Creativity and Evolution: A Metadesign Perspective

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Abstract

In a world that is not predictable, improvisation and evolution 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 making it an opportunity for more creative and more sustainable solutions. User-centered and participatory design approaches have focused primarily on activities taking place at design time. These approaches have not given enough emphasis and they have provided few mechanisms to support systems as living entities that can evolve over time. Metadesign is a unique design approach concerned with opening up solution spaces rather than complete solutions (hence the prefix meta-), and aimed at creating social and technical infrastructures in which new forms of collaborative design can take place. This approach extends the traditional notion of design beyond the original development of a system to include co-adaptive processes between users and systems that enable the users to act as designers in personally meaningful activities and be creative.

Keywords

Metadesign, open systems, engagement, creativity, evolution

Introduction

Design is generally conceived as the conception and planning of the artificial: a normative form of science in contrast to natural sciences ("how things ought to be" versus "how things are") (Simon 1996). Today, however, design is also characterized as a humanistic enterprise in which the subject matter is not fixed (Buchanan & Margolin 1995): an inquiry and experimentation in the activity of making ("how things might be"), which is meant to envision and elaborate possibilities in order to allow people to experience the world in greater and richer ways (Maturana 1997).

In the context of such a design discourse, and related design methodologies (Cross 1984), the idea of metadesign proposed in this article originates inside a linguistic inheritance and intellectual debate calling for a democratization of the creative process of invention, and leading to a strong sense of design as a "change of place, order, or nature"—matching ideas of design as improvisation, modification, and evolution (Giaccardi 2005).

It is our belief that improvisation and evolution are more than a luxury: in a world that is not predictable (Suchman 1987), they are a necessity. The challenge of design is not a matter of getting rid of the emergent, but rather of making it an opportunity for more creative and more sustainable solutions.

In the attempt to create more adequate solutions, *user-centered* and *participatory design* approaches have focused primarily on activities taking place at design time, and have given little emphasis and provided few mechanisms to support systems as living entities that can evolve over time. Our *metadesign* approach, on the contrary, is concerned with opening up solution spaces rather than complete solutions (hence the prefix meta-). The challenge is to create social and technical infrastructures that enable users to cope with the emergent aspects of reality and allow them, when needed and desired, to *act as designers and be creative* (Fischer & Giaccardi 2006). We advocate metadesign as a unique design approach in which new forms of *collaborative design* can take place by redistributing design activities over time and at different levels of interaction with the environment.

This article highlights the relationships between creativity and evolution in our conceptual framework, stressing the role of situated actions and emergent opportunities in the creative evolution of our socio-technical environments. The first part of the article is more theoretical and describes our conceptual framework. The second part provides an overview of the methods, techniques, and support mechanisms that we have identified and used to strengthen the link between creativity and evolution that is fundamental to metadesign. In this second part, examples are drawn from system-building activities and studies in open source development and digital arts conducted at the Center for Lifelong Learning & Design (L3D) over the last two decades.

Foundational Concepts for Metadesign

Metadesign supports improvisation and change to fit the new needs and opportunities that arise during the use of artefacts. In doing so, metadesign addresses critical design challenges, including:

- *Coping with Ill-Defined Problems.* Complex design problems are ill-defined (Rittel & Webber 1984). Because they are not understood well enough to be described in sufficient detail, they cannot be specified accurately in advance, and systems cannot be built faultlessly. The integration of problem framing and problem solving is vital to design and cannot be delegated (e.g., from users to professionals).

- *Supporting Reflective Practitioners.* Schön characterizes design as a reflective conversation with the materials of the design situation (Schön 1983). Designers gradually build their understanding of a design problem and its solution by thinking about what they are doing while doing it, in such a way as to influence further "doing". Being able to create and arrange over time the materials of the design situation is crucial to reveal new opportunities and envision emergent possibilities.

- *Design as a Collaborative Process.* Complex design problems require more knowledge than any single person can possess, and the knowledge relevant to a problem is often distributed among stakeholders with different perspectives and backgrounds (Salomon 1993). Bringing together individuals with different knowledge, abilities, and motivations is critical to generating more creative and sustainable solutions.

In summary, users' situations and needs cannot be fully anticipated because they are ill-defined and change over time. Users need to be engaged in problem framing and problem solving both when the system is designed *and* when the system is used (Fischer 2002). Moreover, keeping the system open to the contributions of diverse individuals is essential to support unplanned and even subversive uses that may lead to more creative and sustainable results. In a world in which solutions are neither given nor confined in one single mind (Bennis & Biederman 1997), the possibility for users to act as owners of problems and migrate from consumers to designers provides the foundation for an *unselfconscious culture of design* (Alexander 1964). In such a culture, inadequacies or unexpected opportunities lead spontaneously to an action to change or improve the system.

Design Time and Use Time

In conventional design approaches, two basic stages can be differentiated: *design time* and *use time*. At design time, with or without user involvement, designers and developers create complete systems for the world as they envision it (the *world-as-imagined*). At use time, users utilize the system; but because their needs, objectives, and contexts can be anticipated only partially at design time (Suchman 1987), the system often requires modification to fit the users' needs (Nardi & O'Day 1999).

In our framework, systems are not completely designed prior to use: users can directly experience their own world (the *world-as-experienced*) and accommodate unexpected issues at use time. Metadesign is fundamentally different from creating complete systems: rather than developing complete solutions, it means developing socio-technical environments that allow users to create the solutions themselves. *It is not less design, but a different kind of design.*

Metadesign is an emerging conceptual framework aimed at defining and creating social and technical infrastructures in which new forms of *collaborative design* can take place by redistributing design activities at different times and levels of interaction with the environment. In contrast, user-centered and participatory design approaches have focused primarily on activities and processes taking place at design time, and have given little emphasis and provided few mechanisms to support systems as living entities that can evolve over time. In *user-centered design* (Norman & Draper 1986), designers generate solutions that place users mainly in a reactive role. In *participatory design* (Schuler & Namioka 1993), designers seek to involve users more deeply in the process, as co-designers. But the focus remains on design time, when designers and users are brought together to envision future contexts of use, and users are empowered to propose and generate design alternatives themselves.

Despite the best efforts at design time, systems need to be evolvable to fit emergent needs, account for changing tasks, and couple with the domain in which users are situated (Fischer 1998). Metadesign shares some important objectives with user-centered and participatory design approaches, but it transcends them in several important dimensions. For example, metadesign creates *open systems* that can be modified by their users and evolve at use time, supporting more complex interactions. This changes the processes by which systems and content are designed and *intentionally* shifts some control from designers to users, enabling users to create and contribute their own visions and objectives, keeping the world and the system in sync.

The Art of Open Systems

Environments supporting creativity and evolution need to be *open systems*—allowing users to modify contents and functionalities as they use the system to solve problems. Open systems provide opportunities for significant changes to the system at all levels. Over the years, our research has identified the following principles for the development of open systems (Fischer 1998):

- *Software systems must evolve; they cannot be completely designed prior to use.* Designers and developers cannot anticipate and plan for every possible situation. To apply to different circumstances and facilitate the construction of new situations, systems must be conceptualized as seeds (described later in this article).

- *Systems must be designed for evolution*. Extending an application in an initially closed design is difficult because of the assumptions implicit in a system designed without extension in mind. Designing a system for evolution from the ground up can provide a context in which change is expected and can take place.

- *Systems must evolve at the hands of the users.* Giving users the ability to change the system as they explore their problem space provides insights that are unique to those experiencing the problems.

- *Evolution of systems must take place in a distributed manner*. Users are distributed in space, in time, and across different conceptual spaces (*i.e.*, with different backgrounds and perspectives). This distribution is fruitful to create opportunities for evolution and generate more creative and sustainable solutions (Fischer 2005).

A Multidimensional Design Space

In an open system, redistributing design activities between design time and use time encompasses a *multidimensional design space* (Giaccardi 2004), comprising three interdependent planes of design that can be summarized as follows:

- **Designing Design**
  This plane of design supports the modifiability of computational structures and the malleability of social infrastructures. It entails *anticipatory methods and techniques* for the design of the design process. At this level, metadesigners must anticipate both users' needs (to some extent) and provide for the potential changes that may occur at use time. Metadesigners play an important role in setting the conditions that will allow users in turn to become designers and in creating a good *seed* (described later in this paper; see also: Fogli & Giaccardi 2007); the possibility of modifying the system that is provided at this level must allow users to respond to the mismatch between what can be foreseen at design time and what will emerge at use time.

- **Designing Together**
  This plane of design defines the way in which metadesigners and users can participate together in the design activity. It entails *participative methods and techniques* for the metadesigners to let the users be involved in the initial setting at design time, and related support mechanisms (such as *critics* and *reuse*, described later in the article) to enable users to learn and in turn become active contributors and eventually designers at use time. At this level, metadesigners and users play a fluid role in collaborative design, being able to intervene at different times and levels of social interaction (*i.e.*, as an individual or a community).

- **Designing the In-Between**
  This plane of design defines how people can experience and negotiate their relationships and socially engage in meaningful activities. It entails *affective*

methods and techniques (such as the use of *mediators* and related support mechanisms, described later in this article) aimed at supporting and facilitating sensorial and emotional responses and sustaining users' engagement in collaborative practices. At this level, users' interactions with the socio-technical environment are crucial in opening up the system to unintended and creative uses.

Creativity and Evolution in the Metadesign Framework

Given the outlined conceptual framework, how are creativity and evolution linked in metadesign? How can this link be sustained and promoted?

In the analysis of the relationships between creativity and evolution, it has been emphasized that in order to support *open-ended and creative evolution* it is fundamental for individuals to be part of the environment experienced by other individuals (Arthur 1994; Taylor 2002). According to Taylor, the "fundamentally new" of an open-ended and creative evolution refers to "the ability of individuals to interact with their environment […] with few restrictions and to evolve mechanisms for sensing new aspects of this environment and for interacting with it in new ways" (Taylor 2002, p. 81). The embodiment and richness of interactions that will lead individuals to the ability to perform new tasks are crucial. In our socio-technical environments, we share this belief by promoting *situated processes and emergent opportunities* (Fischer & Giaccardi 2006), and supporting users' *engagement and sustained participation* (Fogli & Giaccardi 2007) in the socio-technical environment. This section provides an understanding of evolution and creativity in the metadesign framework; methods, techniques, and support mechanisms are detailed in the following sections.

The open systems created by metadesign link creativity and evolution in that they: (a) *promote the transcendence of the individual mind* by supporting the differences in knowledge, abilities, and motivations that exist among users; (b) *support sustained participation* by facilitating users' engagement in personally meaningful activities; and (c) *enable the mutual adaptation and continuous evolution of users and systems* by allowing users to evolve new ways of interacting with the socio-technical environment and enabling systems to adapt to users' changing needs and practices.

Transcending the Individual Mind. In a world in which solutions are neither given nor confined in one single mind, we need to expand the creative process beyond the individual mind (Arias et al. 2000; Fischer 2006). The *distribution* of different knowledge, abilities, and motivations that exist in individuals is critical for users to engage in personally meaningful activities, to collaborate, and to evolve (Fischer & Giaccardi 2007). A good example is the development of open source software (Raymond & Young 2001), in which the sharing of source code allows others to go forward, whereas the original developer cannot or does not go further due to reasons such as loss of interest, time constraints, or a lack of new ideas. Another good example involves creative practices such as art and technology collaboration (Mitchell et al. 2003), the results of which supersede

what a single artist or computer scientist could have done in isolation. Environments for mass collaboration and social production (Tapscott & Williams 2006), such as annotated collections (GenBank), media sharing (Flickr and YouTube), wikis (Wikipedia), folksonomies (del.icio.us), and virtual worlds (Second Life) are other good examples of how the diverse and collective stock of scientific content and artistic or stylistic ideas that individuals and communities share, re-interpret, and use as a basis for new ideas and visions constitutes the vital source of creativity and evolution.

Engaging in Meaningful Activities. Users need to be able to express themselves and engage in personally meaningful activities to act as designers and be creative. To do so, they need to be actively engaged in the system of social and material relationships provided by the socio-technical environment. In relation to this engagement, we have adopted the notion of *co-creation* (Giaccardi 2004; Candy & Edmonds 2002). Co-creation has to do with the collaborative construction of personally meaningful artefacts and activities, and is enabled by the users' capability to share emotions, experiences, and representations with or without any central guidance towards specific objectives or determined strategies. Good examples are distributed systems for visual interaction in the arts (Wilson 2002). These systems usually enable a large number of people to participate in the emergence of an ephemeral visual narrative. The association of each participant with individual local images, strokes, or colours—and their mutual interactions—produce a global narrative in which figurative elements, meanings, and stories emerge and change over time through a process reminiscent of children looking at clouds.

Coping with Experience. Users also need to be able to cope with experience and evolve new ways of interacting with the environment. The evolution of a socio-technical environment is conceived in the metadesign framework as the evolution of a living entity. In our research, we have carefully analyzed why simulation environments such as SimCity, for example, 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 already 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. To support the desired *co-evolution* (Fischer 1998), it is vital to extend the traditional notion of design beyond the original development of the system and include a co-adaptive process between users and a socio-technical environment in which not only users change by using the system, but also the system changes at the hand of the users.

In order to pursue these objectives and promote the link between creativity and evolution in metadesign, we have defined and developed an initial set of methods and support mechanisms according to the schema shown in Table 1.

Table 1: Creativity and Evolution in the Metadesign Framework

Objective	Method	Support Mechanism
Distribution	Externalizations	Critiquing
Co-creation	Mediators	Affect
Co-evolution	Seeds	Reuse

We anticipate this set will continue to grow as we improve our understanding through further development and assessment.

Need for Externalizations, Mediators, and Seeds

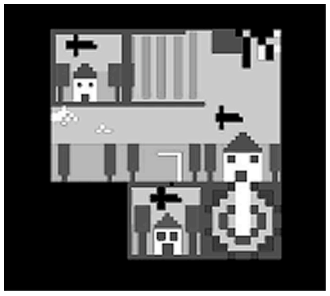
Externalizations. *Externalizations* (Bruner 1996) are one aspect in particular that we have explored to support users in expressing their tacit knowledge, communicating and coordinating their various perspectives, and eventually activating information relevant to the task at hand. Externalizations are essential to participation and to the performance of users' *distributed mind* (Salomon 1993) in that they assist in translating vague mental conceptualizations of ideas into more concrete representations, and provide a means for users to interact with, react to, negotiate around, and build upon ideas. Externalizations focus discussions upon relevant aspects of framing and understanding the problem being studied, thereby providing a concrete ground and a common language among users. For example, L3D has developed a three-dimensional (3D) sketching pen for the *Envisionment and Discovery Collaboratory* (EDC), an environment based on tabletop technology that allows users to collaboratively frame and solve problems of mutual interest (Arias et al. 2000).

Figure 1: 3D Sketching in the Envisionment and Discovery Collaboratory (EDC) allows revealing hidden assumptions and implications of the design situation.

Along with the basic sketching capability of this pen is the ability provided by the EDC to view these representations in 3D space and enhance the visibility of user intentions as well as the implications of their actions on the design situation (Figure 1). The domains explored in the EDC, such as land management, urban planning, and building design, are all examples of open-ended social problems. In these contexts, solutions cannot be optimal, but only more or less sustainable, depending on the participation of diverse stakeholders.

Mediators. *Mediators* (Giaccardi 2006) are one aspect we have explored to facilitate users' engagement in the co-creation of personally meaningful activities. Mediators are classes of environment excitations dynamically generated over the course of the interaction by the interplay between affordances and externalizations, that is, between the capabilities of the tools available for interaction and the individual representations that users produce during the process of interaction. Mediators affect participants' emotional tone and provide a social and dynamic

context for the emergence of meaningful activities. Unlike externalizations (which represent the product of one individual's perception of the external world), mediators are generated over the course of interaction as a result of users' mutual perceptions and actions. For example, in the distributed applications for visual interaction previously mentioned, mediators are the pattern of lines and strokes, the combination of colours, or the set of figurative elements that are generated and continuously modified by the overall drawing activity of the users. The spatial, chromatic, or narrative relationships that these structures identify on the shared canvas elicit the users' flow of emotions, levels of engagement, and modes of conduct, and ultimately facilitate or inhibit the emergence of meaningful images (Figure 2).


(a)

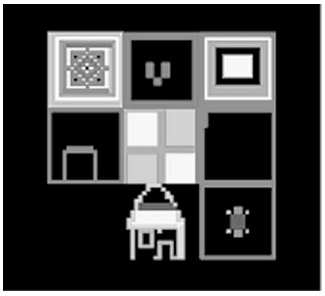

(b)

Figure 2: Olivier Auber, Poietic Generator, http://poietic-generator.net/ (*accessed 26 November 2007). Different kinds of space configurations (a) facilitate or (b) inhibit the emergence of meaningful images on the shared canvas.*

Seeds. Conceiving and designing our socio-technical environments as *seeds* (Fischer & Ostwald 2002) is the aspect we have explored to support the mutual adaptation and continuous evolution of users and systems over time. In our metadesign framework, a seed is not a template or a design schema. Rather, it is a piece of knowledge, content, or code that can be fundamentally created, evolved, and recombined by means of mechanisms that allow its sharing and modification. Seeds keep the system open to be adapted to emerging needs and situations. For example, the Memory Aiding Prompting System (MAPS) is a system that has been developed at L3D with the goal of supporting people with cognitive disabilities and their support communities of caregivers in everyday life (Carmien 2007). Because the challenge of such an objective is to create tools flexible enough to adapt to the unique needs of people with cognitive disabilities, MAPS has been conceptualized and designed as a seed. It provides a simple prompting system for individuals with cognitive disabilities, along with an editing tool that allows caregivers to design their own prompting scripts (for example, reminding the person with cognitive disabilities how to reach the workplace). In this way, caregivers can directly create, share, and modify scripts while the individuals with cognitive disabilities and the system co-evolve: the users develop new ways of interacting with their environment and the system adapts to users' changing needs and practices (Figure 3).

Figure 3: A user with cognitive disabilities takes the bus on her own and goes to the recreational centre, developing a more independent way of living.

Support Mechanisms for Critiquing, Reuse, and Affect

While using a system, users will discover mismatches between their needs and the support that an existing system can provide for them, in terms of both failures and opportunities. These mismatches will lead to breakdowns and serve as potential sources of new insights, new understanding, and new knowledge (Fischer 1994). *Critiquing* and *reuse* are mechanisms aimed at supporting transcendence of the individual mind and allowing users to cope with their emergent needs and practices. They highlight constraints and potential failures (*critiquing*), provide new opportunities for interaction (*reuse*), and promote the overall co-evolution of users and systems. Equally important, *affective mechanisms* allow users to express themselves and socially engage in the co-creation of meaningful artefacts and activities.

Critiquing. Computational critiquing mechanisms, or *critics* (Fischer et al. 1998), are generally embedded into the software system. They instantiate and transcend Schön's theory of design (Schön 1983); they support *reflection-in-action* and increase the *back-talk* of the design situation, which in Schön's framework is determined solely by an individual designers' skills and experience. At L3D, we have explored the application of critics in a number of specific applications, and in particular in the context of *domain-oriented design environments* (Fischer et al. 1998). Domain-oriented design environments are systems that transcend the limits of the activities envisioned by the developer of a design environment by supporting the integration of construction and argumentation. They provide information repositories to store and share domain knowledge, and allow designers to accumulate additional knowledge through interaction with the environment. This is made possible by computational critiquing mechanisms, which analyze an artefact under construction, signal breakdown situations to the designer, and

provide entry points to the space of argumentation directly relevant to the design situation.

Hydra (Fischer et al. 1998), for example, is a domain-oriented design environment for kitchen design developed at L3D. In this environment, critics not only reflect knowledge that applies to all designs, such as accepted standards, building codes, and domain knowledge based on physical principles, but also *externalize* design knowledge that is tied to the specific characteristics of the actual design situation. Moreover, critics support design as an interpretive process by allowing designers to interpret the situation from different perspectives according to their interests. In a perspective concerned with resale value, for instance, critics about where the dishwasher and sink might be placed are redefined, and the designer will be informed whenever a feature that would negatively affect resale value is detected.

Reuse. *Reuse* (Ye & Fischer 2002) provides the opportunity to exchange and manipulate seeds. We can find good examples in both digital arts and open source software development. A peculiar example of reuse is, for example, *Face Poiesis*, an art system by Japanese artists Toshihiro Anzai and Rieko Nakamura. By means of an original painting system, the two artists compose faces by mixing features (such as face shapes, hair, lips, eyes, and other traits) from faces previously created by the artists themselves. The idea is to create a pool of arbitrary individual pieces called *pixema* (seeds in our context), which can be freely identified and exchanged in order to synthesize new paintings (Figure 4 and Figure 5). The results are unexpected and surpass what one single artist might have produced in isolation.

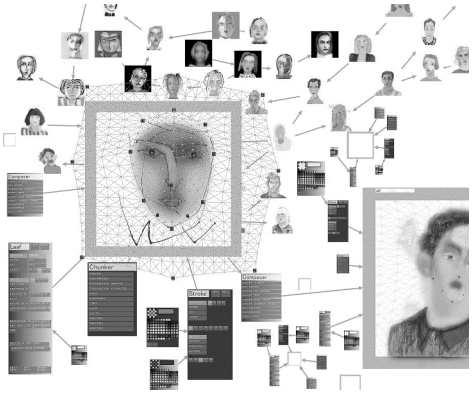


Figure 4 and Figure 5: Toshihiro Anzai and Rieko Nakamura, Face Poiesis, http://www.renga.com (accessed 26 November 2007). Arbitrary features are identified and exchanged in order to synthesize new faces.

Another example of reuse is *CodeBroker* (Ye & Fischer 2002), an active component repository system for Java programmers developed at L3D. *CodeBroker* monitors a software developer's programming activity, infers the developer's immediate programming task by analyzing semantic and syntactic information contained in his or her working products, and actively delivers task-relevant and personalized reusable parts from a reuse repository created by decomposing existing software systems. *CodeBroker* conceptualizes software as a

seed. When the seed is distributed and shared by other interested users and software developers, users and software developers are able to interact with the system and use it creatively in more situations than the original developer had intended.

Affect. *Affective mechanisms* support mutual interaction, facilitating users' active engagement into the socio-technical environment (Giaccardi 2006a). One specific example of an affective mechanism is *emotional tuning*, which facilitates the arousal of an interaction's emotional tone. Emotional tuning enables users to experience the temporal and spatial features of the environment in which they are interacting in terms of proximity (or intimacy) and intentionality; that is, in terms of how "closely" users interact with each other in the information space, and how users' chains of actions can be consistently interpreted as intentions and lead over time to meaningful events. Interesting examples of emotional tuning can be found in the digital arts. As an example, *Open Studio* is a Java-based drawing system by Andy Deck that concurrently links up users to a single pictorial interface, and allows them to participate in the creation of a graphic animation. In *Open Studio*, the drawing tools have been designed to be expressive of users' movements, reacting to the different speeds, directions, and curves of their physical gestures. The visual behaviour expressed by the bodily quality of the strokes, marks, and colours drawn by users on the shared canvas affects users' emotions and intentions, influences the overall emotional tone of the interaction, and consequently encourages or discourages the emergence of meaningful visual narratives (Figure 6). Examples of affective mechanisms in larger and more complex socio-technical environments are described elsewhere (Giaccardi 2006b; Giaccardi 2007).

(a)

(b)

Figure 6: Andy Deck, Open Studio, http://artcontext.org/draw/ (accessed 26 November 2007). Different qualities of strokes and marks influence the emotional tone of the interaction, (a) encouraging or (b) discouraging the emergence of visual narratives.

Conclusions

This article has focused on the co-creative and co-evolutionary aspects of the metadesign framework. It has provided concepts, methods, and support mechanisms to link creativity and evolution in collaborative design, drawing examples from the studies and design activities pursued at the Center for LifeLong Learning and Design (L3D) over the last two decades. This work strengthens the relationships among open systems, creativity, and evolution in an attempt to

promote and advance a coherent conceptual and methodological framework of metadesign. Of course, to make metadesign more ubiquitous, the forces that prohibit or hinder creativity and evolution must be understood and addressed. Examples of such forces are: (a) the resistance to change, because metadesign requires learning efforts and may create unknown difficulties and pressures; (b) the problem of premature standards in technological development; (c) the difficulties created by installed bases and legacy systems within existing organizations; and (d) the issue of who are the beneficiaries versus who is doing the work in order for evolution to occur. An understanding of the related organizational issues, and the more complex social, cultural, and ethical issues entailed by these problems will provide a better framework for their solution and for the further advance of metadesign.

Acknowledgments

A previous version of this article was presented at the 6th International Conference of the European Academy of Design (EAD06) in 2005. The authors thank the members of the Center for LifeLong Learning & Design at the University of Colorado, who have made major contributions to the conceptual framework described in this article. This research was supported by: (1) the National Science Foundation grants REC-0106976, CCR-0204277, and IIS-0613638; (2) SRA Key Technology Laboratory, Inc., Tokyo, Japan; (3) the Coleman Institute, Boulder, Colorado, USA; and (4) Fondazione Eni Enrico Mattei, Milan, Italy.

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