Social Creativity: Turning Barriers into Opportunities for Collaborative Design

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ABSTRACT
Design is a ubiquitous activity. The complexity of design problems requires communities rather than individuals to address, frame, and solve them. These design communities have to cope with the following barriers: (1) *spatial* (across distance), (2) *temporal* (across time), (3) *conceptual* (across different communities of practice, and (4) *technological* (between persons and artifacts). Over the last decade, we have addressed these barriers and have tried to create socio-technical environments to turn them into opportunities for enhancing the social creativity of design communities.

Categories and Subject Descriptors
H.5.3 [**Information Interfaces and Presentation**]: Group and Organization Interfaces – *computer supported cooperative work, organizational design, theory and models.*

General Terms
Design, Human Factors.

Keywords
Design, collaborative design, spatial distance, temporal distance, social distance, technological distance, turning barriers into opportunities, social creativity, artful integration

1. INTRODUCTION
Distance matters. But many research efforts, media developments, and other practices equate distance only with spatial distance, meaning that they focus on communities in which the individual members are at different physical locations [Nardi & Whittaker, 2002; Olson & Olson, 2001]. *Artful integration* (the theme of PDC'2004) calls our attention to *"the collective interweaving of people, artifacts and processes"* as a particular challenge for participatory design. To bring people together in communities, the following additional distances have to be taken into account:

- *temporal* (across time), requiring support for asynchronous, indirect, long-term communication [Fischer et al., 1992; Moran & Carroll, 1996];
- *conceptual* (across different communities of practice), requiring support for common ground and shared understanding [Fischer, 2001; Resnick, 1991]; and
- *technological* (between persons and artifacts), requiring knowledge-based, domain-oriented systems [Fischer, 1994; Terveen, 1995].

These additional distances represent barriers for collaborative design efforts. In our research over the last decade, we have developed information infrastructures as socio-technical environments to create opportunities that design communities can learn from, work with, and collaborate across these barriers as well as exploit them as opportunities to enhance the social creativity of these communities.

This paper first describes the social nature of creativity and then explores the four different barriers. It then documents our efforts to turn these barriers into opportunities for developing socio-technical environments that support social creativity in collaborative design.

2. THE SOCIAL NATURE OF 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]. Although creative individuals [Gardner, 1993; Sternberg, 1988] are often thought of as working in isolation, much of our intelligence and creativity results from interaction and collaboration with other individuals [Csikszentmihalyi, 1996] exploiting barriers caused by distances as sources of new and innovative ideas . Creative activity grows out of the relationship between an individual and the world of his or her work, as well as out of the ties between an individual and other human beings. Much human creativity arises from activities that take place in a context in which interaction (distributed over space, time, and with other people) and the artifacts that embody group knowledge are important contributors to the process. Creativity does not happen inside people's heads, but in the interaction between a person's thoughts and a socio-cultural context [Engeström, 2001]. Situations that support social creativity need to be sufficiently open-ended and complex that users will encounter breakdowns [Schön, 1983]. As any professional designer knows, breakdowns—although at times costly and painful—offer unique opportunities for reflection and learning.

Social creativity explores computer technologies to help people work together. Social creativity is relevant to design because collaboration plays an increasing role in design projects that require expertise in a wide range of domains. Software design projects, for example, typically involve designers, programmers, human-computer interaction specialists, marketing people, and end-user participants [Greenbaum & Kyng, 1991]. Information technologies have reached a level of sophistication, maturity, cost-effectiveness, and distribution that they are not restricted only to enhancing productivity, but they also open up new *creative possibilities* [National-Research-Council, 2003].

Design projects may take place over many years, with initial design followed by extended periods of evolution and redesign. In this sense, design artifacts are not designed once and for all, but instead they evolve over long periods of time. In such long-term design processes, designers may extend or modify artifacts designed by people they actually have never met.

In extended and distributed design projects, specialists from many different domains must coordinate their efforts despite large separations of time and distance. In such projects, long-term collaboration is crucial for success yet difficult to achieve. Complexity arises from the need to synthesize different perspectives, the management of large amounts of information potentially relevant to a design task, and understanding the design decisions that have determined the long-term evolution of a designed artifact.

Table 1 gives an overview of barriers and articulates associated issues that will be further discussed in this paper.

Table 1: Overview of Barriers

Dimension	Core Limitation	Addressed by	Media/Technologies	Challenge
Spatial	Participants are unable to meet face-to-face; low local density of people sharing interests	Computer-mediated communication	E-mail, chat rooms, video conferences, local knowledge in global societies	Achieve common ground; behavior needs to be adjusted to the limitations of the technology
Temporal	Design and use time: Who is the beneficiary and who has to do the work?	Long-term, indirect communication; meta-design	Group memories, Organizational memories	Design rationale, reflexive computer-supported cooperative work (CSCW)
***Conceptual within* domains (different expertise levels)**	Group-think	Communities of Practice, legitimate peripheral participation (LPP)	Domain-oriented design environments (DODEs)	Innovation
***Conceptual between* domains**	Establishing a shared understanding	Communities of Interest; boundary objects	Envisionment and Discovery Collaboratory	Common ground; To bridge different domain semantics, different ontologies
Technological	Requires fluency in interacting with digital media	Distributed cognition, socio-technical environments; meta-design	Agents, critics, simulations	Formalization; support human-problem-domain interaction

3. THE SPATIAL DIMENSION

Barriers. Even though communication technology enables profoundly new forms of collaborative work, Olson and Olson [Olson & Olson, 2001] have found that collaborative design can still be difficult to support at a distance. In addition, critical stages of collaborative work, such as dealing with ill-defined problems or establishing mutual trust, appear to require some level of face-to-face interaction. Brown and Duguid [Brown & Duguid, 2000] present a similar argument: *"Digital technologies are adept at maintaining communities already formed. They are less good at making them*" (p. 226). In contrast, distributed teams of collaborators are able to carry out effective work, and indeed evolve totally new ways of working that have a great impact on their activities [Olson & Olson, 2001]. Open source software communities provide an example of successful collaboration on a large scale mediated by computational media [Fischer et al., 2004; Raymond & Young, 2001; Scharff, 2002].

Opportunities. Bringing spatially distributed people together by supporting net-based communication allows the shift that *shared concerns* rather than shared location becomes the prominent defining feature of a group of people interacting with each other. It further allows more people to be included, thus exploiting local knowledge. These opportunities have been successfully employed by the open source communities.

Transcending the barrier of spatial distribution is of particular importance in locally sparse populations. Addressing this challenge is one of the core objectives of our research work in the CLever project ("Cognitive Levers: Helping People Help Themselves" [CLever, 2004]).

Exploiting the Opportunities. Web2gether [dePaula & Fischer, 2004] is a multi-year-long effort embedded in CLever to provide professional and social support for caregivers of people with cognitive disabilities. Web2gether (see Figure 1) is designed to help caregivers not only find resources, but also form social networks and share their experiences. Sharing experiences is an effective approach in the context of distributed and complex work practices [Bobrow & Whalen, 2002]. It goes beyond the mere access model of technology [Arias et al., 1999] by supporting *informed participation* [Brown et al., 1994] based on the seeding, evolutionary growth, reseeding model [Fischer & Ostwald, 2002].

Figure 1: Web2gether Screen Image

4. THE TEMPORAL DIMENSION

Barriers. A design strategy that can be recommended to anyone aspiring to make a creative contribution or to evolve an artifact in any domain is to master as thoroughly as possible what is already known in a domain — the ultimate goal being to transcend conventions, not to succumb to them. Design processes often take place over many years, with initial design followed by extended periods of evolution and redesign. In this sense, design artifacts (including systems that support design tasks, such as reuse environments [Ye & Fischer, 2002]) are not designed once and for all, but instead evolve over long periods of time. For example, when a new device or technology emerges, most computer networks are enhanced and updated rather than redesigned completely from scratch.

Much of the work in ongoing design projects is done as redesign and evolution, and often the people doing this work were not members of the original design team. To be able to do this work well, or sometimes at all, however, requires that these people "collaborate" with the original designers of the artifact. A special case of this collaboration is *reflexive computer-supported cooperative work (CSCW)*, which supports the same individual user, who can be considered as two different persona at points of time that are far apart [Thimbleby et al., 1990]. In ongoing projects, long-term collaboration is crucial for success yet difficult to achieve. This difficulty is due in large part to individual designers' ignorance of how the decisions they make interact with decisions made by other designers. A large part of this, in turn, consists of simply not knowing what has already been decided and why.

Long-term collaboration requires that present-day designers be aware of the rationale [Moran & Carroll, 1996] behind decisions that shaped the artifact, and aware of information about possible alternatives that were considered but not implemented. This requires that the rationale behind decisions be recorded in the first place. Closed systems present a barrier by not providing opportunities for designers to record rationale for their decisions. Another barrier to overcome is that designers are biased toward doing design but not toward putting extra effort into documentation. This creates an additional rationale-capture barrier for long-term design.

A further barrier raised by long-term design projects is the ability to modify a system's functionality. During the lifecycle of a ongoing design project, the environment in which the artifact functions may have changed in ways that were not anticipated by the original designers. If the system cannot be adapted to its changing environment at use time, it will cease to be useful. One way to view this need for adaptation is to think of the lifecycle of a system as an ongoing design process, sometimes called design-in-use to emphasize that design of a system happens alongside use [Henderson & Kyng, 1991].

Opportunities. In our work, we have focused specifically on *long-term, indirect collaboration* [Fischer et al., 1992] by exploring CSCW technologies that support and represent the intentions and actions of others who cannot be seen and contacted personally. A design support system that fosters long-term indirect collaboration among a community of designers must support communication about not only evolving artifacts but also background context and rationale about the artifacts.

Exploiting the Opportunities. We have explored innovative approaches toward reducing the barrier of temporal distance. *Incremental formalization* [Shipman, 1993] is an attempt to achieve two conflicting goals: (1) assuring that design rationale recording does not take too many cognitive resources away from the primary task to be done; and (2) assuring that the rationale is (at least partially) formalized so that computational support is it easier to retrieve later when needed. Figure 2 shows a component of the Envisionment and Discovery Collaboratory [Arias et al., 2000] to provide contextualized access to information with a tight coupling between action and reflection spaces [Schön, 1983]. In the *Information-Ball system* (*I-Balls*; developed by E. Scharff), users can annotate architectural sketches in the action space.

I-Ball annotations need not be only simple comments associated with specific locations. Users' questions and issues might be generally applicable to a wide variety of designs. For example, in Figure 2 a user is interested in why there are no offices on the third floor. The reason for this architectural design decision is that the upper floors of the building should retreat inside to create a more open view from the outside. This dependency is not obvious from either the internal or external perspective; the I-Balls help users to record and investigate this design rationale.

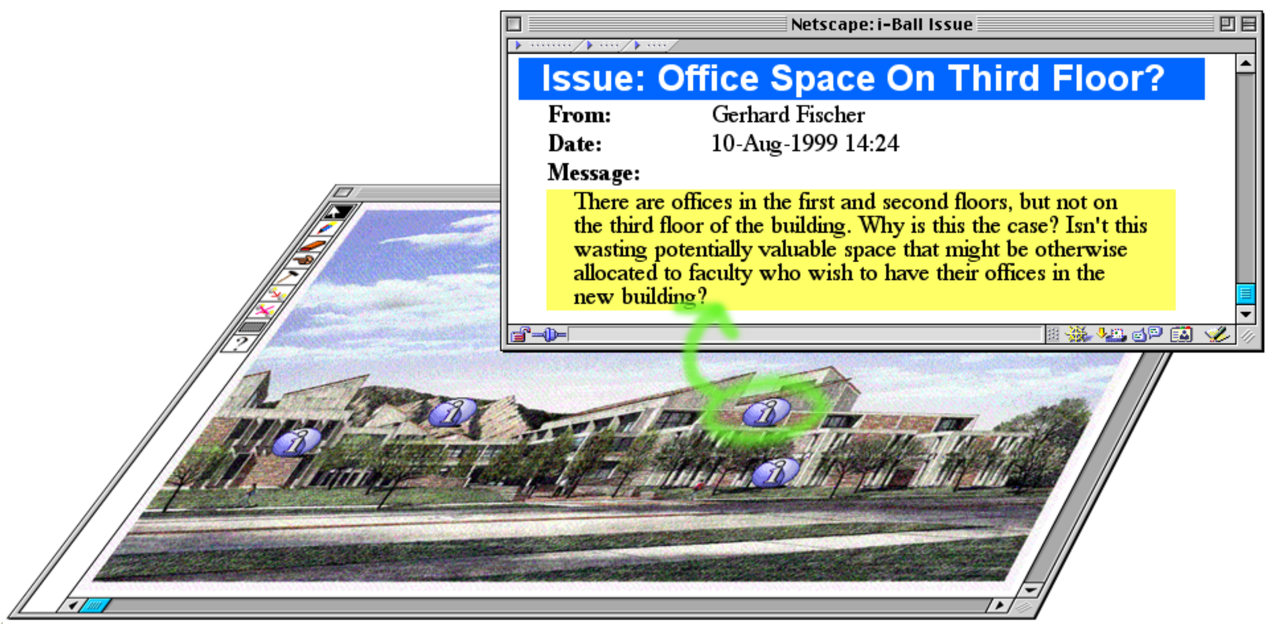

Figure 2: Access to Design Rationale with I-Balls

5. THE CONCEPTUAL DIMENSION

Barriers. Design communities are increasingly characterized by a *division of labor*, comprising individuals who have unique experiences, varying interests, and different perspectives about problems, and who use different knowledge systems in their work. Shared understanding [Resnick et al., 1991] that supports collaborative learning and working requires the active construction of a knowledge system in which the meanings of concepts and objects can be debated and resolved. In heterogeneous design communities, such as those that form around large and complex design problems, the construction of shared understanding requires an interaction and synthesis of several separate knowledge systems. Our own research efforts have focused on supporting communication across two conceptual dimensions: (1) the expertise gap between experts and novices within a particular practice (conceptual barrier *within* a domain); and (2) the conceptual gap between stakeholders from different practices (conceptual dimension *between* different domains).

Homogeneous Design Communities: Communities of Practice. Communities of Practice (CoPs) consist of practitioners who work as a community in a certain domain undertaking similar work. Within each community, however, are individuals with special expertise, such as power-users and local developers [Nardi, 1993]). Examples of CoPs are architects, urban planners, research groups, software developers, and end-users. In our past work, we have developed various types of domain-oriented design environments (DODEs) [Fischer, 1994] to support CoPs by allowing them to interact at the level of the problem domain and not only at a computational level.

Sustained engagement and collaboration lead to boundaries [Wenger, 1998] that are based on shared histories of learning and create discontinuities between participants and non-participants. Domain-oriented systems allow for efficient communication within the community at the expense of making communication and understanding difficult for outsiders. For example, over the last fifteen years, we have created concepts, systems, and stories representing an efficient and effective means for communication within our research group. We have also learned, however, that boundaries that are empowering to insiders are often barriers for outsiders and newcomers to a group. CoPs must be allowed and must desire some latitude to shake themselves free of established wisdom.

Traditional learning and working environments (e.g., university departments and their respective curricula) are disciplinary. Throughout history, the use of disciplines and their associated development of a division of labor have proven to be powerful approaches. However, we also know from all the attempts to support multidisciplinary work that hardly any "real" problems can be successfully approached by a lone discipline [Campbell, 1969].

Heterogeneous Design Communities: Communities of Interest. Communities of Interest (CoIs) [Fischer, 2001] bring together stakeholders from different CoPs to solve a particular (design) problem of common concern. They can be thought of as "communities-of-communities" [Brown & Duguid, 1991] or communities of representatives of communities. Two examples of CoIs are (1) a team of software designers, marketing specialists, psychologists, and programmers, interested in software development; or (2) a group of citizens and experts interested in urban planning, in particular implementing new transportation systems. The Envisionment and Discovery Collaboratory, discussed in Section 4 of this paper, illustrates this last group.

Fundamental challenges facing CoIs are found in building a shared understanding [Resnick et al., 1991] of the task-at-hand, which often does not exist at the beginning, but is evolved incrementally and collaboratively and emerges in people's minds and in external artifacts. Members of CoIs must learn to communicate with and learn from others [Engeström, 2001] who have different perspectives and perhaps different vocabularies to describe their ideas and to establish a common ground [Clark & Brennan, 1991].

Comparing CoPs and CoIs. Learning within CoIs is more complex and multifaceted than legitimate peripheral participation [Lave & Wenger, 1991] in CoPs, which assumes a single knowledge system in which newcomers move toward the center over time. CoIs must simultaneously support a healthy autonomy of the contributing CoPs and at the same time provide possibilities to build on interconnectedness and a shared understanding

Learning in CoPs can be characterized as "learning when the answer is known", whereas learning in CoIs is often a consequence of the fact that the answer is not known (e.g., to a complex, unique design problem) [dePaula & Fischer, 2004]. CoIs have multiple centers of knowledge, with each member considered to be knowledgeable in a particular aspect of the problem and perhaps not so knowledgeable in others [Engeström, 2001]. In informed participation, the roles of "expert" or "novice" shift from person to person, depending on the current focus of attention.

Table 2 characterizes and differentiates CoPs and CoIs along a number of dimensions [Fischer & Ostwald, 2004]. 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 (L3D) is an example: It has many characteristics of a CoP (having developed its own stories, terminology, and artifacts), but by actively engaging with people from outside our community (e.g., other colleges on campus, people from industry, international visitors, and so forth), it also has many characteristics of a CoI. Design communities do not have to be strictly either CoPs or CoIs; they can integrate aspects of both forms of communities. The community type may shift over time, according to events outside the community, the objectives of its members, and the structure of the membership.

Table 2: Differentiating CoPs and CoIs

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 shared understanding
Strengths	Shared ontologies	Social creativity; diversity; making all voices heard
People	Beginners and experts; apprentices and masters	Stakeholders (owners of problems) from different domains
Learning	Legitimate peripheral participation	Informed participation

Both forms of design communities exhibit barriers and biases. CoPs are biased toward communicating with the same people and 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 allow the differentiation of members into novices, intermediates, and experts. It 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.

CoIs are "defined" by their shared interest in the framing and resolution of a design problem. A bias of CoIs is their potential for creativity because different backgrounds and different perspectives can lead to new insights [Bennis & Biederman, 1997]. CoIs have great potential to be more innovative and more transforming than a single CoP if they can exploit the asymmetry of ignorance [Rittel, 1984] as a source of collective creativity. A fundamental barrier for CoIs might be that the participants fail to create common ground and shared understanding. 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.

CoPs are the focus of disciplines such as CSCW: They provide support for work cultures with a shared practice [Wenger, 1998]. The lack of a shared practice in CoIs requires them to draw together diverse cultural perspectives. Computer-mediated communication in CoPs is different from that in CoIs. CoIs pose a number of new challenges, but the payoff is promising because they can support pluralistic societies that can cope with complexity, contradictions, and a willingness to allow for differences in opinions.

Boundary Objects. Boundary objects [Bowker & Star, 2000; Wenger, 1998] are externalizations of ideas that are used to communicate and facilitate shared understandings across spatial, temporal, conceptual, or technological gaps. In design communities, boundary objects help to establish a shared context for communication by providing referential anchoring [Clark & Brennan, 1991]. Boundary objects can be pointed to and named, helping stakeholders to incrementally increase their shared understanding. Grounding communication with external representations helps to identify breakdowns and serves as a resource for repairing them.

In CoPs, boundary objects represent the domain concepts and ontologies that both define and reflect the shared practice. They might take the form of documents, terminology, stories, rules, and unspoken norms. For example, the boundary objects in our community of researchers include research papers, dissertations, and a conceptual framework that encompasses the individuals and work done within the community.

In CoIs, boundary objects support communication across the boundaries of different knowledge systems, helping people from different backgrounds and perspectives to communicate and to build common ground. Boundary objects allow different knowledge systems to communicate by providing a shared reference that is meaningful within both systems. Computational support for CoIs must therefore enable mutual learning through the creation, discussion, and refinement of boundary objects that allow the knowledge systems of different CoPs to interact. In this sense, the interaction among multiple knowledge systems is a means to turn the asymmetry of ignorance into a resource for learning and social creativity [Fischer, 2001].

Boundaries are the locus of the production of new knowledge. 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.

Importantly, boundary objects are evolving artifacts that become understandable and meaningful as they are used, discussed, and refined [Fischer & Ostwald, 2004]. For this reason, boundary objects should be conceptualized as reminders that trigger knowledge, or as conversation pieces that ground shared understanding, rather than as containers of knowledge. The interaction around a boundary object is what creates and communicates knowledge, not the object itself.

Humans serving as knowledge brokers can play important roles in bridging boundaries across or within communities. For example, within design communities that develop around complex software systems, members who are interested in and inclined to learn about the technologies may develop into *power-users* (also known as "local developers" and "gardeners" [Nardi, 1993]) who are able to make modifications and customizations. By making needed changes to a system on behalf of the community, or by teaching others how to do so, power-users help others to transcend the boundary that exists between using a system as it is and modifying it for new purposes.

6. THE TECHNOLOGICAL DIMENSION

The three preceding sections emphasized computer-mediated collaboration among humans to reduce the gaps created by spatial, temporal, and conceptual distances. This section focuses on issues in which the computer plays a more prominent role, partially understanding and doing a complex task. Our interest has been in a relationship in which computers do not emulate human capabilities but complement them [Terveen, 1995]. The technological dimension is an important additional dimension grounded in an observation by Illich: *"a thing is available at the bidding of the user — or could be — whereas persons formally become a skill resource only when they consent to do so, and they can also restrict time, place, and methods as they choose"* [Illich, 1971].

Barriers. Design can be described as a reflective conversation between designers and the designs they create. Designers use materials to construct design situations, and then listen to the "back-talk of the situation" they have created [Schön, 1983]. Unlike passive design materials, such as pen and paper, computational design materials are able to interpret the work of designers and actively talk back to them. Barriers occur when the "back-talk" is represented in a form that users are unable to comprehend (i.e., the back-talk is not a boundary object), or when the back-talk created by the design situation itself is insufficient, and additional mechanisms (e.g.: critiquing, simulation, and visualization components) are needed.

Opportunities. Media change the nature of learning and communication in design. Ideally, new media will improve both individual and collaborative design by augmenting the cognitive abilities of designers and allowing them to transcend some of the barriers that have limited knowledge creation and sharing in design.

We have built domain-oriented design environments in many domains. Some of the major design objectives associated with DODEs are: (1) supporting "human problem–domain interaction" and not just human-computer interaction, (2) increasing the back-talk of the situation, and (3) integrating action and reflection [Schön, 1983]. During this process, we have developed a domain-independent software architecture that describes the tools and knowledge-based mechanisms that support creativity [Fischer, 1994]. Unlike many other computational environments, DODEs play an active role in the knowledge creation, integration, and dissemination process among design communities.

Exploiting the Opportunities. To increase the "back-talk of the situation," we have developed *critiquing systems* [Fischer et al., 1998] that monitor the actions of users as they work and inform the users of potential problems. If users elect to see the information, the critiquing mechanisms find information in the repositories that is relevant to the particular problem, and present this information to the user.

Critics exploit the context defined by the state of the construction, simulation, and specification components to identify potential problems as well as to determine what information to deliver. This context enables precise intervention by critics, reduces annoying interruptions, and increases the relevance of information delivered to designers.

Critics embedded in design environments benefit the creative process by increasing the user's understanding of problems to be solved, by pointing out needs for information that might have been overlooked, and by locating relevant information in very large information spaces. Embedded critics save users the trouble of explicitly querying the system for information. Instead, the design context serves as an implicit query. Rather than specifying their information needs, users need only click on a critiquing message to obtain relevant information. Users thus benefit from information stored in the system without having to explicitly search for it.

7. DISCUSSION

"There is no creativity without constraints"
— Igor Stravinsky

Overview of Barriers and Opportunities. As illustrated and described in the previous sections, our research over the last decade has developed conceptual frameworks and socio-technical environments to support design and design communities. This research was driven forward by analyzing the barriers created by distances. Table 3 provides an overview of the barriers, including limitations and shortcomings, and the opportunities created by them.

Table 3: Overview of Barriers and Opportunities

	Barriers	Opportunities
Spatial	Face-to-face supports maximal bandwidth; face-to-face limits number of participants	Involving larger communities ("the talent pool of the whole world"); exploiting local knowledge
Temporal	Communication through artifacts; inherent difficulty of collaboration between people who do not know each other	Building on the work of the giants before us
Conceptual	Focus solely on communication; group-think	Making all voices heard; integrating diversity
Technological	Focus on what is technologically doable; requires formalization	Things are available all the time; computer-interpretable structures enable support mechanisms

Power-Users and the Fish-Scale Model. The "power-user" model [Nardi, 1993] (domain experts expanding their knowledge and skills in information technology or computer scientists getting involved in some application domains) exists and has proven useful. But it creates formidable challenges for individuals to become proficient in multiple fields [National-Research-Council, 2003]. In contrast, Campbell [Campbell, 1969] believed that the key to interdisciplinary work (as required for collaborative design) is not in *"Leonardos who are competent in all sciences"* or in educating the *"intellectual superhuman"* who knows all about a complex design problem. With information and tools growing exponentially in all disciplines, it is impossible for any single researcher or practitioner to have the time to gain mastery in multiple disciples. Unidisciplinary competence alone, according to Campbell, is a myth.

A more realistic interdisciplinary approach is suggested by Campbell's *fish-scale model* (see Figure 3), which illustrates the attempt to achieve *"collective comprehensiveness through overlapping patterns of unique narrowness."* Instead of disciplines aggregating as clusters of specialties, they would be distributed in overlapping areas, much as the scales of a fish overlap. There are many barriers to the fish-scale model, including institutional and disciplinary structures that operate against interdisciplinary collaboration. But dealing with complex design problems make the fish-scale model (or some other model of collaboration) a *necessity* rather than a luxury.

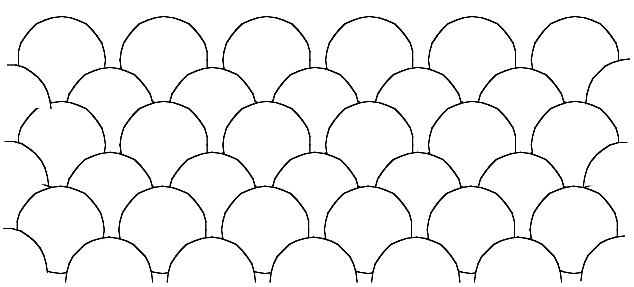

Figure 3: The Fish-Scale Model

Interdisciplinary researchers need not be specialists in all other relevant disciplines, but must at least be aware of the developments (results, methods, tools, media) in other disciplines that relate to their own research interests. Keeping up with relevant developments in other disciplines is difficult, but it can be facilitated by turning barriers into opportunities in collaborative design.

The fish-scale model indicates a promising balance between individuality and social connectedness and between individual and social creativity [John-Steiner, 2000]. Collaborative design requires a balance between (1) interdependence, collective action, and power of connection on the one hand; and (2) individuality, autonomy, and trust in one's own strength on the other hand.

The Importance of Externalizations. Our research in design integrates the task of problem framing with that of problem solving by stressing the importance of externalizations that enable designers to represent both tasks. In this sense, externalizing ideas is not a matter of emptying out the mind but of actively reconstructing it, forming new associations, and expressing concepts in external representations while lessening the cognitive load required for remembering them: *"Externalization produces a record of our mental efforts, one that is 'outside us' rather than vaguely 'in memory.' ... It relieves us in some measure from the always difficult task of 'thinking about our own thoughts' while often accomplishing the same end. It embodies our thoughts and intentions in a form more accessible to reflective efforts."* [Bruner, 1996].

8. CONCLUSIONS

Design is a ubiquitous activity. The complexity of design problems transcends the individual human mind, requiring groups and communities to address them. Bringing people and media together is a means to overcome distances. These distances are not only spatial, but also temporal, conceptual, and technological, each creating barriers of different kinds. Our research has tried to see these barriers as opportunities for artful integration to bring different media together to achieve new levels of social creativity. Our work has only scratched the surface of exploiting the power of collective minds equipped with new media. The challenges of the complex problems that we all face make this approach not a luxury, but a necessity.

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