Chapter 2
A Conceptual Framework for Computer-Supported Collaborative Learning at Work

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Introduction

Learning needs to be examined across the life span because previous notions of a divided lifetime—education followed by work—are no longer tenable (Gardner, 1991). Professional activity has become so knowledge intensive and fluid in content that learning has become an integral and essential part of adult work activities (Drucker, 1994). "Learning is a new form of labor" (p. 395) (Zuboff, 1988) and working is often (and must be) a collaborative effort among colleagues and peers. Knowledge, especially advanced knowledge, is acquired well past the age of formal schooling, and in many situations through educational processes that do not center on the traditional school (Collins & Halverson, 2009; Illich, 1971; National-Research-Council, 2009). Fundamentally new learning opportunities are required making *computer-supported collaborative learning at work* (*CSCL at Work*) a necessity rather than considering a luxury.

I had two opportunities in the past to reflect upon situating CSCL at Work between the primary objectives of the CSCW and the CSCL research communities. In an invited lecture at the ECSCW'2003 conference entitled "Working and Learning When the Answer is Not Known" (http://l3d.cs.colorado.edu/~gerhard/presentations/ecscw-keyn-slides-final.pdf) I argued that the CSCW community should be more concerned with *learning* for the following reasons:

- Learning is an essential part of work, particularly in contexts where the answer is not known.
- Despite learning's important role, the CSCW community has largely neglected to use it as a theoretical and analytical construct.

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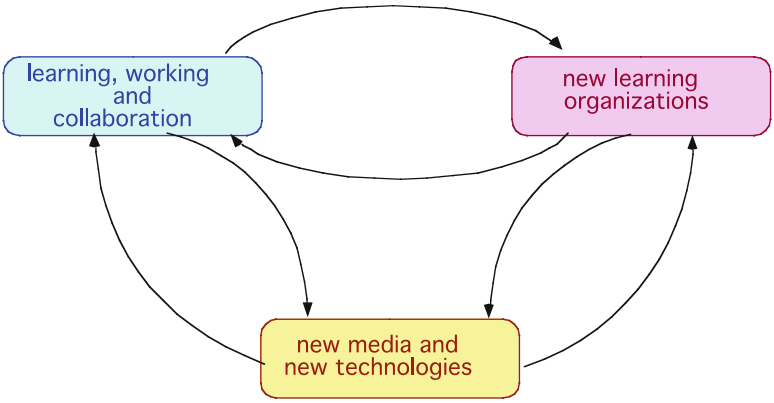

Fig. 2.1 The integration and coevolution between activities, organizations, and media

- Future research challenges for CSCW should give more attention to learning, integrate working with learning and collaboration, and create innovative media to support this integration.

In an invited lecture at the CSCL'2007 conference entitled "Designing Socio-Technical Environments in Support of Meta-Design and Social Creativity" (http://l3d.cs.colorado.edu/~gerhard/presentations/slides-cscl-final.pdf) I argued that the CSCL community should understand learning in *work* environments and not just in schools and that many advanced learning technology developments are too timid and are not thinking radically enough for the following reasons (Fischer, 2007):

- They accept too many established approaches—e.g.: A theory of human learning based solely on school learning is too limited but the success of universal schooling has led us to identify learning with schooling.
- They insufficiently embrace new learning opportunities—e.g.: Exploiting the unique opportunities of social production in which all learners can act as active contributors in personally meaningful problems.
- They reduce digital literacy and fluency to accessing and comprehending existing information rather than empowering learners to reformulate knowledge, to express themselves creatively and appropriately, and to produce and generate information.
- They often do not move beyond "gift-wrapping" and "techno-determinism" to explore the coevolution of learning, new media, and new learning organizations (see Fig. 2.1).

This paper is an elaboration of those ideas, and provides additional arguments about the importance and identity of CSCL at Work as a scientific discipline to rethink and reframe learning to better account for the demands of the knowledge societies of the future. The development of a framework for CSCL at Work has been influenced by numerous other sources including the following:

- Illich's vision of "learning webs" conceiving a different style of learning, showing that "the inverse of school is possible," and defining educational resources (reference services to educators-at-large and to educational objects, skill exchange, peer matching) were articulated 40 years before the World Wide Web made them possible (Illich, 1971).
- Resnick's differentiation of "learning in and out of schools" contrasted specifically: (1) individual cognition in school versus shared cognition outside; (2) pure mentation in school versus tool manipulation outside; (3) symbol manipulation in school versus contextualized reasoning outside school; and (4) generalized learning kin school versus situation-specific competencies outside (Resnick, 1987).
- Engeström's concept of "expansive learning at work" grounded his approach in learning at work in the observation that "people and organizations are all the time learning something that is not stable, not even defined or understood ahead of time. … There is no competent teacher. Standard learning theories have little to offer if one wants to understand these processes" (Engeström, 2001).

The following sections outline a *conceptual framework* (including the impact of new media and the articulation of research questions) and describe *specific developments* to address the challenges derived from the conceptual framework.

Challenges for CSCL at Work

Understanding "Work"

The development of a conceptual framework for CSCL at Work requires some understanding of work and how it gets accomplished (Fischer, Greenbaum, & Nake, 2000; Greenbaum, 1995; Orr, 1996). Work covers a great variety of different activities in an enormous number of application domains. This article focuses primarily on work that can be characterized as *creative problem solving* (in which processes are not well defined) rather than on *routine cognitive skills* (in which processes are well defined). For example, most design and decision-making problems (Simon, 1996) (1) transcend the power of the unaided individual human mind requiring *distributed cognition*; (2) represent wicked, problematic situations rather than given problems requiring the *integration of problem framing and problem solving*; (3) are systemic problems requiring *communities of interest* (CoIs) consisting of participants with multiple expertise; and (4) represent problems to which the answers are not known. The "answer is not known" to these problems because design and decision-making problems represent a *universe of one* supported by the evidence that "85 % of the problems a doctor sees in his office are not in the book" (Schön, 1983). These requirements are addressed by the development of *meta-design, cultures of participation,* and *social creativity*.

CSCL at Work: In Search for a New Understanding of Learning

CSCL at Work is limited in what it can learn from most current approaches to CSCL that are primarily focused on school learning where learning is conceptualized from the perspective that "answers are known" by teachers. School learning is focused on the core objective that the students should learn what the teachers know. This limitation has been articulated by a variety of researchers including Scribner and Sachs who assert: "A decade of interdisciplinary research on everyday cognition demonstrates that school-based learning, and learning in practical settings, have significant discontinuities. We can no longer assume that what we discover about learning in schools is sufficient for a theory of human learning" (Scribner & Sachs, 1990).

Learning can no longer be dichotomized into a place and time to *acquire* knowledge (school) and a place and time to *apply* knowledge (the workplace) (Gardner, 1991). Coverage of relevant subjects in schools is impossible and obsolescence is guaranteed.

The research in our Center for LifeLong Learning & Design (L3D) (http://l3d.cs.colorado.edu/) focuses on making learning a part of life, and is grounded in the exploration of the following basic assumption (Derry & Fischer, 2007):

> If the world of working and living relies on collaboration, creativity, definition, and framing of problems, and if it requires dealing with uncertainty, change, and intelligence that is distributed across cultures, disciplines, and tools—then education should foster transdisciplinary competencies that prepare students for having meaningful and productive lives in such a world.

In addition to being limited by what CSCL at Work can learn from learning in schools, it is also limited in what it can learn from current practices in adult education and workplace learning (Resnick, 1987). Workplace learning is often reduced to *training* by delivering courses that are separated from the contexts in which their subject matter is relevant (Fischer, 2000) and to knowledge management approaches that support only learning from the past (dePaula & Fischer, 2005).

Lifelong learning provides a perspective for CSCL at Work with its basic assumption that learning is inherent in human nature, an ongoing and integral part of our lives, not a special kind of activity separable from the rest of our lives. From this perspective, learning, working, and collaborating are integrated and complement each other (Brown & Duguid, 1991) to cope with the problems articulated in the next section.

The Collaborative Aspect of CSCL at Work: Transcending the Individual Human Mind

CSCL at Work offers important possibilities to cope with *major problems* our societies are facing today that can be classified as follows (Fischer, 2011):

- Problems of a *magnitude* that individuals and even large teams cannot solve (requiring support for distributed cognition)
- Problems being *poorly understood and wicked* requiring the involvement of the owners of problems because they cannot be delegated to others (requiring support for the integration of problem framing and problem solving; see "Narrative 1" for illustration)
- Problems of a *systemic nature* that do not fall within the boundaries of one specific domain (requiring the collaboration of many different minds from a variety of background in CoIs)
- Problems modeling *changing and unique worlds* for which the answers are not known (requiring open, living information repositories, support for end-user development, and meta-design; see "Narrative 2" for illustration)

CSCL at Work and New Media

CSCL at Work can be facilitated and supported by a variety of different technological environments, and should not be reduced to

- "Gift-wrapping" *approaches* that reduce the impact of new media to mechanize old ways of learning, working, and collaborating and where new media have been used primarily as add-ons to existing practices (Fischer, 2000)
- "Technology-driven" *developments* that are grounded in the questionable assumption that new technologies are not only necessary but also sufficient for causing fundamental changes toward a new culture of learning (Thomas & Brown, 2011)

Innovative socio-technical environments for CSCL at Work should support the *coevolution* of a new understanding of (1) learning, working, and collaborating; (2) new media and new technologies; and (3) new learning organizations (see Fig. 2.1).

An example of *gift-wrapping* would be the use of student response systems (such as Clickers) to enhance classroom learning by supporting students to provide feedback and allowing teachers to get a quick assessment of the students' understanding. An example of *technology-driven developments* would be an objective such as "all schools on the Internet" (as promoted by Al Gore around 1994) which is necessary to explore different learning opportunities but *not sufficient* (without accompanied changes in content and pedagogy) to improve learning.

Research Questions

The preceding argumentation provides the foundation for research questions (RQs) that I have first articulated in my presentation at the workshop "CSCL at Work" at the GROUP'2010 conference (Fischer, 2010):

- *RQ-1*: Does *distributed cognition* provide an interesting perspective for CSCL at Work?
- *RQ-2*: Does the *integration of problem framing and problem solving* allow stakeholders to cope with poorly understood and ill-defined problems?
- *RQ-3*: Will *CoIs* be more successful in coping with systemic problems than communities of practice (CoPs)?
- *RQ-4*: How do we create frameworks, media, and organization to learn from each other when *the answer is not known*?

These research questions will be illustrated with two narratives and with developments of components of our conceptual framework in the following sections.

Narrative 1: Writing This Chapter About CSCL at Work

Writing a book chapter like this one is an essential part of my *work* as a researcher. This brief narrative analyzes and describes what this activity will contribute to the conceptual framework for CSCL at Work.

While I am the single author of this article, the work done is best understood from a *distributed cognition* perspective: I have (1) collaborated with many colleagues and students in developing the ideas and systems described (see the "Acknowledgements"); (2) relied on many other sources documented in the literature (see the "References"); and (3) built upon my own work of the past in developing these ideas (see "Introduction"). I made extensive use of tools (which need to be learned, used, and extended if necessary) such as exploiting the review tools of Microsoft-Word and taking advantage of a large, collaboratively constructed Endnote library. My colleagues, students, and the reviewers and the editors of this book provided me with feedback and criticism and facilitated this process with collaborative writing tools.

Going through many iterations of this article not only consisted of solving a problem but also led to numerous versions based on a *reframing* of the problem. The feedback for reflecting more deeply about the problem came for a *CoI*: colleagues with different views of the problem working in the learning sciences, in school learning, in adult education, and in the development of new media. And last but not least: the answer to the question "what is an interesting conceptual framework for CSCL at Work?" was *not known*—and the writing of this article represented learning, working, and collaborating to develop *one* argumentative context for the problem.

The Conceptual Framework

This section describes four components of a conceptual framework for CSCL at Work that we have explored analyzing and supporting the coevolution between learning, working, collaboration, new learning organizations, and new media (see Fig. 2.1).

Distributed Cognition

CSCL at Work should be grounded in a distributed cognition framework because "people think in conjunction and partnership with others and with the help of culturally provided tools and implements" (p. xiii) (Salomon, 1993). Distributed cognition (Hollan, Hutchins, & Kirsch, 2001) is based on the assumption that knowledge does not reside solely in a person's head, but is created in social practices, and mediated by artifacts all situated in socio-technical environments. The objective of workplace learning is to take as much advantage as possible of the knowledge that other people have and exploit the existence of powerful tools. *School learning* and its assessment, in contrast (Resnick, 1987), is often focused on (1) the unaided mind, measured by studying memory, attention, perception, action, and thought, unaided by external devices and other people; (2) individual cognition: people are expected to learn and perform individually; and (3) demand for tool free performance. Creating externalizations (Bruner, 1996) (one of the main objectives of the EDC described in Narrative 2) is of special importance for groups, because "a group has no head." For collaborative design activities, externalizations are a necessity because they create a record of our mental efforts, one that is "outside us" rather than vaguely in memory, and they represent situations which can talk back to us, critiqued, and negotiated (Fischer, Nakakoji, Ostwald, Stahl, & Sumner, 1998; Schön, 1983).

Integration of Problem Framing and Problem Solving

Many problem-solving methodologies assume that problems can be clearly defined a priori—before any solution attempt is made. In work environments, as opposed to the classroom, problems and tasks themselves are ill defined and wicked, and solution attempts represent moving targets requiring an integration of problem framing and problem solving (Rittel, 1984). Work in progress (as it manifests itself in externalizations) suggests ways to proceed, and the development of a solution causes the understanding of the task to grow and change.

Learning on demand (Fischer, 1991) often occurs in the context of integrating problem framing and problem solving as it represents an important opportunity to be exploited by reflection in action (Schön, 1983). Learning on demand is the only viable strategy in a world where we cannot learn everything. It is a promising approach for the following reasons:

- It contextualizes learning by allowing it to be integrated into work rather than relegating it to a separate phase.
- It lets learners see for themselves the usefulness of new knowledge for actual problem situations, thereby increasing the motivation for learning new skills and information.
- It makes new information relevant to the task at hand, thereby leading to better decision making, better products, and better performance.

Table 2.1 Multiple learning strategies

Level	Description	Strengths	Weaknesses
Fix-it level	Fixes the problem by giving performance support without detailed understanding	Keeps focus on task; learning does not delay work	Creates little understanding
Reflect level	Explores argumentative context for reflection ("reflection-in-action")	Understanding of specific issues	Piecemeal learning of (disconnected) issues
Tutorial level	Provides contextualized tutoring (not lecturing on unrelated issues)	Systematic presentation of a coherent body of knowledge	Substantial time requirements

Domain-Oriented Programmable Design Environments

In our own work we have pursued learning on demand in the context of developing conceptual frameworks and innovative systems for *domain-oriented, programmable design environments* (Eisenberg & Fischer, 1994). These environments explore middle ground between *open learning environments* (supporting self-directed learning opportunities but lacking guidance and support) and *intelligent tutoring systems* (providing extensive guidance and support but doing so for problems that might be irrelevant to the workers' tasks at hand). Domain-oriented, programmable design environments support learner control, expressiveness, assistance, modifiability, domain-oriented descriptions, information delivery, contextualization of information to the task at hand, and collaboration between users. They are particularly effective in exploiting the motivation of users by allowing learning to take place in the context of actual problem situations.

Learning on demand supports *multiple learning strategies* in response to the specific situation learners are facing: at certain times, they may be interested in a quick fix or they want to restrict their learning effort to reflect on a specific context, whereas in other situations they may want to explore a domain in a systematic fashion.

Table 2.1 describes three learning strategies with their respective strengths and weaknesses for workplace learning.

Communities of Interest

Working on systemic problems requires the collaboration and coordination of stakeholders from different *CoPs* (Wenger, 1998). We define a *CoI* (Fischer, 2005) as a group of stakeholders brought together from different CoPs, on the basis of a common concern or interest, to solve a particular complex design problem. In contrast to project teams, wherein employees are held together by a formal contract such as a business project, CoI stakeholders are held together by a shared interest.

CoIs are often more temporary than CoPs and cannot rely on a shared social practice. Their raison d'être is a common interest in the framing and resolution of a

design problem. They are less in danger to suffer from *group-think* (Janis, 1972) and can be more innovative and more transforming than CoPs if they can leverage the "symmetry of ignorance" (Rittel, 1984) as a source for collective creative innovations. Challenges facing CoIs are in building a shared understanding of the problem at hand, which often does not exist at the beginning but evolves incrementally and collaboratively. Members of CoIs must learn to communicate with and learn from each other (Engeström, 2001), although they may have different perspectives and perhaps different vocabularies for describing their ideas.

Learning within CoIs is more complex and multifaceted than *legitimate peripheral participation* in CoPs (Lave & Wenger, 1991) which assumes that there is a single knowledge system within which newcomers move toward the center over time. Acting knowledgeably in CoPs is less demanding compared to the challenges of operating within CoIs, which do not share a common language and practice. Strategies to mitigate these challenges and facilitate the sharing of knowledge and allowing knowledgeable performances within CoIs include (1) developing *boundary objects* (Bowker & Star, 2000), (2) engaging *knowledge brokers*, (3) supporting *transdisciplinary collaboration*, and (4) developing new media in support of these processes in order to circumvent the social and technical obstacles that often impede an effective exchange of information within CoIs and create new opportunities for social creativity.

Learning When the Answer Is Not Known

For many problems in work environments, the knowledge to understand, frame, and solve these problems does not already exist, but must be collaboratively constructed and evolved during the problem framing and solving process. Informed participation in a collaborative work setting requires information, but mere access to information is not enough. The participants must go beyond the information that exists to solve their problems. In supporting *learning when the answer is not known*, the primary role of media is not to deliver predigested information to individuals, but to provide the opportunity and resources for social debate, collaboratively created externalizations, and the discussion and reflection about them. To transcend the existing information, tools and artifacts must be able to address the unique demands of idiosyncratic problems allowing stakeholders to incrementally acquire ownership in problems and contribute actively to their solutions. The following sections briefly describe three themes contributing to cope with these challenges:

- *Meta-design* empowers people to act as active contributors engaging in knowledge and tool creation (Fischer & Giaccardi, 2006).
- *Cultures of participation* provide all people with the means to participate and to contribute actively in personally meaningful problems (Fischer, 2011).
- *Social creativity* exploits distances, diversity, and emergence as important sources for new knowledge and provides foundations for mutual learning when the answer is not known (Fischer, Giaccardi, Eden, Sugimoto, & Ye, 2005).

Meta-design

Meta-design (Fischer & Giaccardi, 2006) is focused on "design for designers." Meta-design is grounded in the basic assumption that owners of personally meaningful problems struggle and learn tools that are useful to them, rather than believing in the alternative of "ease of use," which limits them to preprogrammed features (National-Research-Council, 2003). Users are empowered with opportunities, tools, and social rewards to extend a system to fit their needs at use time, rather than being forced to use closed systems created at design time (von Hippel, 2005). As owners of problems, users can be active contributors engaged in creating knowledge rather than passive consumers restricted to the consumption of existing knowledge (dePaula & Fischer, 2005). Meta-design (1) creates artifacts that can be subjected to critical reflection, and be open to adjustment and tweaking; (2) supports unintended and subversive uses (not just anticipated ones); and (3) allows learners to engage in personally meaningful activities.

Meta-design transcends the *limitations of closed systems* that do not give ownership to those who own the problem, but to a selected group of designers whose major challenge is to foresee all possible tasks and breakdowns in order to store answers to questions that might arise thereafter (Suchman, 1987; Winograd & Flores, 1986). Closed systems are likely to contain information that is chronically out of date and they are therefore not suited to the emerging idiosyncratic demands of workplace learning.

Cultures of Participation

Cultures are defined in part by their media and their tools for thinking, working, learning, and collaborating. In the past, the design of most media emphasized a clear distinction between producers and consumers (Benkler, 2006). For example, instructionist, curriculum-driven formal education treats learners as consumers, fostering a mindset in students of "consumerism" rather than "ownership of problems" for the rest of their lives (Illich, 1973). As a result, learners, workers, and citizens often feel left out of decisions by teachers, managers, and policymakers, denying them opportunities to take active roles.

The rise in *social computing* (based on social production and mass collaboration) has facilitated a shift from *consumer cultures* (specialized in producing finished artifacts to be consumed passively) to *cultures of participation* (in which all people are provided with the means to participate and to contribute actively in personally meaningful problems) (Fischer, 2011; Jenkins, 2009). These developments represent unique and fundamental opportunities, challenges, and transformative changes for CSCL at Work as we move away from a world in which a small number of people define rules, create artifacts, and make decisions for many consumers toward a world in which everyone has interests and possibilities to actively participate.

Fostering cultures of participation is supported by meta-design by creating the following mechanisms:

- *Making changes must seem possible*: Contributors should not be intimidated and should not have the impression that they are incapable of making changes; the more users become convinced that changes are not as difficult as they think they are, the more they may be willing to participate.
- *Changes must be technically feasible*: If a system is closed, then contributors cannot make any changes; as a necessary prerequisite, there need to be possibilities and mechanisms for extensions.
- *Benefits must be perceived*: Contributors have to believe that what they get in return justifies the investment they make. The benefits perceived may vary and can include social benefits (increased status in a community, possibilities for jobs) and personal benefits (engaging in fun activities).
- *Sharing of changes must be encouraged*: Evolutionary growth is greatly accelerated in systems in which participants can share their contributions without substantial additional efforts.
- *Meta-designers must exist and be rewarded*: Meta-designers should use their own creativity to create socio-technical environments in which other people can be creative. They must create contexts in which users acting as designers can create content and they must be willing to share control of tools and content.

Social Creativity

Although creative individuals are often thought of as working in isolation, much human creativity arises from activities that take place in a social context in which interaction with other people and the artifacts that embody collective knowledge are important contributors to the process (Csikszentmihalyi, 1996). As argued before, the fundamental problems of the twenty-first century are complex and open ended, requiring ongoing contributions of many minds, particularly from the people who own the problems and are directly affected by them.

CSCL at Work should provide frameworks to invent alternative social organizations and new media that will permit the flourishing of deep interdisciplinary specialties (Derry, Schunn, & Gernsbacher, 2005), as argued for by Campbell (Campbell, 2005): "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's fish-scale model (an architecture to achieve "collective comprehensiveness through overlapping patterns of unique narrowness") provides a viable path toward a new competence, based on the integration of individual and social creativity (Fischer et al., 2005).

Distances (across spatial, temporal, and technological dimensions) and *diversity* (bringing stakeholders together from different cultures in CoIs) are important sources for *social creativity* (Fischer, 2005). Over the last decade, we have designed and

developed socio-technical environments exploring and supporting different aspects of social creativity including (1) the *Envisionment and Discovery Collaboratory* (EDC) described in Narrative 2; (2) the *CreativeIT Wiki* to support the research community in "Creativity and IT"; and (3) collaborated with Google in analyzing the *3D Warehouse* (a set of interconnected tools that include *SketchUp* and *Google Earth*), which stores user-generated 3D models of buildings (and other artifacts) contributed from participants distributed all over the world. In these projects, we have studied different aspects of social creativity, including the impact of cultures of participation, the motivation to contribute, the learning requirements to become a contributor, and the role of curators to organize the emerging large repositories.

Narrative 2: Framing and Solving Urban Planning Problems with the Envisionment and Discovery Collaboratory

The EDC (Arias, Eden, Fischer, Gorman, & Scharff, 2000) represents a new generation of *collaborative* domain-oriented design environments. It shifts the emphasis away from the computer screen as the focal point and creates an immersive environment in which stakeholders can incrementally create a shared understanding. It attempts to maximize the richness of communication between stakeholders in face-to-face interaction, mediated by both physical and computational objects. It is grounded in Schön's "reflection-in-action" problem-solving approach (Schön, 1983) and has been applied to a variety of different design and decision-making problems in urban planning, emergency management, and transportation planning. Stakeholders using the EDC (see Fig. 2.2) convene around a computationally enhanced table that serves as the *action space*. The action space allows users to manipulate an interactive model of the design problem by proposing, exploring, reflecting, and critiquing alternative solutions. The horizontal table is flanked by touch-sensitive vertical tables that serve as the *reflection space*. The reflection space displays information that is relevant to the context as defined by artifact constructed in the action space.

The EDC explores and instantiates the components of our conceptual framework for CSCL at Work in a variety of different dimensions:

Distributed cognition is facilitated and enhanced by a tabletop computing environment that supports groups of people to work and learn together and contains information and tools relevant to the domain under investigation.

The *integration of problem framing and problem solving* is supported by a linkage between the *action space* (see Fig. 2.3) and the *reflection space* (see Fig. 2.4). When the participating stakeholders consider how land should be used in planning a new urban environment, they deal with a complex and wicked situation in which geographic, topological, financial, economic, and political issues are all mixed up together. During their collaborative activities in defining a land use scheme in the action space, they can analyze and reflect upon their decision making at any time with an alternative view of their action in the reflection space. Figure 2.4 illustrates

Fig. 2.2 The envisionment and discovery collaboratory

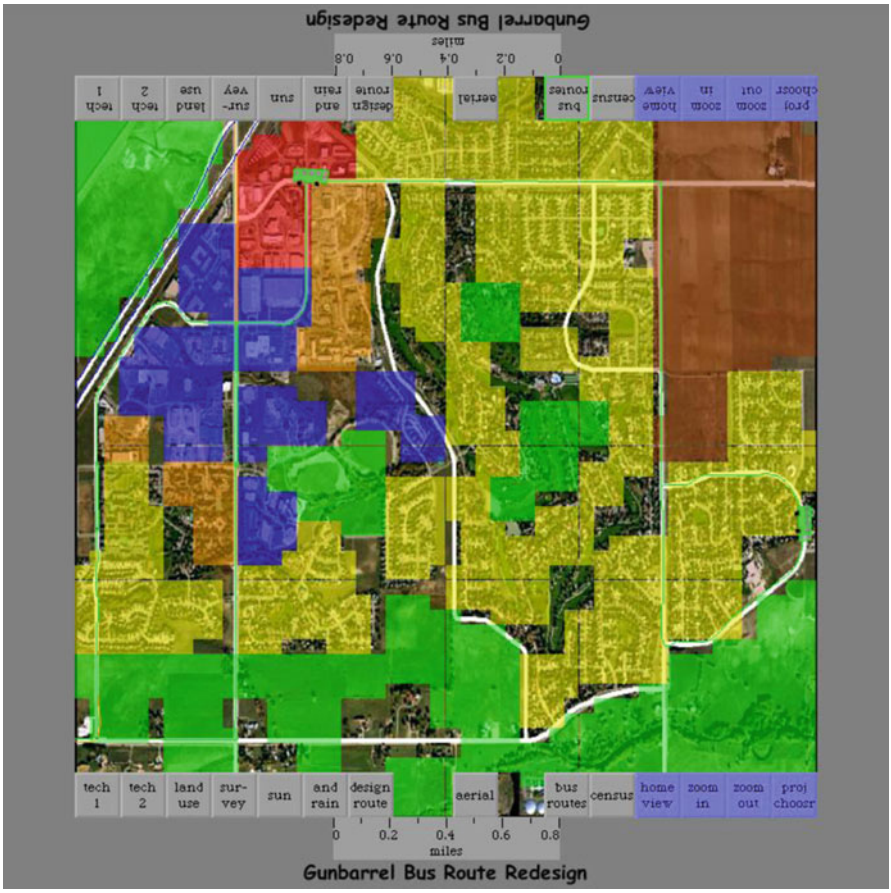

Fig. 2.3 A land-use scenario in the action space

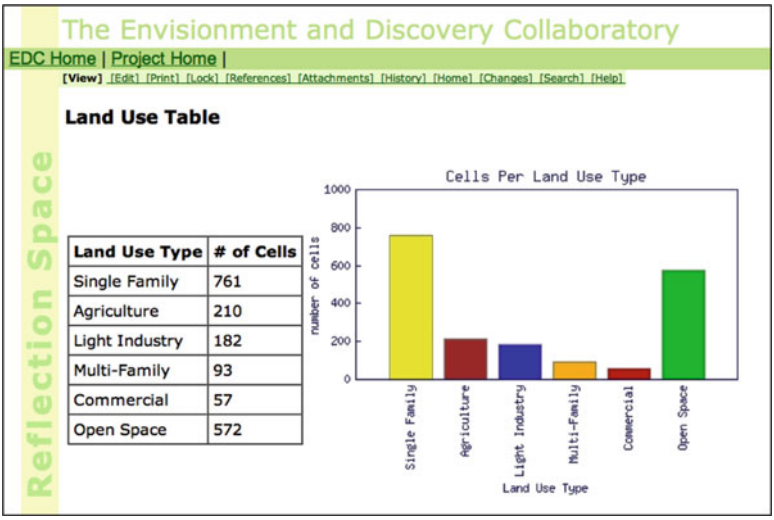

Fig. 2.4 Summary view of land use generated in the reflection space

how the reflection space provides a quantification of decisions made in the design space, giving designers a framework for reflection based on the impacts of their design decisions. Going back and forth between the two spaces provides the participants with numerous learning possibilities. The transition from the action to the reflection space is often triggered by *critics* (Fischer et al., 1998) that signal a breakdown situation (such as the violation of existing knowledge).

CoIs: The EDC brings together stakeholders with different expertise, including professional planners, transportation planners, and financial experts. It exploits the symmetry of ignorance as a source of power for mutual learning by providing all stakeholders with means to express their ideas and their concerns.

Learning when the answer is not known: The three themes identified for helping people cope with this objective are supported by the EDC as follows:

- *Meta-design*: The EDC was envisioned to be an end-user-modifiable version of Simcity, allowing participants (1) to contextualize the existing environment to their own situation, (2) to integrate different information sources, and (3) to develop new structures and processes.
- *Cultures of participation*: The EDC is an environment that is not restricted to the delivery of predigested information to individuals, but it provides opportunities and resources for design activities embedded in social debates and discussions in which all stakeholders can actively contribute rather than being confined to passive consumer roles.
- *Social creativity*: The EDC supports emerging insight as illustrated by the example in Fig. 2.5 in which participants collaboratively try to decide the best location

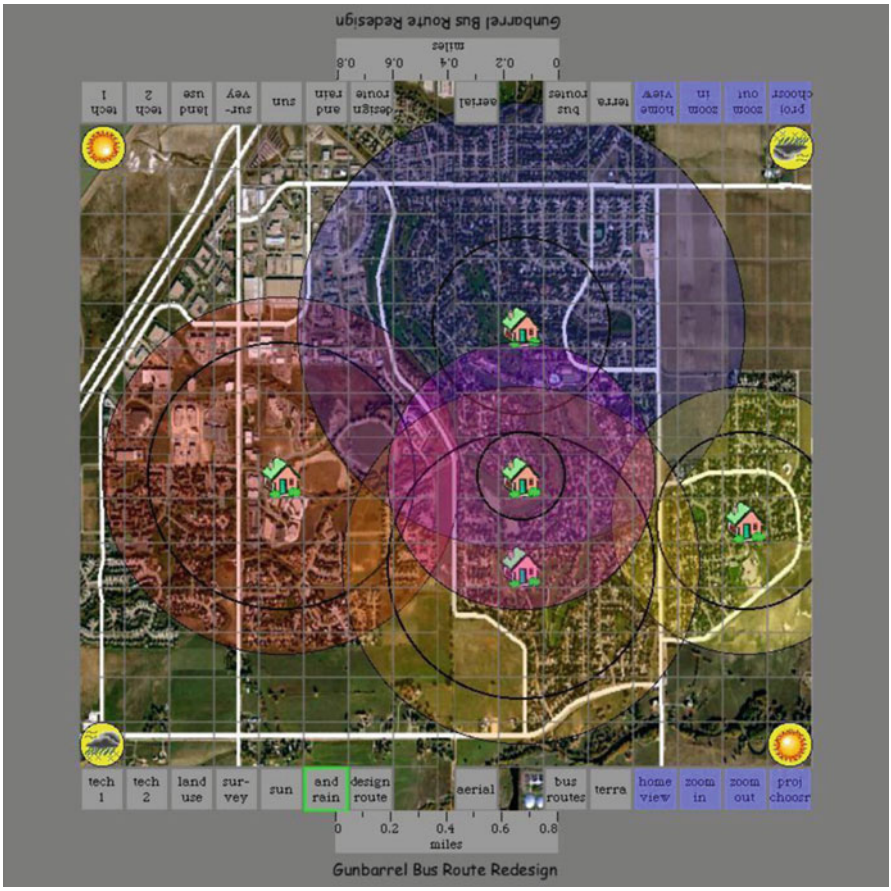

Fig. 2.5 Emerging collaborative insights based on individual contributions in a walking-distance scenario

of a bus stop by analyzing multiple walking distances. Participants indicate where they live on the map (resulting in a house icon appearing at that location). They are supported with task-focused interaction mechanisms to indicate how far they would be willing to walk in good and bad weather. After specifying this information, colored circles (generated by the system) appear around their individual house icons, indicating the range of area that they might be willing to walk to catch a bus. The display (bringing together the results of their individual decisions) shows *emerging patterns* of areas that are suitable for bus routes and bus stops, providing information and perspectives that no individual had in her or his head prior to the problem-solving session. The externalization created by individual actions serves as a source of social creativity for further design and decision making.

Trade-Offs of CSCL at Work

CSCL at Work opens up unique new opportunities for the integration of learning, working, and collaborating—but similar to other major innovations, it will face trade-offs. This section briefly discusses some potential drawbacks.

Being Taken of Task

A researcher needing to finish a paper faces an upcoming deadline when her graduate student informs her that there are much improved versions of the tools (she is using for writing, graphics, and creating references) available. She then faces the *production paradox* (Carroll & Rosson, 1987): how to balance effort and time to get the work done (finishing the article) and do so with suboptimal tools versus engage in learning to use the new tools. The dilemma of the active user is related to the rational choices workers make while facing competing or conflicting situations: analyzing the trade-offs between dealing with pressing problems and investing in long-term solutions (such as learning to use a new technology). Our approaches to CSCL address this paradox by allowing users to choose between different strategies for learning something new (such as Fix-It, Reflect, or Tutorial; see Table 2.1). Another way to tackle the production paradox is to better integrate learning and working by embedding innovations into practices so that learning and use become the same activity through which users can see tangible benefits and long-term impact in their work practices and careers.

Learning on Demand: Making Information Relevant to Users and Tasks Versus Serendipity

Information access and information delivery are two approaches for obtaining information. *Information access* is a user-initiated search, while *information delivery* is a system-initiated presentation of information. In information access schemes, workers articulate information needs, while in information delivery schemes, systems infer information needs. Information delivery is important when workers are not motivated to look for information or when they are not aware of the existence of information or tools relevant to their tasks.

Information delivery approaches create the following trade-off: whether to make *information relevant to users and tasks* or whether to facilitate *serendipity*. In a world of information overload, throwing decontextualized information at users (as in broadcast systems or in tool such as “Microsoft’s Tip of the Day”) is of little use. Models of learners and task (for which information is readily available in today’s computational environment from all sources) can be used to tailor information

in order to avoid bombarding users with irrelevant information (Fischer, 2012). The drawback associated with these approaches takes control away from users what they will see and be confronted with by encapsulating them in "filter bubbles" [Pariser (2011) characterizes this as a shift from human to algorithmic gate-keepers leading to isolation in a "web of one"].

Tools for Learning and Tools for Living

Grounded in our research to create socio-technical environments to support caregivers and persons with cognitive disabilities (Carmien, Kollar, Fischer, & Fischer, 2007), we have identified and explored a fundamental distinction between the following:

- *Tools for living*: Grounded in a distributed cognition perspective, in which intelligence is mediated by tools for achieving activities that would be error prone, challenging, or impossible to achieve
- *Tools for learning*: Grounded in a "scaffolding with fading" perspective leading to autonomous performance by people without tools

This distinction raises fundamental questions about the future of education, learning, working, and the development and use of new media by asking what it means to learn in the twenty-first century. We now live in a world where powerful tools are available for many intellectual activities—allowing people to have instant access to facts, assisting people in spelling, doing arithmetic, and performing numerous other intellectual activities (Pea, 2004).

The Impact and the Future of CSCL at Work

A major impact of CSCL at Work will be (1) to conduct research on the monopoly and exclusiveness of formal school learning (Collins & Halverson, 2009), and (2) to complement and enrich current practices in adult education [that often is reduced to training (Fischer, 2000)]. Inspirations, concepts, and organization may come from analyzing, fostering, and supporting cultures of participation (Fischer, 2011).

CSCL at Work provides the unique opportunity to explore and define conceptually alternative modes of computer-supported, collaborative learning that will enrich learning and working in the twenty-first century. It has the potential to close the gap between school and workplace learning by allowing learners to engage in activities requiring collaboration, creativity, problem framing, and distributed cognition. It will provide insights and alternative models of cognitive activities by illustrating what can be learned as a result of intentional teaching and what can be learned from working on interesting problems with other humans utilizing powerful and innovative computational media.

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