Participation and Design: An Extended View

Yoram Reich[1] *Suresh L. Konda*[2] *Ira A. Monarch*[3]
Eswaran Subrahmanian[1]
[1]**Engineering Design Research Center**
[2]**Software Engineering Institute**
[3]**Center for Design of Educational Computing**
Carnegie Mellon University, Pittsburgh, PA 15213, USA
+1 412 268 5221
yoram@cmu.edu slk@cmu.edu iam@cmu.edu sub@cmu.edu

Abstract

Participation in design is caught between two tendencies: (1) traditional design where experts hold tight to their expertise and authority and (2) participation itself taken to the extreme preventing timely decisions and thereby stalling work. This paper articulates this power/authority versus inefficiency dimension at various levels. Some implications to computer tool design as well as the new potential for participation that computer tools may provide are outlined.

Keywords

Defining Participatory Design, Methods for Participatory Design, Constraints on Participatory Design, Theories of Design.

Introduction

Participatory design has been discussed, off and on, at least since 1971 (Cross, 1972). However, the still prevalent view of the design process is that active involvement of the user is not only not required, it is to be avoided. According to this view, the argument goes, design professionals know what is best when it comes to design (Broadbent and Ward, 1969). Even, as in the case of public housing design, when participation is politically demanded, it is set up to be ineffective (so that different interest groups cancel each other out). While the traditional view has been challenged recently, especially with respect to practice in high-tech or economically powerful customers (Gardiner and Rothwell, 1985) and in certain countries (Wulz, 1986; Ward, 1987; Bodker et al., 1988; Floyd et al., 1989), it still has considerable influence. In what follows we will examine some practical and methodological assumptions, analyze them, and suggest an alternative view which proposes an increasingly expanding form of participation in design, generalizing on previous practical experiences found in the literature.[1]

In *PDC'92: Proceedings of the Participatory Design Conference*. M.J. Muller, S. Kuhn, and J.A. Meskill (Eds.). Cambridge MA US, 6-7 November 1992. Computer Professionals for Social Responsibility, P.O. Box 717, Palo Alto CA 94302-0717 US, cpsr@csli.stanford.edu.

Our View of Participation and Design

We interpret the terms design and participation broadly. Design is purposeful activity aimed at creating a product or process that changes an environment or organization. Often design is set to meet a felt but imprecise need, but sometimes, design creates needs. Design activities always have side effects necessitating further design and opening opportunities previously unforeseen. As for participation, we begin with the proposition that all people potentially affected by a design have a *prima facie* right to be involved in design decision making. In many cases this will require that the traditional asymmetry in decision making between users/customers on the one hand and designers/experts on the other be modified.

The right to participate is limited by a given participant's experience, understanding, motivation, and the pressing need to get things done. The last requires that certain negotiations, which can become very widespread and intense, have to be brought to, at least, a relative and temporary close. Moreover, participatory ideals must confront previously designed environments, institutions, policies, design codes and standards that institute an artificial and social reality that resists the implementation and dissemination of participation. In any given situation, such resistance can never be completely

[1]Quite independent of the user, there is increasing interest in the potential of concurrent or team design where upstream specialists (marketers) and downstream specialists (manufacturers, sellers, maintainers etc.) work on the design team from the start. Notice here that the new thrust is not that there is more than one design specialist; for quite some time, design teams with, say, electrical engineers, aeronautical engineers, etc. have been used. Rather, there are non design-specific specialists on the design team.

overcome, nor necessarily should it. Compromises must be made if practical effects are to be achieved and for learning to take place. Participation brings with it the need to navigate between the expansiveness and dynamism of open systems as well as the decisiveness and maintenance associated with closed systems.

A Critique of Traditional Design

In the "traditional" design situation, user needs are "thrown over the wall" to the designers whose response — the design — is then "thrown over another wall" to downstream experts (e.g., manufacturers, sellers) till it reaches the customer or the end-user. An assumption of traditional design is that active user involvement comes after the design process is over. From this point of view, a producer creates a product and the success or failure of the product in the market [2] determines the success of the design process. Users of designed products are assumed to be essentially consumers of products and have very little or no direct role in creating the products themselves or even communicating their own needs. Product realization is then used, or so it is thought, as a means to make explicit the needs that are often not articulated by the users themselves. In effect in purely capitalist societies, the manufacturer articulates user needs without necessarily involving users or creates needs users accept as their own (Galbraith, 1958).

Objectifying User Needs

In traditionally inspired design situations, from the designer's point of view, the user is, at best, reduced to a databank whence designers draw information they need in order to clarify and reconcile perceived user needs. This trend is manifest in disciplines such as human factors or ergonomics that enables "representing the user in the design process" (Harker and Eason, 1984). The best that the user can ever get is the capacity to self-design using components designed by the designer in isolation (e.g., the 'support-infill' concept in Carp, 1986).

Such situations result in the designer's demanding an objective evaluation of need as an integral part of the design process. However, is it the objective evaluation of needs (that is, the use of certain traditional social science techniques such as surveys, interviews, or questionnaires — however cleverly formulated), that provides an advantage? Or is it just the fact that consumers or users were allowed to become involved during the design process (no matter what the method) and affect the design before the product came to market (Wood and Silver, 1989; Hauser and Clausing, 1988; Bannon, 1990)?

Formulating this question is the starting point for our suggestion that extensive participatory design may be a fruitful alternative to views which underemphasize the active role of the user in the design process (Whyte, 1991). To set out our position, we raise two related issues.

Alternative Methods: Including the User

First, there are grounds to question the notion that user needs can be discovered by objective, or even certain sorts of intersubjective, inquiry.[3] In the simplest case, user needs as identified by traditional social science techniques such as surveys, interviews, etc. may be contaminated by the very formation of the questions being asked. By their very nature, such questions (or data collection techniques) do not allow for user participation in their formulations often leading to distortion of expression (Bannon, 1990). This is why we would emphasize the necessity of participatory formulation of these needs by including users early and, when feasible, throughout its life cycle(s). Moreover, in the case of sophisticated (i.e., complex) products and processes, user needs are either not known or are, at best, inchoate. In these cases, not only is user participation necessary, but also more sophisticated means are needed to support this participation. Examples are computer support for envisionment (Bodker et al., 1988), multi-party communication negotiation and clarification (Subrahmanian et al., 1991), and the various forms of prototyping with users (Floyd et al., 1989; Piela et al., 1991).

The second issue arises from viewing participation in a static manner. Even from the traditional standpoint, if one can devise alternative means to reduce the time required for information regarding the acceptability of a product, not exploring these alternatives would be irrational. Even if the product in question is successful, the total cycle time between versions (or models) based on the traditional approach will take longer and, hence, is potentially more expensive.[4] Obviously, if the

[2] Note that we do not use the term market in the strict economic sense of the term but rather in the spirit of a "market place for ideas".

[3] We take a social constructivist view of the creation of facts in the natural sciences, which we believe, applies all the more to facts determined through social scientific means. This is not to say that empirical feedback is impossible in scientific inquiry or that scientific inquiry is totally subjective. It does open the way, however, to place more emphasis on ethnographic or participatory observer methods in understanding the development and use of software (Curtis et al., 1988, Piela et al., 1991) and to what more recently has been called participatory action research (Whyte, 1991). See Konda et al. (1992) for more discussion of the social constructivist view with respect to design methodology.

[4] A different consequence of long cycle times is that even excellent products when brought to the market later than less well-designed products lose the market competition. Note however that even in such mass markets as consumer electronics, the rule of first-to-market does not guarantee success of a product. Witness the failure of Sony's Betamax technology which, *inter alia*, ignored the consumer's need for a medium which could accommodate the

product is a failure, any approach that leads to either the discovery of the failure potential or the information required to prevent the failure in the first place ought to be considered. Internalizing as much of this iterative process during design is one of the consequences of participation and, hence, could operate even in the absence of perfect markets.

The design space being explored by designers is defined by requirements derived from user needs. However, a design proposal, while possibly meeting these requirements, could raise a host of issues related to usability and other factors. That is, obtaining requirements from user needs is a cascading process. By extension, user needs evolve through the use of related or previous versions of products. Thus, any static technique will be inadequate. Modifications to the process by repeating the cycle of determining user needs imposes time delays. In short, we believe that evaluating user needs on a continual basis through the entire product life-cycle demands user participation. Hence, focusing on extracting needs from users must be changed to a dynamic ongoing activity where the central purpose is continually evolving a design on the basis of the multi-lateral participation of all relevant actors. This requires the acceptance of the legitimacy of multiple, perhaps incompatible, and certainly incommensurate perspectives, and the sympathetic adaptation of multiple perspectives to enhance or improve personal contributions — that of the designer *qua* designer and the user *qua* user.[5]

Aside from the problem of gaining knowledge of user needs is the problem of enabling all people potentially affected by a design outcome to be an effective part of the design process. Even in cases where these needs are considered and, to some extent, addressed, those affected may still become alienated if they do not believe they have been effective participants in the process (Walton and Gaffney, 1991). There is considerable evidence in other cases that user participation leads to more general acceptance of both the process itself and its consequences (Whyte and Whyte, 1988, Whyte et al., 1991, Zuboff, 1988).

Beyond the Traditional View: Multiple Perspectives

It might be thought that an ideal way for involving users in the design process is for the designers to be, for all intents and purposes, the users (for example, Frank Lloyd Wright and the two Taliesens, Wright, 1992). When the designers are the users, they understand perfectly. That is, they understand the needs of the users better than anyone else *could*. The users do not need to communicate needs to the designers because designers-as-users already know them. Since their ideas and values are the users' as well, designers are subject to no external influences and can proceed from their own, subjective ideas and values, and can be as artistic as they are personally capable.

It is this overcoming of the otherness of the users in the traditional ideal of the users-as-designers the ideal of expertise in design can also be seen. According to this ideal, not only are designers in the best position to understand the technical requirements arising in a design situation, they are also in the best position to understand the needs of users; that is what the needs of users *ought* to be. The ideal of participatory design challenges the notion of an expert understanding that can overcome the otherness of the user. This ideal of expertise is the very antithesis of the ideal of participation, since it reduces the many to the one, heterogeneity to homogeneity. It is a classic Platonic move, assuming, as it does, that perfect knowledge can be had by one consciousness transparent to itself without bias or blindness that in fact is constitutive of any single knower.

We reject this Platonic ideal of knowledge and expertise and offer an alternative. In our alternative view, knowledge is not possessed by one homogeneous consciousness, but is essentially social and maintained through being shared and contested by many different consciousnesses. Knowledge is thereby instituted in the face of many different perspectives and for this reason is always liable to undergo change, even radical change, subject to a new point of view taking hold. This conception of knowledge is not new having been expressed by Peirce (1868 and 1878, in Buchler, 1955).

The acceptance of the idea of knowledge through multiple perspectives, exerts its own pressure on increasing participation as much as feasible. That is, quite independent of the salutary effects of participation on the effectiveness and efficiency of design, one can argue for participation as a way to further the multiplicity and diversity of perspectives needed (Lyotard, 1984). Hence this is an alternative motivation for extensive participation.

The new ideal, pragmatically conceived, depends on the creation of communication channels between designers and users which can facilitate the largest feasible bandwidth — the actual bandwidth to be determined contextually and dynamically by all the participants in design. Communication is thus seen as a continuous process of perspective, conceptual, and infor-

average movie without interruption (Bermingham, 1991).

[5]We have argued in Konda et al. (1992), that increasing design effectiveness is essentially increasing the breadth and depth of a shared meaning between the designers participating in the process of the specific design situation which, appropriately contextualized and made persistent, leads to shared memory. Here we extend this notion to include not only different experts in creating this shared meaning but also a range of non-expert designers such as users, resellers, maintainers, etc. (Floyd and Kyng, 1989).

mation exchange, always requiring interpretation and translation of both designers and users who are learning, building, and evolving shared meanings of the design situation (Schrage, 1991). The designers need to learn about the users' needs, about the context in which the problem is posed and about what may be a solution that will suit users' needs and "personality;" while the users need to learn about what is possible to achieve thereby potentially modifying their needs as initially perceived. In this ideal, each participant traces, follows, influences, and is influenced by the evolution of views of the other, while all concensually determine the progress and direction of the design process.

Hence, the participatory form is predicated on the assumption that traditionally conceived power relationships between the expert (the designer) and the non-expert[6] (the user) must be altered. Our contention is that a designer acting to preserve such power will inevitably be a poorer designer than one who acts to extend participation throughout the design activity.[7,8] It is not enough for the designer as the source of design expertise to be in the position of deciding whether or not to share power with the customer, especially when this is only to prepare the latter for future design acceptance. Examples do exist in which this distorted difference in relative power is diminished. The interaction between Boeing and Rolls-Royce (Gardiner and Roy, 1985) and scientific instruments manufacturers and customers are two examples (von Hippel, 1988).

Such examples are very persuasive arguments for the viability of extended participation. However, these are still very small in number. Because participation is a positive-sum game, it requires a re-negotiation of authority structures between the parties involved in *every* design situation. The difficulties of institutionalizing extensive participation in the face of entrenched bureaucratic structures should not be underestimated but neither should they, in our opinion, serve to deter the needed changes. Such participation, and especially cross-fertilization of ideas from very different perspectives, engenders innovations (Kodama, 1990). Gardiner and Rothwell (1985) contended that good and innovative designs often emerge in situations where customers closely participate in the early design stage. Moreover, highly sophisticated innovations can come from users themselves, though usually in subsequent versions of the product[9] (von Hippel, 1988).

Potential Problems with Extending Participation

The issue of the efficiency of participatory design cannot be addressed without clarifying what is meant by efficiency. If by efficiency, we mean the rate at which the design phase is completed as opposed to the rate at which *successful* products reach the market, the case for the usefulness (as opposed to the correctness) of participation, is quite weak. However, if by efficiency we mean the rate of successful products to market, then a strong argument for participation can be made since in the long run significant inefficiencies could result from the failure to address real needs despite the short run potential for inefficiency of extensive participation. Thus the issue of the inefficiency of participation is directly circumscribed by the time-horizon one brings to the issue of design.

A similar problem arises concerning the question of whether participation will necessarily lead to better designs. The fundamental question is whether the purpose of design is to satisfy customer needs or whether design is about satisfying other constituencies such as: the design community itself, the short-term economic status of the firm in question, the patent system, etc. As long as the focus is not on the long term viability of the product, all issues of the efficiency and efficacy of participation in design are essentially moot if not irrelevant.

A more fundamental issue in participation arises when the *form* of participation is addressed. If all those potentially effected by an artifact can participate, two problems surface. The first concerns the operational limit on the number of participants that can viably interact in a particular design situation, noting that this can be different from one situation to the next. The second problem concerns whether those who "ought" to participate will in fact chose to do so when given the opportunity.

The first problem uncovers some very deep issues with respect to participation in all contexts — the most significant

[6]We hasten to add that our use of term 'non-expert' is with considerable hesitance since it is our contention that such labeling is inherently antithetical to effective participation. Furthermore, we maintain that the different participants are equally important, and therefore, must have equal legitimacy in the process of design.

[7]We note here that conferences on design participation emphasizing computer support for participation go back to 1971 (Cross, 1972). In the 1990's we are less sanguine and more skeptical about: (1) the transfer of power on design decisions — the problems surrounding participatory design are not a simple matter of a universal inverting of the power structure between, for example, designers and users; and (2) assuming the existence of sophisticated computer installations for supporting design participation in the near future. What is needed is a focus on specific design contexts, each of which exhibits its own particular problems of interpretation and translation of varying user and expert perspectives, and the honing of computer support tools in a participatory atmosphere responsive to differing design circumstances.

[8]The rudiments of a market for design services and the lack of implicit or explicit collusion amongst service providers should drive the process of increasing participation; a phenomenon we believe is exemplified by this conference itself.

[9]Note, however, that the initial product design usually circumscribes the possible scope of such innovations.

being, arguably, civil governance itself. We obviously cannot tackle this problem here, though we do wish to make one point: the existence of computers enable us to question one of the cognitive bases underlying one of the conventional answers — some form of representative participation. Insofar as representative participation addresses the issue of information volume, i.e., the difficulty in a purely practical sense to involve everyone, the solution was some form of source reduction. We do not argue with this solution in its time and place. Today, however, there are radically different technologies available which can incorporate not source reduction of information but coherent and consistent reduction of the volume of information thus generated. Our contention is that the confluence of high-speed computers, vast storage capacities, and the deeper understanding of computational linguistics permit extensive and inclusive participation while enabling the reduction of information in order to permit action to take place.

We might add here that this perspective has relevance for the second problem raised above since people may be *disinclined* to participate when the amount of information required to participate is not manageable. Our contention is that the appropriate way to resolve the issue of whether those who ought to participate will, is by collecting empirical data on people's choices when they are allowed to participate in a variety of forms and contexts. Note that it is particularly critical to investigate those who did not participate in order to discover the underlying reasons for their decision, so that new forms and support of participation can be developed.

The infusion of computational systems should give rise to generation of data not possible in computerless organizations. Such data can be widely disseminated given that the right computational and organizational support acts to loosen traditional hierarchical structures that increase opportunities for participation (Zuboff, 1988). There are risks embedded in this scenario (Zuboff, 1988). First, users may initially develop resistance to programs that question their judgment. Second, users may develop a tendency to rely on the tool rather than exercising their own judgment. Third, data containing participation records can be used to monitor and control users/designers. We argue that such risks can be minimized in the development of computational tools by involving users provided that such participation can be realized in current design situations.

This is by no means all that needs to be said about this issue. It is only meant to clear the ground for the start of discussions that go considerably beyond the confines of this paper.

Computation and Participation

There are a number of ways of looking at the relationship between computation and participation. From one point of view the relationship concerns whether and to what extent computational products are developed through participation. For example, although Winograd and Flores (1986) have correctly pointed out that system breakdowns must be graceful, such a requirement cannot be formulated and satisfied by careful anticipation and designing as Winograd and Flores contended. A formulation and its solution can be meaningful to practitioners only if it is obtained and maintained through participation. While this is an important point, the participatory view can be extended even further. Taking a wider view of participation can become tantamount to democratizing work. Thus participation in all kinds and phases of production is at issue, including tools for *supporting* participation. That is, it can be asked how the use of computational tools can increase the level of participation itself in all phases of production. Most research on participation and computation to date has focussed on the former, more narrow view. In what follows we will discuss both the narrower and wider views of participation.

Development of Tools Via Participation

The focus on work design in Scandinavian industrial democracy projects has led to participatory methodologies for building computational tools. This is well documented in the work of Floyd et al. (1989). An important aspect of this work is that it focuses on both product and process design simultaneously — the product being a computer tool and the process being the changing nature of work due to the introduction of computer tools. Two theoretical approaches to systems development are presented: a dialectical approach (Mathiassen, 1981) and an activity theory approach (Anderson et al., 1986). The former emphasizes the surfacing of contradictions by viewing the qualities of the phenomena that change. The experience gained from the generation of contradictions is translated into knowledge that can be used in creating realistic plans for development. The latter approach simultaneously considers product and process oriented activities by users and developers to establish commitments, base lines that respond flexibly to the process of development, negotiation, and adoption of multiple perspectives. This approach is intended to create a clear picture of the implications of the project on the organization and the work process.

Another important feature of the Scandinavian work is the emphasis on establishing a common understanding (through mutual learning) between users and developers. This requires that all participants, including users and developers, are operating as a team of experts: users being experts on their work processes and developers being experts on systems. Floyd et al. (1989) present different types of prototyping — exploratory, experimental and evolutionary — used in Scandinavian projects to provide a focus for participation.

Tools for Supporting Participation

The question of the need for tools for supporting participation arises due to the existence of some successes of participation projects carried out in computerless environments indicating that computers are not a prerequisite for participation (Whyte and Whyte, 1988; Whyte, 1991; Whyte et al., 1991). Our answer consists of two parts: first, extensive participation requires facilities to enable the comprehension and use of the resulting volumes of information if action is to take place; and second, that certain forms of computational support may increase the rate and type of participation.

To illustrate, if some cannot or are not willing to participate fully in all discussions, they may monitor the discussion coded through computer medium and comment on them. Their comments are a form of restricted participation but it provides input otherwise inaccessible. Another example is seen when some participants join and conclude later that their participation is too overwhelming in terms of time commitments. While they can stop participating, their original input remains accessible later. Finally, one can envision potential participants who are unable to participate due to conflicts in schedules; in this case, tools which are designed to allow for asynchronous (different-time-different-place) participation.

The participatory design process, including the participatory development of tools, is a complex process whose effectiveness may be enhanced by support from computational tools. Some evidence that computer tools can influence participation is obtained from studying the patterns of interactions different people display via electronic mail or other media systems (Sproull and Kiesler, 1991). For instance, some people that did not participate in face-to-face discussions found it easier to participate through electronic medium.

Different tools support the communication that underlies participation to various degrees. Some tools provide the basis for participants to communicate via a shared workspace (Ishii and Miyake, 1991). Other tools support the communication process by recording the structure of issues raised in the participation process (gIBIS, Conklin and Begeman, 1988). And still other tools can elicit issues from multiple participants, provide feedback and guidance, as well as perform analysis to detect discrepancies between different views (KSS0, Gaines and Shaw, 1989).

Whereas all the above tools were developed for collaboration of experts familiar with the use of computers, no such assumption about the proficiency of users with computers can be made with respect to participation in disciplines remote from computers.

Bootstrapping: A Necessary Requirement of Computer Tools for Participation

In previous sections we have discussed two seemingly distinct issues: (1) the creation of usable computers and (2) the use of computers for participation. However, once we recognize that an adequate solution to the former requires the use of the latter, and vice versa, we arrive at an approach whereby a necessary requirement for usable computational tools are tools which support participation throughout their lifecycle. These tools, in turn, also need to be developed through participation. We illustrate how this might work using our experiences in developing n-dim.

The aim of the n-dim project [Levy and the n-dim group, 1992, Subrahmanian et al., 1991] is to build a design support tool to assist designers all through the design process and continuing throughout the life-cycle of the artifact. The requirements of this support tool were developed on the basis of several empirical studies of the design process and led to the design of a computational information system that raises asynchronous communication to a new level of complexity and effectiveness. This new level of communication is built upon computational structures, such as information models, conceptual networks, and terminological structures that enable information volume reduction via natural language processing and latent semantic analysis.

In the process of developing n-dim, potential users were actively encouraged to use the system[10]. in order for us to discover more detailed requirements and uncover the effects of assumptions made in the design and implementation phases. In the process of obtaining user feedback, we serendipitously discovered that n-dim was useful in encouraging and supporting participation by a variety of people: the designers, affiliated researchers, users, and skeptics. Consequently, a brief description of n-dim follows in order to begin the task of developing computer tools which support participation in a participatory manner.

The basic information-structuring primitive in n-dim is a model which is a set of links between objects. The type of links allowed are defined by the *modeling language* used to create the model. The modeling language is merely another model, which is interpreted specially when used as a language. In order to facilitate the use of information objects in a variety of contexts (models) and to enable users to have different views of the same model, n-dim objects are stored only once. Thus only storage of links is additional overhead

[10]The primary interaction was through an issue-based model (like gIBIS, Conklin and Begeman, 88)

for multiple inclusion of objects. Furthermore, there is a distinction in n-dim between the underlying structure of a model and its visual representation which enable low overhead customization of the display. Hence, different perspectives as manifest either in different models (structures) for a given issue or as different views of the same structure are supported. Thus, in so far as the expression and reconciliation of multiple perspectives is an integral part of participation, participation itself is supported.

n-dim models can be viewed at two basic levels of abstraction: instance and language. As an instance, an n-dim model is restricted to a specific context. When many instances are found where such models are useful, a modeling language can be created. Such languages allow users to create models as starting points for others or themselves to re-use and adapt models previously found useful. The two levels of abstraction are crucial to the usability of n-dim in the sense that they allow designers to proceed in either a top-down or a bottom-up fashion. In the former, the language is defined from which individual instances of the model can be created and elaborated to use rules (see below) and other external computational agents. In the latter, a user creates models of specific situations and from these generalizes to create a modeling language.

While a modeling language defines the set of possible instances of that language, it does not necessarily define the set of *meaningful* instances. To capture semantic, as well as syntactic, information about models, additional facilities are needed. The ability to put *rules* in modeling languages provides these facilities.

n-dim also provides natural language processing and other heuristic tools to aid in the discovery of terminological patterns implicit in large text corpora. Though n-dim's notion of conceptual information modeling allows multiple classifications, the discovered patterns can act as a basis in building conceptual models. Conceptual networks of different disciplines or different paradigms in the same discipline can be articulated on this basis. Interlinking of conceptual networks can be imposed by teams of participants using n-dim to facilitate translation among the disciplines and paradigms. It is this flexibility which assists in exchanging information between those with different world views and hence different structures or models of information.

Such information structuring techniques will allow different participants on the same design team to efficiently retrieve information relevant to their current tasks and decisions, support fast introduction of new team members to on-going projects, and support the evolution of shared meaning as specified and negotiated by the participants.

Conclusions and Future Work

Starting by arguing against an objective inclusion of users in design, we arrived at an alternative approach whereby designers use strategies, similar to participatory action research (Whyte, 1991), to continually construct a social reality out of multiple perspectives that are best appreciated and understood through actual participation and feedback into practice.

From the perspective of developing computer tools, participation serves three purposes. First, it is required for developing a usable tool. Second, it is needed for testing the tool. Third, it is required for collecting data on people participating in various design scenarios, thereby gaining a better understanding on the issues involved. Furthermore, based on this view, we have provided the beginnings of a specification for computer tools to support participation.

We have also discussed the continuous tension that participatory design must face from the pole of power/authority of experts to the pole of the inefficiency in extreme participation. Two dimensions span a space of design scenarios: (1) the product type (from one-of-a-kind to mass production), and (2) the nature of participants (from a homogeneous group of experts to heterogeneous group of designers and users). In the future, we intend to map existing techniques of participation into these and potentially other dimensions thereby furthering the understanding of participatory design. We do argue, however, that extended participation is both necessary and feasible in the modern context though its forms and environments will only be discovered through actual use.

Acknowledgments

This research has been supported in part by the Engineering Design Research Center, a National Science Foundation Engineering Research Center. The views expressed here do not represent any position of the Software Engineering Institute. We thank Barbara Katzenberg and the anonymous reviewers for their comments.

References

[Anderson et al., 1986] Anderson, N. E., Kensing, F., Lassen, M., Lundin, J., Mathiassen, I., Munk-Madsen, A., and Sorgaard, P. (1986). *Professionel Systemudvikling, erfringer, muligheder og handling (Professional System Development: Experience, Possibilities, and Handling).* Teknisk Forlag, Copenhagen.

[Bermingham, 1991] Bermingham, J. A. (1991). Why product development at sony is driven by the engineering and manufacturing groups rather than marketing. Lecture given at the Graduate School of Industrial Administration, 24th September.

[Bodker et al., 1988] Bodker, S., Ehn, P., Knudsen, J. L., Kyng, M., and Madsen, K. H. (1988). Computer support for cooperative design. In *Proceedings of the Second Conference on Computer-Supported Cooperative Work (CSCW'88, Portland, Oregon).*

[Broadbent and Ward, 1969] Broadbent, G. and Ward, A., editors (1969). *Design Methods in Architecture.* Lund Humphiers, London, UK.

[Carp, 1986] Carp, J. C. (1986). Design participation: new roles, new tools. *Design Studies*, 7(3):125–132.

[Conklin and Begeman, 1988] Conklin, J. and Begeman, M. L. (1988). gIBIS: A hypertext tool for exploratory policy discussion. *ACM Transaction on Office Information Systems*, 6(4):303–331.

[Cross, 1972] Cross, N., editor (1972). *Design Participation.* Academy Editions, London, UK.

[Curtis et al., 1988] Curtis, B., Krasner, H., and Iscoe, N. (1988). Field study of the software development process for large systems. *Communications of the ACM*, 31(11):1268–1287.

[Floyd et al., 1989] Floyd, C., Mehl, W.-M., Reisin, F.-M., Schmidt, G., and Wolf, G. (1989). Out of Scandinavia: Alternative approaches to software design and system development. *Human Computer Interaction*, 4(4):253–350.

[Gaines and Shaw, 1989] Gaines, B. R. and Shaw, M. L. G. (1989). Comparing the conceptual systems of experts. In *Proceedings of The Eleventh International Joint Conference on Artificial Intelligence*, pages 633–638, Detroit, MI. Morgan Kaufmann.

[Galbraith, 1958] Galbraith, J. K. (1958). *The Affluent Society.* Houghton Mifflin, Boston, MA.

[Gardiner and Rothwell, 1985] Gardiner, P. and Rothwell, R. (1985). Tough customers: good designs. *Design Studies*, 6(1):7–17.

[Harker and Eason, 1984] Harker, S. D. P. and Eason, K. D. (1984). Representing the user in the design process. *Design Studies*, 5(2):79–85.

[Hauser and Clausing, 1988] Hauser, J. R. and Clausing, D. (1988). The house of quality. *Harvard Business Review*, May-June:63–73.

[Ishii and Miyake, 1991] Ishii, H. and Miyake, N. (1991). Toward an open shared workspace: Computer and video fusion approach of team workstation. *Communication of The ACM*, 34(12):37–50.

[Konda et al., 1992] Konda, S., Monarch, I., Sargent, P., and Subrahmanian, E. (1992). Shared memory in design: A unifying theme for research and practice. *Research in Engineering Design*, 4(1):23–42.

[Levy and the n-dim group, 1992] Levy, S. and the n-dim group (1992). An overview of n-dim. (in preparation).

[Lyotard, 1984] Lyotard, J.-F. (1984). *The Postmodern Condition: A Report on Knowledge.* University of Minnesota Press, Minneapolis, MN.

[Mathiassen, 1981] Mathiassen, I. (1981). Systems development and systems development method. Technical Report DAIMI BP-136, Aarhus University, Computer Science Department, Aarhus, Denmark.

[Peirce, 1955a] Peirce, C. S. (1955a). How to make our ideas clear (1878). In *Philosophical Writings of Peirce*, (edited by J. Buchler), New York, N.Y. Dover Publications.

[Peirce, 1955b] Peirce, C. S. (1955b). Some consequences of four incapacities (1868). In *Philosophical Writings of Peirce*, (edited by J. Buchler), New York, N.Y. Dover Publications.

[Piela et al., 1992] Piela, P., Katzenberg, B., and McKelvey, R. (1992). Integrating the user into research in engineering design systems. *Research in Engineering Design*, 3(4):211–221.

[Reich et al., 1991] Reich, Y., Coyne, R., Modi, A., Steier, D., and Subrahmanian, E. (1991). Learning in design: An EDRC (US) perspective. In Gero, J., editor, *Artificial Intelligence in Design'91, Proceedings of The First International Conference on Artificial Intelligence in Design, Edinburgh, UK*, pages 303–321, Oxford, UK. Butterworths.

[Schrage, M. 1991] Schrage, M. *Shared Minds.* Random House, New York

[Subrahmanian et al., 1992] Subrahmanian, E., Konda, S. L., Levy, S. N., Reich, Y., and Westerberg, A. W. (1992). Modeling and analysis in design. In *Proceedings of the AID'92 Workshop on Preliminary Stages of Engineering Analysis and Modeling.*

[Subrahmanian et al., 1991] Subrahmanian, E., Westerberg, W. A., and Podnar, G. (1991). Towards a shared information environment for engineering design. In Sriram, D., Logcher, R., and Hukuda, S., editors, *Computer-Aided Cooperative Product Development, MIT-JSME Workshop (Nov., 1989)*, Berlin. Springer-Verlag.

[von Hippel, 1988] von Hippel, E. (1988). *The Sources of Innovation.* Oxford University Press, New York, N.Y.

[Walton and Gaffney, 1991] Walton, R. E. and Gaffney, M. E. (1991). Participatory action research: through practice to science in social research. In Whyte, W. F., editor, *Participatory Action Research*, pages 99–126, Newburk Park, CA. Sage Publishers.

[Ward, 1989] Ward, A. (1989). Design archetypes from group processes. *Design Studies*, 8(3):157–169.

[Whyte, 1991] Whyte, W. F., editor (1991). *Participatory Action Research.* Sage Publications, Newbury Park, CA.

[Whyte et al., 1991] Whyte, W. F., Greenwood, D. J., and Lazes, P. (1991). Participatory action research: through practice to science in social research. In Whyte, W. F., editor, *Participatory Action Research*, pages 19–55, Newburk Park, CA. Sage Publishers.

[Whyte and Whyte, 1988] Whyte, W. F. and Whyte, K. K. (1988). *Making Mondragon: The Growth and Dynamics of the Worker Cooperative Complex.* ILR Press, Cornell University Press, Ithaca, N.Y.

[Winograd and Flores, 1986] Winograd, T. and Flores, F. (1986). *Understanding Computers and Cognition: A New Foundation for Design.* Albex Publishing, Norwood, N.J.

[Wood and Silver, 1989] Wood, J. and Silver, D. (1989). *Joint Application Design (trade mark).* John Wiley & Sons, New York.

[Wright, 1992] Wright, F. L. (1992). *"At Taliesin": Newspaper Columns by Frank Lloyd Wright and the Taliesin Fellowship,* compiled by Henning, R. D. Southern Illinois University Press, Carbondale, IL.

[Wulz, 1986] Wulz, F. (1986). The concept of participation. *Design Studies,* 7(3):153–162.

[Zuboff, 1988] Zuboff, S. (1988). *In the Age of the Smart Machine: The Future of Work and Power.* Basic Books, New York, N.Y.