Designing Socio-Technical Environments in Support of Meta-Design and Social Creativity

Gerhard Fischer
Center for Lifelong Learning and Design
University of Colorado, Boulder
http://l3d.cs.colorado.edu/~gerhard/

Abstract: This paper provides elements of a *transformational conceptual framework* for CSCL by focusing on how learning takes place when the answer is not known (this being the case for complex design problems in numerous domains encountered in lifelong learning activities).
The paper postulates, explores, and discusses visions, theories, systems, practices, and methods for CSCL with a focus on *reflective communities* (bringing stakeholders together from many different backgrounds, requiring cultural and epistemological pluralism to make all voices heard*), meta-design* (allowing owners of problems to act as designers and active contributors, and not only as consumers*), and social creativity* (bringing different and often controversial points of view together to create a shared understanding among stakeholders that can lead to new insights, new ideas, and new artifacts).
Innovative *socio-technical environments* are needed to make progress in achieving these objectives. Examples and characteristics of such environments will be briefly presented and discussed. Some implications and challenges for future research in CSCL are derived and articulated.

Keywords
reflective communities, design, meta-design, social production, social creativity, socio-technical environments, symmetry of ignorance, gift-wrapping

Introduction

The goal of the CSCL community and in particular its 2007 conference ("*Of Mice, Minds, and Society*") is to sharpen the community's perspectives on how visions, theories, systems, practices, and methods of CSCL are interwoven and how they interactively contribute to an understanding of the nature of learning in technology-supported environments.

I will argue in this paper that CSCL is not thinking *radically* enough (1) by accepting too many established approaches and organizations (e.g.: a theory of human learning based solely on school learning is too limited), (2) by not embracing 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), and (3) by not providing broader conceptual frameworks for learning in the 21st century. I believe that the CSCL community can and should act as the engine of innovation and radical transformation and contribute to changing the public understanding of learning, collaboration, expertise, attention, control, freedom, and creativity in the digital age.

My contribution is shaped by having participated in the CSCL community from its beginning, by identifying interesting themes in related disciplines (such as computer supported cooperative work, human computer interaction, design, and the learning sciences), and by our research work in the Center for LifeLong Learning & Design (L3D) over the last decade.

Why Now: Opportunities and Challenges?

Stephen Jay Gould argues for the theory of *"punctuated equilibrium"* in biology (long periods of slow change are interspersed with periods of rapid change) and social systems may follow a similar pattern (Collins & Halverson, 2006). People from various scientific disciplines (Benkler, 2006; Bereiter, 2002; Florida, 2002; Tapscott & Williams, 2006) have argued that we are in the midst of a technological, economic, and organizational perturbation, innovation, and transformation that allows us to rethink, renegotiate, and redefine learning, working, and collaboration. One of the fundamental changes taking place is the democratization of knowledge creation, innovation, and creativity (O'Reilly, 2006; Raymond & Young, 2001; von Hippel, 2005). The industrial information society specialized in producing finished goods (like movies, music, software systems, and learning environments) to be specified fully at design time and consumed passively at use time. The emerging networked information society is focusing on the demands of active contributors for evolvable environments (including platforms, seeds, and tools) that are "underdesigned." *Underdesign (Brand, 1995; Fischer & Ostwald, 2005)* in this context does not mean less work and fewer demands for the design team, but it is fundamentally different from creating complete systems. The primary challenge of underdesign lies not in developing specific solutions, but in designing environments that allow the *"owners of problems*" to create solutions themselves at use time. This can be done by providing a seed against which situated cases that arise later can be interpreted. Underdesign is a defining activity for meta-design aimed at creating design spaces for others.

Themes developed in the past for CSCW and CSCL research have often focused on how standardized processes were embedded in workflow systems and curriculum-driven learning environments and how homogenous communities of practice could be supported. Future themes need to be focused on how to improvise, innovate, and learn when the answer is not known, and how to bring different communities of practice together in communities of interest to avoid group think and to exploit the opportunities provided by the *symmetry of ignorance* (Fischer & Ostwald, 2005), *conceptual collisions* (J. Bransford *et al.*, 2006), and *epistemological pluralism* (Turkle & Papert, 1991) by making all voices heard. This is especially important at a time where many high level objectives in education are focused on a climate for test taking, bookkeeping, and cutting expenses—the wrong strategies as economic competition heats up around the globe and societies are exploring news ways to make their individual members more creative, imaginative, and innovative (Friedman, 2005).

Lifelong Learning: A Focus for CSCL

Learning needs to be examined across the lifespan 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 irremovable part of work activities. Learning is a new form of labor and working is often (and needs to be) a collaborative effort among colleagues and peers. In the emerging knowledge society, an educated person will be someone who is willing to consider learning as a lifelong process. More and more 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 (Illich, 1971). In preparing learners to live and work in the knowledge age (Bereiter, 2002), one cannot predict or learn in educational settings what one may need to know during a lifetime of work. Coverage is impossible and obsolescence is guaranteed. CSCL should do a better job of empowering all students to be prepared for future learning and to learn on demand by exploiting the powers of collaboration and new media (Bereiter & Scardamalia, 2006; Fischer, 2000).

Lifelong learning in the world today is a necessity (*"The ultimate goal of education is to prepare students to become competent adults and lifelong learners"(J. D. Bransford et al., 2001)*) and people need to acquire the cognitive and social skills necessary for self-directed, lifelong learning (Drucker, 1994). Our credo for lifelong learning can be formulated as follows: "*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 learning and education should foster competencies that prepare learners for having meaningful and productive lives in such a world."*

By *integrating working and learning*, people learn within the context of their work on real-world problems. Learning does not take place in a separate phase and in a separate place, but is integrated into the work process. People construct solutions to their own problems, and the socio-technical environment advises them when they are getting into trouble and provides directly relevant information. The direct usefulness of new knowledge for actual problem situations greatly improves the motivation to learn the new material because the time and effort invested in learning are immediately worthwhile for the task at hand—not merely for some putative long-term gain. The need to base innovations in learning on more than learning in schools is articulated by (Scribner & Sachs, 1990) as follows: *"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."*

Lifelong learning is a continuous engagement in acquiring and applying knowledge and skills in the context of self-directed problems and should be grounded in descriptive and prescriptive goals such as (Hmelo-Silver, 2004):

- learning should take place in the context of authentic, complex problems (because learners will refuse to quietly listen to someone else's answers to someone else's questions);
- learning should be embedded in the pursuit of intrinsically rewarding activities;
- learning on demand needs to be supported because change is inevitable, coverage is impossible, and obsolescence is unavoidable;
- organizational and collaborative learning must be supported because the individual human mind is limited; and
- skills and processes that support learning as a lifetime habit must be developed.

Understanding and exploring *design* and the *framing and solving* of complex design problems (Simon, 1996) represent fundamental challenges for lifelong learning and these activities provide a rich setting in which to study and apply CSCL. Large and complex design projects cannot be accomplished by any single person, and they often cut across different established disciplines, requiring expertise in a wide range of areas (Arias *et al.*, 2001). Software design projects, for example, involve domain experts, designers, programmers, human-computer interaction specialists, marketing people, and user participants. Design projects are *unique*, and therefore each design project requires learning and produces new knowledge in the form of understanding as well as artifacts. Learners engaged in design must be willing to cope with the uncertain, the unproven, and the ambiguous. Complexity in design arises from the need to synthesize stakeholders' different perspectives of a problem, the management of large amounts of information relevant to a design task, and understanding the design decisions that have determined the long-term evolution of a designed artifact. Successful projects must overcome many barriers to communication and shared understanding. Media and technologies have fundamentally changed the nature of learning and communication in design.

In the effort to develop a coherent and unique intellectual identity for CSCL, there is a rich source of interesting concepts including:

- *distributed intelligence* (Salomon, 1993) — the idea that intelligence is not located in a single mind but is distributed among people and tools that work together and emerges in the process of problem solving;
- *models of community* (Fischer & Ostwald, 2005) — how shared knowledge and common ground is created to support mutual learning and collaborative problem-solving;
- *reflection* (Schön, 1983) — how cognitive skills can help individuals and communities intelligently monitor, assess, and adapt their work through processes such as "reflection-in-action" and "reflection-on-action";
- *boundary objects* (Bowker & Star, 2000) (Star, 1989) — how entities (such as products, standards, or ideas) can serve as communicative interfaces between members of different communities and how they help or hinder collaboration;
- *open, living systems* requiring meta-design approaches (Fischer & Giaccardi, 2006) — how to redistribute power, control, and responsibility by supporting the "creative milieu" in which learners are able to exercise their creativity; and
- *socio-technical design* (Mumford, 1987; Trist, 1981) — how can the evolutionary creation of effective learning and problem-solving environments be made possible with new media with a focus on the interaction between social and technical components.

From Reflective Practitioners to Reflective Communities

The objective of educating "Renaissance scholars" (such as Leonardo da Vinci, who was equally adept in the arts and the sciences (Shneiderman, 2002)) is not reasonable in today's world (National-Research-Council, 2003). We need to invent alternative social organizations that will support *"collective comprehensiveness through overlapping patterns of unique narrowness*" (Campbell, 2005) by integrating different interdisciplinary specialties which are partially overlapping with each other. Such architectures will provide a foundation that people can understand each other based on common ground but at the same time their expertise will be complementary because they will know different things. In doing so, we will move beyond the isolated image of the reflective practitioner towards the sustainability and development of *reflective communities*.

Reflective communities are social structures that enable groups of people to share knowledge and resources in support of collaborative design, working, and learning. Some characteristics of communities being reflective are: avoiding to be stuck in "group think", support for reflection-in-action and reflection-on-action, critiquing (Fischer *et al.*, 1998) establishing common ground and shared understanding, and maintaining group productivity with joint attention (Barron, 2000). Effective reflective communities must be aware of barriers and biases in computer-mediated collaboration and must exploit opportunities with the support of socio-technical environments (Bromme *et al.*, 2005).

Different communities grow around different types of design practice and each design community is unique. Two communities will be briefly discussed: *communities of practice* (CoPs) (Wenger, 1998) and *communities of interest* (CoIs) (Fischer & Ostwald, 2005).

CoPs consist of practitioners who work as a community in a certain domain. Learning within a CoP takes the form of *legitimate peripheral participation* (Wenger, 1998), an 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 which create discontinuities between participants and non-participants. Highly developed knowledge systems 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.

CoIs bring together stakeholders from different CoPs; they form by their collective concern with the resolution of a particular problem and they can be defined as "communities of communities". Examples of CoIs are: (1) teams interested in software development that includes software designers, users, marketing specialists, psychologists, and programmers, (2) groups of citizens and experts interested in urban planning, and (3) domain experts, media specialists, teachers, and learners exploring the design of new innovative learning environments. Collaborative design problems explored by CoIs represent ideal candidates to explore, understand, and support *learning when the answer is not known*. Because design problems are unique, 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. The primary role of media in such settings is not to deliver pre-digested information to individuals, but to provide the opportunity and resources for social debate and discussion (Bruner, 1996) by allowing stakeholders to incrementally acquire ownership in problems and contribute actively to their solutions. The fundamental barrier and opportunity facing CoIs is that knowledge distribution is based on a *symmetry of ignorance (or knowledge)* (Fischer & Ostwald, 2005), in which each stakeholder possesses some, but not all, relevant knowledge, and the knowledge of one participant complements the ignorance of another (Engeström, 2001).

Meta-Design: A Methodology for CSCL

In an unpredictable world, improvisation, evolution, and innovation are more than a luxury: they are a necessity. The challenge of design is not a matter of getting rid of the emergent, but rather of including it and making it an opportunity for more creative and more adequate solutions to problems. Unfortunately, a large number of media are designed from a perspective of seeing and treating humans primarily as consumers (Fischer, 2002). Rather than providing access only to a small group of "high-tech scribes," media need to be designed to allow all participants to be and act *as designers* when they desire to do so, specifically in *personally meaningful and important activities*.

Meta-design (Fischer & Giaccardi, 2006) is focused on "design for designers": an emerging conceptual framework aimed at defining and creating social and technical infrastructures in which new forms of collaborative design can take place. It extends the traditional notion of system design beyond the original development of a system. It is grounded in the basic assumption that future uses and problems cannot be completely anticipated at design time when a system is developed. Users, at use time, will discover mismatches between their needs and the support that an existing system can provide for them. These mismatches will lead to breakdowns that serve as potential sources of new insights, new knowledge, and new understanding. In our research we are investigating fundamental aspects of meta-design such as:

- approaches for supporting domain-orientation by bringing tasks to the forefront and providing time on task, thereby supporting specific communities of practice;

- the use of techniques such as critiquing, simulations, and argumentation to increase the back-talk of the artifacts;
- frameworks and principles for the creation of open, evolvable systems to put owners of problems in charge, allowing users to invest the world with their own meaning;
- collaborative technologies to allow all participants to move from access to informed participation.

Meta-design is of specific importance for ill-defined, wicked design problems (Rittel, 1984) that cannot be delegated (e.g., from problem owners to computer professionals) because they are not understood well enough to be described in sufficient detail. Partial solutions need to "talk back" (Schön, 1983) to the owners of the problems who have the necessary knowledge to incrementally refine them.

Social Creativity: The Potential of CSCL

Meta-design advocates a shift in focus from finished products or complete solutions to conditions, contexts, and tools for users that allow them to be creative in further evolving artifacts and organizations (von Hippel, 2005). Meta-design supports *creativity* in which participants from all walks of life (not just skilled professionals) transcend the information given to incrementally acquire ownership in problems and to contribute actively to their solutions. Creative communities require *active contributors* (people acting as designers in personally meaningful activities), not just consumers (Fischer, 2002). 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 but elements of organization can and frequently do stifle creativity (Florida, 2002).

The claim by Csikszentmihályi (Csikszentmihalyi, 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. Creative individuals can make a difference 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 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 cannot be completely planned actions: they are situated actions exploring the resources available in reflective communities (such as: willingness to take risks and to persevere when things go wrong, understanding that problems will not have unique solutions, and coping with ambiguity). 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.

Much human creativity arises from activities that take place in a social context in which interactions with other people and the shared artifacts are important contributors to the process. Social creativity comes alive in socio-technical environments in which communities collaborate and in which symmetry of ignorance, conceptual collisions, and epistemological pluralism are appreciated and exploited as sources of creativity.

Communities can be characterized by distances and diversity and by the resulting *division of labor* (Levy & Murnane, 2004), among individuals who have unique experiences, varying interests, and different perspectives about problems, and who use different knowledge systems in their work (characteristics which are associated with communities of interest). Distances and diversity should not be considered as constraints and barriers but as opportunities to generate new ideas, new insights, and new environments (National-Research-Council, 2003). The challenge is often not to reduce heterogeneity and specialization, but to support it, manage it, and integrate it by finding ways to build bridges between local knowledge sources and by exploiting conceptual collisions and breakdowns as sources for innovation. Social creativity can be distributed (Derry & Fischer, 2007): (1) *spatially* (across physical distance); (2) *temporally* (across time); (3) *conceptually* (across different communities); and (4) *technologically* (between persons and artifacts). Creativity can be enhanced by integrating diversity, making all voices heard, 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.

Externalizations (Bruner, 1996) (such as components, partial work products, design rationale, catalogs of existing solutions) are critically more important for social interactions because groups have "no head." Externalizations support creativity by: (1) producing a record of our mental efforts that is outside us rather than vaguely in memory; (2) causing us to move from vague mental conceptualizations of an idea to a more concrete representation of it, creating situational back-talk and making thoughts and intentions more accessible to reflection; (3) providing a means for others to interact with, react to, negotiate around, and build upon an idea (especially if they are represented as boundary objects); and (4) contributing to a common language of understanding.

Socio-Technical Design: Environments Supporting CSCL

There is *no media-independent* communication or interaction: tools, materials, and social arrangements always mediate activity. The processes of thinking, learning, working, and collaborating are all functions of our media (Bruner, 1996). Cognition is shared not only among minds, but among minds and the structured media within which minds interact (Salomon, 1993). Major advances in the development of the human race and societies have come not from increases in brain size, but rather from the steady accretion of new tools for intellectual work (the major development being the transition from an oral to a literate society). As we enter a world of *"pervasive computing, with always-on Internet access, reliable quality of service networks, and sufficient levels of technological fluency"* (Pea, 2004), we must address how socio-technical design and environments *will* shape 21st century learning and education.

Many current educational uses of technology are restricted to what can be thought of as *gift wrapping (Fischer, 2000)*: meaning, technology is used as an add-on to traditional practices rather than as a catalyst for fundamentally rethinking what education and learning should and could be. But shortcomings of traditional practices (such as passivity in lectures, fixed curricula, memorization, and decontextualized learning) are not overcome by introducing technology, whether that technology takes the form of intelligent tutoring, multimedia presentations, or distance learning.

Learners should not only learn *with* new media (changing the *how* by learning differently); they must also learn *about* new media (changing the *what* by learning different things); and new models of distributed intelligence need to be explored (Derry & Fischer, 2007). S*ocio-technical design* encourages learners to become active designers. The design of new socio-technical environments should be conceptualized in the dialectical tension between *tradition* (to avoid techno-centrism) and *transcendence* (to avoid gift-wrapping) (Ehn, 1989). Learners need to practice the cognitive, interactional, social, and technical skills necessary for self-directed, lifelong learning required for the 21st century. Media and technologies for learning must not only deliver predigested information to individuals, but provide support and resources for discussion, social debate, and collaborative design (Bruner, 1996).

The *Seeding, Evolutionary Growth, and Reseeding (SER) Process Model* (Fischer *et al.*, 2001) depicts the lifecycle of large evolving socio-technical environments as developed by reflective communities. It postulates that systems that evolve over a sustained time span must continually alternate between periods of unplanned evolutions and periods of deliberate (re)structuring and enhancement. The SER model encourages system designers to conceptualize their activity as meta-design, thereby aiming to support users as active contributors. We have explored the feasibility and usefulness of the SER model for reflective communities engaged in the development of urban planning environments, organizational memories, course information environments, and open source systems. The evolution of these systems share common elements, all of which relate to sustained knowledge use and construction in support of informed participation.

Examples

Developments in coping with complex design problems of the last few years have been based on effective, large-scale collaborative efforts. These developments are most prominent in

- *open-source software* (Raymond & Young, 2001) — an activity in which a community of software developers collaboratively construct systems to help solve problems of shared interest and for mutual benefit;
- *collaboratively constructed encyclopedias* (Benkler, 2006) — with Wikipedia being the most visible example: an example of a collaborative design activity producing content that harnesses the contribution of many minds;
- *massively multiplayer online games* (Tapscott & Williams, 2006) — such as Second Life, a virtual environment in which almost all content is contributed by the players; and
- *knowledge building* (Bereiter & Scardamalia, 2006) — with a focus on conceptual artifacts such as theories, designs and plans and supported by knowledge building environments.

The Internet and associated Web 2.0 technologies (O'Reilly, 2006) serves as a communication medium that expands and supports social creativity by decentralizing production and distribution with meta-design. The developments of peer production of information, knowledge, and culture (Benkler, 2006) represent a unique moment of opportunity and challenge, in which the CSCL community could and should be a leader, not just a follower. The concepts briefly described in this paper (reflective communities, meta-design, and social creativity) are well suited as a starting point to develop a conceptual framework for a deeper understanding of these developments.

In our research activities we have *self-applied* the emerging conceptual framework discussed in the paper to our own research, learning, and teaching activities. I will briefly describe two of these efforts.

The Envisionment and Discovery Collaboratory (EDC). As argued before: most significant real-world design problems are framed and solved by groups of individuals rather than by individuals in isolation. The EDC (Arias et al., 2001) is a long-term research platform exploring conceptual frameworks for new paradigms of learning (including collaborative learning, self-directed learning, and learning on demand) in the context of design problems where the answer is not known. It represents a socio-technical environment supporting reflective communities by incorporating a number of innovative technologies including: table-top computing environments, the integration of physical and computational components supporting new interaction techniques, and an open architecture supporting meta-design activities.

The vision of the EDC is to provide contextualized support for reflection-in-action (Schön, 1983) within collaborative design activities. It brings together participants from various backgrounds to collaborate in resolving design problems. The contexts explored in the EDC (e.g., urban planning, emergency management, and building design) are all examples of ill-defined, open-ended design problems. The knowledge to understand, frame, and solve these problems does not already exist (Engeström, 2001) but is constructed and evolves during the solution process.

The EDC shifts the focus of design activities away from the computer towards an increased understanding of the human, social, and cultural system that defines the context in which systems are used. It serves as an immersive social context in which a community of stakeholders can create, integrate, and disseminate information relevant to their lives and the problems they face. Providing multiple avenues for participation and boundary objects is important because participants in the EDC may not share a common background. They represent a community of interest, bringing together stakeholders from different domains who have different background knowledge and different things to contribute. The exchange of information is encouraged by providing stakeholders with tools to express their own opinions, requiring an open system that can accommodate and evolve based on new information. For example, city planners contribute formal information (such as the detailed planning data found in Geographic Information Systems), whereas citizens may use less formal techniques (such as sketching and using Google Earth for embedding the sketches in authentic environments) to describe a situation from their points of view.

Our research activities centered around the EDC are currently further evolved and extended within a project supported by the NSF-CISE "Science of Design" Program entitled *"A Meta-Design Framework for Participative Software Systems"* in which we explore (1) how *participative software systems* can achieve the best fit between the software system and its ever-changing context of use, problems, domains, users, and communities of users; (2) the *scientific foundation* for designing participative software systems as socio-technical environments that empower users, as owners of problems, to engage actively and collaboratively in the continual development of software systems; (3) a *meta-design framework* to guide software developers to design participative software systems; and (4) a demonstration that meta-designed systems can be supported by the *Seeding, Evolutionary Growth, and Reseeding (SER)* process model.

Courses-as-seeds (dePaula *et al.*, 2001) is an educational model that explores meta-design and social creativity in the context of fundamentally changing the nature of courses taught in universities. Its goal is to create a culture of informed participation (Fischer & Ostwald, 2005) that is situated in the context of university courses transcending the temporal boundaries of semester-based classes. Traditionally, the content of a course is defined by the resources provided by instructors (such as lectures, readings, and assignments). By involving students as active contributors, courses do not have to rely only on the intellectual capital provided by the instructors. Courses are conceptualized based on the SER model, in which the instructor provides the initial seed rather than a finished product (Rogoff *et al.*, 1998).

An essential aspect of courses-as-seeds is the transformation of traditional classroom roles. Students act as active contributors—active not only in the assignments that are given to them, but also active in the design of the courses themselves. Instructors' roles are likewise transformed from a "sage on the stage" to a "coach on the side." Students choose their own projects and form teams based on personal interest and share their work in Wiki-based course information environments. We are actively pursuing this research with the support of a project supported by the NSF-CISE "Creativity and IT" Program entitled *"A New Generation Wiki for Supporting a Research Community in Creativity and IT"* in which we (1) examine how current wiki-like environments are limited; (2) analyze and create specifically additional objects (such as mind maps, videos, anecdotes, and stories); (3) explore different modes interacting with such an environment (including: face-to-face activities, synchronous, asynchronous); and (4) utilize new paradigms (such as meta-design) for developing systems that are open and extensible.

Conclusions

The CSCL community can and should explore, design, and assess new *transformational conceptual frameworks for learning and education.* New media and new technology provide new exciting possibilities to rethink learning, teaching, working, and collaborating. Almost all serious educational reformers believe that new media and new technology on their own cannot transform learning to meet the demands of the future. Technology is only one part of the necessary cultural change. Cultural change implies that all stakeholders participating in the process of change have to reflect and change their behaviors, their objectives, and their values.

Some of the themes and challenges for future CSCL research articulated briefly in this article focused on: how can we help people of all ages learn to think and act more creatively; how can we help people develop mindsets for acting as active contributors in reflective communities that are key to creativity; and how can we create socio-technical environments grounded in these objectives?

References

Arias, E. G., Eden, H., Fischer, G., Gorman, A., & Scharff, E. (2001). Transcending the Individual Human Mind: Creating Shared Understanding through Collaborative Design. In J. M. Carroll (Ed.), *Human-Computer Interaction in the New Millennium* (pp. 347-372). New York: ACM Press.

Barron, B. (2000). Achieving Coordination in Collaborative Problem-Solving Groups. *Journal of Learning Sciences, 9*(4), 403-436.

Benkler, Y. (2006). *The Wealth of Networks: How Social Production Transforms Markets and Freedom*. New Haven: Yale University Press.

Bereiter, C. (2002). *Education and Mind in the Knowledge Age*. Mahwah, NJ: Lawrence Erlbaum.

Bereiter, C., & Scardamalia, M. (2006). Education for the Knowledge Age: Design-Centered Models of Teaching and Instruction. In P. A. Alexander & P. H. Winne (Eds.), *Handbook of Educational Psychology* (pp. 695-713). Maywah, NJ: Lawrence Erlbaum Associates.

Bowker, G. C., & Star, S. L. (2000). *Sorting Things Out: Classification and Its Consequences*. Cambridge, MA: MIT Press.

Brand, S. (1995). *How Buildings Learn: What Happens After They're Built*. New York: Penguin Books.

Bransford, J., Vye, N., Stevens, R., Kuhn, P., Schwarts, D., Bell, P., et al. (2006). Learning Theories and Education: Toward a Decade of Synergy. In P. Alexander & P. Winne (Eds.), *Handbook of Educational Psychology (2nd ed)* (pp. 209-244). Mahwah, NJ: Erlbaum.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.). (2001). *How People Learn: Brain, Mind, Experience, and School*. Washington, D.C.: National Academy Press.

Bromme, R., Hesse, F., & Spada, H. (2005). *Barriers and Biases in Computer-Mediated Knowledge Communication*. Dordrecht, Netherlands: Kluwer Academic.

Bruner, J. (1996). *The Culture of Education*. Cambridge, MA: Harvard University Press.

Campbell, D. T. (2005). Ethnocentrism of Disciplines and the Fish-Scale Model of Omniscience. In S. J. Derry, C. D. Schunn & M. A. Gernsbacher (Eds.), *Interdisciplinary Collaboration — An Emerging Cognitive Science* (pp. 3-21). Mahwah, NJ: Lawrence Erlbaum.

Collins, A., & Halverson, R. (2006). *The Second Educational Revolution: From Apprenticeship to Schooling to Lifelong Learning (forthcoming)*.

Csikszentmihalyi, M. (1996). *Creativity — Flow and the Psychology of Discovery and Invention*. New York, NY: HarperCollins Publishers.

dePaula, R., Fischer, G., & Ostwald, J. (2001). Courses as Seeds: Expectations and Realities. In P. Dillenbourg, A. Eurelings & K. Hakkarainen (Eds.), *Proceedings of The European Conference on Computer-Supported Collaborative Learning* (pp. 494-501). Maastricht, Netherlands.

Derry, S. J., & Fischer, G. (2007). Transdisciplinary Graduate Education. (forthcoming), from http://l3d.cs.colorado.edu/~gerhard/papers/transdisciplinary-sharon.pdf

Drucker, P. F. (1994). The Age of Social Transformation. *The Atlantic Monthly*(November), 53-80.

Ehn, P. (1989). *Work-Oriented Design of Computer Artifacts*. Stockholm: Arbetslivscentrum.

Engeström, Y. (2001). Expansive Learning at Work: Toward an Activity Theoretical Reconceptualization. *Journal of Education and Work, 14*(1), 133-156.

Fischer, G. (2000). Lifelong Learning - More Than Training. *Journal of Interactive Learning Research, Special Issue on Intelligent Systems/Tools In Training and Life-Long Learning, 11*(3/4), 265-294.

Fischer, G. (2002). Beyond 'Couch Potatoes': From Consumers to Designers and Active Contributors, in FirstMonday (Peer-Reviewed Journal on the Internet). from http://firstmonday.org/issues/issue7_12/fischer/

Fischer, G., & Giaccardi, E. (2006). Meta-Design: A Framework for the Future of End User Development. In H. Lieberman, F. Paterno & V. Wulf (Eds.), *End User Development: Empowering people to flexibly employ advanced information and communication technology* (pp. 427-458). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Fischer, G., Grudin, J., McCall, R., Ostwald, J., Redmiles, D., Reeves, B., et al. (2001). Seeding, Evolutionary Growth and Reseeding: The Incremental Development of Collaborative Design Environments. In G. M. Olson, T. W. Malone & J. B. Smith (Eds.), *Coordination Theory and Collaboration Technology* (pp. 447-472). Mahwah, NJ: Lawrence Erlbaum Associates.

Fischer, G., Nakakoji, K., Ostwald, J., Stahl, G., & Sumner, T. (1998). Embedding Critics in Design Environments. In M. T. Maybury & W. Wahlster (Eds.), *Readings in Intelligent User Interfaces* (pp. 537-559). San Francisco: Morgan Kaufmann.

Fischer, G., & Ostwald, J. (2005). Knowledge Communication In Design Communities. In R. Bromme, F. W. Hesse & H. Spada (Eds.), *Barriers and Biases in Computer-Mediated Knowledge Communication* (pp. 213-242). New York, N.Y.: Springer.

Florida, R. (2002). *The Rise of the Creative Class and How It's Transforming Work, Leisure, Community and Everyday Life*. New York, NY: Basic Books.

Friedman, T. L. (2005). *The World is Flat: A brief history of the twenty-first century*. New York: Farrar, Straus and Giroux.

Gardner, H. (1991). *The Unschooled Mind*. New York: BasicBooks.

Hmelo-Silver, C. E. (2004). Problem-Based Learning: What and How Do Students Learn? *Educational Psychology Review, 16*(3), 235-266.

Illich, I. (1971). *Deschooling Society*. New York: Harper and Row.

Levy, F., & Murnane, R. J. (2004). *The New Division of Labor: How Computers are Creating the Next Job Market*. Princeton: Princeton University Press.

Mumford, E. (1987). Sociotechnical Systems Design: Evolving Theory and Practice. In G. Bjerknes, P. Ehn & M. Kyng (Eds.), *Computers and Democracy* (pp. 59-77). Brookfield, VT: Avebury.

National-Research-Council. (2003). *Beyond Productivity: Information Technology, Innovation, and Creativity*. Washington, DC: National Academy Press.

O'Reilly, T. (2006). What Is Web 2.0 - Design Patterns and Business Models for the Next Generation of Software. from http://www.oreillynet.com/pub/a/oreilly/tim/news/2005/09/30/what-is-web-20.html

Pea, R. D. (2004). The Social and Technological Dimensions of Scaffolding and Related Theoretical Concepts for Learning, Education, and Human Activity. *The Journal of the Learning Sciences, 13*(3), 423-451.

Raymond, E. S., & Young, B. (2001). *The Cathedral and the Bazaar: Musings on Linux and Open Source by an Accidental Revolutionary*. Sebastopol, CA: O'Reilly & Associates.

Rittel, H. (1984). Second-Generation Design Methods. In N. Cross (Ed.), *Developments in Design Methodology* (pp. 317-327). New York: John Wiley & Sons.

Rogoff, B., Matsuov, E., & White, C. (1998). Models of Teaching and Learning: Participation in a Community of Learners. In D. R. Olsen & N. Torrance (Eds.), *The Handbook of Education and Human Development — New Models of Learning, Teaching and Schooling* (pp. 388-414). Oxford: Blackwell.

Salomon, G. (Ed.). (1993). *Distributed Cognitions: Psychological and Educational Considerations*. Cambridge, United Kingdom: Cambridge University Press.

Schön, D. A. (1983). *The Reflective Practitioner: How Professionals Think in Action*. New York: Basic Books.

Scribner, S., & Sachs, P. (1990). On The Job Training: A Case Study. In *National Center on Education and Employment* (pp. 1-4).

Shneiderman, B. (2002). *Leonardo's Laptop — Human Needs and the New Computing Technologies*. Cambridge, Mass: MIT Press.

Simon, H. A. (1996). *The Sciences of the Artificial*. Cambridge, MA: The MIT Press.

Star, S. L. (1989). The Structure of Ill-Structured Solutions: Boundary Objects and Heterogeneous Distributed Problem Solving. In L. Gasser & M. N. Huhns (Eds.), *Distributed Artificial Intelligence* (Vol. II, pp. 37-54). San Mateo, CA: Morgan Kaufmann Publishers Inc.

Tapscott, D., & Williams, A. D. (2006). *Wikinomics: How Mass Collaboration Changes Everything*. New York, NY: Portofolio, Penguin Group.

Trist, E. L. (1981). The Sociotechnical Perspective: The Evolution of Sociotechnical Systems as a Conceptual Framework and as an Action Research Program. In A. H. VanDeVen & W. F. Joyce (Eds.), *Perspectives on Organization Design and Behavior* (pp. 19-75). New York, NY: Wiley.

Turkle, S., & Papert, S. (1991). Epistemological Pluralism and the Revaluation of the Concrete. In I. Harel & S. Papert (Eds.), *Constructionism* (pp. 161-191). Norwood, NJ: Ablex Publishing Corporation.

von Hippel, E. (2005). *Democratizing Innovation*. Cambridge, MA: MIT Press.

Wenger, E. (1998). *Communities of Practice: Learning, Meaning, and Identity*. Cambridge, UK: Cambridge University Press.

Acknowledgements

The author thanks the members of the Center for LifeLong Learning & Design at the University of Colorado, who have made major contributions to ideas described in this paper. The paper has *greatly* benefited from the insightful comments to an earlier draft by: Cindy Atman, Allan Collins, Melissa Dawe, Sharon Derry, Holger Dick, Hal Eden, Elisa Giaccardi, Cindy Hmelo-Silver, Anders Morch, Tamara Sumner, and Jennifer Turns.

The research was supported by grants from (1) the National Science Foundation, (a) REC-0106976 “Social Creativity and Meta-Design in Lifelong Learning Communities”, (b) IIS-0613638 “A Meta-Design Framework for Participative Software Systems”, (c) IIS- 0709304 “A New Generation Wiki for Supporting a Research Community in Creativity and IT”; (2) SRA Key Technology Laboratory, Inc., Tokyo, Japan; and (3) the Coleman Institute, Boulder, CO.