# Seeding, Evolutionary Growth, and Reseeding: Enriching Participatory Design with Informed Participation

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**ABSTRACT**
Historically, *participatory design (PD)* has focused on system development at design time by bringing developers and users together to envision contexts of use. But despite the best efforts at design time, systems need to evolve at use time to fit new needs, account for changing tasks, and incorporate new technologies. In this paper, we argue that systems should be designed as *seeds* that are able to evolve.

The *evolutionary growth* of the seed is driven by *informed participation*, in which active users explore complex design problems and, in the process, create new information. When evolutionary growth can no longer proceed efficiently, a *reseeding* phase is required to organize, formalize, and generalize information so that it may support a new period of evolutionary growth.

Informed participation requires social changes as well as new interactive systems that provide the opportunity and resources for social debate and discussion rather than merely delivering predigested information to users. This paper presents key issues for designing new media in support of informed participation. These issues have been explored through several applications of the *DynaSites* system in contexts including collaborative design and courses-as-seeds.

**Keywords**
informed participation; seeding, evolutionary growth, reseeding; collaborative design practices; meta-design; open systems; evolving information repositories; courses-as-seeds; consumer and designer mindsets

## INTRODUCTION

Cultures are substantially defined by their media as well as their tools for thinking, working, learning, and collaborating. Much of the new media is designed to regard humans only as consumers, television being the most obvious medium promoting this mindset and behavior [Postman, 1985]. Unfortunately, a consumer mindset [Fischer, 1998] does not remain limited to television, but in many cases extends to other activities and domains in our culture.

Our research interest is in designing the social and technical infrastructures in which new forms of collaborative design can take place. For most of the design domains that we have studied over many years (ranging from urban design to graphics and software design) [Arias et al., 2000], the knowledge to understand, frame, and solve problems is not given, but is constructed and evolved during the problem-solving process [Schön, 1983]. *Informed participation* [Brown & Duguid, 2000; Brown et al., 1994] is a form of collaborative design in which participants from all walks of life—not just skilled computer professionals—transcend beyond the information given [Bruner, 1973] to incrementally acquire ownership in problems and to contribute actively to their solutions [Schuler & Namioka, 1993].

This paper addresses the ongoing enhancement and evolution of conceptual frameworks and information environments to support informed participation. We have explored this in (1) design and design environments [Fischer, 1994], as well as (2) courses-as-seeds and course information environments [dePaula et al., 2001]. *Courses-as-seeds*, an innovative approach to learning, is used in this paper as our exemplary domain.

## CONCEPTUAL FRAMEWORK

Our conceptual framework attempts to use the seeding, evolutionary growth, reseeding (SER) model to broaden the historical focus of participatory design (PD) beyond the initial design of a system. It addresses some of the challenging unresolved issues of PD by demonstrating that no real borders exist between design practice and practice of use, and that these phases are highly related if informed participation is supported.

### Seeding, Evolutionary Growth, Reseeding Model

The SER model [Fischer et al., 2001] is a descriptive and prescriptive model for large evolving information repositories. It postulates that systems that evolve over a sustained time span must continually alternate between periods of activity and unplanned evolution, and periods of deliberate (re)structuring and enhancement. The SER model is based on the observation that design problems in the real world require *open systems* that users can modify and evolve. Because design problems cannot be completely anticipated at *design time* (when the system is developed), users will inevitably discover mismatches at *use time* between their problems and the support a system provides.

The SER model encourages system designers to conceptualize their activity as *meta-design* [Fischer & Scharff, 2000], thereby aiming to support users as designers in their own right, rather than as passive consumers of systems and information. In this perspective, users are seen as knowledge workers [Drucker, 1994] who do design and solve problems, as well as designers in use [Henderson & Kyng, 1991] who modify their systems as needed to suit their purposes.

We have explored the feasibility and usefulness of the SER model in the development of domain-oriented design environments [Fischer, 1994], organizational memories [Lindstaedt, 1996], course information environments [dePaula et al., 2001], and open systems approaches [Fischer & Scharff, 2000; Raymond & Young, 2001]. The evolutions of these systems share common elements, all of which relate to sustained knowledge use and construction in support of informed participation.

**Seeding.** In the past, large and complex information systems were built as "complete" artifacts through the large efforts of a small number of people. Conversely, instead of attempting to build complete systems, the SER model advocates building seeds that can be evolved over time through the small contributions of a large number of people.

A *seed* is an initial collection of domain knowledge that is designed to evolve at use time. It is created by environment developers and future users to be as complete as possible. However, no collection of knowledge can be truly complete due to the situated and tacit nature of knowledge as well as the constant changes occurring in the environment in which the system is embedded [Suchman, 1987; Winograd & Flores, 1986]. No absolute requirements exist for the completeness, correctness, or specificity of the information in the seed. In fact, the shortcomings in these respects often provoke users to add new information to the seed.

**Evolutionary Growth.** The evolutionary growth phase is one of decentralized evolution as the seed is used and extended to do work or explore a problem. In this phase, developers are not directly involved because the focus is on problem framing and problem solving. Instead, the participants are those stakeholders who have a direct stake in the problem at hand.

During the evolutionary growth phase, the seed plays two roles simultaneously: (1) it provides resources for work (information that has been accumulated from prior use), and (2) it accumulates the products of work, as each project contributes new information to the seed. During the evolutionary growth phase, users focus on solving a specific problem and creating problem-specific information rather than on creating reusable information. As a result, the information added during this phase may not be well integrated with the rest of the information in the seed.

**Reseeding.** Reseeding is a deliberate and centralized effort to organize, formalize, and generalize information and artifacts created during the evolutionary growth phase [Shipman & McCall, 1994]. The goal of reseeding is to create an information space in which useful information can be found, reused, and extended. As in the seeding phase, developers are needed to perform substantial system and information space modifications, but users must also participate because only they can judge what information is useful and what structures will serve their work practices.

Reseeding is necessary when evolutionary growth no longer proceeds smoothly. It is an opportunity to assess the information created in the context of specific projects and activities, and to decide what should be incorporated into a new seed to support the next cycle of evolutionary growth and reseeding. For example, open source software systems [Raymond & Young, 2001] often evolve for some time by adding patches, but eventually a new major version must be created that incorporates the patches in a coherent fashion.

### Informed Participation

Informed participation attempts to address the open-ended and multidisciplinary design problems that are most pressing in our society. These problems, which typically involve a combination of social and technological issues [Greenbaum & Kyng, 1991], do not have "right" answers, and the knowledge to understand and resolve them changes rapidly, thus requiring an ongoing and evolutionary approach to problem solving.

Informed participation involves a *community of interest* [Fischer, 2001] made up of people from several backgrounds, each having a unique stake in a common problem. Participants are engaged in both learning and contributing activities. New knowledge is constructed when learning and contributing feed each other, ultimately producing a greater shared understanding than could be achieved by each of the participants individually [Resnick et al., 1991].

Informed participation shares many objectives with *participatory design* [Schuler & Namioka, 1993], which aims to involve users in the design of artifacts they will use. Our approach emphasizes *mutual learning* for sharing the unique knowledge that each participant brings to the design problem, and *evolution-based design approaches*, in which problem framing and problem solving are intertwined [Schön, 1983]. Another key emphasis of informed participation is leveraging prior and related design efforts to serve as a sources of problem-solving knowledge. Although no two problems are exactly the same, similar problems can provide valuable insights that help to understand the problem at hand. In this spirit, the outcomes and products of informed participation are seen as potentially valuable resources for future reuse and are accumulated for this purpose. Informed participation begins where traditional participatory design of an information system leaves off, and extends into the system's lifecyle as the focus of participation shifts from designing a system to using and evolving it [Fischer et al., 2001; Henderson & Kyng, 1991; Ostwald, 1996].

Informed participation is impossible in communities in which most of the members regard themselves as consumers [Fischer, 1998]. Individuals within communities must be encouraged to evolve into *power-users* [Nardi, 1993], who not only use artifacts and information, but also modify and extend them [Mackay, 1990]. Individuals (acting as designers) must acquire a new mindset—they no longer are passive receivers of knowledge, but need to be active researchers, constructors, and communicators of knowledge. Knowledge is no longer handed down from above (either from specialists in design, from managers in organizations, or from teachers in courses), but is constructed collaboratively in the context of work [Scardamalia & Bereiter, 1994].

Informed participation is based on the fundamental claim that one of the major roles of new media is to provide the opportunity and resources for social debate and discussion [Arias et al., 1999], rather than to merely provide access to predigested information. Designing systems for informed participation has several dimensions: (1) a *social* dimension of designing new social practices and processes [Dourish, 2001]; (2) a *cognitive* dimension, requiring an understanding of the interference between solving a task (or building an artifact) and documenting work so others can build upon it [Moran & Carroll, 1996]; and (3) a *technical* dimension of creating new media that allow participants to contribute new information without acquiring extensive technical skills [Fischer & Scharff, 2000].

Information environments for informed participation must support the following activities:

- *Building, Referring, Extending.* As opposed to delivering existing information to users, systems for informed participation should enable users to contribute their knowledge and expertise by extending the current state of knowledge or an idea expressed by a peer. The goal is not merely to accumulate information but to construct new knowledge collaboratively, leading to "living" information spaces [Terveen et al., 1995].
- *Formalizing, Restructuring, Reusing.* The products of each project or design session contribute to a larger accumulation of information relevant to the problem domain. The goal is not for the system to contain complete solutions to problems, but rather for it to accumulate resources that enable users to generate new ideas—to go beyond where they could have gone if they had started from scratch [Fischer & Ostwald, 2001; Shipman & Marshall, 1999].

Enabling evolution and sustaining informed participation over extended periods of time requires not only systems that are able to support communication and accumulate information, but also *a process model and mechanisms to improve and refine the accumulated information so it can inform future design tasks.*

## APPLICATION DOMAINS

To gain a deep understanding of the challenges and possibilities associated with informed participation, we have explored the concept in several application domains, including collaborative design [Arias et al., 1999] and courses-as-seeds [dePaula et al., 2001]. This section briefly discusses informed participation in urban design, and then goes into more detail about courses-as-seeds.

### Collaborative Design

To move beyond frameworks that are based solely on providing access to existing information, we have been developing the Envisionment and Discovery Collaboratory (EDC) [Arias et al., 2000]. The central theoretical vision of the EDC is to provide contextualized support for reflection-in-action [Schön, 1983] within collaborative design activities. The EDC combines an *action space*, implemented as a game-game-board on which physical objects are placed by the users and sensed by an underlying simulation, with a *reflection-space*, implemented as an open-ended information environment that holds and manages the considerable amount of information required to understand complex situations and alternate perspectives. In Figure 1 the horizontal surface is the action space and the vertical surface is the reflection space.


Figure 1: The EDC Environment

The shared physical context provided by the EDC environment helps people to articulate their knowledge and communicate with others [Dourish, 2001]. The EDC

Table 1: Comparison of Courses-as-Seeds and Traditional Courses

| Courses as finished products | Courses as seeds |
|---|---|
| Students answer problems given to them by the instructor | Participants construct knowledge about topics that are personally meaningful |
| Students interact mainly with the teacher and compete with other students for grades | Participants are a community of practice and collaborate to build shared understanding |
| Students are complete novices in the subject matter and make no contribution to other students | Course participants are knowledgeable people in their own working environments and have much to offer |
| A course is given over a period of years, more or less in the same form | A course is considered as a seed that will evolve continuously |
| Students are recipients of knowledge (the assumption is that the teacher/instructional designer has all the relevant knowledge) | Participants are not just passive recipients of knowledge, but active contributors, (i.e., they actively co-design the class curriculum) |
| From time to time the teacher/instructional designer will incorporate new ideas into the course so the course doesn't become outdated | The content of the course is enriched through the interaction of knowledgeable people, and important and relevant additions are incorporated into the course before it is taught the next time |

provides a physical representation through which users can express their views, learn other views, and coordinate these views. As an engaging forum, the EDC motivates participation and gives problem owners a voice in framing problems. As a reflective information source, it captures important information not anticipated at system design time, integrates new knowledge with existing knowledge, and aims to actively deliver information to users when they need it.

The EDC is an explicit attempt to create an open, end-user modifiable system that users are able to extend during the evolutionary growth phase of the SER model. The EDC addresses some of the shortcomings of such closed systems as SimCity [Maxis, 2000], in which the functionality is fixed at design time. For example, the only way to reduce crime in a simulated city is to add more police stations because that was the only alternative conceived by the system designers. Other solutions, such as increasing social services, cannot be explored. As a result, closed systems such as SimCity may be good tools for education or entertainment, but they are inadequate for actual planning tasks, as our empirical investigations have clearly demonstrated [Arias et al., 2000].

Simulations within the EDC are modified by using Visual AgenTalk (VAT) [Repenning et al., 2000], a graphical end-user programming language. VAT enables EDC users to create new simulation objects and modify behaviors of existing objects, thus supporting evolution of the EDC seed to enable exploration of issues not anticipated during system seeding.

### Courses-as-Seeds

*Courses-as-seeds* [dePaula et al., 2001] is an educational model that explores informed participation in the context of university courses. The goal is to create a culture of informed participation that is situated in the context of university courses and yet extends beyond the temporal boundaries of semester-based classes. Courses are conceptualized as seeds, rather than as finished products, and students are viewed as informed participants who play an active role in defining the problems they investigate [Rogoff et al., 1998]. The output of each course contributes to an evolving information space that is collaboratively designed by all course participants, past and present.

Central to the courses-as-seeds model is the use of an information environment that enables each offering of the course to build upon the products of prior classes, as well as serving as a forum for class discussions and a workspace for projects. Evolutionary growth is driven by discussions and by projects that explore a problem or issue from a new perspective, ideally building upon the work of a prior project or class. The results of these activities are captured in the information environment.

Reseeding is an opportunity to reflect upon the learning that has occurred in the past semester and to set the initial course for the next semester. The work products from the semester are integrated with those of prior semesters to form foundation for the next semester. New system functionalities may be implemented in response to requirements exposed in the past semester.

The role of technology in the courses-as-seeds model is to form and sustain active design communities [Wenger, 1998] in which participants contribute ideas from their own unique perspectives and connect them with ideas of their peers as well as with the work of prior courses. From this perspective, mere *access* to existing information and knowledge (e.g., seeing courses as finished products, either in the classroom or on the Web) is a very limiting concept that at worst leads to "consumer" cultures [Fischer, 1998]. Table 1 compares the courses-as-seeds model with traditional courses and identifies the main characteristics of the approaches.

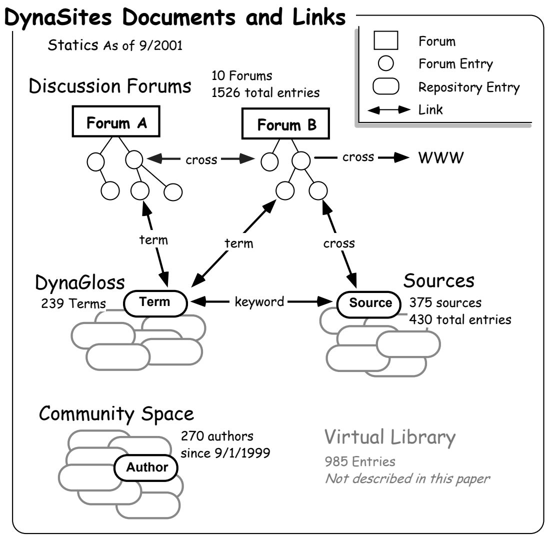


Figure 2: DynaSites Information Architecture

## DYNASITES: SUPPORT FOR INFORMED PARTICIPATION

DynaSites [Ostwald, 2001] is an environment for creating and evolving Web-based information repositories in support of collaborative working, learning, and design. Information spaces created with DynaSites offer the following promises and opportunities for informed participation:

- They are owned by the people and communities who use them to do their work, not by specialists, management, or teachers [Fischer & Ostwald, 2001].
- They are open and evolvable systems, serving not only as repositories of information, but also as *living* mediums of communication and innovation [Terveen et al., 1995].
- They evolve through small contributions made by many people rather than large contributions made by few people [Fischer et al., 2001; Raymond & Young, 2001].

We have used DynaSites to explore the implications of informed participation and the SER model in the application domains described above. DynaSites served as the reflection space for the EDC environment as well as a course information environment within the courses-as-seeds model. This section first describes the DynaSites system and then the use of DynaSites in the courses-as-seeds domain.

### DynaSites Architecture

The DynaSites system houses many individual information spaces, called *documents,* each of which are extensible. Some documents are owned by a particular community, such as a university course or a research project, whereas others are shared, meaning they can be accessed and extended by all DynaSites users. DynaSites documents are influenced by the concept of *threaded discussion forums* [LaLiberte, 1995], which have proven to be successful in mediating communication among communities of users. Threaded discussion forums are typically stand-alone information spaces; in contrast, however, DynaSites documents exist in a larger environment consisting of other community-owned documents as well as shared documents, each of which manages a specific type of information (Figure 2). The shared documents enable awareness of ideas and people across individual documents and thereby across the communities that own the documents.

The shared documents include:

- *Sources*, a shared repository for literature references. Each entry can be rated by users and is associated with its own discussion thread for comments and annotations.
- The *Community Space*, a repository of persona pages that hold information about DynaSites users. Persona pages are designed by users and contain information they wish to share.
- *DynaGloss*, a shared and extensible glossary of terminology. Each term can be annotated or redefined by any user.

The goal of DynaSites is to improve its information space over time by integrating the individual documents to form gateways to new ideas and new people. The documents in DynaSites are integrated by several linking strategies (Figure 2):

- *Term links* connect terms defined in DynaGloss with the entries throughout DynaSites in which the term appears. Term links are *automatically* created when a defined term occurs in the body of an entry.
- *Keyword links* connect keywords assigned by users to Sources entries with the corresponding definitions in DynaGloss.
- *Cross links* are manually created by users to connect any two entries in DynaSites, or to connect an entry to an arbitrary URL on the Web.
- *Author links* (not shown in Figure 2) connect all entries in DynaSites to the persona pages of their authors.

Although most of the links are automatically created and updated by the system, information must first be represented formally—in a manner that the system can interpret. For example, terms must be spelled identically to be automatically linked to corresponding glossary entries. Together, these linking strategies aim to create a rich web of information that connects ideas, people, and literature references. To provide an illustration of how DynaSites supports the SER model in the context of courses-as-seeds, we next describe our experiences with several courses conducted by the authors at the University of Colorado (course information is available at: http://www.cs.colorado.edu/~gerhard/courses/).

### Supporting Courses-as-Seeds

DynaSites has been used to support several different courses taught at the University of Colorado at Boulder (for details, see [Ostwald, 2001]), most recently in a course entitled *Designing the Information Society of the New Millennium*, Spring 2000. The goal of this course was to allow participants to explore how new media will impact learning, designing, and collaboration in the information society of the new millennium.

Course activities consisted of readings, discussions, independent research, and a semester-long project. These activities were carried out within DynaSites. For example, participants were given questions for each reading and asked to post their responses in DynaSites prior to the classes in which that reading would be discussed. Projects also used DynaSites to coordinate, communicate, and store their products.

At the end of the semester, the course information space contained 362 entries. Analysis of the contents (for details, see [dePaula et al., 2001]) revealed the following characteristics that limit its usefulness and usability for future participants:

- The responses to reading assignments often contained interesting insights but the entries were almost invariably named with a default title (e.g., "Re: Assignment 7"). This practice resulted in discussion threads consisting of up to 25 entries with identical names. This structure offers no indication of the contents of the entries and thereby virtually eliminates any chance that the interesting insights will be found by future participants;
- Related entries in different parts of the information space were only rarely linked together using the cross-linking functions provided by the DynaSites system. For example, the information from group projects were not linked to discussions of related reading assignments. In this sense, the information space fails to reflect the development of key ideas throughout the course;
- Literature references, URLs and key terminology—items that might have been formally represented in one of DynaSite's special-purpose shared documents—were instead embedded within discussion entries as plain text where they are invisible to the system's linking mechanisms and therefore less likely to be found by future participants.

In summary, the content and structure of the information accumulated during the semester was meaningful to the course participants but not to people who did not participate in its creation.

## ASSESSMENT

### Reseeding techniques and Issues

The information space characteristics described above illustrate that information generated during informed participation is specific to the contexts in which is it created, and therefore it may not be meaningful or useful in different contexts. For example, information structures that were created to store responses to reading assignments were naturally organized by assignment and by participant. Future users, however, are not likely to be interested in the assignment, per se, but rather in the entries that express a valuable point of view. The challenge for reseeding is to impose a more general structure on the information—one that makes sense to those who did not participate in its creation, and that brings related pieces of information together to increase coherence and provide new opportunities for extensions.

It is important to recognize that any reseeding operation has the potential to change the original meaning of information. For example, restructuring information can destroy the original context that contributed to the meaning of individual entries. Reseeding operations that destroy original information can also be seen as unfair to the creators of the information, especially if the creators do not participate in the reseeding process. Reseeding should therefore strive to create new information structures that provide access to the original information without actually modifying it.

For example, the cross linking mechanism in DynaSites can be used to create an annotated index of information about a particular topic. Such an index consolidates information that was previously scattered throughout the information space and provides a useful new structure without affecting the original information. Although DynaSites provides a mechanism to create cross links, its textual interface makes this process cumbersome. Systems aiming to promote graphical operations such as restructuring and cross-linking must offer better support for visualizing and manipulating structures.

Because a major goal of informed participation is to empower stakeholders to have as much control and ownership over their design process as possible, they should be involved in reseeding processes. We have not thus far engaged course participants in reseeding activities because a semester is barely enough time to get participants used to the courses-as-seeds model. An alternate view of reseeding, however, is as a way to *begin* the semester. In this approach, participants are introduced to the courses-as-seeds model by examining the products created by prior courses and collaboratively creating information structures that will be extended during the semester.

We are also exploring how to motivate participants to exercise more discipline when adding information to the seed. Performing tasks such as formalization and integration at use time is another way for participants to assume control and ownership over their design process, but this requires extra work which may not be seen as part of the original task, especially within the traditional culture of education. For example, students are often not motivated even to choose descriptive titles for their reading assignment responses, and instead accept the default title supplied by the system. People are naturally hesitant to adopt and learn yet another information technology such as DynaSites or to do additional work from which they may not personally benefit [Grudin, 1994]. To engage users in reseeding activities at use time, the efforts required must be lowered (e.g., through improved tools), and the perceived benefits of performing the extra work, raised.

### Toward a Culture of Informed Participation

Our initial experiences with the courses-as-seeds model have shown that technology alone will not bring about informed participation in the classroom. The courses-as-seeds model is grounded in educational theory [Rogoff et al., 1998] that challenges the established power relationships in a course. The instructor is more a meta-designer or facilitator who creates affordances for students to engage in informed participation. It is obvious that such fundamental changes will transcend the power of any technology. Although we believe that new technologies will be necessary to effectively support courses-as-seeds, they will definitely not be sufficient.

In a culture of informed participation, knowledge workers will see providing additional information as part of their work rather than as an extra task. A first step in this direction is to identify and encourage members of the community who are interested and inclined to become *power-users* [Nardi, 1993]. These users are more willing to learn new mechanisms and can assume a leadership role within the community, helping others to see a benefit in formalizing and perhaps even helping them to learn how. The emergence of such roles is another indication of community formation and should be considered as an essential aspect of informed participation.

## CONCLUSION

The core concern of informed participation is to understand how collaborative design processes can be based on participation of the people affected by the decisions reached, the artifacts built, and the technology designed. The application domains (collaborative design and courses-as-seeds) in which we have explored informed participation are design domains. Collaborative problem solving and decision making in these domains requires that a variety of stakeholders with different background knowledge and interests be brought together.

Informed participation (and its conceptual embedding into the SER model) represents a framework for participatory design that is concerned with:

- the collaborative interactions that take place during the *use and evolution* of a system rather than just the original design and development of the system, and
- *sustaining* the usefulness and usability of technology in use over extended periods of time.

Our experience with the courses-as-seeds model highlights the relationship between these two concerns. Informed participation produces new knowledge that could not be anticipated at design time, but rather can only be produced at use time in the context of solving real problems. Although informed participation is the driving force for evolutionary growth, a complementary participatory design process that aims to integrate new information (and potentially to enhance system functionality) is required for sustainability.

From the perspective of the SER model,

- *participatory design* in the past was mostly concerned with the seeding phase and a focus on the collaboration between user and developer, although attention has been paid recently to the transition from seeding to evolutionary growth (i.e., use practices);
- *informed participation* was originally mostly concerned with evolutionary growth (i.e., collaborative design among a community of interest), but recently we have been paying more attention to reseeding (e.g., sustaining informed participation through ongoing cycles of evolutionary growth and reseeding) and to collaborative interactions between end-users, power-users, and developers.

By supporting informed participation effectively, we address one of the fundamental challenges for participatory design and human-computer interaction research: to invent and design a culture in which all participants in collaborative design processes can express themselves and engage in personally meaningful activities. Our work has addressed some of the fundamental questions of PD such as “Where does the design practice end, and the practice of use begin?” The SER model provides a conceptual framework that demonstrates that informed participation can enrich our understanding and practice of participatory design to support all aspects of collaborative design.

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