participatory design became a life cycle method involving not only early design activities such as requirements analysis and scenario envisionment, but installation, adoption, and the emergence of changed workplace practices. All major project decisions throughout a period of six years were made collaboratively.

These projects and methods vary across many dimensions. At one level, it is perfectly useful to consider them all as examples of participatory design. However, it also is useful to consider the consequences of different implementations of participatory design. For example, facilitating participation as a user advocate, a brainstorm leader, a technology mediator, or as a developer committed to participation all are quite different. User advocates, as in the Utopia project, have taken a side: when users and designers disagree, they support the users. This clarity can help since everyone knows who is who. But it also can lead to the dismissal of technical insights based on their source alone. Brainstorm leaders, as in PICTIVE, probably are seen as relatively more objective, but their input to designers also will be perceived as highly optional. The exercises are good for generating good ideas and good experiences, but they deal with very low-resolution and often crude approximations of the actual design issues and decisions.

Technology mediators represent both sides to one another in the real design process; they must balance everything to remain both technically and ideologically credible to everyone. This is challenging and dangerous; the mediators are thwarted if they are rejected by any of the major stakeholders. Developers committed to participation also must balance perspectives, in this case, they must balance their role as developers with their role as facilitators of the users and other stakeholders, and of the continuing participatory interaction. This

33 S. Hodas, "Technology Refusal and the Organizational Culture of Schools."

creates tension when the developers as developers are convinced of a course of action and ready to move ahead, but as facilitators must support the users who may be unsure or opposed.

All participatory design methods address the challenge of Simon's game-theoretic image of user involvement in design. They make user involvement an ongoing process, much like the conversation between the composer and the engineer, as opposed to a transaction. But they do this in many different ways. One important focus for current research on participatory design is to better analyze the space of methods and techniques, and to understand when they are most useful and how they can be combined.

9 Human Development

Simon's vignette of the composer and the engineer suggests one of the most profound tenets of participatory design, namely, that everyone can be, and should be, a designer. Indeed, Simon's central premise in *The Sciences of the Artificial*; that humans control the natural world by creating the artificial world, by designing tools and artifacts including buildings, social institutions, and symbol systems, places design at the core of what it is to be human. This sentiment is becoming pervasive. For example, topics such as universal access to computing and end-user programming currently are prominent in the information technology landscape.

When Simon's composer and engineer discuss design, they each learn something. But we can take Simon's vision a step further. If they work together *doing design*, they may build upon their shared lingua franca, and upon their respective domain expertise to learn quite a lot about one another's worlds, and about requirements analysis, planning and problem-solving, implementation in various senses, and adoption and social change. Design can provide not merely a common topic, a shared orientation to knowledge, but an activity for engaging knowledge that makes learning and human development ineluctable.

Any implementation of participatory design is an example of how this can work. When designers and users work through a brief PICTIVE activity together, they are both changed, not merely in that instance of design, but more generally in how they can think about how their counterparts in design see, think, and react. Designers learn to see their professional activity more broadly in terms of the impacts it can have on people, and that even relatively low-level decisions are never arbitrary to the end-user. Users learn that designs are not givens, but that they consist of choices among often a wide variety of alternatives.

Broader and more sustained and participatory relationships can evoke more profound changes in the participants. In our six-year project with a group of public school teachers, we observed a series of dramatic role changes.[34] At first, the teachers were "practitioner-informants"; we observed their classroom practices and

34 J.M. Carroll, M.B. Rosson, G. Chin, and J. Koenemann, "Requirements Development in Scenario-Based Design."

we interviewed them. Subsequently, the teachers became directly and actively involved in the requirements development process as "analysts." Some two and one-half years into the project, the teachers assumed responsibility as "designers" for key aspects of the project. Finally, the teachers became "coaches" to their own colleagues within the public school system. These transitions exemplified the defining characteristics of developmental change: active resolution of manifest conflicts in one's activity, taking more responsibility, and assuming greater scope of action.[35] Each successive stage can be seen as a relatively stable organization of knowledge, skills, and attitudes that resolves the instigating conflict.

Developmental change in adults is, of course, more complex than the classic Piagetian examples, such as the development of conservation in the pre-operational child. The stages we observed are not singular competencies, but relatively complex ensembles of collaboration, social norms, tool manipulation, domain-specific goals and heuristics, problem solving, and reflection-in-action. They are social constructions achieved through enculturation, constituted by the appropriation of the artifacts and practices of a community.[36] Adult growth is not a monolithic achievement as when successive stages build upon the cognitive structures and enabled activity of prior stages, but ultimately replace those structures. It is continual elaboration. The teachers still are practitioners whose classroom practices we regularly observe, and whose classroom expertise we still interrogate. They seem to us and to themselves to be representative practitioner-informants. However, they now *also* are analysts and designers, and often coaches. Indeed, effective design coaches probably must be experienced designers, successful designers must be skilled analysts, and analysts must have attained significant domain knowledge.

An important modulation of the developmental perspective in this analysis is the need for a relativistic viewpoint with respect to the nature of knowledge and expertise. In classic developmental work, it is the child who is developing, and indeed doing so by becoming more like the adult. In contrast, our collaboration with the teachers was clearly one of mutual learning. The researchers in our group learned a vast amount about the practices, the exigencies, the values, and the politics of public schools. The teachers could present a complementary analysis of the development of *our* capacities to collaborate in the design of educational activities and technologies. Such reflexivity is inherent in any participatory design project.

10 Collaborating with Simon's Ant

I first read *The Sciences of the Artificial* in the late 1970s. I was intrigued by the idea that design could be considered a kind of problem solving; it stretched the concept of problem solving I had been taught as a graduate student in cognitive psychology. And I really liked the idea that design is not a residual category of problem

35 J. Piaget, and B. Inhelder, *The Psychology of the Child* (New York: Basic Books,1969); and L.S. Vygotsky, *Mind in Society* (Cambridge, MA: Harvard University Press, 1978).

36 L.S. Vygotsky, *Mind in Society.*

solving, not a collection of miscellaneous loose ends, but rather lies right at the core of what humans do and what they are. Through the years, many readers have had reactions like this to Simon's book.

A very vivid image for me from that first encounter was the story of the ant crossing a beach (pp. 51–52 of the third edition). In the story, the ant weaves a complex trajectory, but not because the ant itself is complex. The ant is simple. The complexity, observes Simon, is in the beach. The lesson Simon draws from the parable of the ant is that the apparent complexity of organisms, including human beings, derives largely from the complexity of the environment within which they act. I found this lesson riveting, but incomplete. How could one ever confidently identify the simple, underlying ant structures unless one could describe, and partially out of the overall description, the complex environmental structures?

In the early 1980s—I can no longer recall exactly when this was—I wrote a letter to Simon asking whether he agreed with a further conclusion regarding the ant; namely that, in order to understand the underlying structures of human cognition, one would have to describe in detail the tasks, the technology, the social conventions, and all other environmental features that contribute to human performance. It was a great thrill to me when he agreed with this point. However, in retrospect after two decades, it's a pretty obvious point. The parable of the ant, however vivid and stimulating, actually obscures the point by placing the ant on a beach, a somewhat randomly structured, and therefore arbitrarily complex, environment. A better example might be an ant navigating the corridors of an ant colony.

I am ready to suggest another elaboration of the ant: We must talk to the ant, work shoulder to shoulder with the ant, and walk a mile in the ant's shoes if we really want to understand the beach and the ant's trajectory as it crosses the beach. Much of the complexity of an organism's environment can never be gleaned from the most careful tracking of its actions in the environment. Even if the behavior pattern is augmented by the richest analysis of the environment as a structure, we still would not learn enough about the meaning of the environment to the organism. This time I can't write Simon a letter, but again I think the point is an obvious one, obscured a bit perhaps by the vivid image of the ant on the beach.

Communicating directly with actors in order to understand their experience of their environments and their needs for new designs is not simple. Designers and users live different lives, have different values, make different interpretations, and speak different languages. I am reminded of Wittgenstein's[37] remark in the *Philosophical Investigations* that, if a lion could speak, we wouldn't understand him. Collaborating with Simon's ant would be at least as difficult. Such examples bring to mind Simon's other image: the composer and the engineer sharing the contemporary lingua franca

37 L. Wittgenstein, *Philosophical Investigations*, G.E.M. Anscombe, translator (Englewood Cliffs, NJ: Prentice-Hall, Third Edition, 1999).

of design. As the space of participatory design concepts and techniques has developed and diversified through the past two decades, the chances for ants and lions of all sorts to finds ways to share their experiences and meanings have continued to improve.

Participatory design is not a single procedure or ingredient. It is a commitment regarding power and inclusion. In many cases, achieving it requires fundamentally changing our values and identities. But that is not too much to ask. In any case, our particular designs will age quickly. They are responses to the environment as it is, and the environment is always changing. Our designs will be superseded, and superseded again and again. As Simon put it (p. 163), "What we call 'final' goals are in fact criteria for choosing the initial conditions that we will leave to our successors."

We can afford to get our design outcomes wrong, since all of our outcomes will disappear anyway. But we cannot afford to be wrong about the criteria we leave to future designers. This is why *The Sciences of the Artificial* matters as much today as it did in 1969. And this is why understanding, developing, and employing participatory design is crucial to realizing the vision it illuminates. Simon suggested that humans steer their own evolution through design, and that our designs create new contexts within which we evolve (pp. 165–166). The emphasis of participatory design on variety in perspectives, representations, processes, and developmental trajectories helps to ensure that we will bequeath a rich world to our successors.