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Meta-Design: A Framework for the Future of End-User Development

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Abstract

In a world that is not predictable, improvisation, evolution, and innovation are more than a luxury: they are a necessity. The challenge of design is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems.

Meta-design is an emerging conceptual framework aimed at defining and creating social and technical infrastructures in which new forms of collaborative design can take place. It extends the traditional notion of system design beyond the original development of a system to include a co-adaptive process between users and a system, in which the users become co-developers or co-designers. It is grounded in the basic assumption that future uses and problems cannot be completely anticipated at design time, when a system is developed. Users, at use time, will discover mismatches between their needs and the support that an existing system can provide for them. These mismatches will lead to breakdowns that serve as potential sources of new insights, new knowledge, and new understanding.

This paper is structured in four parts: conceptual framework, environments, applications, and findings and challenges. Along the structure of the paper, we discuss and explore the following essential components of meta-design, providing requirements, guidelines, and models for the future of end-user development: (1) the relationship of meta-design to other design methodologies; (2) the *Seeding, Evolutionary Growth, Reseeding (SER) Model*, a process model for large evolving design artifacts; (3) the characteristics of *unselfconscious cultures of design*, their strengths and their weaknesses, and the necessity for owners of problems to be empowered to engage in end-user development; (4) the possibilities created by meta-design to bring *co-creation* alive; and (5) the need for an integrated design space that brings together a *technical infrastructure* that is evolvable, for the design of *learning environments and work organizations* that allow end-users to become active contributors, and for the design of *relational settings* in which users can relate, find motivations and rewards, and accumulate social capital.

Keywords

design for change; design time; use time; underdesign; seeding, evolutionary growth, reseeding model; unselfconscious cultures of design; open systems; domain-oriented design environments; Envisionment and Discovery Collaboratory; interactive art; co-creation; social capital; value-feelings; design space.

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1 Introduction

Considering end-user development and meta-design as a challenge, one has to move beyond the binary choice of low-level, domain-unspecific interactive programming environments and over-specialized application systems defined by the two end-points on a spectrum:

- ***Turing Tar Pit:*** *"Beware of the Turing Tar Pit, in which everything is possible, but nothing of interest is easy."* (Alan Perlis)
- ***The Inverse of the Turing Tar Pit:*** *"Beware of over-specialized systems, where operations are easy, but little of interest is possible."*

The Turing Tar Pit argument provides a supporting argument as to why interactive programming environments, such as Lisp, Logo, Smalltalk, Squeak, Agentsheets, and many others [Lieberman, 2001] are not ideal for supporting meta-design. These tools provide the ultimate level of openness and flexibility (e.g., Squeak is an open source implementation of Smalltalk written entirely in itself). As general-purpose programming languages, they are capable of representing any problem that computers can be used to solve, and as open systems they let users change any aspect of the system if necessary. Although these systems are useful as computational substrates, they by themselves are insufficient for meta-design. The essential problem with these systems is that they provide the incorrect level of representation for most problems [Shaw, 1989]. Expressing a problem and designing a solution in these systems requires creating a mapping from the context of the problem to the core constructs provided by the programming language and its supporting library. On the other side of the spectrum, *domain-specific but closed systems* (e.g., SimCity 4 [Electronic-Arts, 2004]) provide extensive support for certain problem contexts, but the ability to extend these environments is fundamentally limited.

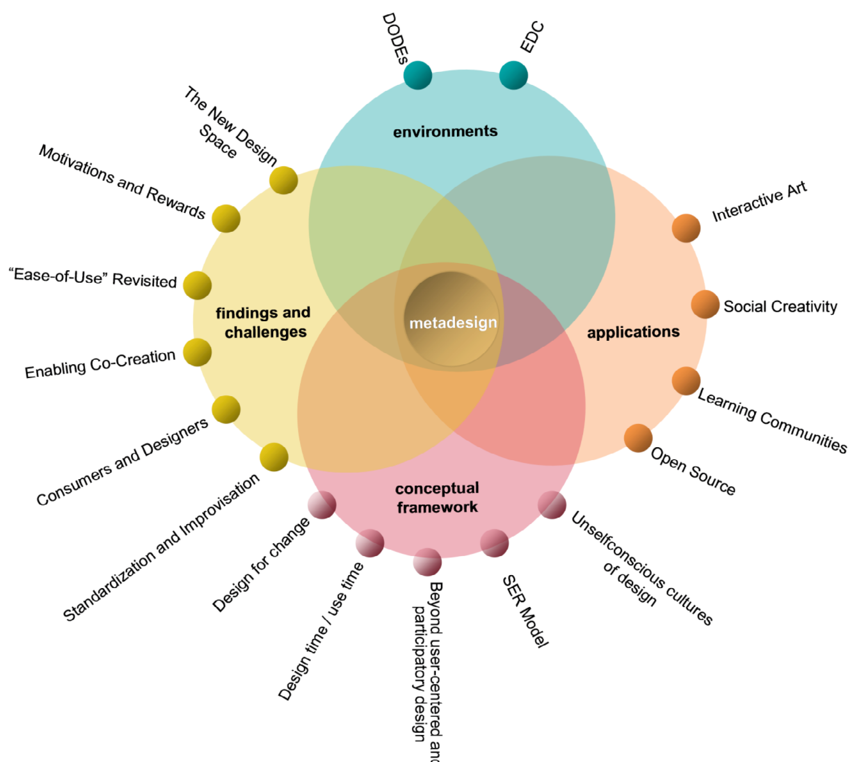

Figure 1: The Structure of Our Contribution: How Themes Are Interrelated

Based on our research over the last two decades at the Center for Lifelong Learning and Design at the University of Colorado, Boulder, we will first provide some arguments for the desirability and need of meta-design. We will then develop a conceptual framework for meta-design and illustrate the approach with prototype developments mostly drawn from our own work. The description of meta-design approaches in several application areas (with a focus on interactive art) shows the potential and applicability of the concept. We will conclude with a section of findings and challenges for future developments. Figure 1 illustrates how different themes of the paper are interrelated and how they contribute to the unifying theme of meta-design.

2 The Rationale for Meta-Design

In a world that is not predictable, improvisation, evolution, and innovation are more than luxuries: they are necessities. The challenge of design is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems. Meta-design is a conceptual framework defining and creating 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 (e.g., urban design, software design, design of learning environments, and interactive art) the knowledge to understand, frame, and solve problems is not given, but is constructed and evolved during the problem-solving process.

Meta-design addresses the following three necessities for socio-technical environments [Fischer & Scharff, 2000]:

1. They must be flexible and evolve because they cannot be completely designed prior to use.
2. They must evolve to some extent at the hands of the users.
3. They must be designed for evolution.

The goal of making systems modifiable and evolvable by users does not imply transferring the responsibility of good system design to the user. Domain experts (who see software development as a means to an end) will design tools and create contents of a different quality than professional software designers (for whom software is both a means and an ends). Domain experts are not concerned with the tool per se, but in doing their work. However, if the tool created by the developer does not satisfy the needs or the tastes of the user (who knows best), then the user should be able to adapt the system without always requiring the assistance of the developer.

Meta-design extends the traditional notion of system design beyond the original development of a system to include a co-adaptive process between users and system, in which the users become *co-developers* [Mackay, 1990]. Users learn to operate a system and adapt to its functionality, and systems are modified to adapt to the practices of its users. Meta-design supports the dialogue evolving between the participants in the process of co-adaptivity — that is, the software artifact and the human subject — so that both move beyond their original states. In this way, meta-design sustains the interactive feedback of information amongst technological and human systems and their components, a practice early recognized and adopted by those artists that utilized technology in the production of art [Shanken, 2002].

An example that we have studied extensively involves *high-functionality applications* (HFAs) [Fischer, 2001]. These systems already contain too much unused functionality (at least in the abstract) — so why would it be necessary to create even more functionality? Even though HFAs are large and complex, it is often the case that the functionality required for a specific problem does not exist in the system. Meta-design approaches to HFAs [Eisenberg & Fischer, 1994] are necessary because (1) the information and functionality represented in the system can never be complete because 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 compared to after several years. If systems cannot be modified to support new practices, users will be locked into old patterns of use, and they will abandon a system in favor of one that better supports the way they want to work.

3 A Conceptual Framework for Meta-Design

Extending the traditional notion of system design beyond the original development of a system, *meta-design* [Fischer & Scharff, 2000; Giaccardi, 2003] includes a process in which users become *co-designers* not only at design time, but throughout the whole existence of the system. A necessary, although not sufficient condition for meta-design is that software systems include advanced features permitting users to create complex customizations and extensions. Rather than presenting users with closed systems, meta-design provides them with opportunities, tools, and social reward structures to extend the system to fit their needs. Meta-design shares some important objectives with user-centered and participatory design, but it *transcends* these objectives in several important dimensions, and it has changed the processes by which systems and content are designed. Meta-design has shifted some *control* from designers to users and empowered users to create and contribute their own visions and objectives. Meta-design is a useful perspective for projects for which "*designing the design process*" is a first-class activity (this perspective of meta-design is not restricted to end-user development, but can be applied to the work of professional software engineers as well [Floyd et al., 1992]). This means that creating the technical and social conditions for broad participation in design activities is as important as creating the artifact itself [Wright et al., 2002] because *"a piece of software does not guarantee you autonomy. What it is, what it is mixed with, how it is used are all variables in the algorithms of power and invention that course through software and what it connects to"* [Fuller, 2003].

Compared to traditional design approaches, meta-design puts the emphasis on different objectives (see Table 1 [Giaccardi, 2003]; some of these shifts overlap with those emerging in the aesthetics of interactive art [Ascott, 2003]). A number of these objectives are further elaborated and discussed in the following sections.

Table 1: Traditional Design versus Meta-Design

Traditional Design	Meta-Design
guidelines and rules	exceptions and negotiations
representation	construction
content	context
object	process
perspective	immersion
certainty	contingency
planning	emergence
top-down	bottom-up
complete system	seeding
autonomous creation	co-creation
autonomous mind	distributed mind
specific solutions	solutions spaces
design-as-instrumental	design-as-adaptive
accountability, know-what (rational decisioning)	affective model, know-how (embodied interactionism)

3.1 Design for Change

Meta-design has to do not only with *situatedness* in order to fit new needs at use time and account for changing tasks, it has to do also with the *embeddedness* of computer artefacts in our daily life and practices [Ehn & Malmborg, 1999]. This represents a challenge to the idea of user participation and empowerment, as well as tailorability, because it becomes necessary to look not only to professional work practices, but also to a private life more and more blurred with professional life within "mixed reality environments" [Pipek & Kahler, 2004]. To argue that design for change (in buildings, in systems, in socio-technical environments) [Dittrich & Lindeberg, 2003] is nearly universal does not help much in understanding how the process works, nor in conjuring how it might go better. Our idea of design must be reframed. Meta-design contributes to the invention and design of cultures 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 associated with design for change:

1 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?
2 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?
3 How we can deal with the active participation and empowerment of a subject, the profile of which tends to blur and dissolve beyond the limits of definite and independent professional domains, practices, and technologies?

3.1 Design Time and Use Time

In all design processes, two basic stages can be differentiated: design time and use time (see Figure 2). At *design time*, system developers (with or without user involvement) create environments and tools. In conventional design approaches, they create complete systems for the world-as-imagined. At *use time*, users use the system but their needs, objectives, and situational contexts can only be anticipated at design time, thus, the system often requires modification to fit the user's needs. To accommodate unexpected issues at use time, systems need to be underdesigned at design time, while directly experiencing their own world. *Underdesign* [Brand, 1995] in this context does not mean less work and fewer demands for the design team, but it is fundamentally different from creating complete systems. The primary challenge of underdesign is in developing not solutions, but environments that allow the *"owners of problems"* [Fischer, 1994b] to create the solutions themselves at use time. This can be done by providing a context and a background against which situated cases, coming up later, can be interpreted [Fischer, 1994a]. Underdesign is a defining activity for meta-design aimed at creating design spaces for others.

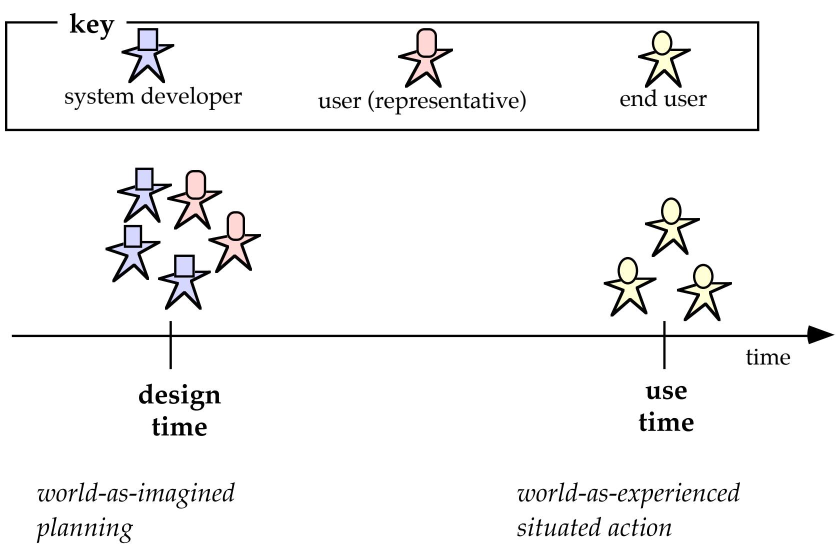

Figure 2: Design Time and Use Time

However, as indicated in Figure 3, we do not assume that being a consumer or being a designer is a binary choice for the user*:* it is rather a continuum ranging from passive consumer, to well-informed consumer [Fischer, 2002] , to end-user, to power users [Nardi, 1993], to domain designer [Fischer, 1994a] all the way to meta-designer (a similar role distribution or division of labor for domain-oriented design environments is defined in Figure 5 and in [Morch, 2004]). It is also the case that the same person is and wants to be a consumer in some situations and in others a designer; therefore *"consumer/designer" is not an attribute of a person, but a role assumed in a specific context*.

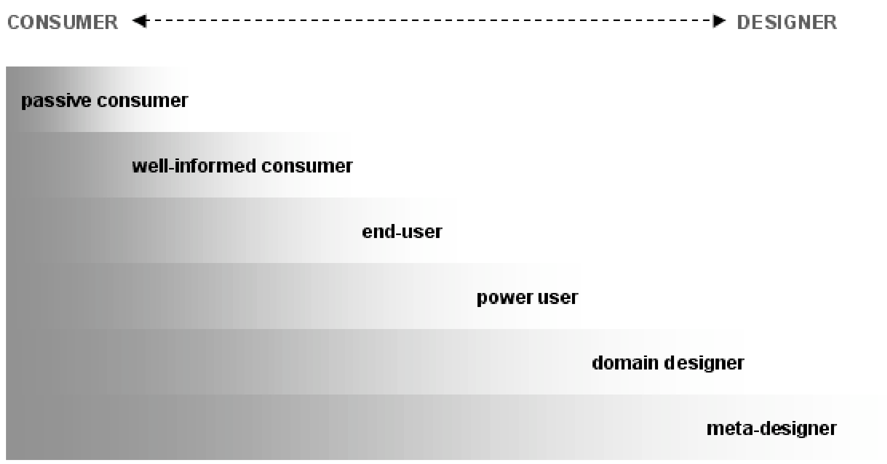

Figure 3: Beyond Binary Choices – The Consumer/Designer Spectrum

A critical challenge addressed by our research is to support a *migration path* [Burton et al., 1984] between the different roles mentioned in Figure 3: consumers, power-users, and designers are nurtured and educated, not born, and people must be supported to assume these roles.

3.2 Beyond User-Centered Design and Participatory Design

User-centered design approaches [Norman & Draper, 1986] (whether done *for* users, *by* users, or *with* users) have focused primarily on activities and processes taking place at design time in the systems' original development, and have given little emphasis and provided few mechanisms to support systems as *living* entities that can be evolved by their users. In user-centered design, designers generate solutions that place users mainly in reactive roles.

Participatory design approaches [Schuler & Namioka, 1993] seek to involve users more deeply in the process as co-designers by empowering them to propose and generate design alternatives themselves. Participatory design supports diverse ways of thinking, planning, and acting by making work, technologies, and social institutions more responsive to human needs. It requires the social inclusion and active participation of the users. Participatory design has focused on system development at design time by bringing developers and users together to envision the contexts of use. But despite the best efforts at design time, systems need to be evolvable to fit new needs, account for changing tasks, deal with subjects and contexts that increasingly blur professional and private life, couple with the socio-technical environment in which they are embedded, and incorporate new technologies [Henderson & Kyng, 1991].

Different from these approaches, meta-design creates *open systems* that can be modified by their users and evolve at use time, supporting more complex interactions (rather than linear or iterative processes). Open systems allow significant modifications when the need arises. The evolution that takes place through modifications must be supported as a "first class design activity." The call for open, evolvable systems was eloquently advocated by Nardi [Nardi, 1993]: *"We have only scratched the surface of what would be possible if end users could freely program their own applications. . . . As has been shown time and again, no matter how much designers and programmers try to anticipate and provide for what users will need, the effort always falls short because it is impossible to know in advance what may be needed. . . . End users should have the ability to create customizations, extensions, and applications . . . {p. 3}."*

3.3 The Seeding, Evolutionary Growth, and Reseeding (SER) Process Model

The *seeding, evolutionary growth, and reseeding (SER)* model [Fischer & Ostwald, 2002] is a process model for large evolving systems and information repositories based on the postulate that systems that evolve over a sustained time span must continually alternate between periods of activity and unplanned evolutions and periods of deliberate (re)structuring and enhancement. The SER model encourages designers to conceptualize their activity as meta-design, thereby supporting users as designers in their own right, rather than restricting them to being passive consumers. Figure 4 provides an illustration of the SER model.

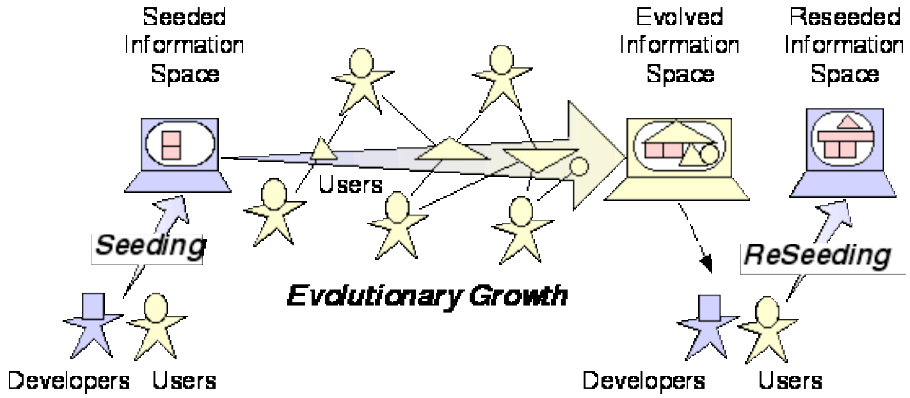

Figure 4: The Seeding, Evolutionary Growth, and Reseeding Process Model

We have explored the feasibility and usefulness of the SER model in the development of complex socio-technical systems. The evolutions of these systems share common elements, all of which relate to sustained knowledge use and construction in support of informed participation.

Seeding. System design methodologies of the past were focused on the objective of building complex information systems as "complete" artifacts through *the large efforts of a small number of people*. Conversely, instead of attempting to build complete and closed 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 information repository 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, but the shortcomings and breakdowns 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 have a direct stake in the problem at hand and are designing solutions to problems.

During the evolutionary growth phase, the information repository 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 repository 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.

3.4 Towards an Unselfconscious Culture of Design

Being ill-defined [Rittel, 1984], design problems cannot be delegated (e.g., from users to professionals) because they are not understood well enough to be described in sufficient detail. Partial solutions need to "talk back" [Schön, 1983] to the owners of the problems who have the necessary knowledge to incrementally refine them. Alexander [Alexander, 1964] has introduced the distinction between an unselfconscious culture of design and a selfconscious culture of design. In an *unselfconscious* culture of design, the failure or inadequacy of the form leads directly to an action to change or improve it. This closeness of contact between designer and product allows constant rearrangement of unsatisfactory details. By putting owners of problems in charge, the positive elements of an unselfconscious culture of design can be exploited in meta-design approaches by creating media that support people in working on their tasks, rather than requiring them to focus their intellectual resources on the medium itself.

Informed participation [Brown & Duguid, 2000], for instance, is a form of collaborative design in which participants from all walks of life (not just skilled computer professionals) transcend beyond the information given to incrementally acquire ownership in problems and to contribute actively to their solutions. It addresses the challenges associated with open-ended and multidisciplinary design problems. These problems, involving a combination of social and technological issues, *do not have "right" answers*, and the knowledge to understand and resolve them changes rapidly. To successfully cope with 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.

Table 2: Comparing Selfconscious and Unselfconscious Cultures of Design

	selfconscious	unselfconscious
definition	an explicit, externalized description of a design exists (theoretical knowledge)	process of slow adaptation and error reduction (situated knowledge)
original association	professionally dominated design, design for others	primitive societies, handmade things, design for self
primary goal	solve problems of others	solve own problems
examples	designed cities: Brasilia, Canberra; Microsoft Windows	naturally grown cities: London, Paris; Linux
strengths	activities can be delegated; division of labor becomes possible	many small improvements; artifacts well suited to their function; copes with ill-defined problems
weaknesses	many artifacts are ill-suited to the job expected of them	no general theories exist or can be studied (because the activity is not externalized)
requirements	externalized descriptions must exist	owners of problems must be involved because they have relevant, unarticulated knowledge
evaluation criteria	high production value; efficient process; robust; reliable	personally meaningful; pleasant and engaging experience; self-expression
relation with context	context required for the framing of the problem	both problem framing and solving take place within the bigger context

4 Environments Supporting Meta-Design

The objectives and the impact of meta-design transcend the development of new computational environments and address mindsets, control, motivations, and the willingness to collaborate with others. Even the most sophisticated computational environments will not be sufficient to achieve these objectives, but they are necessary to allow owners of problems to act as informed participants in personally meaningful tasks. Meta-design will benefit from all of the following developments (many of them discussed in other chapters of this book):

- to offer *task-specific languages* that take advantage of existing user knowledge among domain professionals [National-Research-Council, 2003] and to hide *low-level computational details* as much as possible from users (see Figure 5);
- to provide *programming environments* (such as Squeak, Agentsheets, and others [Lieberman, 2001] that make the functionality of the system transparent and accessible so that the computational drudgery required of the user can be substantially reduced;
- to exploit the power of *collaboration* [Arias et al., 2000; Nardi & Zarmer, 1993]; and
- to support *customization, reuse, and redesign* effectively [Morch, 1997; Ye & Fischer, 2002].

In this section, we briefly describe two of our developments (*domain-oriented design environments* and the Envisionment and Discovery Collaboratory) that were inspired by meta-design and in return contributed to our understanding of meta-design.

4.1 Domain-Oriented Design Environments

Domain-oriented design environments [Fischer, 1994a] support meta-design by advancing human-computer interaction to *human problem-domain interaction*. Because systems are modeled at a conceptual level with which users are familiar, the interaction mechanisms take advantage of existing user knowledge and make the functionality of the system transparent and accessible. Thus, the computational drudgery required of users can be substantially reduced.

Figure 5 illustrates a layered architecture in support of *human problem-domain interaction*. This architecture allows domain designers to engage in end-user development by describing their problems with the concepts of a design environment rather than with low-level computer abstractions [Girgensohn, 1992].

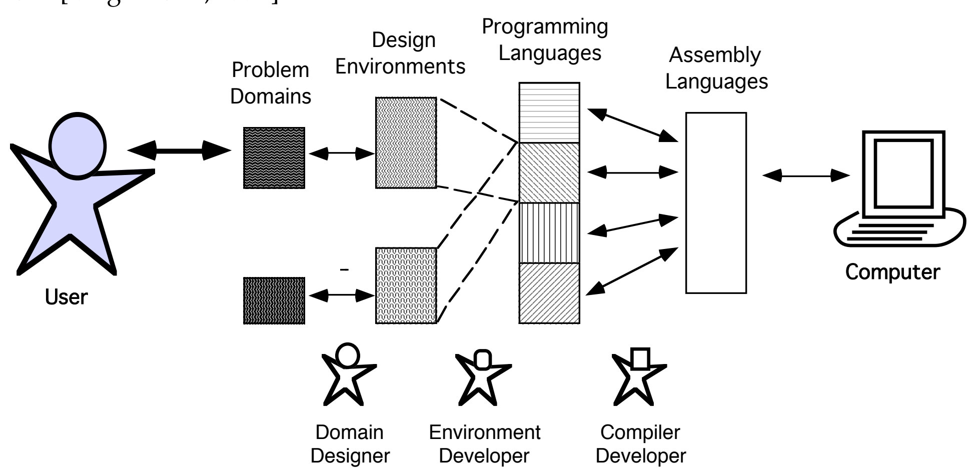

Figure 5: A Layered Architecture Supporting Human Problem-Domain Interaction

4.2 The Envisionment and Discovery Collaboratory

The *Envisionment and Discovery Collaboratory* [Arias et al., 2000] is a second-generation design environment focused on the support of *collaborative design* by integrating physical and computational components to encourage and facilitate informed participation by all users in the design process.

The Envisionment and Discovery Collaboratory represents an explicit attempt to create an *open system* (following the process of the SER model) to address some of the shortcomings of closed systems. Closed systems (in which the essential functionality is anticipated and designed at design time; see Figure 2) are inadequate to cope with the tacit nature of knowledge and the situatedness of real-world problems. In our research, we have carefully analyzed why simulation environments such as SimCity [Electronic-Arts, 2004] are not used for real planning and working environments. SimCity supports some superficial kinds of modifications (such as changing the appearance of buildings in the city), but most functional aspects of the simulation environment have been determined at the original design time. For example, the only way to reduce crime in a simulated city is to add more police stations. It is impossible to explore other solutions, such as increasing social services. Because the functionality of the system was fixed when the system was created, exploring concepts that were not conceived by the system designers is difficult. Due to SimCity's closed nature, it may be a good tool for passive education or entertainment, but it is inadequate for actual city planning tasks, as our empirical investigations have demonstrated [Arias et al., 2000]. One vision that drives the Envisionment and Discovery Collaboratory is to create an end-user extensible version of SimCity.

The Envisionment and Discovery Collaboratory supports users to create e*xternalizations* [Bruner, 1996] that have the following essential roles to support informed participation:

- They assist in translating vague mental conceptualizations of ideas into more concrete representations. They require the expression of ideas in an explicit form, and in this process may reveal ideas and assumptions that previously were only tacit [Polanyi, 1966].
- They provide a means for users to interact with, react to, negotiate around, and build upon ideas. Such a "conversation with the materials" of the design problem [Schön, 1983] is a crucial mode of design that can inspire new and creative ideas.
- They focus discussions upon relevant aspects of the framing and understanding the problem being studied, thereby providing a concrete grounding and a common language among users.

5 Application of Meta-Design Approaches

Different domains express a meta-design approach, applying related concepts and methodologies. Some of these applications, when conceptualized as meta-design, suggest new insights (e.g., interactive art), others rather represent a concrete assessment of our conceptual framework (e.g., learning communities). We illustrate here how the application of meta-design approaches have transformed existing design approaches in different domains, including interactive art, information repositories, design environments, and classrooms as design studios.

5.1 Interactive Art

Interactive art, conceptualized as meta-design, focuses on *collaboration and co-creation*. The original design (representing a *seed* in our framework) establishes a context in which users can create and manipulate at the level of code, behaviour, and/or content, and perform meaningful activities. Interactive art is based on the premise that computational media, as discrete structures, allow people to operate at the sources of the creative process, and that this creativity can be shared and no longer limited to the realm of professional artists. Therefore, interactive art puts the *tools* rather than the object of design in the hands of users. It creates interactive systems that do not define content and processes, but rather the *conditions for the process of interaction*. These objectives correspond to cultural shifts in the emerging aesthetics of interactive art [Ascott, 2003].

Interactive artworks have an "experiential" or aesthetic dimension that justifies their status as art, rather than as information design. According to Manovich [Manovich, 2001], these dimensions include a particular configuration of space, time, and surface articulated in the work; a particular sequence of user's activities over time to interact with the work; and a particular formal, material, and phenomenological user experience. But most of all, when conceptualized as meta-design, they include the *indeterminacy of the event of creation* [Giaccardi, 2001a], given by the empowerment of users' creative capabilities in an open and collaborative environment. Through interactivity, users do not simply send and receive a mono-directional flow of information, but act as performers of a mutual exchange between themselves and the computer, or between themselves and other users. Interactive art is concerned with setting up and seeding the place of this exchange, and sees interaction itself as the real *object* of creative production.

The aesthetics of co-creation developed in interactive art comes up with an approach to design that shares with meta-design concerns about interaction, participation, and collaboration as means for an expansion of human creativity. Interactive art shows us how different kinds and different layers of interactivity and connectivity [Giaccardi, 1999] can affect the socio-technical flexibility of the system. Hence we are shown its capability to increase the scope and complexity of the space of creation (which can correspond to the space of problem framing/problem solving from a nonartistic perspective).

Electronic Café. Artistic practices based on the interactive and participatory use of networked technologies adopted meta-design as a term for an alternative design approach and art vision since the beginning of the 1980s. One of the most significant practices of meta-design in the field of interactive art is the Electronic Café project (see Figure 6) by Kit Galloway and Sherrie Rabinowitz (1984; http://www.ecafe.com/**).** This project integrates social and technological systems by setting up computational environments and a wide range of interactions that enable people to control the context of their cultural and artistic production as autonomous, electronic communities [Youngblood, 1984].

The Electronic Café was a pervasive telecommunications system characterized as an accessible, flexible, end-user modifiable (in terms of files, archives, and environment), and visual components-based system. By incorporating fully interactive word processing, handwriting, drawing, animation and slow-scan video, and providing the ability to combine these elements, the Electronic Café provided a structure that allowed its users the greatest possible freedom (at that time) to design and control their own information environments.

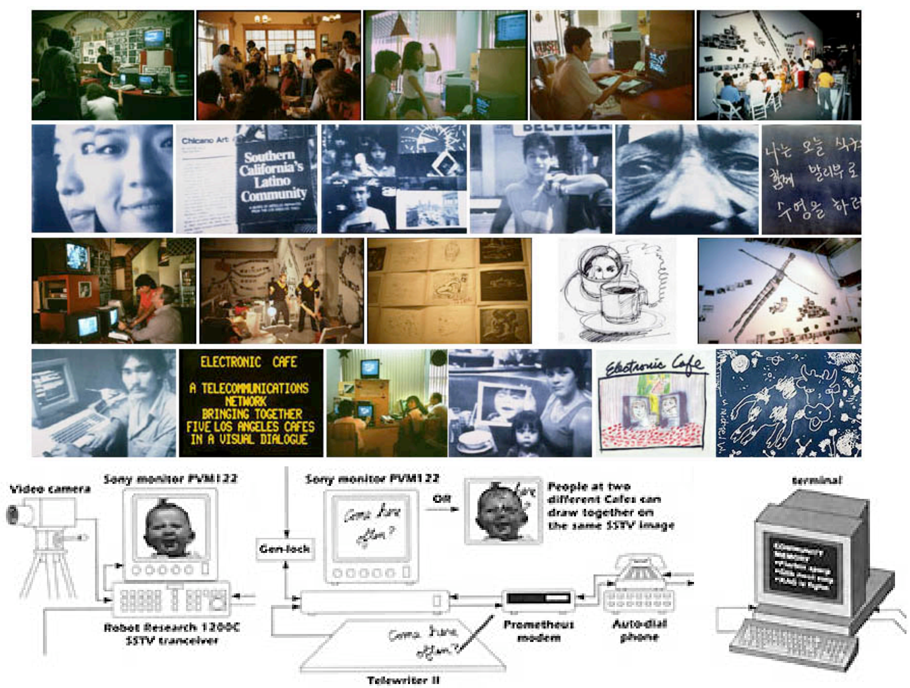

Figure 6: The Electronic Café Project. © 1995/2002 Kit Galloway & Sherrie Rabinowitz

With their work, the artists highlighted design requirements and guidelines that characterize a consistent path of research and experimentations in the field of interactive art. In particular, the *visual component* of environments was important to determine the transcendence of barriers of literacy and language. Also important was users' exposure to the aesthetic sensibility of the involved artists in a *direct, experiential manner*; that is to say, by being in the world in the same way. According to Rabinowitz: "*It's a kind of spontaneous encounter that can't be engineered or marketed*" [Youngblood, 1984].

A-Volve. As new technological possibilities arise, so do interactive art advances, enhancing the layers of interaction and collaboration. New computational development not only allows users to create content, fostering evolution by elaborations, completions, and additions, they also allow the modification of the behaviour of an interactive system or the change of the interactive system itself. In the first case, the user can modify the behaviour of the system at use time through interaction with the system. In *A-Volve* (http://www.iamas.ac.jp/~christa/; see Figure 7), for example, users interact in real-time with virtual creatures in the space of a water-filled glass pool. These virtual creatures are products of evolutionary rules and are influenced by human creation and decision. Users can design any kind of shape and profile with their fingers on a touch screen and automatically the designed creature will be "alive", able to swim in the real water of the pool and to react to users' hand movements in the water. In A-Volve, algorithms are the seed, and they ensure the "animal-like" behaviour of the creatures, but none of the creatures is precalculated. They are all born exclusively in real time and evolve through *different layers of interaction* (creation, human-creature interaction, creature-creature interaction, and human-human interaction) [Sommerer & Mignonneau, 1997a; Sommerer & Mignonneau, 1997b].

Figure 7: "A-Volve" - Design and Interaction. ©1994/1995, Christa Sommerer & Laurent Mignonneau interactive computer installation supported by ICC-NTT Japan and NCSA, USA

SITO. Current projects of interactive art, especially when networked, allow the modification or the development from scratch of the interactive system and its features. In these projects, the source is often developed by a community of artists, and can be adjusted and improved at different levels and different times according to the "talk-back" deriving from the continuing and direct experience of the creative environment and the resulting changing needs. For example, in SITO, which is a virtual community of "*articipants*" (artists-participants), interaction and evolution occur both at the level of the development of the source and at the level of the creation, elaboration and completion of collective artworks (in the section called Synergy). SITO (http://www.sito.org; see Figure 8) is active for twenty-four hours and is open to anyone. Most of SITO's collaborative art projects (such as Gridcosm) start from seed images by different artists and involve the serial manipulation or the creation of several "generations" of images, variously interlinked.

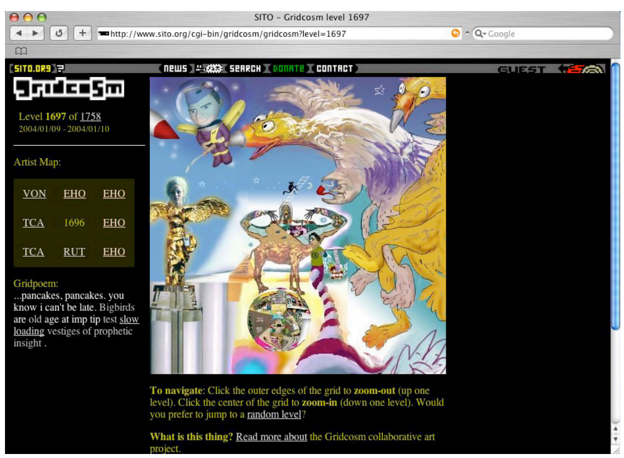

Figure 8: One Layer of Interaction in SITO/Gridcosm

The focus is on shaping a "*collaborative synchronicity*" (a concept close to the idea of a work practice in the business field) in which users interact and communicate both by expressing opinions about the community and their projects and by discussing the ongoing collaborative process (concepts, technical aspects, interaction rules, image creation and aesthetical issues, and suggestions for further developments) [Verle, 1999]. This allows the system and the supporting scripts to be modified by the power users [Nardi, 1993] of the community on the basis of *continuous feedback and suggestions*.

Table 3: Comparing Three Interactive Art Projects from a Meta-Design Perspective

	The Electronic Café (1984)	A-Volve (1997)	SITO Synergy (since 1993)
Design contributions of the users	Participation in system development and content generation (these two activities occur at different times)	Participation in content generation and algorithm instantiation (these two activities overlap)	Participation in content generation and manipulation; support of script development and modification; definition and negotiation of interaction rules (all these activities are continuous)
Capabilities of the users	Creation, storage and retrieval of texts, images and videos (both individual and collective)	Generation and modification of artificial life creatures, their behavior and evolution	Creation, elaboration, and completion of collective images
Empirical analysis	Users and artists collaborate both at design time and use time: seeding (data bank)	Users and artists collaborate both at design time and use time: seeding, evolutionary growth (artificial creatures)	Users/artists collaborate both at design time and use time: seeding, evolutionary growth, reseeding (images and interaction schemes)
Selection criteria	Early attempt; direct "encounter" between people and artists through the system	Interactive installation open to an "ordinary" audience; different layers of interaction and collaboration (creation, human-creature interaction, creature-creature interaction, and human-human interaction); *embeddedness*	Online community of art lovers; different layers of interaction and collaboration (content, rules, source); *situatedness*

5.2 Social Creativity

Complex design problems require more knowledge than any single person can possess, and the knowledge relevant to a problem is often distributed among all users, each of whom has a different perspective and background knowledge, thus providing the foundation for *social creativity* [Arias et al., 2000]. Bringing together different points of view and trying to create a shared understanding among all users can lead to new insights, new ideas, and new artifacts. Social creativity can be supported by innovative computer systems that allow all users to contribute to framing and solving these problems collaboratively. By giving all users a voice and empowering them to contribute, meta-design approaches are a prerequisite to bring social creativity alive.

Project complexity forces large and heterogeneous groups to work together on projects over long periods of time. The large and growing discrepancy between the amount of such relevant knowledge and the amount any one designer can remember imposes a limit on progress in design. For socio-technical systems to effectively support collaborative design, they must adequately address not only the problem situations, but also the collaborative activity surrounding the problem. By addressing real-world problems that are inherently ill-structured and ill-defined, systems must cope with problem contexts that change over time.

Providing *closed systems*, in which the essential functionality is fixed when the system is designed, is inadequate for coping with dynamic problem contexts. Providing *open systems* is an essential part of supporting collaborative design. By creating the opportunities to shape the systems, the owners of the problems can be involved in the formulation and evolution of those problems through the system. The challenge for these open systems is to provide opportunities for extension and modification that are appropriate for the people who need to make changes. The Envisionment and Discovery Collaboratory (see section 4.2), for example, supports social creativity by empowering users to act as designers.

5.3 Learning Communities

One of the most impoverished paradigms of education is a setting in which *"a single, all-knowing teacher tells or shows presumably unknowing learners something they presumably know nothing about"* [Bruner, 1996]. *Courses-as-seeds* [dePaula et al., 2001] is an educational model that explores *meta-design* in the context of university courses by creating a culture of informed participation [Brown et al., 1994]. It explores how to supplement community-based learning theories [Rogoff et al., 1998] with innovative collaborative technologies. Participants shift among the roles of learner, designer, and active contributor. The predominant mode of learning is peer-to-peer, and the teacher acts as a "guide on the side" (a meta-designer) rather than as a "sage on the stage."

Courses are conceptualized as *seeds* (see section 3.3 and [dePaula et al., 2001]), rather than as finished products, and students are viewed as informed participants who play active roles in defining the problems they investigate. The output of each course contributes to an evolving information space that is collaboratively designed by all course participants, past and present.

As in all meta-design activities, the meta-designer (i.e., the teacher) gives up some control; there is little room for micro-managed curricula and precise schedules. The courses-as-seeds model requires a mindset in which plans conceived at the beginning of the course do not determine the direction of learning but instead provide a resource for interpreting unanticipated situations that arise during the course [Suchman, 1987]. Examples of courses-as-seeds can be found at http://www.cs.colorado.edu/~gerhard/courses/.

5.4 Open Source

Open source development [Fischer et al., 2003; Raymond & Young, 2001; Scharff, 2002] is not *directly* applicable to end-user development because the users/domain designers in open source communities are highly sophisticated programmers. But there are many lessons to be learned in open source developments for meta-design, and the meta-design framework can in turn contribute to a better understanding of open source development by analyzing it as a *success model* for organizing large-scale distributed cooperative work [Resnick, 1994].

In open source development, a community of software developers collaboratively constructs systems to help solve problems of shared interest and for mutual benefit. The ability to change source code is an enabling condition for collaborative construction of software by changing software from a fixed entity that is produced and controlled by a closed group of designers to an open effort that allows a community to design collaboratively on the basis of their personal desires and following the framework provided by the seeding, evolutionary growth, and reseeding process model [Fischer & Ostwald, 2002]. Open source invites passive consumers to become active contributors [Fischer, 2002].

Open source development [Raymond & Young, 2001; Resnick, 1994; Scacchi, 2002; Scacchi, 2004] is an example of unselfconscious design because (1) the developers are the owners of problems, (2) they create software systems primarily for their specific needs, and (3) the software is personally meaningful and important. *Sharing and collaborating* is common in open source communities. People reuse the whole system developed by others by adapting the system to their own needs.

Using open source as a success model for collaborative design [Scharff, 2002], we have identified the following principles relevant to meta-design [Fischer et al., 2003]:

1. *Making changes must seem possible:* Users should not be intimidated and should not have the impression that they are incapable of making changes; the more users become convinced that changes are not as difficult as they think they are, the more they may be willing to participate.
2. *Changes must be technically feasible:* If a system is closed, then users cannot make any changes; as a necessary prerequisite, there needs to be possibilities for extension.
3. *Benefits must be perceived:* Contributors have to believe that what they get in return justifies the investment they make. The benefits perceived may vary and can include: professional benefits (helping for one's own work), social benefits (increased status in a community, possibilities for jobs), and personal benefits (engaging in fun activities).

4. *Open source environments must support tasks that people engage in:* The best open source system will not succeed if it is focused on activities that people do rarely or consider of marginal value.
5. *Low barriers must exist to sharing changes*: If sharing is awkward, it creates an unnecessary burden that participants are unwilling to overcome. Evolutionary growth is greatly accelerated in systems in which participants can share changes and keep track of multiple versions easily.

6 Findings and Challenges for the Future

This section provides some findings and challenges that can be seen as open questions for the future of end-user development: the tension between standardization and improvisation, and between being a consumer and/or a designer; ways of enabling co-creative processes and supporting meaningful activities as an issue of motivation and finally of technology appropriation; and the new design space defined by meta-design and its shifts from traditional design.

6.1 Standardization and Improvisation

Meta-design creates an inherent tension between standardization and improvisation. The SAP Info (July 2003, page 33) argues to reduce the number of customer modifications for the following reasons: *"every customer modification implies costs because it has to be maintained by the customer. Each time a support package is imported there is a risk that the customer modification my have to be adjusted or re-implemented. To reduce the costs of such on-going maintenance of customer-specific changes, one of the key targets during an upgrade should be to return to the SAP standard wherever this is possible".* Finding the right balance between standardization (which can suppress innovation and creativity) and improvisation (which can lead to a Babel of different and incompatible versions) has been noted as a challenge in open source environments in which forking has often led developers in different directions. The reseeding phase of the SER models tries to address this problem.

6.2 Consumers and Designers

Cultures are substantially defined by their media and their tools for thinking, working, learning, and collaborating. A great amount of new media is designed to see humans only as consumers [Fischer, 2002]. The importance of meta-design rests on the fundamental belief that humans (not all of them, not at all times, not in all contexts) want to be and act as designers in personally meaningful activities. Meta-design encourages users to be actively engaged in generating creative extensions to the artifacts given to them and has the potential to break down the strict counterproductive barriers between consumers and designers [Brown & Duguid, 2000].

Many computer users and designers today are domain professionals, competent practitioners, and discretionary users, and should not be considered as naïve users or "dummies." They worry about tasks, they are motivated to contribute and to create good products, they care about personal growth, and they want to have convivial tools that make them independent of "*high-tech scribes*" (whose role is defined by the fact that the world of computing is still too much separated into a population of elite scribes who can act as designers and a much larger population of intellectually disenfranchised computer phobes who are *forced* into consumer roles). The experience of having participated in the framing and solving of a problem or in the creation of an artifact makes a difference to those who are affected by the solution and therefore consider it personally meaningful and important.

A fundamental challenge for the next generation of computational media and new technologies is not to deliver predigested information to individuals, but to provide the opportunity and resources for social debate, discussion, and collaborative design. In many design activities, learning cannot be restricted to finding knowledge that is "out there." For most design problems (ranging from urban design to graphics design and software design, which we have studied over many years), the knowledge to understand, frame, and solve problems does not exist; rather, it is constructed and evolved during the process of solving these problems, exploiting the power of *"breakdowns"* [Fischer, 1994c; Schön, 1983]. From this perspective, *access* to existing information and knowledge (often seen as the major advance of new media) is a very limiting concept [Arias et al., 1999; Brown et al., 1994].

By arguing for the desirability of humans to be designers, we want to state explicitly that there is nothing wrong with being a consumer and that we can learn and enjoy many things in a consumer role (e.g., listening to a lecture, watching a tennis match, attending a concert, and admiring a piece of art). As argued in section 3.1, "consumer/designer" is not an attribute of a person, but a role assumed in a specific context. Good designers, for instance, should be well-informed consumers (e.g., they should exploit reuse as a powerful design strategy by "consuming" existing information and using the contributions of the "giants" who preceded them).

Meta-design creates the enabling conditions *"to engage the talent pool of the whole world"* [Raymond & Young, 2001]. Design engagement, from participation in planning to participation in continuous change (from do-it-yourself to adaptable environments), gives all the people access to the tools, resources, and power that have been jealously guarded prerogatives of the professional. The idea of a possible "design by all" always produces strong reactions in the field of professional designers, who perceive meta-design and end-user development as a challenge to their design expertise. The goal of making systems modifiable by users does not imply transferring the responsibility of good system design to the user. In general, "normal" users do not build tools of the quality that a professional designer would because users are not concerned with the tool per se, but in doing their work. Even so, professionalism is a particular kind of specialization, and specialization is the technique of production-line technology. As we develop new technologies, we need also to develop new roles and new images of ourselves.

Designers have to give up some control. Content creation in large information repositories must be *distributed*. This distribution can be supported by meta-design, as evidenced by digital libraries [Wright et al., 2002], the world-wide web, open source software [Scharff, 2002], and interactive art [Giaccardi, 2003]. Designers must engage in co-creative and evolutionary processes that enable people to design for themselves. To do so, meta-designers seed both the technical infrastructure and the social environment in which the system is embedded. Their goal of creating the technical and social conditions for collaborative design activities becomes as important as creating the artifact itself, and it requires attitude and capabilities. Meta-designers need to be good *systems integrators* [Kit Galloway, personal communication], able to actively interface a multiplicity of tools, services, and organizations, as well as good *facilitators*, capable of establishing collaborative relationships and using their own creativity to set the socio-technical environment in which other people can, in turn, be creative.

6.3 Enabling Co-Creation

In a world that is not predictable, and where solutions are neither given nor confined in one single mind, meta-design allows exploration of the collaborative dimension of human creativity. This produces a novel approach in the design of both interactive systems and their socio-technical environment that aims to include the emergent as an opportunity for evolution and innovation. Meta-design deals with *co-creation* [Giaccardi, 2003]. It enables and activates collaborative processes that allow the emergence of creative activities in open and evolvable environments.

The possibility for the user to transform from viewer to co-creator, or from consumer to co-designer requires [National-Research-Council, 2003] an expansion of the creative process in art and in design, respectively. Interactive art — and its networked practices in particular — explores the expansion of human creativity in terms of an expansion of the inter-subjective dimension, and deals primarily, although not exclusively, with feelings and emotions rather than with rational decision making.

A cross-case analysis of networked practices of interactive art shows that co-creation is perceived by users as an inter-subjective experience engendered by collaborative activities, which does not show necessarily any explicit goal. Main motivational paths to co-creation are emotionally driven and based on the perception of the environment as open and unpredictable. Computationally, such an environment enables co-creation by allowing two main techniques [Giaccardi, 2003]:

- ***Emotional seeding*** is based mainly on an exploitation of *non-verbal communication*. It takes place thanks to the visual embodiment of the emotional tone and activities of participants within the interactive system. The embodiment [Dourish, 2001] of participants in the computational environment, as engendered by emotional seeding, ensures that time, space, and physicality are experienced in relational, rather than merely informational, terms.

- ***Agency patterning*** is the setting of specific spatial-temporal parameters aimed to let dynamic agencies emerge from the system. It defines size, resolution, and level of the agency that is performing a global activity.

The attention paid by interactive art to the design of *relational settings and affective bodies* (that is, to the conditions and dynamics for mutual interaction) produces an understanding of the spatial-temporal parameters of an interactive system in terms of inter-subjective proximity and individuals' intentionality. That is, interactive art deals in terms of how "closely" people interact with each other, and how their intentions determine and recognize chains of actions and meaningful events, over time.

6.4 "Ease-of-Use" Revisited

"Ease-of-use" along with the "burden of learning something" are often used as arguments for why people will not engage in design. Building systems that support users to act as designers and not just as consumers is often less successful than the meta-designers have hoped for. A student in one of our courses reacted to our attempts to establish a meta-design culture as follows: "*Humans want things as easy as possible for them. The reason why we are a consumer society is because that's what we want to be."*

The end-user modifiability and end-user programming features themselves add even considerably more functionality to already very complex environments (such as high functionality applications and large software reuse libraries) — and our empirical analyses clearly show that not too many users of such systems are willing to engage in this additional learning effort. Beyond just defining them, extensions need to be integrated (stored, made retrievable, sustained) in the work environment. The answer to this challenging situation may be in the development of social structures around these systems such as *collaborative work practices* [Nardi, 1993; National-Research-Council, 2003].

Without the willingness to learn something, users remain trapped with *"over-specialized systems where operations are easy, but little of interest is possible"*(see section 1). Based on our work with user communities [Arias et al., 2000], it is obvious that serious working and learning do not have to be unpleasant — they can be empowering, engaging, and fun. Many times the problem is not that *programming is difficult, but that it is boring* (e.g., in cases where domain designers are forced to think and articulate themselves at the level of human-computer interaction rather than human problem-domain interaction; see Figure 5). Highly creative owners of problems struggle and learn tools that are useful to them, rather than believing in the alternative of "ease-of-use," which limits them to preprogrammed features [National-Research-Council, 2003].

Meta-design can tackle this learning problem in two different ways by paying attention to the following equation:

$$utility = value / effort,$$

meaning that people will decide on the worthiness of doing something (utility) by relating the (perceived) value of an activity to the (perceived) effort of doing it. In many design activities, the question to be asked is: "Who puts in the effort?" Often an important trade-off exists: *more effort at design time results in smaller effort at use time.* From a meta-design perspective, to create the structures that will empower users at use time and greatly reduce their endeavor, major efforts at design time are needed. However, *value consideration at design time* can induce an organization to put in the effort in order to establish a culture of "design in use" and produce "better" systems that: (1) more people will buy (*economic incentive*), or (2) more people will use (*social capital*).

At the same time, *value consideration at use time* is greatly influenced by allowing people to engage in personally meaningful tasks, and it can induce them to serious working and learning. People are willing to spend considerable effort on things that are important to them, so the value dimension for truly personal meaningful activities is more important than the effort dimension. For example, learning to drive an automobile is not an easy task, but almost all people learn it because they associate a high personal value with it.

6.5 Motivation and Rewards

The creation of new environments and the emergence of new social mindsets and expectations lead to succeeding waves of new technologies. Peer-to-peer (P2P) computing, open source, and extreme programming (XP), for instance, could be considered in software design as new developments mostly originating with user communities (i.e., P2P and open source) that reflect a shift of human motives and express the human desire to be in control of human destiny [Raymond & Young, 2001]. For an example in existing technology, we could consider the Internet, and describe the following *socio-technical upward spiral* [Giaccardi, 2003]: (1) exploitation of computational malleability and modifiability (e.g., the world-wide web); (2) shared design activities and reinterpretation for democratic purposes (e.g., online communities); or (3) the emergence of new social mindsets and expectations as a result of new environments.

What makes people, over time, become active contributors and designers and share their knowledge requires therefore a new "design culture", involving a mindset change and principles of social capital accumulation. But before new social mindsets and expectations emerge, users' active participation comes as a function of simple motivational mechanisms and activities considered personally meaningful.

One focus of meta-design is the design of the socio-technical environment in which the interactive system is embedded, and in which users are recognized and rewarded for their contributions and can accumulate social capital. *Social capital* is based on specific benefits that flow from the trust, reciprocity, information, and cooperation associated with social networks [Fischer et al., 2003; Florida, 2002; Putnam, 2000]. However, an *analysis* of co-creation, and a survey [Giaccardi, 2003] of the way in which some theories and practices of meta-design address the issue of motivation in relation to the new social relationships produced by emergent artificiality and increasing interconnectivity contribute to question the values plane associated with the design of socio-technical environments. Beside the consideration and evaluation of the specific benefits that can be associated with social networks, the "lasting value" of social capital can be conceptualized as a form of human creativity, and fundamentally based on inter-subjective relationships, feelings, and emotions. We assign importance through *value-feelings* that make us experience emotion only in regard to that which matters [Thompson, 1999]. *Emotions*, as value feelings, generate the world of our values, and enable us to "see" a situation that addresses us immediately, *here and now*, before deliberating rationally about it [Donaldson, 1991].

Meta-design enhances spontaneous and autonomous ways of relating and interacting, and in doing so it liberates processes of construction of reality that enable substantial participation and flexibility in the transformation of our environment. From this perspective, meta-design can be seen as *socio-technical know-how* [Giaccardi, 2003] embodied in the evolving practices of fluid and interdependent communities, rather than driven exclusively by explicit motivations and benefits. This orientation towards a co-creative framework matches those trends in socio-technical systems design, which — assuming a technological modifiability both at design and use time — call for attention to the relationships and interconnections occurring between the micro and macro levels of the socio-technical environment [Callon & Latour, 1981; Mumford, 1987]. It also matches the need for "non-targeted" design in a "shared infrastructure" scenario, where technologies (and we would add human and social systems, i.e., organizations) are heterogeneous, intertwined and interdependent [Pipek & Kahler, 2004].

6.6 The New Design Space of Meta-Design

Meta-design encompasses three levels of design, meant as a new "design space". These three levels of design can be summarized as: (1) *designing design*; (2) *designing together*; and (3) *designing the "in-between"*. Such levels of design refer to the field of meanings that the term meta-design has developed in the course of its various uses. They correspond, quite evidently, to the anticipatory, participatory, and socio-technical issues raised by meta-design, and highlighted in this chapter. We can think of the design space of meta-design as *a three-fold design space* [Giaccardi, 2003] aimed at integrating the design of (1) a technical infrastructure that is evolvable, (2) a learning environment and work organization that allows users to become active contributors, and (3) a socio-technical system in which users can relate and find motivations and rewards.

The **first level of meta-design** (*designing design*) refers to the concept of *higher-order design*, and the possibility of a malleability and modifiability of structures and processes, as provided by computational media. It can be seen as the ground for a design approach that focuses on general structures and processes, rather than on fixed objects and contents. Methodologically, this first level entails methods and techniques for designing at a meta-level (e.g., *underdesign*). It can be seen as the field where meta-designers play an important role in establishing the conditions that will allow users, in turn, to become designers. This first level of meta-design concerns the impossible task of fully anticipating at design time users' needs and tasks, situations and behaviours. The possibility of transforming and modifying components, contents, and even contexts by interacting with the system and adjusting it allows the user to respond to the deficit between what can be foreseen at design time and what emerges at use time. This non-anticipatory feature of meta-design is realized through principles of *end-user modifiability and programming* [Girgensohn, 1992; Lieberman, 2001] and *seeding mechanisms* [Fischer & Ostwald, 2002]. It provokes a creative and unplanned opportunism, which focuses on situated processes and emergent conditions, rather than on the anticipatory aspects of decision-making.

The **second level of meta-design** (*designing together*) is concerned with the way in which designers and users can *collaborate* on the design activity, both at design time and at use time. Methodologically, this second level provides participatory methods and techniques for letting users be involved in the initial setting stage at design time, and it relies on *critiquing methods and techniques* [Fischer et al., 1998] for enabling users to learn and become in turn designers at use time. It can be seen as the level at which designers and users play a fluid role in the collaborative design activity at different times and different planes of social interaction (i.e. from individual to communitarian). This second fold can be framed as a response to issues concerning the participation of the users in the design process due to the impossibility of completely anticipating users' needs and tasks at design time. Compared to traditional participatory approaches to design, meta-design represents an advance on the methodological level by supporting structural changes and co-evolutionary processes and transforming participation into a *participative status* [Dourish, 2001] of the user coupling with the system rather than as a way of increasing the probability a design will be used as intended.

The **third level of meta-design** (*designing the "in-between")* concerns the design of *relational settings and affective bodies*. It aims to support existing social networks, and to shape new ones. Both existing and novel social networks, though, are not simply determined by technology. Rather, they are a system of relationships that people experience and negotiate in relation to technology itself. From this perspective, technology is seen as "a trigger for structural change" or an intervention into the active relationship between people and their organisational structures that can alter roles and patterns of interaction [Dourish, 2001]. Within an interactive system conceived as a relational system, co-evolution takes place through reciprocal and recursive interactions [Maturana, 1997], whereas co-creation is triggered by the senses, emotions, and interactions of the users "embedded" and active within the computational environment [Giaccardi, 2003] and therefore capable of affecting and being affected ("affective bodies"). Methodologically, the third level of meta-design defines how co-evolutionary processes and co-creative behaviours can be sustained and empowered on the basis of the way in which people relate (both with the technical system and among themselves) within a computational environment. This level can be seen as a response to socio-technical issues. The design of the socio-technical system is neither only a matter of designing and adjusting technological artifacts in harmony with the people that will use that system, nor only a matter of understanding how to accumulate social capital. It is also a matter of methods and techniques to allow those sensing, emotioning, and "affective" activities (e.g., *emotional seeding and agency patterning*) that can sustain a condition of "inhabited technology" [Pipek & Kahler, 2004; Giaccardi, 2001b].

These three levels of meta-design are interdependent. They provide a *structural openness* given by computational malleability (first level of meta-design) corresponding to and integrated with an *interactive openness* [Stalder, 1997] given by collaborative (second level) and embodied (third level) relationships and activities. They can also be considered dimensions of meta-design, encompassing at different levels the cognitive (selfconscious vs. unselfconscious design), social (social creativity), computational (systems, environments), and methodological aspects relevant to meta-design, finally meant not only as a collaborative design activity, but also as a possible cultural strategy of technology appropriation according to which the "tool" is also a "place" [Pipek & Kahler, 2004; Giaccardi, 2001b]. Table 4 provides on overview of the different relationships.

Table 4: Overview of the Design Space for Meta-Design

	Levels of meta-design	Description of the level	Problem	Dimensions	Methods and techniques	
INTEGRATION	**First level of meta-design**	***Designing design:*** meta-designers play an important role in establishing the conditions that will allow users to become designers	***Anticipation:*** users' needs and task cannot be fully anticipated at design time (they are ill-defined and change over time)	Epistemological /Computational	***End-user development and seeding***: users transform, modify, and adjust systems to achieve greater fit between what can be foreseen at design time and what emerges at use time	STRUCTURAL OPENNESS
	Second level of meta-design	***Designing together:*** designers and users collaborate in the design activity, both at design time and at use time, and at different levels of social aggregation (as an individual, group, and/or community)	***Participation.*** Users need to be engaged in the problem framing/problem solving process both at design time and use time.	Social/ Cognitive	***Participatory design:*** users are involved in the initial setting stage at design time, while *critiquing and other support techniques* empower users to learn and become designers at use time	INTERACTIVE OPENNESS
	Third level of meta-design	***Designing the in-between:*** defines how co-evolutionary processes and co-creative behaviours can be sustained	***Socio-technical:*** Social and technical dimensions need to be integrated not only in order to be optimized and efficient, but to let new interactions and relationships emerge	Cognitive / Social	***Emotional seeding and agency patterning***: methods and techniques to allow sensing, emotioning, and "affective" activities among users	

7 Conclusions

Meta-design is not only a technical problem, it also requires new cultures and new mindsets. If the most important role of digital media in the future is to provide people with a powerful medium to express themselves and engage in personally meaningful activities, the medium should support them to work on the task, rather than require them to focus their intellectual resources on the medium itself. In this sense, computers are empowering artifacts: they are not only powerful tools, but also powerful *meta-tools* that can be used to create problem-specific tools. This empowerment, though, cannot be fully utilized until owners of problems are enabled "to retool". By putting the computational technology directly into the hands of owners of problems, meta-design is an important step to unleash the ultimate power of computer technology.

Meta-design is a conceptual framework informing a specific socio-technical methodology for end-user development, which includes design techniques (e.g., underdesign), process models (e.g., the SER model) and motivational mechanisms for communication, collaboration, and social capital accumulation (e.g., emotional seeding and reward structures). We have evaluated our approach in different settings, with different task domains, and with different users. Meta-design is a promising approach to overcome the limitations of closed systems and to support applications of informed participation and social creativity. However, it creates many fundamental challenges in the technical domain as well as in the social domain, including: (1) the tension between standardization and improvisation, (2) the additional efforts to integrate the work into the shared environment, (3) the willingness of users to engage in additional learning to become designers, (4) effective ways of supporting meaningful activities and enabling co-creation, (5) the need for social capital and technology appropriation, and (6) the need for a new, integrated design space that brings together the design of both technical and social conditions.

Meta-design allows a sort of creative and unplanned opportunism [Wood, 2000], and it addresses one of the fundamental challenges of a knowledge society [Florida, 2002]: to invent and design a culture in which all participants in a collaborative design process can express themselves and engage in personally meaningful activities. End-user development requires a change in mindsets and cultures — people who *want to be active contributors and designers, not just consumers.* If we achieve this culture and mindset change and we provide people with the right computational environments, then we will have a chance to make one of the most challenging and exciting research topics a reality!

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