Chapter 3
Learning in Communities: A Distributed Intelligence Perspective

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Distributed Intelligence: Transcending the Individual Human Mind

The power of the unaided individual mind is highly overrated (Arias et al., 2001). In most traditional approaches, *human cognition* has been seen as existing solely "inside" a person's head, and studies on cognition have often disregarded the physical and social surroundings in which cognition takes place. *Distributed intelligence* (or *distributed cognition*) (Hollan et al., 2001; Pea, 2004; Salomon, 1993) provides an effective theoretical framework for understanding what humans can achieve and how artifacts, tools, and sociotechnical environments can be designed and evaluated to empower human beings and to change tasks. Our research efforts are focused to exploit the power of omnipotent and omniscient technology based on reliable and ubiquitous computing environments and an increasing level of technological fluency to help people to facilitate and support learning in communities.

Social Creativity

Social creativity explores computer media and technologies to help people work and learn together (Bennis & Biederman, 1997). It is specifically relevant to complex design problems because they 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.

Information technologies have reached a level of sophistication, maturity, cost-effectiveness, and distribution such that they are not restricted only to enhancing productivity but they also open up *new creative possibilities* (National Research Council, 2003).

Our work is grounded in the basic belief that there is an "*and*" and not a "*versus*" relationship between individual and social creativity (Fischer et al., 2005). Creativity occurs in the relationship between an individual and society, and between an individual and his or her technical environment. The mind, rather than driving

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on solitude, is clearly dependent upon the reflection, renewal, and trust inherent in sustained human relationships (John-Steiner, 2000). We need to support this distributed fabric of interactions by integrating diversity, by making all voices heard, by increasing the back-talk of the situation, and providing systems that are open and transparent, so that people can be aware of and access each other's work, relate it to their own work, transcend the information given, and contribute the results back to the community (Fischer et al., 2004; Hippel, 2005).

In complex design projects, collaboration is crucial for success, yet it is difficult to achieve. Complexity arises from the need to synthesize different perspectives, to exploit conceptual collisions between concepts and ideas coming from different disciplines, to manage large amounts of information potentially relevant to a design task, and to understand the design decisions that have determined the long-term evolution of a designed artifact.

Exploiting Diversity and Distances by Making All Voices Heard

Social creativity thrives on the *diversity* of perspectives by making all voices heard. It requires constructive dialogs between individuals negotiating their differences while creating their shared voice and vision. We have explored different sources of creativity by exploiting four different *distances: spatial, temporal, conceptual, and technological* (Fischer, 2005).

Voices from different places: Spatial distance. Bringing spatially distributed people together with the support of computer-mediated communication allows the prominent defining feature of a group of people interacting with each other to become *shared concerns rather than shared location*. It extends the range of people to be included, thereby exploiting local knowledge. These opportunities have been successfully employed by the open source communities, collaborative content creation communities (such as Wikipedia) as well as by social networks of people who have a shared concern (such as a family member with a disability). 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 (Cognitive Levers: Helping People Help Themselves) project (CLever, 2005; dePaula, 2004).

Voices from the past: Temporal distance. 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, 2005)) are not designed once and for all, but instead evolve over long periods of time. Much of the work in ongoing design projects is done as redesign and evolution; often, the people doing this work were not members of the original design team. Long-term collaboration requires that present-day designers be aware of not only the rationale (Moran & Carroll, 1996) behind decisions that shaped the artifact, but also any information about possible alternatives that were considered but not implemented. This requires that the rationale behind decisions be recorded in the first place. A 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 (Grudin, 1987).

The idea of exploiting and building on the voices of the past to enhance social creativity is important not only for software reuse but for our overall cultural heritage. In cultural evolution there are no mechanisms equivalent to genes and chromosomes (Csikszentmihalyi, 1996); therefore, new ideas or inventions are not automatically passed on to the next generation, and education becomes a critical challenge to learn from the past. Many creativity researchers have pointed out that the discoveries of many famous people (e.g., Einstein who could build on the work of Newton) would have been inconceivable without the prior knowledge, without the intellectual and social network that simulated their thinking, and without the social mechanisms that recognized and spread their innovations.

Voices from different communities: Conceptual distances. To analyze the contribution of voices from different communities, we differentiate between two types of communities: communities of practice (CoPs) and communities of interest (CoIs). This distinction will be further elaborated below.

Communities of Practice (Wenger, 1998) consist of practitioners who work as a community in a certain domain undertaking similar work. For example, copier repair personnel who work primarily in the field but meet regularly to share "war stories" about how to solve the problems they encountered in their work make up a CoP (Orr, 1996). 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 and more knowledgeable.

Sustained engagement and collaboration lead to boundaries that are based on shared histories of learning and that create discontinuities between participants and nonparticipants. 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 insider are often barriers to outsiders and newcomers to the group.

A community of practice has many possible paths and many roles (identities) within it (e.g., leader, scribe, power-user, visionary, and so forth). Over time, most members move toward the center, and their knowledge becomes part of the foundation of the community's shared background.

Communities of Interest (Fischer, 2001) 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" (Brown & Duguid, 1991). Examples of CoIs are (1) a team interested in software development that includes software designers, users, marketing specialists, psychologists, and programmers, or (2) a group of citizens and experts interested in urban planning. Stakeholders within CoIs are considered as informed participants who are neither experts nor novices, but rather both; they are experts when they communicate their knowledge to others, and they are novices when they learn from others who are experts in areas outside their own knowledge.

Communication in CoIs is difficult because they come from different CoPs, and therefore use different languages, different conceptual knowledge systems, and different notational systems (Snow, 1993). Members of CoIs must learn to communicate with and learn from others (Engeström, 2001) who have different perspectives and perhaps a different vocabulary for describing their ideas. In other words, this symmetry of ignorance must be exploited.

Comparing CoPs and CoIs. Learning by making all voices heard within CoIs is more complex and multifaceted than *legitimate peripheral participation* (Lave & Wenger, 1991) in CoPs. Learning in CoPs can be characterized as "learning within a single knowledge system," whereas learning in CoIs is often a consequence of the fact that there are multiple knowledge systems. 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.

Table 3.1 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)* 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., from 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, but 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 3.1 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 allows 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* (Janis, 1972) 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.

Voices from virtual stakeholders: Technological distances. The preceding subsections emphasized computer-mediated collaboration among humans to reduce the gaps created by spatial, temporal, and conceptual distances. Voices from virtual stakeholders are embedded in artifacts such as books and in more interesting and powerful ways in computational artifacts.

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. 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.

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