End-User Development and Meta-Design: Foundations for Cultures of Participation

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Abstract

The first decade of the World Wide Web predominantly enforced a clear separation between designers and consumers. New technological developments, such as the cyberinfrastructure and Web 2.0 architectures, have emerged to support a participatory Web and social computing. These developments are the foundations for a fundamental shift from *consumer culture*s (specialized in producing finished goods to be consumed passively) to *cultures of participation* (in which all people are provided with the means to participate actively in personally meaningful activities). End-user development and meta-design provide foundations for this fundamental transformation. They explore and support new approaches for the design, adoption, appropriation, adaptation, evolution, and sharing of artifacts by all participating stakeholders. They take into account that cultures of participation are not dictated by technology alone: they are the result of incremental shifts in human behavior and social organizations.

The design, development, and assessment of five particular applications that contributed to the development of our theoretical framework are described and discussed.

Keywords:

End-User Development, Meta-Design, Underdesign, Cultures of Participation, Ecologies of Participation, Envisionment and Discovery Collaboratory (EDC), Memory Aiding Prompting System (MAPS), SketchUp, 3D Warehouse, Google Earth, SAP Community Network (SCN), CreativeIT Wiki

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1 Introduction

Cultures are defined in part by their media and their tools for thinking, working, learning, and collaborating [McLuhan, 1964]. In the past, the design of most media emphasized a clear distinction between producers and consumers [Benkler, 2006]. Television is the medium that most obviously exhibits this orientation [Postman, 1985] and in the worst case contributes to the degeneration of humans into *"couch potatoes"* [Fischer, 2002] for whom remote controls are the most important instruments of their cognitive activities. In a similar manner, our current educational institutions often treat learners as consumers, fostering a mindset in students of "consumerism" [Illich, 1971] rather than "ownership of problems" for the rest of their lives [Bruner, 1996]. As a result, learners, workers, and citizens often feel left out of decisions by teachers, managers, and policymakers, denying them opportunities to take active roles in personally meaningful and important problems.

The personal computer can produce, in principle, an incredible increase in the creative autonomy of the individual. But historically these possibilities were often of interest and accessible only to a small number of "high-tech scribes." *End-user development (EUD)* [Lieberman et al., 2006] is focused on the challenge of allowing users of software systems who are not primarily interested in software per se to modify, extend, evolve, and create systems that fit their needs.

What the personal computer has done for the individual, the Internet has done for groups and communities. The first decade of Internet use was dominated by broadcast models and thereby extended the existing strong separation of "designers" and "users" imposed by existing media. *Meta-design* [Fischer & Giaccardi, 2006] is an evolving framework to exploit computational media in support of collaboration and communication to foster cultures of participation.

2 End-User Development (EUD)

Familiarity with software applications has become an essential requirement for professionals in a variety of complex domains: architects, doctors, engineers, biochemists, statisticians, and film directors (among many others) all depend for their livelihood on the mastery of various collections of applications [Eisenberg & Fischer, 1994]. These applications, to be at all useful, must provide domain professionals with complex, powerful functionality. In doing so, however, these systems likewise increase the cognitive cost of mastering the new capabilities and resources that they offer. Moreover, the users of these applications will notice that "*software is not soft*"—that is, that the behavior of a given application cannot be changed or meaningfully extended without substantial reprogramming.

The need for end-user development is not a luxury but a necessity: computational systems modeling some particular "world" are never complete; they must evolve over time because (1) the world changes and new requirements emerge; and (2) skilled domain professionals change their work practices over time—their understanding and use of a system will be very different after a month and certainly after several years. If systems cannot be modified to support new practices, users will be locked into existing patterns of use.

These problems were recognized early in the context of expert systems and domain-oriented environments as illustrated by the following two examples:

- *Expert systems:* The TEIRESIAS system [Davis, 1984] was a module to support domain professionals to augment the existing knowledge base of a medical expert system; the objective of this component was to establish and support interaction at a discourse level that would allow domain professionals to articulate their knowledge without having to program in Lisp.
- *Domain-oriented environments*: The JANUS-MODIFIER system [Fischer & Girgensohn, 1990; Girgensohn, 1992] supported not just human-computer interaction but *human problem-domain interaction* to allow kitchen designers to introduce new components and new critiquing rules into design environments in support of kitchen design.

From a more theoretical perspective, EUD can address the following problems and challenges:

- *Ill-defined or wicked problems* [Rittel & Webber, 1984] cannot be delegated from domain professionals to software professionals, but require the creation of externalizations that talk back to the owner of the problem [Schön, 1983].
- *Breakdowns* [Fischer, 1994] are experienced by domain professionals and not by the system developers; if domain professionals can respond to these breakdowns without relying on "high-tech scribes," systems will evolve in response to real needs.

Professional programmers and *domain professionals* define the endpoints of a continuum of computer users. The former like computers because they can program, and the latter because they get their work done. The goal of supporting domain professionals to develop and modify systems does not imply transferring the responsibility of good system design to the end-user [Burnett et al., 2004]. Normal users will in general not build tools of the quality a professional designer would (which was recognized as one of the basic limitations of second-generation design methods [Rittel, 1984]). However, if a tool does not satisfy the needs or the tastes of the end-users (who know best what these requirements are), then end-users should be able to adapt and evolve the system [Wulf et al., 2008].

The concepts of end-user programming (EUP), end-user software engineering (EUSE), end-user development (EUD), meta-design, and cultures of participation are related with each other but emphasize different research directions and challenges. Table 1 provides a brief description of these frameworks.

Table 1: A Differentiation between Related Frameworks

Framework	Major Objectives
End-User Programming (EUP)	Empower and support end-users to program (with techniques such as: programming by demonstration, visual programming, scripting languages, and domain-specific languages)
End-User Software Engineering (EUSE)	Add to EUP support for systematic and disciplined activities for the whole software lifecycle (including: reliability, efficiency, usability, version control)
End-User Development (EUD)	Focus on a broader set of developments (e.g., creating 3D models with SketchUp, modifying games); it puts end-users as owners of problems in charge and makes them independent of high-tech scribes
Meta-Design	Define a framework and a design methodology to explicitly “design for designers” by defining contexts that allow end-users to create content; applicable to different contexts and encompasses principles that may apply to programming, software engineering, architecture, urban planning, education, interactive arts, and other design fields
Cultures of Participation	Foster a culture (supported by meta-design) in which people have the opportunity to actively participate in personally meaningful problems in ways and at levels that they are motivated to do so.

3 A “New World” Based on Cultures of Participation

As the research community interested in EUD gathered in 2009 for the *Second International Symposium on End-User Development* [Pipek et al., 2009], an interesting question was: What has changed since the first symposium that took place in 2003 (as documented in the book *End-User Development* [Lieberman et al., 2006], which includes a chapter about the future of EUD [Klann et al., 2006])? The major innovation and transformation that emerged between 2003 and 2009 was the *participatory web* (or Web 2.0 [O'Reilly, 2006]) and social computing [Kellogg, 2007], complementing and transcending the *broadcast web* (or Web 1.0), which dominated the first decade of the web.

The Web 1.0 model primarily supports web page publishing and e-commerce, whereas the Web 2.0 model is focused on collaborative design environments, social media, and social networks creating feasibility spaces for new cultures that allow people to participate rather than being confined to passive consumer roles [Brown et al., 1994].

This transformation represents a fundamental shift from *consumer cultures* (focused on passive consumption of finished goods produced by others) [Postman, 1985] to *cultures of participation* (in which all people are provided with the means to participate actively in personally meaningful activities) [Fischer, 2002; von Hippel, 2005]. End-user development is an essential component of this transformation, but its impact is much broader: this transformation represents a change and new opportunity for social production, for mass collaboration, for civic and political life, and for education.

The EUD research community has struggled to make its objectives and techniques known to the world for the last 20 years. The Web 2.0 world has attracted a very large number of contributors and created a number of success models (including open source software, Wikipedia, Second Life, YouTube, and 3D Warehouse, to name just a few) by breaking down the boundaries between producers and consumers. The research community interested in EUD now has an opportunity to apply its research findings to create an theoretical framework to deeply understand these new developments and evolve them further.

This "new world" has established new discourses, including the following:

- Beyond the dichotomy between consumers and producers, new, middle-ground models have emerged such as
  - *prosumers* [Tapscott & Williams, 2006], who are techno-sophisticated and comfortable with the technologies with which they grew up. They have little fear of hacking, modifying, and evolving artifacts to their own requirements. They do not wait for someone else to anticipate their needs, and they can decide what is important for them. They participate in learning and discovery and engage in experimenting, exploring, building, tinkering, framing, solving, and reflecting.
  - *professional amateurs* [Brown, 2005; Leadbeater & Miller, 2008], who are innovative, committed, and networked amateurs working to professional standards. They are a new social hybrid, and their activities are not adequately captured by the traditional dichotomous definitions of work and leisure, professional and amateur, consumption and production.
  - *social production* and *mass collaboration* [Benkler, 2006], which are based on the following facts: (a) a tiny percentage of a very large base is still a substantial number of people; (b) beyond the large quantitative numbers of contributors, there exists a great diversity of interests and passions among users (which can be characterized by the Long Tail [Anderson, 2006]); and (c) while human beings often act for material rewards, they can also be motivated by social capital, reputation, connectedness, and the enjoyment derived from giving things of value away [Fischer et al., 2004]
- An emphasis on *open systems*, which are systems focused on the "unfinished" and take into account that design problems have no stopping rule, need to remain open and fluid to accommodate ongoing change, and for which "continuous beta" becomes a desirable rather than a to-be-avoided attribute.
- The importance of *user-generated content*, in which "content" is broadly defined: (a) creating artifacts with existing tools (e.g., writing a document with a word processor) or (b) changing the tools (e.g., writing macros to extend the word processor as a tool). In specific environments (such as open source software), the content is subject to the additional requirement of being computationally interpretable.
- Moving from guidelines, rules, and procedures to *exceptions, negotiations, and work-arounds* to complement and integrate accredited and expert knowledge with informal, practice-based, and situated knowledge [Suchman, 1987][Orr, 1996; Winograd & Flores, 1986].
- Exploiting the Long Tail [Anderson, 2006] of knowledge distribution, allowing people from around the world to engage in topics and activities about which they feel passionate.
- Fostering and supporting richer *ecologies of participation* (see Section 4.1).
- Creating a new understanding of motivation, creativity, control, ownership, and quality (see Section 4.2).

4 Meta-Design

Meta-design [Fischer & Giaccardi, 2006] is focused on "design for designers." It creates open systems at design time that can be modified by their users acting as co-designers, requiring and supporting more complex interactions at use time. Meta-design is grounded in the basic assumption that future uses and problems cannot be completely anticipated at design time, when a system is developed. At use time, users will invariably discover mismatches between their needs and the support that an existing system can provide for them. Meta-design contributes to the invention and design of socio-technical environments [Mumford, 1987] in which humans can express themselves and engage in personally meaningful activities. The conceptual frameworks that we have developed around meta-design explore some fundamental challenges including the following:

- How we can support skilled domain workers who are neither novices nor naive users, but who are interested in their work and who see the computer as a means rather than as an end?
- How we can create co-adaptive environments, in which users change because they learn, and in which systems change because users become co-developers and active contributors?

- How we can deal with the active participation and empowerment in domains whose boundaries blur and dissolve beyond the limits of definite and independent professional domains, practices, and technologies?

Meta-design allows significant modifications when the need arises. It reduces the gap in the world of computing between a population of elite high-tech scribes who can act as designers and a much larger population of intellectually disenfranchised knowledge workers who are *forced* into consumer roles.

The *seeding, evolutionary growth, and reseeding (SER) model* [Fischer & Ostwald, 2002] is an emerging descriptive and prescriptive model in support of meta-design. Instead of attempting to build complete systems at design time, the SER model advocates building *seeds* (in participatory design activities with meta-designers and end-users) that can evolve over time through small contributions of a large number of people (being the defining characteristics of a culture of participation). It postulates that systems that evolve over a sustained time span must continually alternate between periods of planned activity (the seeding phase), unplanned evolution (the evolutionary growth phase), and periods of deliberate (re)structuring and enhancement (the reseeding phase). A seed is something that has the potential to change and grow. In socio-technical environments, seeds need to be designed and created for the *technical* as well as the *social* component of the environment.

To be more specific about the role of meta-designers: *what do they do?* They use their own creativity to create socio-technical environments in which other people can be creative. The main activity of meta-designers shifts from determining the meaning, functionality, and content of a system to encouraging and supporting end-users acting as designers to engage in these activities. Meta-designers must be willing to share control of how systems will be used, which content will be contained, and which functionality will be supported. They do so with a focus on *underdesign* [Brand, 1995; Habraken, 1972]which can be characterized as follows:

- it is grounded in the need for "loose fit" in designing artifacts at design time so that unexpected uses of the artifact can be accommodated at use time; it does so by creating contexts and content creation tools rather than content;
- it avoids that design decisions will be made in the earliest part of the design process, when everyone knows the least what is really needed;
- it offers users (acting a designers at use time) as many alternatives as possible, avoiding irreversible commitments they cannot undo (one of the drawbacks of overdesign);
- it acknowledges the necessity to differentiate between structurally important parts for which extensive professional experience is required and which should therefore not be easily changed (such as structure bearing walls in buildings) and components which users should be able to modify to their needs because their personal knowledge is most relevant; and
- it creates technical and social conditions for broad participation in design activities by supporting "hackability" and "remixability".

The American Constitution can be considered as one of the biggest success stories in underdesign [Simon, 1996]. Written over 200 years ago, and only updated by a small number of amendments, it still serves as a foundation of the US nation in a world which has changed dramatically.

4.1 Richer Ecologies of Participation

The traditional notions of developer and user are unable to reflect the fact that many socio-technical environments nowadays are developed with the participation of many people with varied interests and capabilities. Cultures of participation require contributors with diverse background knowledge who require different support and value different ways of participating. Many collaborative design environments serve *only as content management* systems: participants contribute and share their *own* interests and abilities, and additional activities such as critiquing, rating, tagging, deliberating, extending, improving, and negotiating do not take place and are not adequately supported; their value is therefore not sufficiently recognized.
Figure 1 (inspired by the "reader to leader" framework of Preece and Shneiderman [Preece & Shneiderman, 2009]) illustrate a richer ecology underlying cultures of participation by postulating four major roles.

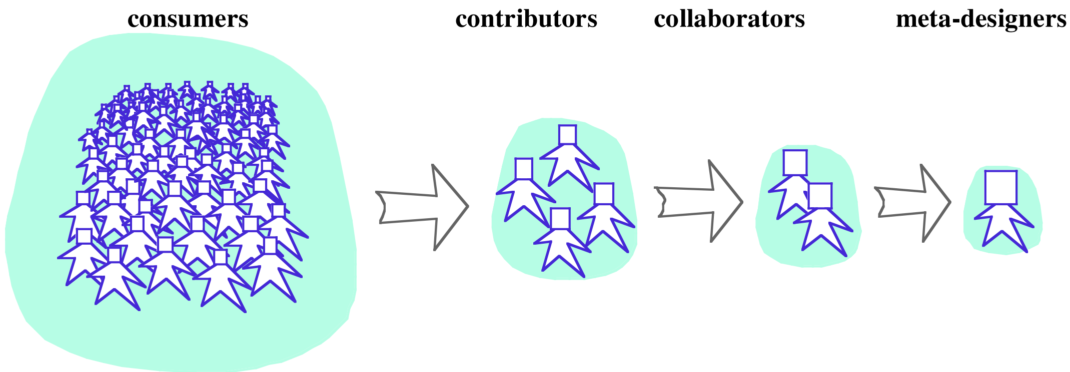

Figure 1: Different Levels of Participation and Engagement

As participants move from left to right, the complexity of the tasks which they do and the demand for how much they have to learn is increasing. To accept these additional efforts participants must consider these tasks as personally meaningful [Fischer, 2002] and the migration paths need to be supported by gentle slope systems in which the transitions from one level to a another level are smooth.

Within one level, these roles can be further differentiated. Early studies [Gantt & Nardi, 1992] already identified that EUP and EUD is more successful if supported by collaborative work practices rather than focusing on individuals. Gantt and Nardi observed the emergence of *"gardeners"* (also known as *"power users"* and *"local developers"*), who are technically interested and sophisticated enough to perform system modifications that are needed by a community of users but that other end-users are not able or not inclined to perform.

A detailed analysis of open-source software systems [Ye & Fischer, 2007] revealed a variety of different roles: (1) *passive users* (using the system); (2) *readers* (trying to understand how the system works by reading the source code); (3) *bug reporters* (discovering and reporting bugs); (4) *bug fixer*s (fixing bugs); (5) *peripheral developers* (occasionally contributing new functionality or features); (6) *active developers* (regularly contributing new features and fixing bugs); and (7) *project leader(s)* (initiating the project and being responsible for its vision and overall direction).

In the SketchUp/3D Warehouse/Google Earth (see Section 5.4) environments, a similar role distribution can be observed: contributors create new models with SketchUp, raters and taggers evaluate and describe these models, and curators organize models in collections and create narratives (see Figure 7).

4.2 Motivation, Control, Ownership, Creativity, and Quality

As argued before, understanding and fostering cultures of participation with meta-design requires paying attention to factors from political, economical, and social domains [Fischer, 2007]. This section takes a brief look at a few of those factors.

Motivation. Human beings are diversely motivated beings. We act not only for material gain, but for psychological well-being, for social integration and connectedness, for social capital, for recognition, and for improving our standing in a reputation economy. The motivation for going the extra step to engage in EUD was articulated by Rittel [Rittel, 1984]: *"The experience of having participated in a problem makes a difference to those who are affected by the solution. People are more likely to like a solution if they have been involved in its generation; even though it might not make sense otherwise."* Meta-design relies on intrinsic motivation for participation and it has the potential to influence this by providing contributors with the sense and experience of joint creativity, by giving them a sense of common purpose and mutual support in achieving it, and in many situations by replacing common background or geographic proximity with a sense of well-defined purpose, shared concerns, and the successful common pursuit of these.

Control. As argued above, meta-design supports users as active contributors who can transcend the functionality and content of existing systems. By facilitating these possibilities, *control* is distributed among all stakeholders in the design process. The importance of this distribution of control has been emphasized as important for architecture [Alexander, 1984]: *"I believe passionately in the idea that people should design buildings for themselves. In other words, not only that they should be involved in the buildings that are for them but that they should actually help design them."* Other arguments indicate that shared control will lead to more innovation [von Hippel, 2005]: *"Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents."*

Ownership. Our experiences gathered in the context of the design, development, and assessment of our systems indicate that meta-design methodologies are less successful when users are brought into the process late (thereby denying them ownership) and when they are "misused" to fix problems and to address weaknesses of systems that the developers did not fix themselves. Meta-design does work when users are part of the participatory design effort in establishing a meta-design framework, including support for intrinsic and extrinsic motivation, user toolkits for reducing the effort to make contributions, and the seeding of use communities in which individuals can share their contributions.

Social Creativity. Where do new ideas come from in meta-design environments and cultures of participation? The creativity potential is grounded in (1) user-driven innovations, (2) taking advantage of breakdowns as sources for creativity, and (3) exploiting the symmetry of ignorance and conceptual collisions [Fischer, 2000]. To increase social creativity requires: (1) *diversity* (each participants should have some unique information or perspective); (2) *independence* (participants' opinions are not determined by the opinions of those around them) [Surowiecki, 2005]; (3) *decentralization* (participants are able to specialize and draw on local knowledge) [Anderson, 2006]; and (4) *aggregation* (mechanisms exist for turning individual contributions into collections, and private judgments into collective decisions). In addition, participants must be able to express themselves (requiring technical knowledge how to contribute), must be willing to contribute (motivation), and must be allowed to have their voices heard (control).

Quality. Many teachers will tell their students that they will not accept research findings and argumentation based on articles from Wikipedia. This exclusion is usually based on considerations such as: *"How are we to know that the content produced by widely dispersed and qualified individuals is not of substandard quality?"*

The online journal *Nature* (http://www.nature.com/) has compared the quality of articles found in the *Encyclopedia Britannica* with Wikipedia and has come to the conclusion that *"Wikipedia comes close to Britannica in terms of the accuracy of its science entries."* This study and the interpretation of its findings has generated a controversy, and Tapscott and Williams [Tapscott & Williams, 2006] have challenged the basic assumption that a direct comparison between the two encyclopedias is a relevant issue: *"Wikipedia isn't great because it's like the Britannica. The Britannica is great at being authoritative, edited, expensive, and monolithic. Wikipedia is great at being free, brawling, universal, and instantaneous."*

There are many more open issues to be investigated about quality and trust [Kittur et al., 2008] in cultures of participation, including: (1) errors will always exist, resulting in learners acquiring the important skill of always being critical of information rather than blindly believing in what others (specifically experts or teachers) are saying; and (2) ownership as a critical dimension: the community at large has a greater sense of ownership and thereby is more willing to put an effort into fixing errors. This last issue has been explored in open source communities and has led to the observation that *"if there are enough eyeballs, all bugs are shallow"* [Raymond & Young, 2001].

5 The Ubiquity of Meta-Design: Exploring Different Application Domains

Meta-design transcends end-user development by studying and supporting cultures of participation not only in the area of software artifacts, but in numerous other domains of information and cultural production and it explores different purposes associated with the artifacts under development. In our research, we have explored meta-design [Fischer & Giaccardi, 2006] in the following areas:

- *design of computational artifacts* [Lieberman et al., 2006], with an emphasis on customization, personalization, tailorability, end-user modifiability, and design for diversity;
- *architectural design* [Brand, 1995], with an emphasis on underdesign and support for an "unself-conscious culture of design" [Alexander, 1964];
- *new models of teaching and learning* [Brown, 2005; Rogoff et al., 1998], with an emphasis on learning communities, teachers as meta-designers, and courses-as-seeds [dePaula et al., 2001]; these approaches challenge the assumption that information must move from teachers and other credentialed producers to passive learners and consumers [Illich, 1971];
- *open source* [Raymond & Young, 2001], with an emphasis on open source as a success model of decentralized, collaborative, evolutionary development [Scharff, 2002]; and

- *interactive art* [Giaccardi, 2004], with an emphasis on collaboration and co-creation facilitated by putting the tools rather than the object of design in the hands of users.

In our currently active research, we are further deepening our understanding of meta-design and cultures of participation with the following projects which be be described in the following sections:

- the *Envisionment and Discovery Collaboratory*, a table-top computing environment supporting stakeholders from diverse backgrounds in face-to-face meetings;
- the *Memory Aiding Prompting System (MAPS)* supporting people with cognitive disabilities and their caregivers;
- the *"SketchUp+3D WAREHOUSE+ Google Earth"* environment in which people from around the world can share 3D models created with SketchUp, and allowing these models to be referenced and displayed in Google Earth;
- the *SAP COMMUNITY NETWORK,* an example of a successful socio-technical environment consisting of more than one million registered users forming a highly active online community; and
- the *CREATIVEIT,* a wiki-based environment fostering and supporting the evolving scientific community participating in the NSF Program on "Creativity and IT."

5.1 The Envisionment and Discovery Collaboratory (EDC)

The EDC [Arias et al., 2000] is a long-term research platform that explores conceptual frameworks for democratizing design in the context of framing and resolving complex urban planning by bringing together participants from various backgrounds in face-to-face meetings. The knowledge to understand, frame, and solve such problems does not already exist [Engeström, 2001], but is constructed and evolves during the solution process—an ideal environment to study meta-design and cultures of participation.

The EDC represents a *socio-technical environment* that incorporates a number of innovative technologies, including table-top computing, the integration of physical and computational components supporting new interaction techniques [Eden, 2002], and an open architecture supporting meta-design activities.

Figure 1 shows members of the Boulder City Council and the Regents of the University of Colorado using our table-top computing environment to engage in participatory problem solving and decision making related to urban planning issues that are of concern to all participants.

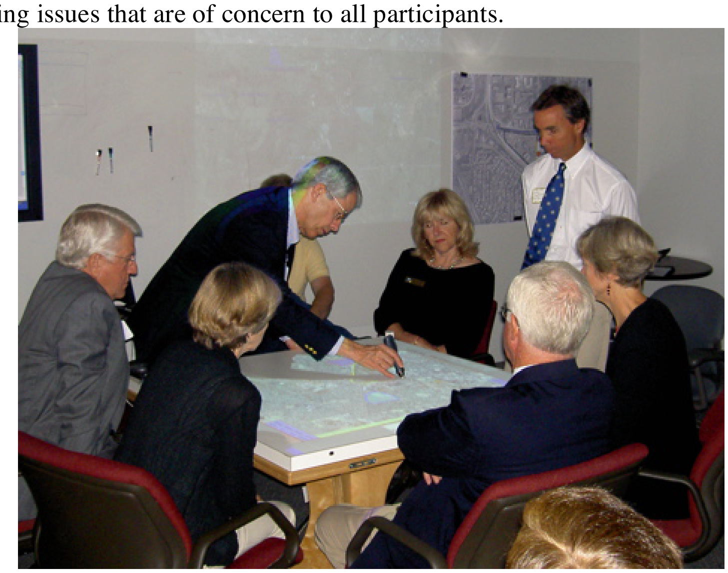

Figure 2: A Participatory Problem Solving and Decision Making Environment

The table-top computing environment supports participation by maximizing the richness of communication among stakeholders in face-to-face interaction, mediated by both physical and computational objects.

The vision of the EDC is to provide contextualized support for *reflection-in-action* [Schön, 1983] within collaborative design activities. In our research with the EDC during the last decade, we have observed:

- More creative solutions to problems can emerge from the collective interactions with the environment by *heterogeneous communities* (such as *communities of interest* [Fischer, 2001], which are more diverse than *communities of practice* [Janis, 1972; Wenger, 1998]).

- Boundary objects are needed [Star, 1989] to establish common ground and establish shared understanding for communities of interest.
- Participants must be able to naturally express what they want to say [Myers et al., 2006].
- Interaction mechanisms must have a “low threshold” for easy participation and a “high ceiling” for expressing sophisticated ideas [Shneiderman, 2007].
- Participants are more readily engaged if they perceive the design activities as personally meaningful by associating a purpose with their involvement [Brown et al., 1994; Rittel, 1984].

Obstacles to further investigated of the above observations rest with the difficulties of democratizing the design of the EDC [von Hippel, 2005] by providing more control to the participants. Each urban-planning problem is *unique*: it has to take into consideration the geography, culture, and population of specific cities. Currently, EDC developers have to customize the system at the source-code level to reflect the specific characteristics of the city and its urban planning problem. In most cases, EDC developers (the meta-designers) do not have sufficient knowledge of the problem and the social context; they do not know which issues are of greatest concern to the city planners and citizens and which conflicts need to be resolved through the EDC system. The domain- and context-specific knowledge is sticky, tacit, and difficult to transfer from local urban planners to EDC developers [Polanyi, 1966].

We are in the process to create a more powerful meta-design environment, the *Scenario-Design-Kit (SDK)* that will empower participants to dynamically configure the EDC system to fit their specific needs without detailed knowledge of programming.

Figure 3 illustrates a scenario that urban planners would be able to construct with the proposed SDK. Charged with community engagement on a new development, the planners will utilize the SDK to pull together numerous geographic information system (GIS) resources (maps, plans, census data, existing buildings, traffic statistics, etc.) related to a proposed project. Selecting from a number of pre-existing tools, models, and simulations, planners assemble an environment for a series of community meetings to allow neighborhood groups to understand and provide feedback on the impacts of the new construction.

The EDC interactive table (pane (a) in Figure 3, used as an action space for citizen participants), will allow them to bring their individual perspectives to the process and collectively interact with the emerging design (for example, sketching proposed elements). Sketches will be shown in Google Earth as a simple 3D model (pane b) to allow participants to visualize the impacts of the design on neighborhood views and local environments so they can discuss whether proposed high building would block the view of the mountains from certain neighborhoods. As the process progresses, the crude sketches could be used to locate exemplars in the 3D Warehouse (pane c) or they could be imported to SketchUp to create more complete models to be used in both the action space and the 3D Google-Earth *reflection space* [Schön, 1983].

In addition, the SDK will support creation of wiki spaces (pane d) to host participatory discussion issues surrounding the proposed development. The wiki will be integrated with the EDC interactive table and Google Earth to allow the results of design sessions to be captured and provide access to broader participation by neighbors. The wiki websites will serve as reflection spaces and allow those who could not participate in the meeting to view the sketches in Google Earth and provide their comments and ideas as feedback. The collected feedback will then be linked to the project, and future discussions of the development activate display of the comments that are contextualized to the design elements.

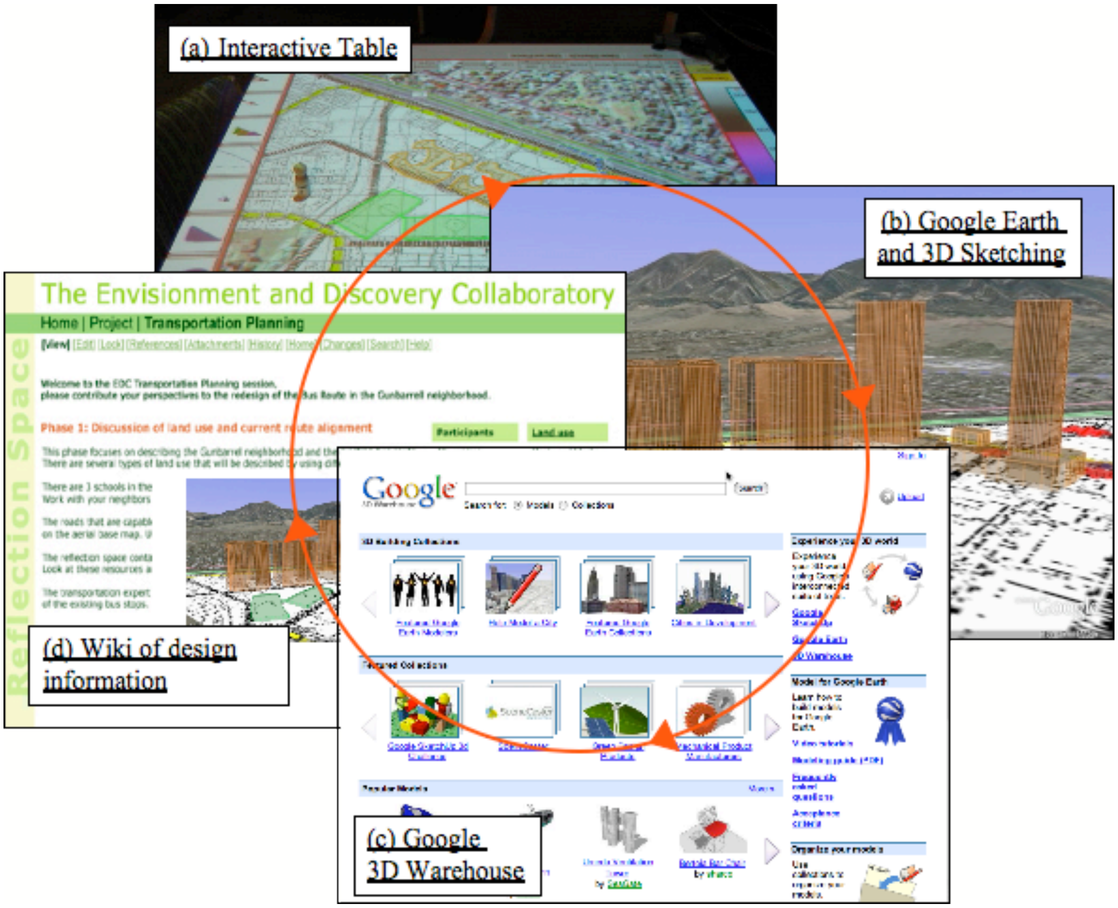

Figure 3: The Integration among the Three Applications

Another dimension of the EDC research consists of deepening our understanding of and support for the creative processes and technologies needed to integrate *individual and social creativity* [Fischer et al., 2005]. The Carretta project [Fischer & Sugimoto, 2006; Sugimoto et al., 2004] has integrated and intertwined collective interaction by using tabletop environments with handheld technologies (i.e., by using PDAs and other personal devices). These initial efforts will exploit the participatory Web for supporting cultures of participation that complement face-to-face sessions and activities beyond co-located meetings.

5.2 Memory Aiding Prompting System (MAPS)

Individuals with cognitive disabilities are often unable to live independently due to their inability to perform activities of daily living, such as cooking, housework, or shopping. By being provided with *socio-technical environments* [Mumford, 1987] to extend their abilities and thereby their independence, these individuals can lead lives less dependent on others. Our research in this context [Carmien & Fischer, 2008] explored end-user development, meta-design, and cultures of participation by supporting mobile device customization, personalization, configuration by caregivers and effective use by clients.

Abandonment Based on the "*Universe of One*". People with cognitive disabilities represent a *"universe of one"* problem: a solution for one person will rarely work for another. The "*universe of one*" conceptualization includes the empirical finding that (1) *unexpected islands of abilities* exist: clients can have unexpected skills and abilities that can be leveraged to ensure a better possibility of task accomplishment; and (2) *unexpected deficits of abilities* exist. Accessing and addressing these unexpected variations in skills and needs, particularly with respect to creating task support, requires an intimate knowledge of the client that *only caregivers* can provide. Currently, a substantial portion of all assistive technology is abandoned after initial purchase and use resulting in that the very population that could most benefit from technology is paying for expensive devices that end up in the back of closets after a short time.

A unique challenge of meta-design in the domain of cognitive disabilities is that the clients themselves cannot act as designers, but the caregivers must accept this role (see Figure 4). Caregivers, who have the most intimate knowledge of the client, need to become the end-user designers. The scripts needed to effectively support users are specific for particular tasks, creating the requirement that the people who know about the clients and the tasks (i.e., the local caregivers rather than a technologist far removed from the action) must be able to develop scripts.

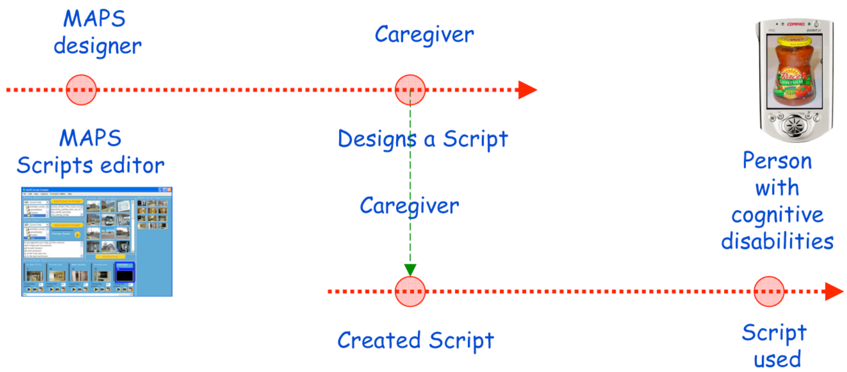

Figure 4: Meta-Design: Empowering Caregivers to Act as Designers

Caregivers generally have no specific professional technology training nor are they interested in becoming computer programmers. This creates the need for design environments with extensive end-user support to allow caregivers to create, store, and share scripts [Fischer, 2006]. Figure 5 shows the MAPS design environment for creating complex multimodal prompting sequences allowing sound, pictures, and video to be assembled by using a film-strip-based scripting metaphor. The design environment supports a multi-script version that allows caregivers to present the looping and forking behavior that is critical for numerous task support situations.

The design of MAPS involved three different groups of participants: (1) assistive technology professionals and special education teachers, (2) parents of clients, and (3) professional caregivers. MAPS was tested with representatives of several different groups resulting in the identification of the following requirements for meta-design:

- discover and learn about the client's and caregiver's world and their interactions;
- observe and analyze how tasks and learning of tasks were currently conducted;
- understand and explicate the process of creating and updating scripts;
- comprehend and analyze the process of using the scripts with a real task; and
- gain an understanding of the role of meta-design in the dynamics of MAPS adoption and use.

By designing the MAPS environment to enable script redesign and reuse, caregivers were able to create an environment that matched the unique needs of a individual person with cognitive disabilities. MAPS represents an example for democratizing design by supporting meta-design, embedding new technologies into socio-technical environments, and helping people with cognitive disabilities and their caregivers have more interesting and more rewarding lives.

Figure 5: The MAPS Design Environment for Creating Scripts

5.3 Modeling the World in 3D: SketchUp, 3D Warehouse, and Google Earth

Having the whole world modeled in 3D and allowing users to explore this virtual world on their computers is the objective behind Google's effort to integrate the following three systems: SketchUp, 3D Warehouse, and Google Earth. The amount of work and local knowledge needed to achieve this is beyond the scope and capability of any locally operating development team. It requires the contributions of a large user base, and as such represents a unique, large-scale example for assessing the conceptual framework underlying meta-design and cultures of participation.

SketchUp (http://sketchup.google.com/) is a highly interactive, direct manipulation 3D-modeling environment. Figure 6 shows a model of the Denver Public Library developed with SketchUp. Being a high-functionality environment with a "low threshold and high ceiling," developing sophisticated and highly creative models with SketchUp requires a *nontrivial learning effort*. Powerful learning mechanisms for SketchUp are critical to allow everyone to contribute to learn how to do so. These mechanisms, together with the added value of participation are important to motivate enough stakeholders to contribute to creative collaborations.

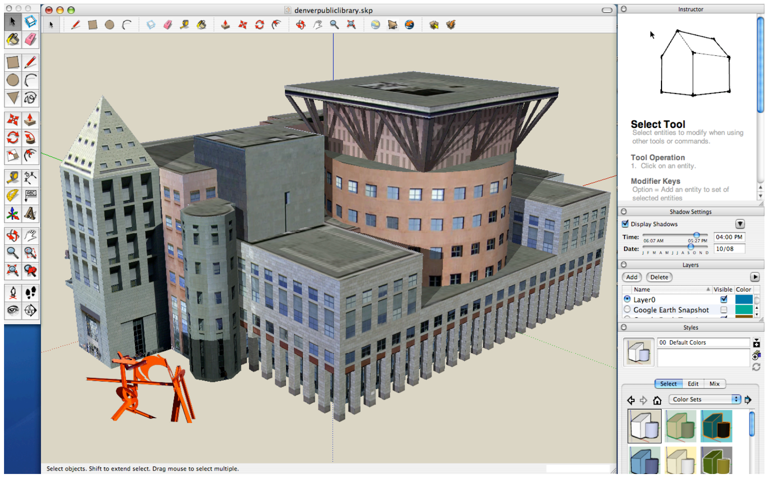

Figure 6: A 3D Model Developed in SketchUp

The ***3D Warehouse*** (http://sketchup.google.com/3dwarehouse/) is an information repository for the collection of models created by all users who are willing to share their models. It contains ten thousands of models from different domains, including buildings, houses, bridges, sculptures, cars, and so forth and it supports *collections* (see Figure 7) to organize models. In addition, the environment supports tagging, ratings, and reviews by the participating community. Interested users can utilize the 3D Warehouse for creative collaborations by sharing, downloading, modifying, extending, and reusing existing models.

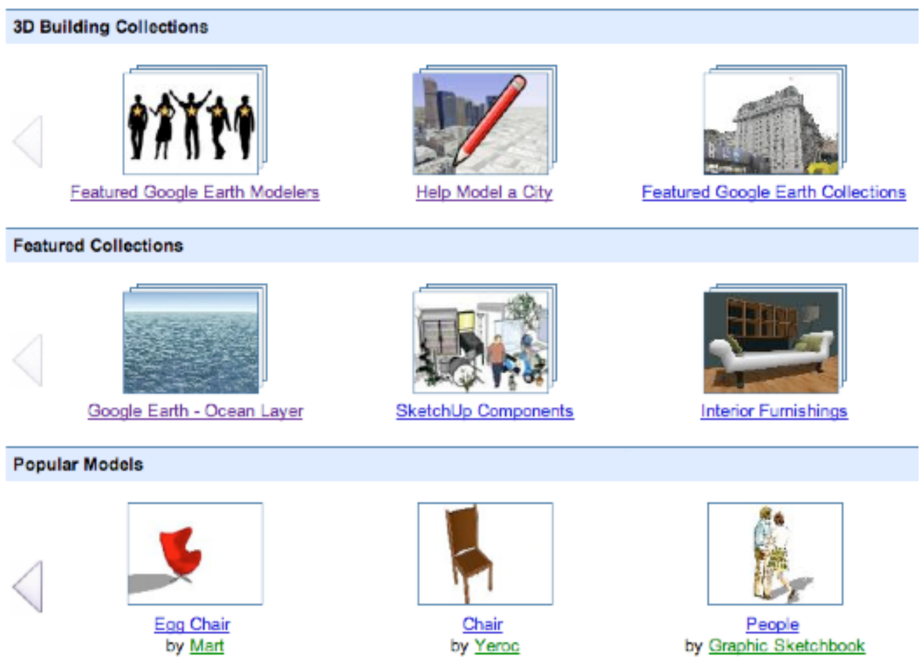

Figure 7: Collections of Models in the 3D Warehouse

Google Earth has the capability to show 3D objects that consist of users' submissions that were developed by using SketchUp. Figure 8 shows an example illustrating the interplay of the three systems: the downtown area of the city of Denver in Google Earth, populated by 3D buildings created by users of SketchUp and stored in the 3D Warehouse. The three systems are integrated in the following way: 3D models can be shared by uploading them from SketchUp to the 3D Warehouse, where they can be searched, shared, and re-stored. Models can be downloaded from the 3D Warehouse to SketchUp (for further modification and evolution) and to Google Earth (if the models have a location on Earth) to be viewed by anyone.

Figure 8: Downtown Denver in 3D

In the ongoing collaboration with our partners from the Google Boulder office, we are exploring how to support cultures of participation in the process of modeling the whole world in 3D by pursuing the following research issues:

- Allowing users to act as active contributors to *achieve sufficient mastery* of SketchUp requires extensive learning support.
- Assessing the effectiveness of different reward structures to *motivate* users to participate in the collaborative effort to model the whole world, including recognition by the community and featuring the best models in the 3D Warehouse and Google Earth.
- Supporting a *richer ecology of participation* (see Section 4.1) including roles such as creators, raters, curators, power users, and local developers, while attending to the diversity and independence of participants.
- Collaborating with Google in its ongoing effort to (1) more tightly integrate the three subsystems to reduce the demands required for participation and (2) facilitate their systems with other environments, such as the EDC (see Figure 3), and other 3D environments, such as Second Life.

5.4 SAP Community Network (SCN)

Diverse and distributed communities represent important instances of cultures of participation. The distribution is *multi-dimensional* [Fischer, 2005]: (1) *spatially* (across physical distance allowing the shift that *shared concern* rather than shared location becomes the defining feature of a group of people interacting with each other); (2) *temporally* (across time; design processes often take place over a long period, with initial design followed by extended periods of evolution and redesign); (3) *conceptually* (across different communities, including homogeneous and heterogeneous communities of practice); and (4) *technologically* (between persons and artifacts to support distributed cognition). These communities face the challenge of avoiding the reinvention of knowledge and artifacts already known by someone. This hurdle is articulated in the slogan *"If only HP knew what HP knows"* [Sieloff, 1999] indicating that cultures of participation are negatively impacted by a lack of awareness what others have done.

We have studied SCN [Gorman & Fischer, 2009] as an example of a successful socio-technical environment consisting of more than one million registered users forming a highly active online community [Hagel & Brown, 2008] of developers, consultants, integrators, and business analysts building and sharing knowledge about SAP technologies via wikis, expert blogs, discussion forums, code samples, training materials, and a technical library (https://www.sdn.sap.com/irj/sdn). We have collected a comprehensive data set that includes all of the posting activity of more than 120,000 users from June 2003 through May 2008.

To get a better understanding of processes and dynamics in a culture of participation such as SCN, we have developed an initial analytic framework to measure a number of factors, including attributes such as (1) *responsiveness* (how often and quickly members get responses to their requests), (2) *engagement* *intensity* (how many helpers and responses are required to answer questions; and (3) *role distribution* (the ratio of users who ask questions to those who answer questions).

Our analysis [Gorman & Fischer, 2009] indicates that we can find patterns in the data that hint toward an environment that is supportive of cultures of participation. The SCN environment provides support and motivation for users to contribute, as can be seen in the time it takes users to receive a response to their post (see Table 2). This time is significantly less than in two other environments we analyzed for comparison, the Open Source communities of Commons and Lucene [Ye & Fischer, 2007]. In the SCN the median response time is 23 minutes, less than a third of the time it takes in the second-best environment.

Table 2: Statistical Features for First Response Time of the Three Distributed Online Communities

The first, second, and third quartile times required for a post from one user to receive a response from another user.

First Response Time	Q1 (25%)	Q2 (Median)	Q3 (75%)
SDN	**6 m**	**23 m**	**3 h 10 m**
Commons	9 m	3 h 56 m	14 h 15 m
Lucene	24 m	1 h 27 m	5 h 51 m

In addition to this *quantitative* analysis, we have engaged in a limited *qualitative* analysis to understand the impact of incentive systems on participation. SCN uses a point system to reward users for their participation, but these features can have negative effects. Points are highly valued, and some users may resort to "gaming the system" to earn points.

5.5 CreativeIT Community

The emerging CreativeIT Community, consisting of participants (researchers, artists, graduate students) in the NSF CISE research program on "Creativity and IT" (http://www.nsf.gov/pubs /2007/nsf07562/-nsf07562.htm), is a relatively small community (less than 100 active participants). With the support of NSF grants, we have designed and seeded a wiki-based socio-technical environment (http://swiki.cs.colorado.edu/CreativeIT) to support and foster an evolving scientific community. The unique challenges of this specific community are that people working in interdisciplinary projects or in niches of their disciplines are often isolated in their local environments and unaware of relevant work in other disciplines. The CreativeIT Wiki allows us to assess and collect a variety of data using tools such as Google Analytics as well as our own tools to gain a better understanding of the value of recording implicit interactions and/versus engaging participants in explicit activities (such as tagging, rating, commenting).

Our ongoing research with the CreativeIT Wiki is focused on gaining a deeper understanding how to support and foster cultures of participation by exploring and analyzing:

- how *awareness mechanisms* will give the participants better overviews over activities;
- how short- and long-term effects in participation can be achieved through *events* taking place in the wiki (e.g., special presentations of the most popular contributions or nominations for the most creative participants);
- how *social support tools* that support participants to find and connect to other participants, represent themselves to other researchers, and create networks of interests can influence user activities;
- how the *social environment* (the number of users, the activities , the level of discussions, and making the environment more *permissive* and unstructured versus more *prescriptive* and structured) will influence social creativity and participation; and
- how *rating systems* allowing participants to rate other people's contributions will increase the trust and interest in existing content.

6 Drawbacks of Cultures of Participation

Cultures of participation open up unique new opportunities for mass collaboration and social production, but they are not without drawbacks. One such drawback is that humans may be forced to cope with the burden of being active contributors in *personally irrelevant activities*.

This drawback can be illustrated with "do-it-yourself" societies. Through modern tools, humans are empowered to perform many tasks themselves that were done previously by skilled domain workers serving as agents and intermediaries. Although this shift provides power, freedom, and control to customers, it also has forced people to act as contributors in contexts for which they lack the experience that professionals have acquired and maintained through the daily use of systems, as well as the broad background knowledge to do these tasks efficiently and effectively (e.g., companies offloading work to customers).

Substantially more experience and assessment is required to determine whether the *advantages* of cultures of participation (such as extensive coverage of information, creation of large numbers of artifacts, creative chaos by making all voices heard, reduced authority of expert opinions, and shared experience of social creativity) will outweigh the *disadvantages* (accumulation of irrelevant information, wasting human resources in large information spaces, and lack of coherent voices). Such a determination will depend on creating a deeper understanding of these trade-offs [Carr, 2008; Lanier, 2006].

7 Conclusions

For a couple of decades the rise of digital media has been providing new powers for the *individual*. The world's networks are now providing enormous unexplored opportunities for *groups and communities*. Providing all citizens with the means to become co-creators of new ideas, knowledge, and products in personally meaningful activities presents one of the most exciting innovations and transformations, with profound implications in the years to come.

This paper has described reasons why cultures of participation supported by meta-design are desirable. Despite the fact that some EUD environments and their supporting research have been around for years and some success models exist [Lieberman et al., 2006], there is evidence that the impact of academic research efforts in this area has been limited.

We do know, however, that digital media are powerful catalysts of cultural change. The challenge for the EUD research community is not only understanding, supporting, and participating in existing cultures, but also shaping, transforming, and fostering new cultures. Humans all over the world have the opportunity today not only to be exposed to cultures of consumerism [Postman, 1985], but to become active contributors in cultures of participation. Without an analytic model and a demystification of media to deeply understand and explain new emerging phenomena and environments, however, we will only be able to treat cultures of participation as curiosities or transient fads [Benkler, 2006]. The potential impact of cultures of participation supported by meta-design is substantial: they erode monopolistic positions held by professions, educational institutions, and experts, and they increase the diversity of perspectives on the way the world is and the way it could be. They require new metaphors, new levels of discourse, and new environments to think, reflect, and support working, learning, and collaboration for alternative and more democratic futures.

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9 References

Alexander, C. (1964) *The Synthesis of Form,* Harvard University Press, Cambridge, MA.

Alexander, C. (1984) "The State of the Art in Design Methods." In N. Cross (Ed.), *Developments in Design Methodology,* John Wiley & Sons, New York, pp. 309-316.

Anderson, C. (2006) *The Long Tail: Why the Future of Business Is Selling Less of More,* Hyperion, New York, NY.

Arias, E. G., Eden, H., Fischer, G., Gorman, A., & Scharff, E. (2000) "Transcending the Individual Human Mind—Creating Shared Understanding through Collaborative Design," *ACM Transactions on Computer Human-Interaction*, 7(1), pp. 84-113.

Benkler, Y. (2006) *The Wealth of Networks: How Social Production Transforms Markets and Freedom,* Yale University Press, New Haven.

Brand, S. (1995) *How Buildings Learn: What Happens after They're Built,* Penguin Books, New York.

Brown, J. S. (2005) *New Learning Environments for the 21st Century*, available at http://www.johnseelybrown.com/newlearning.pdf.

Brown, J. S., Duguid, P., & Haviland, S. (1994) "Toward Informed Participation: Six Scenarios in Search of Democracy in the Information Age," *The Aspen Institute Quarterly*, 6(4), pp. 49-73.

Bruner, J. (1996) *The Culture of Education,* Harvard University Press, Cambridge, MA.

Burnett, M., Cook, C., & Rothermel, G. (2004) "End-User Software Engineering," *Communications of the ACM*, 47(9), pp. 53-58.

Carmien, S. P., & Fischer, G. (2008) "Design, Adoption, and Assessment of a Socio-Technical Environment Supporting Independence for Persons with Cognitive Disabilities." In *Proceedings of Chi 2008,* ACM, Florence, Italy, pp. 597 - 607.

Carr, N. (2008) *Is Google Making Us Stupid?* , available at http://www.theatlantic.com/doc/200807/google.

Davis, R. (1984) "Interactive Transfer of Expertise." In B. G. Buchanan, & E. H. Shortliffe (Eds.), *Rule-Based Expert Systems: The Mycin Experiments of the Stanford Heuristic Programming Project,* Addison-Wesley Publishing Company, Reading, MA, pp. 171-205.

dePaula, R., Fischer, G., & Ostwald, J. (2001) "Courses as Seeds: Expectations and Realities." In P. Dillenbourg, A. Eurelings, & K. Hakkarainen (Eds.), *Proceedings of the European Conference on Computer-Supported Collaborative Learning*, Maastricht, Netherlands, pp. 494-501.

Eden, H. (2002) "Getting in on the (Inter)Action: Exploring Affordances for Collaborative Learning in a Context of Informed Participation." In G. Stahl (Ed.), *Proceedings of the Computer Supported Collaborative Learning (Cscl '2002) Conference*, Boulder, CO, pp. 399-407.

Eisenberg, M., & Fischer, G. (1994) "Programmable Design Environments: Integrating End-User Programming with Domain-Oriented Assistance." In *Human Factors in Computing Systems, Chi'94 (Boston, Ma),* ACM, New York, pp. 431-437.

Engeström, Y. (2001) "Expansive Learning at Work: Toward an Activity Theoretical Reconceptualization," *Journal of Education and Work,* 14(1), pp. 133-156.

Fischer, G. (1994) "Turning Breakdowns into Opportunities for Creativity," *Knowledge-Based Systems, Special Issue on Creativity and Cognition,* 7(4), pp. 221-232.

Fischer, G. (2000) "Social Creativity, Symmetry of Ignorance and Meta-Design," *Knowledge-Based Systems Journal (Special Issue on Creativity & Cognition), Elsevier Science B.V., Oxford, UK,* 13(7-8), pp. 527-537.

Fischer, G. (2001) "Communities of Interest: Learning through the Interaction of Multiple Knowledge Systems," *24th Annual Information Systems Research Seminar In Scandinavia (IRIS'24)*, Ulvik, Norway, pp. 1-14.

Fischer, G. (2002) *Beyond 'Couch Potatoes': From Consumers to Designers and Active Contributors, in Firstmonday (Peer-Reviewed Journal on the Internet),* available at http://firstmonday.org/issues/issue7_12/fischer/.

Fischer, G. (2005) "Distances and Diversity: Sources for Social Creativity." In *Proceedings of Creativity & Cognition*, ACM, London, April, pp. 128-136.

Fischer, G. (2006) "Distributed Intelligence: Extending the Power of the Unaided, Individual Human Mind." In *Proceedings of Advanced Visual Interfaces (Avi) Conference, Venice, May 23-26, 2006*, pp. 7-14.

Fischer, G. (2007) "Meta-Design: Expanding Boundaries and Redistributing Control in Design." In *Proceedings of Interact'2007*, Rio de Janeiro, Brazil, September pp. 193-206.

Fischer, G., & Giaccardi, E. (2006) "Meta-Design: A Framework for the Future of End User Development." In H. Lieberman, F. Paternò, & V. Wulf (Eds.), *End User Development*, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 427-457.

Fischer, G., Giaccardi, E., Eden, H., Sugimoto, M., & Ye, Y. (2005) "Beyond Binary Choices: Integrating Individual and Social Creativity," *International Journal of Human-Computer Studies (IJHCS) Special Issue on Computer Support for Creativity (E.A. Edmonds & L. Candy, Eds.)*, 63(4-5), pp. 482-512.

Fischer, G., & Girgensohn, A. (1990) "End-User Modifiability in Design Environments." In *Human Factors in Computing Systems, (Chi'90) (Seattle, Wa)*, ACM, New York, pp. 183-191.

Fischer, G., & Ostwald, J. (2002) "Seeding, Evolutionary Growth, and Reseeding: Enriching Participatory Design with Informed Participation," *Proceedings of the Participatory Design Conference (PDC'02)*, Malmö University, Sweden, pp. 135-143.

Fischer, G., Scharff, E., & Ye, Y. (2004) "Fostering Social Creativity by Increasing Social Capital." In M. Huysman, & V. Wulf (Eds.), *Social Capital and Information Technology*, MIT Press, Cambridge, MA, pp. 355-399.

Fischer, G., & Sugimoto, M. (2006) "Supporting Self-Directed Learners and Learning Communities with Sociotechnical Environments," *International Journal Research and Practice in Technology Enhanced Learning (RPTEL)*, 1(1), pp. 31-64.

Gantt, M., & Nardi, B. A. (1992) "Gardeners and Gurus: Patterns of Cooperation among Cad Users." In P. Bauersfeld, J. Bennett, & G. Lynch (Eds.), *Proceedings of Acm Chi'92 Conference on Human Factors in Computing Systems*, ACM, New York, pp. 107-117. Available at: http://www.acm.org/pubs/articles/proceedings/chi/142750/p107-gantt/p107-gantt.pdf.

Giaccardi, E. (2004) *Principles of Metadesign: Processes and Levels of Co-Creation in the New Design Space*, Ph.D. Dissertation, CAiiA-STAR, School of Computing, Plymouth, UK.

Girgensohn, A. (1992) *End-User Modifiability in Knowledge-Based Design Environments*, Ph.D. Dissertation, University of Colorado at Boulder.

Gorman, A., & Fischer, G. (2009) "Toward an Analytic Framework for Understanding and Fostering Peer-Support Communities in Using and Evolving Software Products." In *Proceedings of the International Conference Communities and Technologies (C&T'2009) Penn State University, June* pp. 1-9.

Habraken, J. (1972) *Supports: An Alternative to Mass Housing*, Urban International Press, UK.

Hagel, J., & Brown, J., S. (2008) *Innovation on the Edge: How Sap Seeds Innovation*, available at http://www.businessweek.com/print/innovate/content/jul2008/id20080723_353753.htm.

Illich, I. (1971) *Deschooling Society*, Harper and Row, New York.

Janis, I. (1972) *Victims of Groupthink*, Houghton Mifflin, Boston.

Kellogg, W. A. (2007) *Supporting Collaboration in Distributed Teams: Implications for E-Research (Contribution to the Ecscw Workshop "Realising and Supporting Collaboration in E-Research")*, available at http://www.e-researchcommunity.org/docs/ecscw07/submissions/Kellogg.pdf.

Kittur, A., Suh, B., & Chi, E. H. (2008) "Can You Ever Trust a Wiki? Impacting Perceived Trustworthiness in Wikipedia " In *Proceedings of Cscw 2008*

Klann, M., Paterno, F., & Wulf, V. (2006) "Future Perspectives in End-User Development." In H. Lieberman, F. Paternò, & V. Wulf (Eds.), *End User Development*, Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 475-486.

Lanier, J. (2006) *Digital Maoism: The Hazards of the New Online Collectivism*, available at http://www.edge.org/3rd_culture/lanier06/lanier06_index.html.

Leadbeater, C., & Miller, P. (2008) *The Pro-Am Revolution — How Enthusiasts Are Changing Our Economy and Society*, available at http://www.demos.co.uk/files/proamrevolutionfinal.pdf.

Lieberman, H., Paterno, F., & Wulf, V. (Eds.) (2006) *End User Development* Kluwer Publishers, Dordrecht, The Netherlands.

McLuhan, M. (1964) *Understanding Media: The Extensions of Man*, The MIT Press, Cambridge, MA.

Mumford, E. (1987) "Sociotechnical Systems Design: Evolving Theory and Practice." In G. Bjerknes, P. Ehn, & M. Kyng (Eds.), *Computers and Democracy*, Avebury, Aldershot, UK, pp. 59-76.

Myers, B. A., Ko, A. J., & Burnett, M. M. (2006) "Invited Research Overview: End-User Programming." In *Human Factors in Computing Systems, Chi'2006 (Montreal)*, pp. 75-80.

O'Reilly, T. (2006) *What Is Web 2.0 - Design Patterns and Business Models for the Next Generation of Software*, available at http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html.

Orr, J. (1996) *Talking About Machines — an Ethnography of a Modern Job,* ILR Press/Cornell University Press, Ithaca.

Pipek, V., Rossen, M. B., deRuyter, B., & Wulf, V. (Eds.) (2009) *End-User Development*, Springer, Heidelberg.

Polanyi, M. (1966) *The Tacit Dimension,* Doubleday, Garden City, NY.

Postman, N. (1985) *Amusing Ourselves to Death—Public Discourse in the Age of Show Business,* Penguin Books, New York.

Preece, J., & Shneiderman, B. (2009) "The Reader-to-Leader Framework: Motivating Technology-Mediated Social Participation," *AIS Transactions on Human-Computer Interaction*, 1(1), pp. 13-32.

Raymond, E. S., & Young, B. (2001) *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary,* O'Reilly & Associates, Sebastopol, CA.

Rittel, H. (1984) "Second-Generation Design Methods." In N. Cross (Ed.), *Developments in Design Methodology,* John Wiley & Sons, New York, pp. 317-327.

Rittel, H., & Webber, M. M. (1984) "Planning Problems Are Wicked Problems." In N. Cross (Ed.), *Developments in Design Methodology*, John Wiley & Sons, New York, pp. 135-144.

Rogoff, B., Matsuov, E., & White, C. (1998) "Models of Teaching and Learning: Participation in a Community of Learners." In D. R. Olsen, & N. Torrance (Eds.), *The Handbook of Education and Human Development — New Models of Learning, Teaching and Schooling,* Blackwell, Oxford, pp. 388-414.

Scharff, E. (2002) *Open Source Software, a Conceptual Framework for Collaborative Artifact and Knowledge Construction*, Ph.D. Dissertation, University of Colorado at Boulder.

Schön, D. A. (1983) *The Reflective Practitioner: How Professionals Think in Action,* Basic Books, New York.

Shneiderman, B. (2007) "Creativity Support Tools: Accelerating Discovery and Innovation," *Communications of the ACM,* 50(12), pp. 20-32.

Sieloff, C. G. (1999) "'If Only Hp Knew What Hp Knows': The Roots of Knowledge Management at Hewlett-Packard," *Knowledge Management*, 3(1), pp. 47-53.

Simon, H. A. (1996) *The Sciences of the Artificial,* third ed., The MIT Press, Cambridge, MA.

Star, S. L. (1989) "The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving." In L. Gasser, & M. N. Huhns (Eds.), *Distributed Artificial Intelligence, Volume II*, Morgan Kaufmann Publishers Inc., San Mateo, CA, pp. 37-54.

Suchman, L. A. (1987) *Plans and Situated Actions,* Cambridge University Press, Cambridge, UK.

Sugimoto, M., Hosoi, K., & Hashizume, H. (2004) "Caretta: A System for Supporting Face-to-Face Collaboration by Integrating Personal and Shared Spaces." In *Proceedings of Chi2004, Vienna, Austria*, pp. 41-48.

Surowiecki, J. (2005) *The Wisdom of Crowds,* Anchor Books, New York.

Tapscott, D., & Williams, A. D. (2006) *Wikinomics: How Mass Collaboration Changes Everything,* Portofolio, Penguin Group, New York, NY.

von Hippel, E. (2005) *Democratizing Innovation,* MIT Press, Cambridge, MA.

Wenger, E. (1998) *Communities of Practice — Learning, Meaning, and Identity,* Cambridge University Press, Cambridge, UK.

Winograd, T., & Flores, F. (1986) *Understanding Computers and Cognition: A New Foundation for Design,* Ablex Publishing Corporation, Norwood, NJ.

Wulf, V., Pipek, V., & Wonc, M. (2008) "Component-Based Tailorability: Enabling Highly Flexible Software Applications," *International Journal of Human-Computer Studies*, 66, pp. 1-22.

Ye, Y., & Fischer, G. (2007) "Designing for Participation in Socio-Technical Software Systems." In C. Stephanidis (Ed.), *Proceedings of 4th International Conference on Universal Access in Human-Computer Interaction (Beijing, China),* Springer, Heidelberg, pp. 312-321.