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Beyond Binary Choices: Integrating Individual and Social Creativity

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Abstract:

The power of the unaided individual mind is highly overrated. Although society often thinks of creative individuals as working in isolation, intelligence and creativity result in large part from interaction and collaboration with other individuals. Much human creativity is social, arising from activities that take place in a context in which interaction with other people and the artifacts that embody collective knowledge are essential contributors.

This paper examines: (1) how individual and social creativity can be integrated by means of proper collaboration models and tools supporting distributed cognition; (2) how the creation of shareable externalizations ("boundary objects") and the adoption of evolutionary process models in the construction of meta-design environments can enhance creativity and support spontaneous design activities ("unselfconscious cultures of design"); and (3) how a new design competence is emerging—one that requires passage from individual creative actions to synergetic activities, from the reflective practitioner to reflective communities, and from given tasks to personally meaningful activities. The paper offers examples in the context of collaborative design and art practice, including urban planning, interactive art, and open source. In the effort to draw a viable path "beyond binary choices", the paper points out some major challenges for the next generation of socio-technical environments to further increase the integration of individual and social creativity.

Keywords:

Collaborative design; individual creativity; social creativity; collaboration models; distributed cognition; boundary objects; Seeding, Evolutionary Growth, Reseeding (SER) process model; meta-design; Envisionment and Discovery Collaboratory (EDC); Caretta; Renga; CodeBroker; interactive art; open source; software reuse; reflective communities; socio-technical systems; unselfconscious cultures of design.

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1. Introduction

"The strength of the wolf is in the pack,
and the strength of the pack is in the wolf."
Rudyard Kipling

This paper analyzes the relationship between individual and social creativity. In many arguments and writings, Rodin's sculpture *The Thinker* dominates our collective imagination as the purest form of human inquiry: the lone, stoic thinker. Most perceptions of creativity have focused on this image of the solitary process [John-Steiner, 2000]. The analysis of creative people and creative objects, however, has demonstrated that most scientific and artistic innovations emerge from joint thinking, passionate conversations, and shared struggles among different people, emphasizing the importance of the social dimension of creativity.

Human interaction is not only needed but central to social creativity; however, people participate in such collaborative inquiry and creation as individuals, and individuals need the reflection time depicted by Rodin's sculpture. Without such individual reflection, it is difficult to think about contributions to social inquiry or creativity. Kipling's wolf quote above indicates that there is an *"and"* rather than a *"versus"* relationship between individual and social creativity. Social creativity does not necessitate the development of environments in which the interests of the many inevitably supersede those of the individual. Individuality makes a difference, and organizations get their strength to a large extent from the creativity and engagement of their individual members. In addition, appropriate socio-technical settings can amplify the outcome of a group of creative people by both augmenting individual creativity and multiplying it rather than simply summing up individual creativity. In social creativity settings, people may be separated by space, by time, by living in different conceptual worlds, and by interacting with technologies; rather than limiting creativity, however, these distances can serve to enhance creativity [Fischer, 2004]. Social creativity, which exhibits a "distributed" nature [Harrington, 1990], is the product of different shaping forces: the individual; the mix among individuals (the distinctive interests, skills, and knowledge that compose specific communities); and the interactions between them and their social and technical environment at large [Mockros & Csikszentmihályi, 1999].

We have studied creativity in the context of collaborative design and art practice, including urban planning, interactive art, and open source, and we have developed conceptual frameworks to understand and support creativity. This paper describes socio-technical environments that we have developed and studied in different design areas to facilitate and support the integration of individual and social creativity by exploring fully the distributed nature of collaboration. Further, the paper discusses some of the lessons learned in our research efforts.

2. The Nature of Creativity

Creativity is often associated with ideas and discoveries that are fundamentally novel with respect to the whole of human history (*historical creativity*). Creativity, however, also happens in daily real problem-solving activities, and not only in research labs or art studios as exceptional events. We are primarily concerned here with ideas and discoveries in everyday work practice that are novel with respect to an individual human mind or social community (*psychological creativity*) [Boden, 1991]—a capacity inherent to varying degrees in all people, and needed in most problem-solving situations.

Analyzing the contributions of outstanding creative people [Gardner, 1993] helps to establish a framework for creativity, but understanding creativity in the context of everyday activities is equally important for people to create better work products. The analysis of everyday design practices [Rogoff & Lave, 1984] has shown that knowledge workers and designers have to engage in creative activities to cope with the unforeseen complexities of real-world tasks.

We argue that the nature of creativity has four essential pieces: (1) originality, (2) expression, (3) social evaluation, and (4) social appreciation within a community. *Originality* means people having unique ideas (mostly in the realm of *psychological creativity)* or applying existing ideas to new contexts. These ideas or new applications are of little use if they are only internalized; they need to be *expressed and externalized* so that *social evaluation* can take place wherein other people (with different backgrounds and perspectives) can understand, reflect upon, and improve them. Last, s*ocial appreciation* refers to the effects of social rewards, credits, and acknowledgements by others (e.g., reward structures such as in a gift economy and a market economy) that motivate (or thwart) further creative activities [Fischer et al., 2004].

2.1. Individual Creativity

Creative individuals can make a huge difference, as analyzed and shown by Gardner [Gardner, 1995] in exemplary cases, such as movie directors, champions of sports teams, and leading scientists and politicians. Individual creativity comes from the unique perspective that the individual brings to bear in the current problem or situation. It is the gestalt result of the life experience, culture, education, and background knowledge that the individual has, as well as the personal meaningfulness that the individual finds in the current situation. Creative actions obviously cannot be planned actions; rather, they can only be situated actions, after reflecting upon the situational talk-back of the environments, either technical or social. In this sense, individual creativity can be greatly enhanced by providing appropriate socio-technical settings. However, despite the inherent social aspect of creativity, individual knowledge, imagination, inspiration and innovation are the bases for social creativity; without inspirational sparks from the individual, social creativity simply has no chance to flare up in the first place. Augmenting and then better utilizing individual creativity is thus essential for achieving social creativity.

2.2. Social Creativity

"Great discoveries and improvements invariably involve the cooperation of many minds!"— Alexander Graham Bell

The power of the unaided individual mind is highly overrated [John-Steiner, 2000; Salomon, 1993]. As argued above, although creative individuals [Gardner, 1995; Sternberg, 1988] are often thought of as working in isolation, much of our intelligence and creativity results from interaction and collaboration with other individuals [Csikszentmihályi & Sawyer, 1995]. Creative activity grows out of the relationship between an individual and the world of his or her work, as well as from the ties between an individual and other human beings [Fischer et al., 1998; Gardner, 1995]. Much human creativity arises from activities that take place in a social context in which interactions with other people and the artifacts that embody group knowledge are important contributors to the process. Creativity does not happen inside a person's head, but in the interaction between a person's thoughts and a socio-cultural context [Engeström, 2001].

To support social creativity, situations need to be sufficiently *open-ended* and *complex* that users will encounter new, unpredictable conditions, and will eventually experience *breakdowns* [Schön, 1983]. As any professional designer knows, breakdowns—although at times costly and painful—offer unique opportunities for reflection and learning, underscoring the importance of the back-talk of situations [Fischer et al., 1998].

Another form of social creativity is *co-creation* [Giaccardi, 2004], defined here as the process leading to the emergence and sharing of creative activities and meanings in a socio-technical environment. Co-creation is a situated experience, usually engendered by a combination of synchronization and improvisation [Nonaka & Konno, 1998], and supported by enabling users in the socio-technical environment to share emotions, experiences, and representations. Co-creation is particularly important for the design of systems exhibiting purposes, but not explicit goals (such as in the case of art and loose social systems). To support both the individual and the social aspects of creativity, as well as the interplay between them, co-creation may take on different forms, such as (1) *serial*: creating something (perhaps in isolation) that is then brought into the social venue so that others can build upon it (either in the social context or in isolation); (2)

parallel: separately creating elements that are then brought together and combined into something new; (3) *simultaneous*: jointly creating something at the same time.

3. Frameworks for Creativity

Our work is grounded in the basic belief that there is an *"and"* and not a *"versus"* relationship between individual and social creativity. Creativity is an interactional process occurring in the relationship between an individual and society, and between an individual and the technical environment. Therefore, a systemic approach—based on processes in which individual and social creativity mutually reinforce each other—is necessary to enhance creativity effectively. The mind, rather than driving on solitude, clearly depends upon the reflection, renewal, and trust inherent in *sustained human relationships* [John-Steiner, 2000]. Hence, we need to support this distributed fabric of interactions by integrating *diversity*, *making all voices heard*, and increasing the *back-talk of the situation* [Fischer et al., 1998; Schön, 1983]. Furthermore, we need to provide *systems that are open and transparent*, so that people can be aware of and be able to access each other's work.

Individual and social creativity can be integrated by means of proper collaboration models, appropriate community structures, boundary objects, process models in support of natural evolution of artifacts, and meta-design. The combination of above elements can enhance this integration by providing the right environment and interactions. This section delineates the relationship between each element and creativity.

3.1. The Fish-Scale Model for Collaboration

The traditional model for collaboration, the "division of labor," is inadequate in addressing issues of social creativity. *Division of labor* [Levy & Murnane, 2004] refers to specialized tasks within a given framework of reference; in contrast, social creativity is a matter of emergent interactions and meanings. The fundamental difference between social creativity and division of labor can be summarized as the following:

- social creativity: collective outcome > sum of individual efforts
- division of labor: collective outcome = sum of individual efforts

Division of labor tries to divide tasks among a group of people by functions. For social creativity, people collaborate with each other by taking up tasks that fit well with their knowledge and personal interest.

The *fish-scale model* (see Figure 1) [Campbell, 1969] can be considered an alternative to the traditional division of labor that can augment social creativity. The basic objective of Campbell's model of omniscience, which we address here as a model of collaboration, is the "collective comprehensiveness through overlapping patterns of unique narrowness". The model depicts a competence that can never be embodied in a single mind, so a new focus is necessary: "Make me a novel fish-scale. Let my pattern of inevitably incomplete competence cover areas neglected by others" [Campbell, 1969].

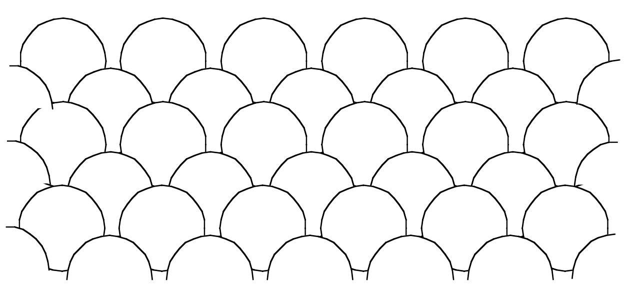

Figure 1: The Fish-Scale Model

Creating sufficient overlap is essential for the fish-scale model to succeed. For example, many software design problems transcend the individual human mind and require collaboration from different minds because knowledge is distributed across domains and individuals [Arias et al., 2000; Bennis & Biederman, 1997; Curtis et al., 1988; John-Steiner, 2000]. Figure 2 illustrates different collaboration paths in software development. The lengths of the lines in the figure relate to the difficulty of collaboration:

- Model 1: Collaboration between a software professional (with no knowledge about the application domain) and a domain expert (with no knowledge about software) is very difficult due to the lack of a shared understanding.
- Model 2: The collaboration distance is reduced if a software professional acquires some domain knowledge.
- Model 3: Similarly, the collaboration distance is reduced if a domain expert acquires some software knowledge.
- Model 4: The most productive collaboration occurs when each contributor has some knowledge of the other.

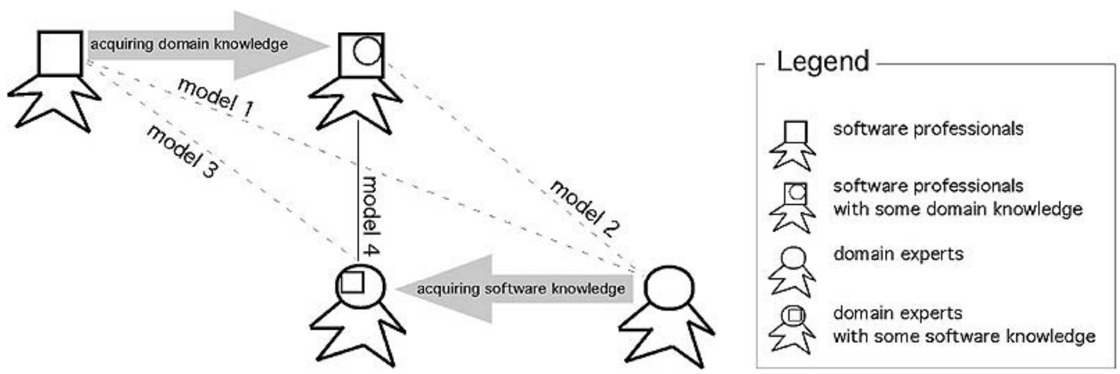

Figure 2: Collaboration Paths in Software Development.

3.2. Structure of Community: Communities of Practice and Communities of Interest

The fish-scale model of collaboration finds an application of great creative potential in communities. Because the community type may shift over time—according to events outside the community, the objectives of its members, and the structure of the membership—collaboration models can vary over time as well. However, it is necessary to distinguish between two main types of communities: *Communities of Practice* (CoPs) [Wenger, 1998] and *Communities of Interest* (CoIs) [Fischer, 2001], and to compare them in order to understand the respective strengths and weaknesses in supporting the integration of individual and social creativity.

Communities of Practice (CoPs) consist of practitioners who work as a community in a certain domain undertaking similar work. Learning within a CoP takes the form of *legitimate peripheral participation* (LPP) [Lave & Wenger, 1991], which is a type of apprenticeship model in which newcomers enter the community from the periphery and move toward the center as they become more knowledgeable. *Open source communities* [Raymond & Young, 2001; Ye et al., 2004], consisting of people who share an interest in the production and use of a software system, exemplify many characteristics of CoPs. The members participate according to their own interests and their own skills. As their skills grow in their interactions, they may move beyond their initial roles and take more responsibility. As a result, products evolve, and people grow as well [Ye et al., 2004]. Sustained engagement and collaboration lead to boundaries that are based on shared histories of learning and create discontinuities between participants and non-participants. Highly developed knowledge systems (including conceptual frameworks, technical systems, and human organizations) are biased toward efficient communication *within* the community at the expense of acting as barriers to communication with outsiders—boundaries that are empowering to the insiders are often barriers to outsiders and newcomers to the group.

Communities of Interest (CoIs) bring together stakeholders from different CoPs and are defined by their collective concern with the resolution of a particular problem. CoIs can be thought of as "communities of communities" or a community of representatives of communities. Examples of

CoIs are: (1) a team interested in software development that includes software designers, users, marketing specialists, psychologists, and programmers; (2) a group of citizens and experts interested in urban planning; and (3) a group of interactive artists comprising people with very different backgrounds and expertise (e.g., visual artists, musicians, performers, designers, architects, computer scientists).

Table 1 characterizes and differentiates CoPs and CoIs along a number of dimensions. The point of comparing and contrasting CoPs and CoIs is not to pigeonhole groups into either category, but rather to identify patterns of practice and helpful technologies. People can participate in more than one community, or one community can exhibit attributes of both a CoI and a CoP. Our *Center for LifeLong Learning and Design (L^3D)* at the University of Colorado at Boulder is an example: It has many of the characteristics of a CoP (having developed its own stories, terminology, and artifacts), but by actively engaging with people from outside the L^3D community (e.g., other colleges on campus, people from industry, international visitors, and so forth), it also has many of the characteristics of a CoI. Communities do not have to be strictly either CoPs or CoIs; they can integrate aspects of both forms of communities, and may shift over time as the nature of the concerned problems change.

Table 1: Differentiating Communities of Practice and Communities of Interest

Dimensions	CoPs	CoIs
Nature of problems	Different tasks in the same domain	Common task across multiple domains
Knowledge development	Refinement of one knowledge system; new ideas coming from within the practice	Synthesis and mutual learning through the integration of multiple knowledge systems
Major objectives	Codified knowledge, domain coverage	Shared understanding, making all voices heard
Weaknesses	Group-think	Lack of a mutual awareness
Strengths	Shared ontologies	Diversity; social creativity; new insights
People	Beginners and experts; apprentices and masters	Stakeholders (owners of problems) from different domains
Learning	Legitimate peripheral participation	Informed participation

Both forms of communities exhibit strengths and weaknesses. *CoPs* are biased toward efficient communications with the same kind of people by taking advantage of a shared background. The existence of an accepted, well-established center of expertise and a clear path of learning toward this center allows the differentiation of members into novices, intermediates, and experts. This distinction makes these attributes viable concepts associated with people, and provides the foundation for legitimate peripheral participation as a workable learning strategy. The barriers imposed by CoPs are that *group-think* can suppress exposure to, and acceptance of, outside ideas; the more someone is at home in a CoP, the more that person forgets the strange and contingent nature of its categories from the outside.

A strength of *CoIs* is their potential for *creativity* because different backgrounds and different perspectives can lead to new insights [Bennis & Biederman, 1997; Campbell, 1969]. CoIs have great potential to be even more innovative and more transforming than a single CoP if they can exploit this *asymmetry of ignorance* [Rittel, 1984] as a source of social creativity. A fundamental barrier for CoIs might be that the participants fail to create common ground and shared understanding [Clark & Brennan, 1991]. This barrier is particularly challenging because CoIs often are more temporary than CoPs: They come together in the context of a specific project and dissolve after the project has ended.

The environments supporting creativity that are presented in detail in Section 4 describe different examples of community structure and their support for creativity. All of them, however, encompass a “distributed” structure that enhances both individual and social creativity and make them mutually reinforce each other.

3.3. Boundary Objects in Support of Distributed Cognition

The fish-scale collaboration model is not only an opportunity, it is also necessary in many complex problem situations because complex design problems require more knowledge than any single person can possess [Arias et al., 2000; Salomon, 1993], and the knowledge relevant to a problem is often distributed among stakeholders from different perspectives and backgrounds [Arias, 1995]. However, in a world in which solutions are neither given nor confined in one single mind [Bennis & Biederman, 1997], we need not only new models of collaboration, but also effective creativity support tools [Shneiderman, 2002]. Social creativity requires active contributors (people acting as designers in personally meaningful activities), not just consumers [Fischer, 2002]. The necessity of "activating" the users and transforming them into "designers" or "creative practitioners" requires the expansion of the creative process from the individual to the group [National-Research-Council, 2003]. For example, the sharing of products of individual creativity enables other people to work on them as a continuous activity without repeating unnecessary work. The open source perspective (see Section 4.4), for instance, demonstrates that the sharing of source code makes it possible for others to go forward when the original developers stop due to various reasons, such as loss of interest, or lack of time or new ideas.

One particular aspect of supporting social creativity and promoting distributed cognition is the externalization of *tacit knowledge* [Polanyi, 1966], both individual and collective. Individual tacit knowledge means intuition, judgment, and common sense — the capacity to do something without necessarily being able to explain it. In contrast, the tacit knowledge of a group means knowledge existing in the distinct practices and relationships that emerge from working or living together over time.

Externalizations [Bruner, 1996] support creativity in the following ways:

- They cause us to move from a vague mental conceptualization of an idea to a more concrete representation of it, which creates situational balk-talk [Schön, 1983], making thoughts and intentions more accessible to reflection.
- They produce a record of our mental efforts, one that is outside us rather than vaguely in memory.
- They relieve us from the difficult task of thinking about our own thoughts.
- They provide a means for others to interact with, react to, negotiate around, and build upon an idea.
- They contribute to a common language of understanding.

Externalizations are critically more important for social interactions because a group has no "head". *Boundary objects* [Arias & Fischer, 2000; Bowker & Star, 2000; Star, 1989] are objects that serve to communicate and coordinate the perspectives of various constituencies. They serve multiple constituencies in situations where each constituency has only partial knowledge and partial control over the interpretation of the object. Boundary objects perform a brokering role involving translation, coordination, and alignment among the perspectives of specific CoPs.

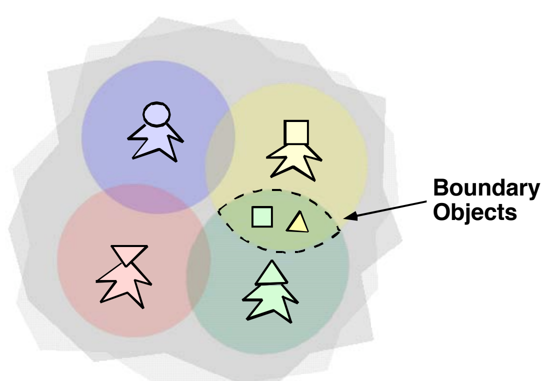

Figure 3: Boundary Objects: Understanding and Sharing across Different Domains

Boundary objects can be either abstract (conceptual) or concrete (physical); they have to be plastic enough to adapt to local needs and the constraints of the CoPs employing them for local use, yet robust enough to maintain a common identity across domains for shared recognition and meaning translation. The creation and management of boundary objects is a key process in developing and maintaining coherence across intersecting social worlds. For example, the formal languages of software system analysis are foreign and opaque to users. In their place, software designers need to develop a variety of other techniques, such as: (1) mock-ups, (2) end-user programming languages and domain-oriented design environments, (3) partial prototypes, and (4) scenarios.

Boundaries are the locus of the production of new knowledge and therefore an important source for creativity. They are where the unexpected can be expected, where innovative and unorthodox solutions are found, where serendipity is likely, and where old ideas find new life. The diversity of CoIs may cause difficulties, but it also may provide unique opportunities for knowledge creation and sharing [Arias et al., 2000].

Boundary objects should be conceptualized as *evolving artifacts* that become understandable and meaningful as they are used, discussed, and refined [Ostwald, 1996]. For this reason, boundary objects can act as "reminders" that trigger relevant knowledge, or as "conversation pieces" that ground shared understanding, rather than as containers of knowledge. It is the interaction around a boundary object, not the object itself, that creates and communicates knowledge.

We are exploring ways to create *active boundary objects* that can activate information relevant to the task at hand in order to increase the *back-talk of the situation* [Schön, 1983]. These may take the form of computational critics and virtual stakeholders that integrate background knowledge into the situation, bring forth diverse perspectives, and allow all voices to be heard. To support the creation and evolution of active boundary objects, it is important to provide systems that can:

- create awareness of each other's work;
- afford individual reflection and exploration;
- enable co-creation (in multiple forms: simultaneous, parallel, and serial),
- allow participants to build on the work of others; and
- provide mechanisms to help draw out the tacit knowledge and perspectives.

In the environments presented in detail in Section 4, boundary objects are represented by different *evolving artifacts*, or "conversation pieces", such as knowledge externalizations in the Envisionment and Discovery Collaboratory (EDC) and Caretta, painting in Renga, and code in Open Source Software (OSS).

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

The *seeding, evolutionary growth, and reseeding (SER)* process model [Fischer & Ostwald, 2002] depicts the lifecycle of large evolving systems and information repositories. It postulates 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 requires support of users as designers in their own right, rather than restricting them to only passive consumer roles. Figure 4 provides an illustration of the SER model.

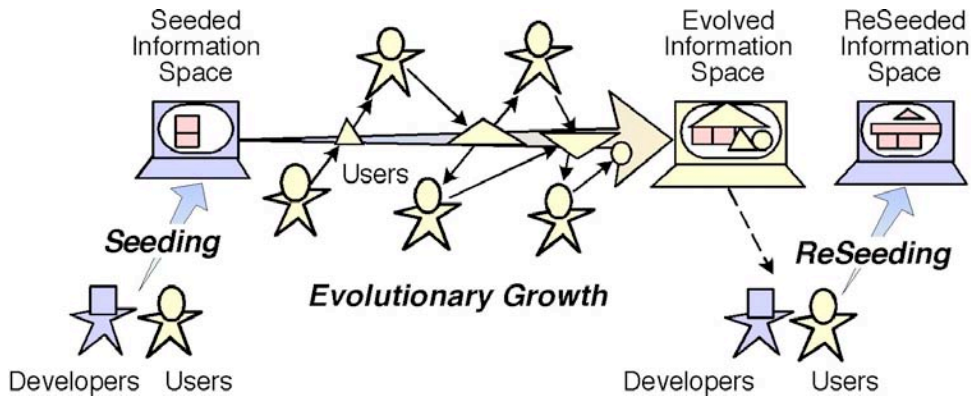

Figure 4: The Seeding, Evolutionary Growth, and Reseeding Process Model

The SER model provides a framework that supports social creativity through supporting individual creativity. Users of a seed are empowered to act not just as passive consumers, but as informed participants who can express and share their creative ideas. System design methodologies of the past were focused on 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*. During the evolutionary growth phase, the seeded system 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 specific problems 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 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.

The environments presented in detail in the Section 4 all follow the SER process. As shown by these environments, seeds can be "pieces" of *knowledge* in EDC and Caretta, *content* in Renga, or *code* in OSS that can be created, evolved, and recombined by means of any mechanisms that allow their sharing and modification.

3.5. Meta-Design: Creating Opportunities for Creativity

To bring social creativity alive, media and environments must support meta-design. The perspective of *meta-design* [Fischer & Giaccardi, 2004] characterizes objectives, techniques, and processes to allow users to act as designers and be creative. The need for meta-design is founded on the observation that design, in the real world, requires open systems that users can modify and evolve. Because problems cannot be completely anticipated at design time when the system is developed, users at use time will discover mismatches between their problems and the support that a system provides. These mismatches will lead to breakdowns that serve as potential sources for new insights, new knowledge, and new understanding. Meta-design advocates a shift in focus from finished products or complete solutions to conditions for users to fix mismatches when they are encountered during use.

Alexander [Alexander, 1964] introduced the distinction between an unselfconscious culture of design and a selfconscious culture of design. In the *unselfconscious* culture of design, the failure or inadequacy of the design 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. The positive elements of the unselfconscious culture of design can be exploited in meta-design approaches by creating media that support people in working on their tasks and being creative, rather than requiring them to focus their intellectual resources on the medium itself.

Meta-design creates the foundations for an unselfconscious culture of design, or a *socio-technical know-how* [Giaccardi, 2004] embodied in the evolving practices of fluid and interdependent communities. It has the potential to establish a new level of social creativity by providing resources for users to become active contributors in personally meaningful activities that arise in unpredictable environments. By supporting *creativity of use* [Hill, 2003], meta-design encourages users to be naturally active and creative, provides them with infrastructures and process models (such as the SER model; see Section 3.4) that sustain such an attitude, and introduces a change in our cultural mindsets and habits.

Meta-design supports *informed participation* [Brown & Duguid, 2000], 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.

4. Examples of Environments That Support Creativity

This section describes four examples of environments that the authors have developed, designed, and assessed over the last decade to understand and explore the relationship between individual and social creativity. These environments have been used to gain a deeper understanding of the different elements of the framework described in Section 3. Table 2 summarizes the key aspects of these environments, which are detailed in the following descriptions of each single environment.

Table 2: Aspects of Support for Creativity Explored in System Development and Studies

	EDC	Caretta	Face Poiesis	CodeBroker
Domain	transportation planning; flood mitigation	urban planning	interactive art	open source software
Participants	diverse stakeholders	diverse stakeholders	artists	software developers
Collaboration model	explore symmetry of ignorance to construct new understanding	diversified exploration of solutions from multiple perspectives	creation, sharing, and evolution of digital images	division of tasks according to interest and knowledge
Boundary objects	shared representation in a construction space	shared problem	shared painting	source code
Process model	conjecture, refutation, and discussion	short cycle of alternating individual reflection and group discussion	crossing of *pixema* assigned by artists according to each one's sensibility	parallel individual development with punctuated integration
Meta-design support	adaptable to new environments	enabling personally meaningful solution	supporting co-creation with *pixema* exchange	offering a participation platform
Integration of individual and social creativity	face-to-face discussion in a shared construction space	intuitive integration of shared space and individual space	individual creativities are expressed by *pixema*, and	individual code leverages others' codes, and individual code is

			different *pixema* are synthesized in new paintings	integrated back into the whole system

4.1. Envisionment and Discovery Collaboratory: Supporting Communities of Interest

The Envisionment and Discovery Collaboratory [Arias et al., 2000] is an environment in which participants collaboratively solve problems of mutual interest. The problem contexts explored in the EDC, such as urban transportation planning, flood mitigation, and building design, are all examples of open-ended social problems. In these contexts, "optimal" solutions do not exist, and the satisfying [Simon, 1996] solutions depend on the participation of diverse stakeholders [Rittel, 1984]. The EDC empowers users to act as designers in situated learning and collaborative problem-solving activities. For most design problems, the knowledge to understand, frame, and solve them does not already exist, but is constructed and evolved during the solution process, exploiting the power of the "symmetry of ignorance" and "breakdowns." The EDC is an environment in which *social creativity* can come alive [Fischer, 2000].

Figure 5 shows the EDC in use, illustrating some of the features just described above. The EDC supports *face-to-face* problem-solving activities by bringing together individuals who share a common problem. The problem is discussed and explored by providing participants with a shared construction space in which they interact with physical objects that are used to represent the situation currently being discussed. As users manipulate physical objects, a corresponding computational representation is created and incrementally updated by using technologies that recognize the placement and manipulation of physical objects. Computer-generated information is projected back onto the horizontal physical construction area, creating an augmented reality environment. This physical construction is coupled with information relevant to the problem currently being discussed.

Figure 5: The Envisionment and Discovery Collaboratory

The collaborative design activities supported by the EDC rely upon the contribution and active participation of all involved stakeholders. Design domains consist of *ill-defined and wicked problems* [Schön, 1983], for which there are no correct answers, and in which framing problems is a major aspect of problem solving. The collaboration of stakeholders is an inherent aspect of these domains. For example, citizens, urban planners, and transportation experts who solve or are influenced by urban transportation issues are themselves an integral part of the problem context. The goal of the EDC is to bring together these stakeholders—each of them or each group owning one part of the problem—to solve problems of mutual interest and to take active roles in addressing the problems that shape their lives.

The EDC has allowed exploration of individual and social creativity through interaction and participation across a variety of different dimensions:

- **Individual interaction with computational artifacts ⇔ Shared interaction, supporting interaction with others through the computational artifacts as a shared medium.** Many approaches to computational support for collaborative activities have focused on the network as the shared medium and the individuals' interactions through that medium via their individual computational devices. The EDC attempts to extend this model to explore how shared interaction with the computational models within the same physical space [Olson & Olson, 2001] can provide ways to tap into elements of social interaction that occur naturally in such shared spaces.
- **Individual agendas ⇔ Creation of shared focus.** One aspect that often confronts attempts to create common ground is that the perspectives that participants bring to the meeting often are closely tied with (sometimes implicit) agendas. Often the format of the interaction acts to reinforce these agendas rather than moderate among them. Experiments with physical models as a means of focusing discussion around the shared problem [Arias, 1996] have demonstrated that a common focus helped to create a better appreciation of other perspectives. The EDC builds upon this model for interaction and includes support for dynamic computational models as part of the interaction as well as for dynamic linkages to information relevant to the task at hand [Fischer et al., 1996].
- **Reliance on explicit knowledge ⇔ Bringing out tacit knowledge.** Often, critical aspects of the perspectives being brought to the EDC are based on knowledge not previously externalized and formalized. These are sometimes individual perspectives that have been experienced but never expressed. The *effective environment* [Gans, 1991] is the environment as understood and experienced by its users. While the description of an 8x12 room as having 96 square feet is reasonably explicit, it bears little meaning in certain contexts. People moving from a small house to a medium-sized house may perceive such a room as being quite spacious, yet people moving to that same house from a mansion might perceive the room as quite cramped. By allowing shared interaction through a descriptive process, the EDC supports methods whereby such perspectives can be drawn out and brought to the table, enhancing individual and collective contributions to the creative process.
- **Expert tools ⇔ Providing access to design for people with different perspectives and from various backgrounds.** A critical element in the design of the EDC is the support for participation by individuals whose valuable perspectives are related to their embedded experiences (e.g., neighborhood residents) rather than on any domain expertise. The overall design of the EDC, targeted toward these participants, employs the use of physical objects to create an inviting and natural interaction with the simulation, and recognizes that parallel interaction capability is essential to support this natural interaction [Eden, 2002]. The development of active critics [Fischer et al., 1998] and virtual stakeholders [Arias et al., 1997] supports informed participation.
- **Dependence on model monopolies ⇔ Creating boundary objects.** One danger of any model (computational or otherwise) is that it embodies certain assumptions and perspectives that, if not questioned, can lead to an imbalance of influence within the process. These forms of *model monopoly* [Bråten, 1983] need to be balanced by having open representations of the models that allow for deeper understanding, experimentation, and possibly refutation. The goal is to permit a migration toward shared representations that are useful across contexts as boundary objects. The EDC design goals are to provide an open environment and design process that will allow these models to be developed and extended.
- **Reliance on high-tech scribes ⇔ Supporting meta-design.** Creating models within the EDC requires a considerable amount of programming effort. This represents a high degree of reliance upon high-tech scribes, distancing the real designers from the medium of expression.

Environments (even domain-oriented ones) that are open and easily modifiable and extensible are still elusive. While we continue to work on support for end-user development [Fischer & Giaccardi, 2004], we are also looking at ways to harness existing tool use, integrate with existing practice, develop models (such as OSS [Raymond & Young, 2001]), and empower local developers [Nardi, 1993].

Working from a meta-design perspective, we have begun to include mechanisms within the EDC to allow participants to inject content into the simulations and adapt the environment to new scenarios. The next steps include creating ways to link to existing data and tools so that participants can draw on information from their own areas of expertise to contribute to the emerging, shared model. By exploring these spectra, the EDC has given us insights into collaboration that draws on both individual and social aspects of creativity.

4.2. Caretta: Integrating Personal and Shared Spaces

Caretta is a system for supporting face-to-face collaboration by integrating personal and shared spaces [Sugimoto et al., 2004]. This system is used to support users in urban planning tasks, which are categorized as open-ended social problems. In urban planning tasks, all the stakeholders want to devise their "best" ideas and need to discus and negotiate with each other to create mutually agreeable design plans. Individual reflections and group discussions often happen in parallel: Some participants individually try to come up with their own ideas, and other participants collectively evaluate existing plans. Therefore, collaborative urban planning tasks are spiral and entwined processes that require the smooth integration of individual and social creativity; individual creativity drives social creativity, and social creativity triggers further individual creativity. Existing computational media, however, do not fully support users' individual and group activities at the same time [Gutwin & Greenberg, 1998]. Caretta is designed to overcome this shortcoming. It provides users with personal spaces for individual reflections, a shared space for group discussions, and intuitive transition methods between these spaces.

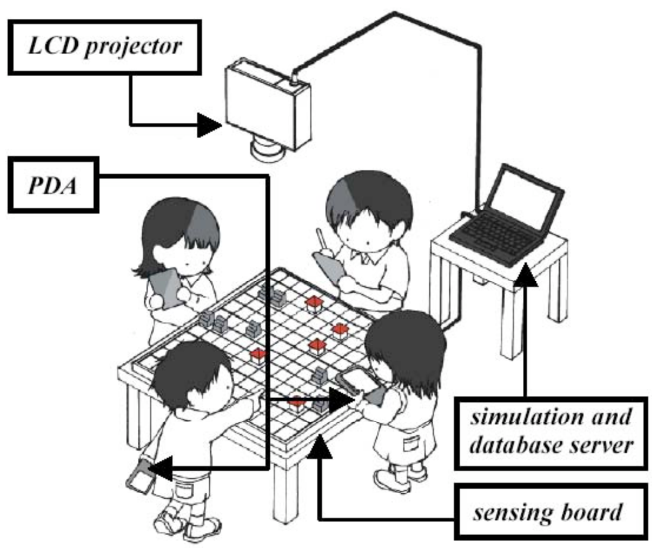

Figure 6: An Overview of *Caretta*

In Caretta, a multiple-input sensing board, appropriately called SensingBoard [Sugimoto et al., 2002], is used for the users' shared space, and Personal Digital Assistants (PDAs) are used for individual users' personal spaces, as shown in Figure 6. Users of Caretta can discuss and negotiate with each other in the shared space by manipulating physical objects, each of which is enhanced by a radio frequency (RF) tag for rapid object recognition. An augmented reality technology for overlaying virtual graphics onto the shared space through a liquid crystal display (LCD) projector creates an immersive collaborative environment that enhances interactions and mutual awareness among users.

A personal space of Caretta works for individual users' reflections because they can freely examine their ideas without being disturbed by other users. Providing each user with a personal space enhances the diversity of individual users' activities: Based on their knowledge and experiences, users can externalize and elaborate their own ideas, which can lead to individual creativity. Providing users with the shared space allows them to share physical boundary objects, and enhances interactions and negotiations with other users, which can lead to social creativity. By providing users with intuitive transition methods between the personal and shared spaces, Caretta allows users to easily copy the current situation on the shared space (e.g., a design plan shared and discussed by a group of users) to individual users' personal spaces, and display design plans devised by individual users on their personal space onto the shared space. Therefore, Caretta can support users in seamlessly conducting their tasks on both spaces, and enhance collaborative problem-solving processes that require individual and social creativity.

Figure 7: Caretta in Use

User studies of Caretta (Figure 7) have demonstrated the following individual and social creativity examples:

- A user working on his personal space was not disturbed by the others and could concentrate on his individual reflection. In this case, however, users did not always conduct their individual activities separately: They were loosely coupled because they worked to find a suitable design plan for the same town from individually different viewpoints. This enhances the diversity of design plans devised by individual users, and raises the possibility of finding creative solutions.
- By allowing users to simultaneously manipulate sharable boundary objects on the shared space, Caretta enhanced interactions among users and raised the level of their engagement and awareness.
- By using the intuitive transition methods, a user working on his personal space could easily return to the shared space, and vice versa. For example, a user who devised a design plan on his personal space could immediately make his design plan appear on the shared space. The plan shared and reviewed by all users became a trigger for activating group discussions. It was then modified by and augmented with other plans devised by users on their own personal spaces, and finally accepted by the users as their group plan. Some users actually copied a plan discussed on the shared space on their personal spaces, individually examined it, and again proposed the modified plan on the shared space. By reviewing design plans proposed by others, users did not have to examine similar plans repeatedly. This example indicated that the features of Caretta effectively worked to support not only individuals but also social creative planning processes.

The Caretta user studies have demonstrated that there is an "and" and not a "versus" relationship between individual and social creativity. In Caretta, individual and social creativity are mutually augmented: users' individual work on their personal space is augmented by their group work on the shared space, and vice versa.

Comparison between the EDC and Caretta. At a meta-level, both EDC and Caretta demonstrate some interesting aspects of co-creation and cross fertilization as part of their creative process of development. The developers of these systems were co-located during a post-doctoral visit and participated in considerable discussion regarding some of the early mock-ups and prototypes of the EDC, including ideas for future directions and requirements. After this visit, separate, parallel efforts continued, resulting in two separate systems that share many similarities, such as the use of mechanisms to track physical pieces that support interaction with a computational model.

Separate developments have also explored different aspects of the application of this basic idea. The EDC has had as its primary focus the creation of an environment to support participation and learning in design, based on its roots in our collaboration with our urban planning colleague. In addition, emphasis is placed on the study of interaction techniques in the shared action space, the creation of computational models to support shared understanding, and the use of critiquing mechanisms to link between action and reflection. The underlying hardware technologies have been developed only to show the proof of concept. Although some effort has been made in exploring the use of PDAs to integrate individual spaces into shared interaction, the major emphasis has been to use the shared interaction space to combine support for individual and social aspects of creativity.

The Caretta project has been able to put considerable effort into the development of the underlying technologies, moving from analog to digital technology in order to support stable performance in tracking and identifying hundreds of objects. The technology has been used in a variety of projects, ranging from supporting school children in learning music appreciation to urban-planning activities, and has been used to support the study of new learning technologies in various contexts. In Caretta, tools for supporting individual creativity and social creativity are separated physically (between the board and PDAs) and seamlessly integrated virtually.

The separate paths traced by these projects based on early, open interactions demonstrates how divergence, as an aspect of social creativity, allows a form of expansive learning to take place.

4.3. Renga Creations: Entwining Individual Creativities in Interactive Art

Interactive art is based on the premise that computational media enable people to operate at the source of the creative process [Reichardt, 1971], where images, for instance, can be created and manipulated pixel by pixel not only by the original artist, but also by those who would normally be constrained to a "viewer" role. This means that creativity can be shared and is no longer limited to individual artists [Candy & Edmonds, 2002a; Popper, 1993; Wilson, 2002]. The expansion of the creative process claimed by interactive art involves different forms of transcendence: from access to active participation [Fischer, 2002; Popper, 1988], from autonomous minds to distributed cognition [Ascott, 2004; Salomon, 1993], and from individual creativity to social creativity [Candy & Edmonds, 2002b]. These facets, allowing the production of artworks that could not be created in isolation or even "exist" [Giaccardi, 1999; Giaccardi, 2000], make interactive art an invaluable source of possible combinations between individual and social creativity [Mamykina et al., 2002], and serve as an inspiring model for the authors of this paper. In particular, from a meta-design perspective [Fischer & Giaccardi, 2004], the interactive art community can offer insights into the process of *co-creation* (see Section 2.2); that is, the exploration and development of dynamics and models for the successful activation of collaborative processes and creative activities [Candy & Edmonds, 2002c; Giaccardi, 2004]. The model of collaboration promoted by interactive art can range from a creative relationship among few, well-acquainted people to a larger set of interactions within a specific community (an interesting example is the virtual community "SITO" [Fischer & Giaccardi, 2004]), and it can include even larger and informal groups (as in the case of the "Poietic Generator" [Giaccardi, 2004]). In this section, we explore a model of collaboration based on a long-term relationship between two Japanese artists, Toshihiro Anzai and Rieko Nakamura. Their *Renga* creations [Anzai & Nakamura, 2004] are an exemplary case of how individual and social creativity can be successfully integrated without annihilating individual personalities, but rather stimulating them in a closer creative relationship.

Renga creations by Anzai and Nakamura question the borders between individuals, but are based on the idea of "embrace": they are neither a solitary monologue nor the result of a virtual and gigantic personality formed by the fusion of individuals: They are a form of "dialogue". Unlike "individual work that often tends to chop things into pieces", Anzai says, "when you work with a *renjiu* [each member of the group involved in the creative process, literally 'linked person'], you have to start with other elements. You can't create anything by trying to separate yourself from others" [Anzai, 1994]. Renga, or linked image, is a new methodology of image creation at the intersection of art, telecommunication networks, and multimedia. In Renga creations, the artists share and exchange computer graphics artworks by means of telecommunication networks. In this way, an image (which we can consider as a seed in our framework) will turn into a new piece by going through modification and transformation by different artists, thus creating a series of growing imageries.

Anzai and Nakamura have been collaborating and developing systems for Renga creation since 1992. Their latest work (as of 2004) is called *Face Poiesis* and is based on the principles of "pollination, breeding, and hybridization" between individually created images. By means of an original painting system that Anzai has developed, the two artists compose faces by mixing features (such as outlines, hair, lips, eyes, and other traits) from faces that they had previously created. The idea is to create a "pool of *pixema*", or individual pieces produced by different artists, that can be exchanged to synthesize new paintings.

Figure 8(a) illustrates a snapshot of Tabula Pixema, the software used to extract pixema from the artists' previous paintings. To integrate individual and social creativity meaningfully, Anzai and Nakamura have designed a process that is quite sophisticated. In fact, a pixema is not a fixed form or color, but a variable to which negotiable pixema can be assigned by the artist according to his or her sensibility. Paintings are not fixed, but are created assuming future and continuous exchanges with new and different pixema. As a result, a painting—as an aggregation of pixema—contains an infinite number of individual paintings by the artists, and at the same time is seamlessly entwined with each artist's work in a never-ending multiplication process.

Figure 8(b) illustrates an instance of pixema aggregation; the resulting face is produced by the original combination of individual paintings and pixema arbitrarily extracted from the artists' previous drawings. *Face Poiesis* is an experiment of "genetic exchange", in which paintings by Anzai and Nakamura are the result of an infinite and original cycle of seeding (creation of pixema), evolutionary growth (series of growing imagery by aggregation of pixema), and reseeding (exchange, reuse, and pollination of *pixema*). In this cycle, individual painting is the expression of each artist's individual creativity (his or her distinctive sensibility, personality, and drawing style); the "pool of pixema" from which artists pick up elements from previous drawings to synthesize new paintings is a source of visual variables that nourishes artists' social creativity (and not a fixed collection of individual pieces). Interestingly, in *Face Poiesis*, the seeding, evolutionary growth, and reseeding model is based on the principles of "pollination" and "breeding", which recall principles of cross-system reuse and cross-domain reuse applied in open source development (see Section 4.4).

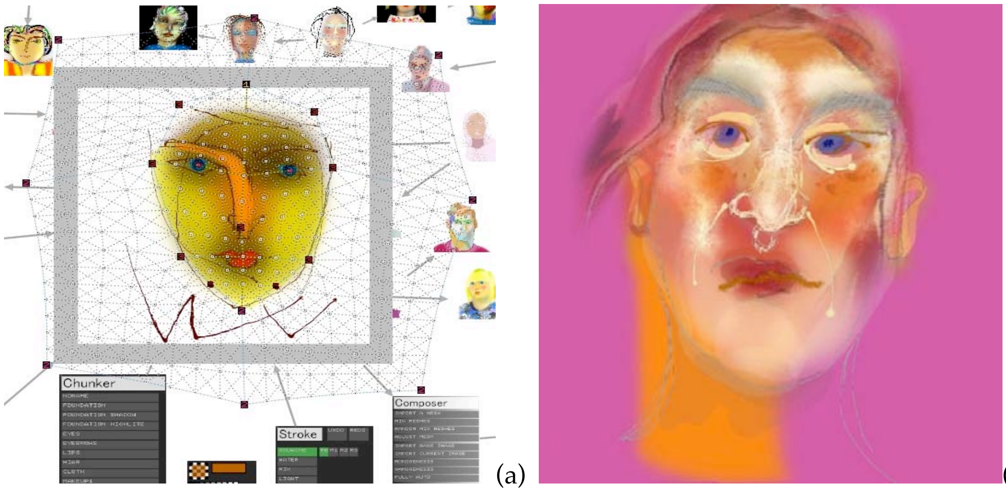

Figure 8: *Face Poiesis*: An Example of Renga Creation [Anzai & Nakamura, 2004]

4.4. CodeBroker: Fostering Social Creativity by Facilitating Reuse in Open Source

Most successful Open Source Software systems [Raymond & Young, 2001; Resnick, 1994; Scacchi, 2002; Scacchi, 2004], such as Apache and Linux, are developed through the collaboration of a large number of developers. In other words, OSS can be viewed as the product of social creativity. Although most modern software systems are also results of social collaboration (i.e., few systems are now developed by a single software developer), OSS displays several distinctive features related to the main theme of this paper—the tight integration of individual and social creativity in meta-designed socio-technical environments that support SER.

The development of a successful OSS system follows the SER process model (see Section 3.4). It often starts as a result of individual creativity: The original system developer creates an innovative new software system as a seed, which is the externalization of the creativity of—and the embodiment of the knowledge of—the original developer. When the seed is distributed and shared by other interested users and software developers, these players are able to interact with the system and use it creatively in more situations than the original designer had intended. During such uses, users experience breakdowns that lead to evolutionary growth of the original system when the breakdowns are fixed by the users themselves.

Users and the original developer spontaneously form a community of practice, bonded by their shared interest in the use and development of the system. Subsequent system evolution is realized through the active participation of the community members, with the support of such communication and coordination tools as mailing lists and concurrent version control systems.

In most cases, those community members do not meet each other face to face; their development activities are conducted individually in a geographically distributed fashion. The individual creative inputs contribute to social creativity because the system can serve as a sharable boundary object for all. Different members look at the system in different ways due to their different use contexts, knowledge, skills, and personal interests [von Krogh et al., 2003]. Most members are interested in only a particular portion of the system and contribute to the development of that portion. Their development is primarily for their specific needs, and is *personally meaningful and important* [Fischer, 2002]. Yet because they are all working on the same system, they are able to talk with each other and leverage the efforts of other members through the sharing and reuse of the whole system. Collectively, the development of the OSS system becomes a form of social creativity, mediated by the evolving system.

Thus the success of OSS development as a realization of social creativity is predicated on the reuse of development efforts as a result of the individual creativity of each community member. OSS can be argued as the software industry's most successful form of large-scale software reuse [Brown & Booch, 2002]. However, the large-scale reuse aspect of OSS has not been given enough attention, and its potential has not been fully understood and leveraged. First, it is still very difficult for community members to become aware of each other's contributions because of the distributed nature of the development efforts. Second, cross-system reuse and cross-domain reuse are still rare and difficult.

Researchers and practitioners alike currently focus on OSS at a system level. They are interested in what the system as a whole can do and how to change a system to better suit a particular need. Our research approach instead focuses on OSS at a parts level. We believe that the benefits of OSS can be increased and the social creativity in OSS communities can be augmented significantly by thinking of OSS systems as collections of reusable components, or parts, rather than as a monolithic system to be reused. When a system is decomposed, each of its parts becomes candidates for reuse. Even if the whole system does not fit the needs of a developer, many of its parts might be useful. By reducing the granularity of reusable units, the chances for reuse increase, and the chances of solving a problem someone else has already solved decrease.

Each part of an OSS system is the product of the individual creativity of its developer(s). In its current whole-system reuse practice, such individual creativity has to be leveraged together with the whole system, which is the boundary object, and only the community members associated with the system are able to benefit. Our vision is to make each part a boundary object shared by different communities of OSS systems and thus to foster cross-community social creativity by facilitating cross-system reuse.

We have developed a reuse support system called *CodeBroker* [Ye, 2001] (see Figure 9) to create awareness of each other’s work so that efforts are not wasted on the continuous “re-invention of the wheel”, and people can focus on what has not been done before. CodeBroker monitors software developers’ programming activities, infers their immediate programming task by analyzing semantic and syntactic information contained in their working products, and actively delivers task-relevant and personalized reusable parts [Fischer et al., 1998] from a reuse repository created by decomposing existing software systems. For example, in the “Editing space” in Figure 9, a programmer is trying to write a program module that can create a random number between two integers. The *Listener* agent of CodeBroker analyzes the partially written module and creates an inferred reuse query based on the analysis. The reuse query is then passed to the *Fetcher* agent, which searches a component repository and retrieves reusable components that match the reuse query. Retrieved components are presented by the *Presenter* agent in the “Delivery buffer” (lower part of Figure 9). In this case, the first component *getInt* in the “Delivery buffer” is exactly what the programmer needs. Furthermore, the *Illustrator* agent in CodeBroker can autonomously retrieve an example program that uses the *getInt* component and show it in the “Example” buffer to help the programmer understand how to use the component.

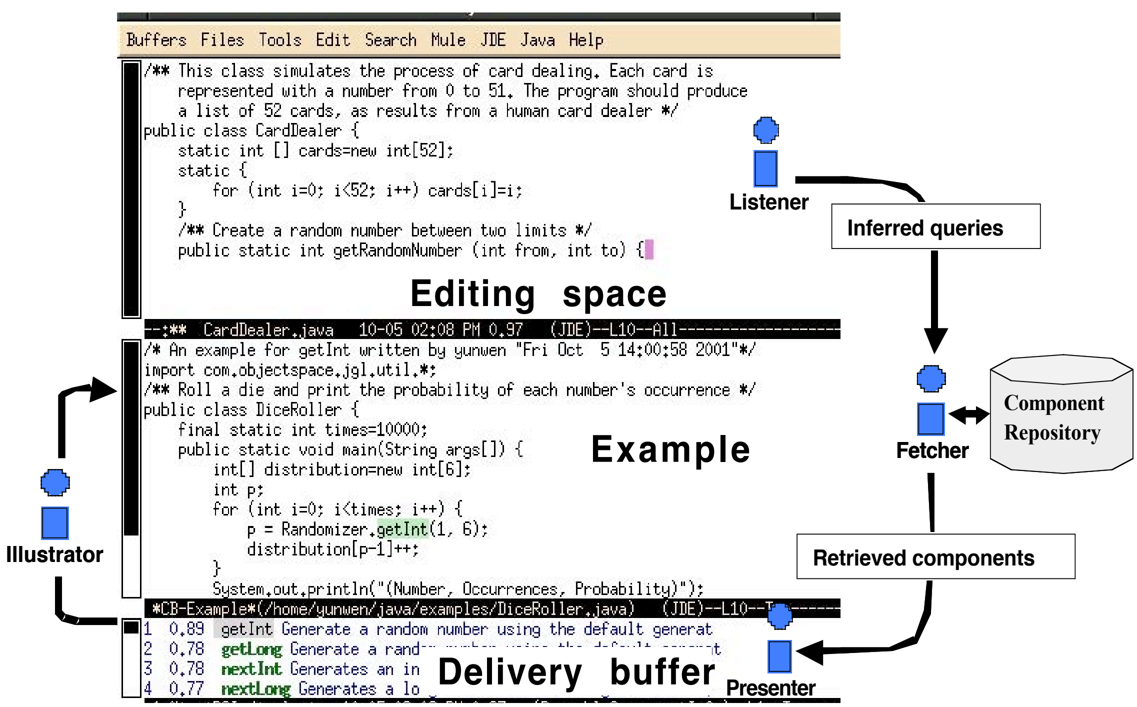

Figure 9: A Screen Image of CodeBroker and Its System Architecture

CodeBroker facilitates the sharing of source code as a way of facilitating social creativity. "Programmers working on complimentary projects can each leverage the results of others, or combine resources into a single project. One project may spark the inspiration for another project that would not have been conceived without it. And worthy projects need not be orphaned when the programmer moves on" [DiBona et al., 1999].

5. Lessons Learned: Towards a New Design Competence

Individual creativity has limits. In today's society the Leonardesque aspiration, "the goal of creating current-day Leonardos who are competent in all of science" (see p. 330 in [Campbell, 1969]) has to fail because the individual human mind is limited [Arias et al., 2000]. The locus of "truth" and "knowledge" is shifting from individual minds to a collective social product only imperfectly represented in any one mind (see p. 331 in [Campbell, 1969]). Creativity is a matter of individual, environment, and interactions, and it is important to provide externalization support and go beyond the isolated image of the reflective practitioner towards the design of reflective communities.

As the examples in Section 4 have shown, a systemic approach is necessary to enhance creativity effectively. In the design of software systems that support creativity, the boundary between the design of the code and the design of social systems dissolves almost completely. However, even though they are provided with the opportunity of being designers and active contributors, many users still choose to be passive consumers or observers [Fischer, 2002]. The challenges for the next generation of socio-technical environments require the shifts of design fuses along the dimensions proposed in the following sections.

5.1. From Individual Creative Actions to Synergetic Activities

The claim by Csikszentmihályi (p. 1 in [Csikszentmihályi, 1996]) that *"an idea or product that deserves the label 'creative' arises from the synergy of many sources and not only from the mind of a single person"*, does not exclude individual creativity. Creativity needs the "synergy of many", and this kind of synergy is facilitated by meta-design. However, a tension exists between creativity and organization. A defining characteristic of social creativity is that it transcends individual creativity and thus requires some form of organization. Elements of organization can and frequently do stifle creativity [Florida, 2002], so our experiences in collaborative design have exposed two barriers to capturing information [Fischer et al., 2004]:

1. Individuals must perceive a direct benefit in contributing that is large enough to outweigh the effort [Grudin, 1989].
2. The effort required to contribute must be minimal so it will not interfere with getting the real work done [Carroll & Rosson, 1987].

These two barriers must be overcome to sustain the passage from individual creative actions to synergetic activities.

5.2. From Reflective Practitioners to Reflective Communities

"Even within disciplines, disciplinary competence is not achieved in individual minds, but as a collective achievement made possible by the overlap of narrow specialties" ([Campbell, 1969] p. 348). We need to invent alternative social organizations that will permit the flourishing of narrow interdisciplinary specialties [Campbell, 1969] as well as new media to support these socio-technical environments. The fish-scale model presented in Section 3.1 provides a viable path towards a new design competence, based on the integration of individual and social creativity, and successful models for the development of communities promoting distributed cognition.

The goal is to go beyond the isolated image of the reflective practitioner and move towards the sustainability and development of *reflective communities*. The objective to educate "Renaissance scholars" (for example, Leonardo da Vinci, who was equally adept in the arts and the sciences)—that is, students whose majors and minors are from widely separated fields of study—is not reasonable [National-Research-Council, 2003]. Rather, the objective for us is the creative potential of "Renaissance communities", meant as reflective communities. The efforts to create alliances between information technology and creative practices [National-Research-Council, 2003] are examples for creating reflective communities. Examples of institutions that (following various educational strategies) encourage, promote, and support the formation of reflective communities include such education and research centres as (1) the Planetary Collegium (http://www.planetary-collegium.net); (2) the cross-fertilization between art and human-computer interaction at Carnegie Mellon University (http://www.hcii.cs.cmu.edu/); (3) the Digital Bauhaus effort within the school of arts and communication at Malmö University (http://www.k3.mah.se/); (4) the Creativity & Cognition Studios at the University of Technology, Sydney (http://research.it.uts.edu.au/creative/ccrs/); and (5) the Alliance for Technology, Learning, and Society at The University of Colorado at Boulder (http://www.colorado.edu/atlas/).

5.3. From Given Tasks to Personally Meaningful Activities

To motivate people to become active contributors and designers and share their knowledge requires a new "design culture", involving a *mindset* change [Fischer, 2002] and principles of *social capital* accumulation [Fischer et al., 2004; Florida, 2002; Putnam, 2000]. But before new social mindsets and expectations can emerge, users' active participation must be a function of simple motivational mechanisms and activities considered *personally meaningful*.

To sustain creativity, one focus is to embed the design of interactive systems in the socio-technical environment in which users are recognized and rewarded for their contributions by accumulating social capital. Social capital is based on specific benefits that flow from the trust, reciprocity, information, and cooperation associated with social networks. However, an analysis of co-creation, and a survey [Giaccardi, 2004] 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 some culturally biased assumptions of social capital theory, and call for further investigation of the values plane associated with the design of socio-technical environments. This analysis of these practices shows that, besides the consideration and evaluation of the specific benefits that can be associated with social networks, *the "lasting value" of social capital can be conceptualised as a form of human creativity*, fundamentally based on inter-subjective relationships, feelings, and emotions. Supporting the results of some recent cognitive studies, the analysis shows that 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]. The passage from given tasks to personally meaningful activities goes by way of how social capital, and ultimately emotions, are sustained and nourished in the socio-technical environment.

Sustaining *personally meaningful activities* is essential for the success of unselfconscious design [Fischer, 2002]. 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. While new technologies and new media are important for creativity, the most fundamental contributing factors are *social structures and mindsets*. Creativity flourishes best in a unique kind of social environment: one that is stable enough to allow continuity of effort, yet diverse and broad-minded enough to nourish creativity in all its subversive forms. Practice without process becomes unmanageable, but process without practice damps out the creativity required for innovation; the two sides exist in perpetual tension [Florida, 2002].

6. Conclusions

Individual creativity and social creativity do not represent a binary choice; they can and need to be integrated to develop innovative solutions to complex design problems. The conceptual framework and the socio-technical environments presented and discussed in this paper are initial attempts to systematically exploit this integration. A smooth integration of individual and social creativity requires a socio-technical environment that enables the fish-scale collaboration model through the utilization of boundary objects, and follows the seeding, evolutionary growth, and reseeding model by providing a meta-design environment that allows and encourages users to become active participations.

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