Exploring, Understanding, and Designing Innovative Socio-Technical Environments for Fostering and Supporting Mass Collaboration

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Abstract: Mass collaboration involving large number of people working and learning together is emerging in the digitally networked environment. *Socio-technical environments* fostering mass collaboration are facilitated by the technical infrastructure of the Internet, and they support collaborating participants to solve problems, share information, and engage in the joint construction of artifacts and knowledge.

Based on our conceptual, empirical, and design-based research over the last decade, this chapter (1) explores *needs and opportunities* for mass collaboration, (2) outlines *theoretical frameworks* (including: cultures of participation, meta-design, richer ecologies of participation, and different models for knowledge creation, accumulation, and sharing), (3) describes specific *application domains* (including: CreativeIT Wiki, SAP Community Network, and Massive Open, Online Courses), and (4) identifies *research challenges* grounded in findings "how things are" to provide design requirements for "how things could or should be" in the years to come.

Introduction

Mass collaboration occurs when large numbers of people work and learn together. Specific components of mass collaboration (participation, coordination, cooperation, collaboration, and social production) depend on the nature of the problems being tackled. In general, it is better suited to problems with a nearly-decomposable structure [Simon, 1996] in which the modularity allows that participants (or group of participants) can work on specific modules independently facilitating decentralized innovation. Mass collaboration has social and technical components and is best fostered and supported by *socio-technical environments* [Fischer & Herrmann, 2011]. The focus of our research is on mass collaborations in which people voluntary participate and contribute because they want to and because they can. On the *social* side, an interesting *uniqueness* of mass collaboration is that the collaborative social practices and social production occurs not in tightly knit communities with many social relations to reinforce the sense of common purpose and community, but in large groups of participants who are geographically, temporally, and conceptually dispersed (see examples in Table 2). On the *technical* side, mass collaboration is facilitated by new digitally networked environments [Tapscott & Williams, 2006]. Projects exploit the technological infrastructure provided by the Internet and employ different social software and computer-supported collaboration tools.

Mass Collaboration

Mass collaboration offers important and interesting possibilities to cope with *major problems* our societies are facing today including: (1) problems of a *magnitude* which individuals and even large teams cannot solve; and (2) problems of a *systemic nature* requiring the collaboration of many different minds from a variety of backgrounds. For these kinds of problems, mass collaboration is a necessity rather than an optional approach. It represents not only a more democratic mode of production [von Hippel, 2005] and it is not only important for new approaches in learning and education [Fischer, 2009], but it represents an innovative approach in a broad spectrum of human activities (see Table 1 for specific examples). Mass collaboration works best when at least the following conditions are present [Tapscott & Williams, 2006]: (1) the *objects of production* are digital facilitating sharing and remixing; (2) the *tasks* can be modeled as nearly decomposable systems [Simon, 1996] and can therefore be chunked into "pieces" that individuals can contribute; (3) the *costs of integration and aggregation* in an global, shared repository is reasonable.

Transcending the Unaided, Individual Human Mind

Figure 1 provides a qualitative overview of the *historical developments* of new media that had a major impact on mass collaboration (discussed in detail in chapter 1 by A. Collins "A Brief History of Mass Collaboration").

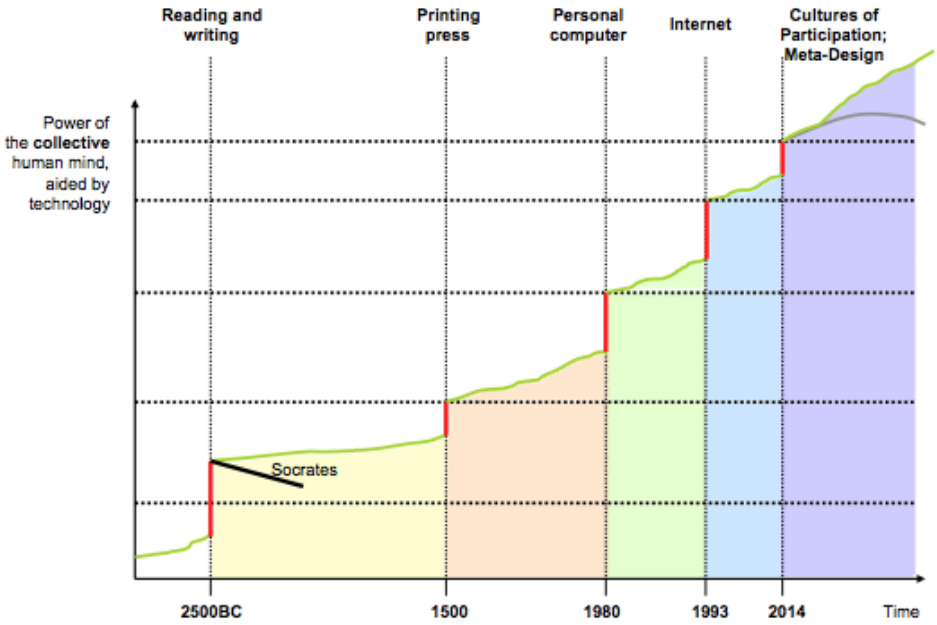

Fig. 1: Qualitative Overview of Major Developments Transcending the Limitations of the Unaided, Individual Human Mind

There is no media-independent communication, interaction, and collaboration: tools, materials, and social arrangements always mediate activity. The possibilities and the practice of mass collaboration are functions of the media with which we collaborate. Cognition is shared not only among minds, but also among minds and the structured media and artifacts within which minds

interact [Bruner, 1996; Resnick et al., 1991; Salomon, 1993]. Chapter 4 by U. Cress explores related ideas.

The networked information society [Benkler, 2006] provides foundations and supports new possibilities for individual action and decentralized shared creation of artifacts (these items are discussed in more detail in the section "Examples" below):

- *citizens* (not only professional film makers in Hollywood) can reach millions of people with YouTube movies;
- *faculty members* can teach ten thousands of students (and not only students in their classrooms) with massive open online courses (MOOCs);
- *developers* and users of complex software systems can help each other; and
- *niche communities* (e.g.: researchers being interested in creativity and IT) can share information and artifacts.

In order to explain these developments, we have developed some theoretical frameworks that are discussed below.

Differentiating Different Modes and Models of Collaborative Actions

The concept of "mass collaboration" is interpreted and used in different ways and the boundaries to the following related concepts are often not precisely defined [Kvan, 2000]— and to do so maybe an important research challenge for the future (Chapter 3 by M. Elliott "Stigmergy" also discusses these differentiations):

- *participation* overlaps with many aspects of mass collaboration (how it is used in our framework for cultures of participation see section below and [Fischer, 2011]);
- *coordination* is characterized by establishing structures, processes, context, and relationships; e.g.: meta-designers (such as the designers of Wikipedia) create contexts to which everyone can contribute content, and curators organize individual contributions in collections (in the 3D-Warehouse) and increase the overall quality and quantity of content in the Encyclopedia of Life (see Table 1);
- *cooperation* is characterized by relationships in which sub-tasks are divided up, done separately be different people, and then the results are brought together; information is shared as needed and authority is retained by each contributor;
- *collaboration* connotes more durable and pervasive relationships, everyone works together on a shared task, and shared problem spaces are jointly created [Stahl, 2006]. Collaborations require a commitment to a common mission and authority is determined by the collaborative structure. The distribution of the individual contributions can be differentiated along the following dimensions: (1) *social distribution* making activities more fun, more motivating, and by sharing the burden of coping with large problems ("getting the job done effectively and more quickly"); and (2) *epistemological distribution* by providing richer learning opportunities and suggesting new ways of thinking about problems.

Mass Collaboration and Education

An interesting *early vision of mass collaboration and education* was provided by Illich's concept of "Learning Webs" (chapter 6 in [Illich, 1971]) in which he outlines educational systems (25 years before the Internet was developed) that *"provide all who want to learn with access to available resources at any time in their lives; empower all who want to share what they know to*

find those who want to learn it from them; and, finally furnish all who want to present an issue to the public with the opportunity to make their challenge known".

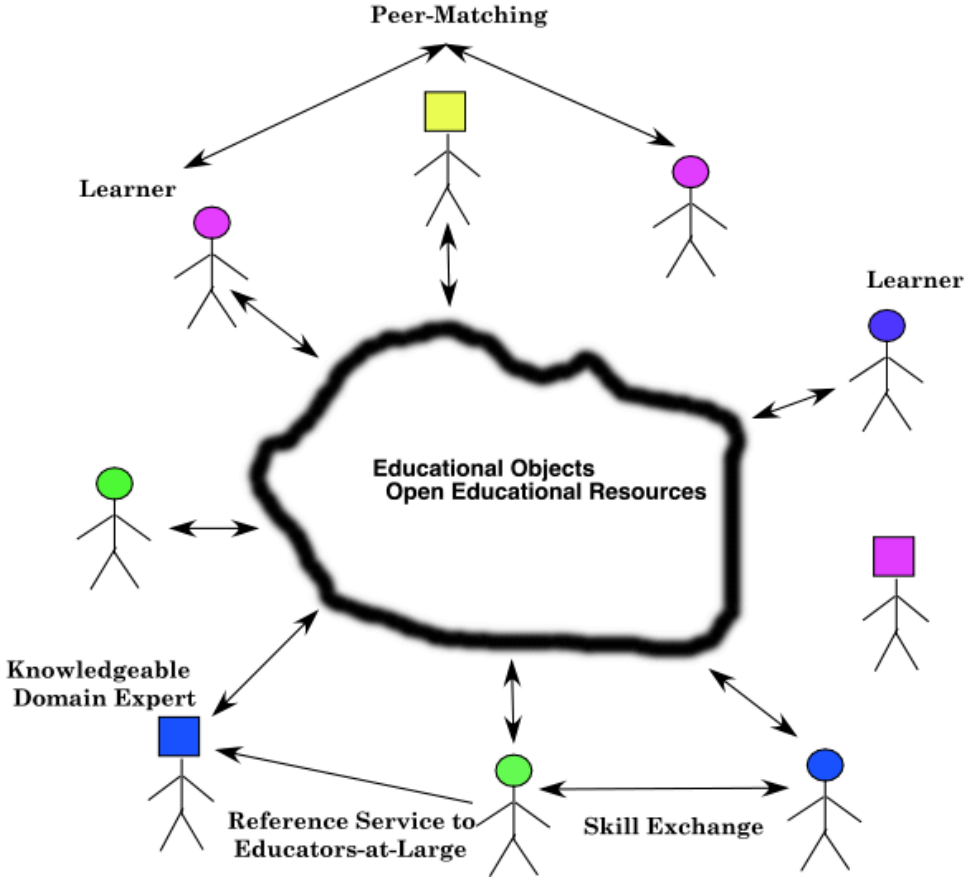

Fig. 2: An Illustration of Illich's Learning Webs

Instead of funneling all educational programs through teachers, Illich envisioned educational environments focused on self-motivated learning supported by (1) links to open educational resources, (2) skill exchange between learners being knowledgeable in different domains, (3) peer-matching, and (4) reference services to educators-at-large as illustrated in Figure 2.

Theoretical Frameworks

The four dimensions described in this section contributing to a theoretical framework are based on our research activities over the last decade to understand, explore, and support mass collaboration.

Cultures of Participation

Mass collaboration represents a fundamental shift from *consumer cultures* (focused on passive consumption of finished goods produced by others) to *cultures of participation* (in which all people are provided with the means to participate actively in personally meaningful activities) [Fischer, 2011; Gee, 2004; Jenkins, 2009; von Hippel, 2005].

Cultures are defined in part by their media and their tools for thinking, working, learning, and collaborating [McLuhan, 1964]. In the past, the design of most media emphasized a clear distinction between producers and consumers [Tapscott & Williams, 2006]. Television is the medium that most obviously exhibits this orientation [Postman, 1985] and in the worst case contributes to the degeneration of humans into *"couch potatoes"* [Fischer, 2002] for whom remote controls are the most important instruments of their cognitive activities. In a similar manner, our current educational institutions often treat learners as consumers, fostering a mindset in students of "consumerism" [Illich, 1971] rather than "ownership of problems" for the rest of their lives [Bruner, 1996]. 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 in personally meaningful and important problems.

Meta-Design

Meta-design [Fischer & Giaccardi, 2006] is a methodology that characterizes objectives, techniques, and processes for creating new media and environments that allow all participants to act as *designers* and contribute to and benefit from the creativity of the group. A fundamental objective of meta-design is to create socio-technical environments that will help all learners and workers to be creative by allowing them to go beyond the explicitly described functionality of any artifact, to use it in new ways, to evolve it by creating new content, and to explore its potential for new processes. Meta-design is instrumental for *"the ability to reformulate knowledge, to express oneself creatively and appropriately, and to produce and generate information rather than simply to comprehend it"* [National-Research-Council, 1999]. It appeals to diverse audiences to be engaged as active contributors rather than just as passive consumers (1) by supporting them in designing and building their own socio-technical environments, (2) by situating computation in new contexts and (3) by developing tools that democratize design, innovation, and knowledge creation.

The power and the coverage of systems supporting mass collaboration and of information environments created by mass collaboration is based on the fact that these systems can evolve not only by a small number of designers but by the contribution of all participants. In order for these processes to take place the systems must be designed for evolution. In *conventional design approaches* designers create complete systems and make decisions for users for situational contexts and for tasks that they can only anticipate. In meta-design approaches meta-designers "underdesign" systems [Brand, 1995; Brown & Duguid, 2000]: they create contexts in which participants can contribute content so that unexpected uses of the artifact or missing information can be accommodated by the participants. *Underdesign* is not less work and it is not less demanding, but it is different: it does create solutions, but it creates environments in which "owners of problems" in situated settings can create solutions themselves.

Meta-design is focused on the design of (1) the *technical infrastructure* providing mechanisms, such as end-user modifiability and end-user development, that allow stakeholders to evolve the system at use time; (2) *learning environments and work organizations* that allows stakeholders to migrate from passive consumers to end-users, users, and power users; and (3) *socio-technical environments* in which stakeholders are recognized and rewarded by their contribution and can accumulate social capital.

The goal of making systems extensible by users does not imply transferring the responsibility of good system design to the user. Normal users will in general not build tools of the quality a professional designer would. In fact, they are not concerned with the tool, per se, but in doing their work. However, if the tool does not satisfy the needs or the tastes of the users (which they know best) then users should be able to adapt the system without always requiring the assistance of developers.

Ecologies of Participation and Collaboration

Individuals (learners, workers, citizens) have different motivations for doing things, and those motivations create different levels of participation. To understand, foster, and support cultures of participation requires differentiating, analyzing, and supporting distinct roles that can be found in cultures of participation [Preece & Shneiderman, 2009].

For mass collaboration to become viable and be successful, it is critical that a sufficient number of participants take on the more active and more demanding roles. To encourage and support *migration paths towards more demanding roles* (giving people more responsibility, more authority, and more decision making power), mechanisms are needed that lead to more involvement, motivation, and that facilitate the acquisition of additional knowledge required by the more demanding and involved roles. Grounded in a "low threshold and high ceiling" architecture that allows new participants to contribute as early as possible and experienced participants to cope with complex tasks by offering broad functionality, mechanisms are needed to address the following requirements: (1) scaffolding to support migration paths; (2) special interaction features for different levels of participation; (3) supporting different level of granularity of participation to account for different time and effort investments; and (4) rewards and incentives to reduce the funnel effect from one level to the next [Porter, 2008]. Figure 3 illustrates these different roles and their relationships. In addition to migration towards more demanding roles, more research is also needed to identify and analyze factors that *cause people to move in the other direction* including not enough time, lack of challenges, and fading interests [Preece & Shneiderman, 2009].

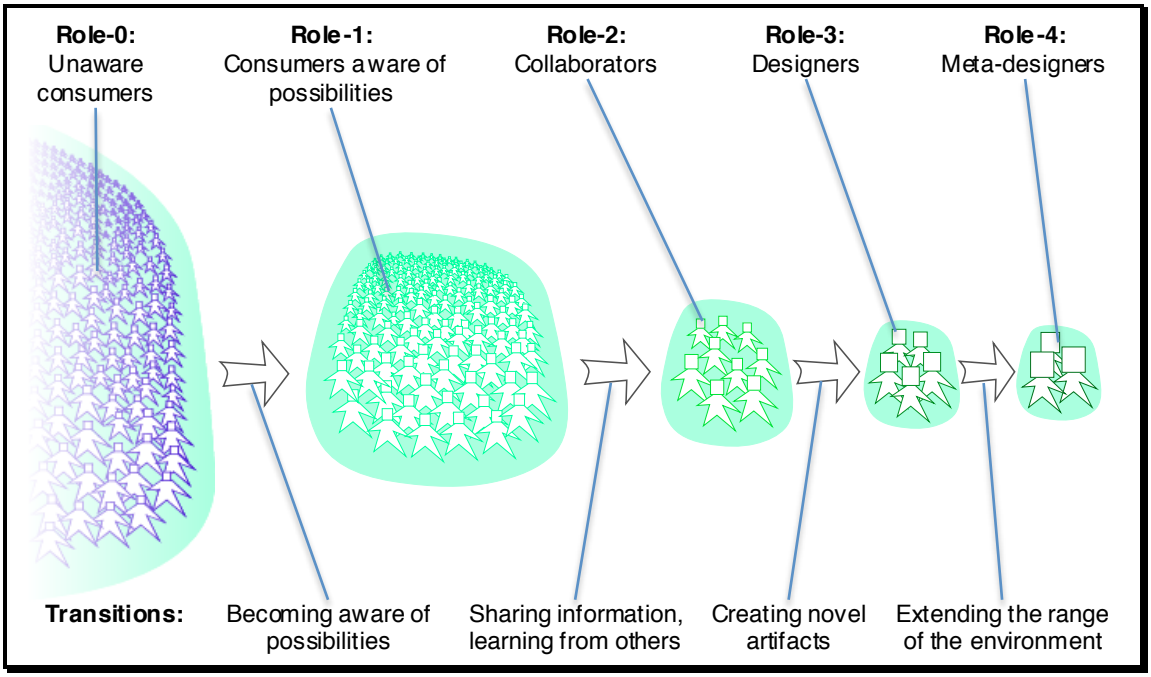

Fig. 3: Identification of Different Roles in Rich Ecologies of Participation

Transcending the dichotomy between consumers and producers, new, middle-ground models for participation and collaboration have emerged such as

- *prosumers* [Tapscott & Williams, 2006], who are self-directed learners or techno-sophisticated and comfortable with the technologies with which they grew up. They do not wait for someone else to anticipate their needs, and they can decide what is important for them. They participate and collaborate in learning and discovery and engage in experimenting, exploring, building, tinkering, framing, solving, and reflecting;
- *professional amateurs* [Brown, 2005; Leadbeater & Miller, 2008], who are innovative, committed, and networked amateurs working to professional standards. They are a new social hybrid, and their activities are not adequately captured by traditional frameworks that strictly separate work and leisure, professional and amateur, consumption and production, and formal and informal learning.

Different Models for Knowledge Creation, Accumulation, and Sharing

To exploit the full potential of mass collaboration (by promoting cultures of participation and being supported by meta-design) will require breaking down the barriers and distinctions between designers and users, teachers and learners (creating "communities of learners" [Rogoff et al., 1998]), consumers and producers (creating "prosumers" [Tapscott & Williams, 2006]) and between professionals and amateurs (creating "prom-ams" [Leadbeater & Miller, 2008]).

Achieving these objectives will allow and support participants (not all of them, not at all times, and not in all contexts) to be and act as *active contributors in personally meaningful activities* [Fischer, 2002]. This will lead to new processes of knowledge creation, accumulation, and sharing. For the information society of today, two basic models can be differentiated [Fischer, 2009]:

MODEL-AUTHORITATIVE ("Filter and Publish") is characterized by a small number of experts (such as teachers) acting as contributors and a large number of passive consumers (such as learners). In such cultures, strong input filters exist based on:

- substantial knowledge is necessary for contributions (e.g.: the in-depth understanding of established fields of inquiry or the need to learn specialized high-functionality tools); and
- extensive quality control mechanisms exist (e.g.: the certification of professionals or low acceptance rates for conference and journal articles); and
- large organizations and high investments for production are required (e.g.: film studios such as Hollywood, newspaper production facilities).

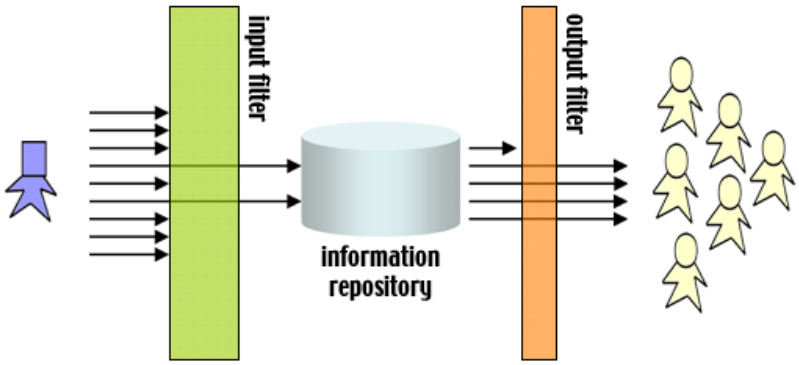

Fig. 4: MODEL-AUTHORITATIVE underlying Professionally Dominated Cultures

The *advantage* of this model (this is at least the basic underlying assumption) is the likelihood that the quality and trustworthiness of the accumulated information is high because the strong input filters will reject unreliable and untrustworthy information. Based on the smaller size of the resulting information repositories, relatively weak output filters are required. The *disadvantage* of this model is that it greatly limits that "all voices can be heard". Their intake is limited because with only a small number of contributors too many views are unexplored and underrepresented because the controlling mechanisms behind the input filters suppress broad participation from different constituencies.

MODEL-DEMOCRATIC ("Publish and Filter") can be characterized by weak input filters allowing users not only to access information but to become active contributors by engaging in participation and collaboration. The weak input filters result in much larger information repositories (with information repositories such as the World Wide Web being the prime example).

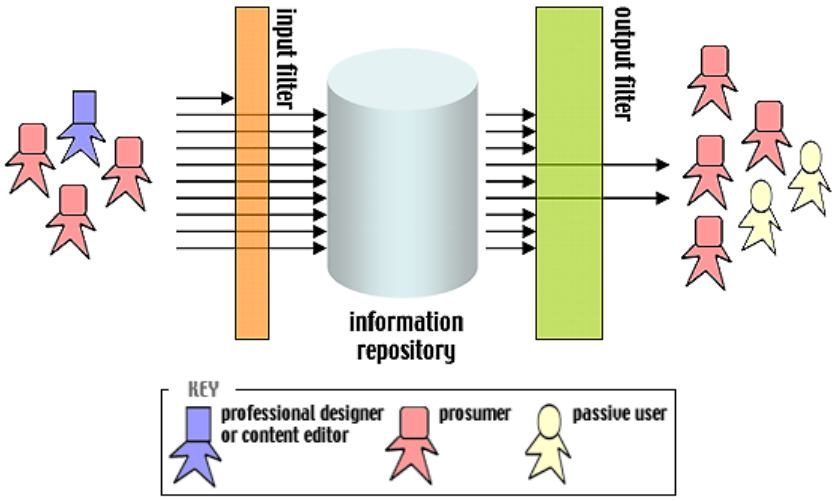

Fig. 5: MODEL-DEMOCRATIC underlying Mass Collaboration

MODEL-DEMOCRATIC on the technical side requires powerful support for creating content (such as meta-design environments), for organizing content (such as supporting collections by curators), and for distributing content (such as powerful search capabilities and recommender systems). On the social side, it requires active contributors (who master the design tools and who are motivated to contribute), curators (who organize the large information repositories) and coaches (who assist in helping learners to identify and locate relevant information).

MODEL-DEMOCRATIC provides the foundation for socio-technical environments in which information, knowledge, and artifacts can be produced not only by many more people, but also by individuals and in subjects and styles that could not pass the filters of *MODEL-AUTHORITATIVE*.

Artifacts created by *MODEL-AUTHORITATIVE* and *MODEL-DEMOCRATIC* can complement each other and they may fulfill different needs as articulated by Cory Doctorow [Lanier, 2006]: *"Wikipedia isn't great because it's like the Britannica. The Britannica is great at being authoritative, edited, expensive, and monolithic. Wikipedia is great at being free, brawling, universal, and instantaneous."*

Examples of Socio-Technical Environments Based on Mass Collaboration

The rise of large-scale collaborative efforts based on mass collaboration has created a number of success cases in a variety of different domains and a brief overview will be provided in the first part of this section. The remaining parts will describe our own efforts anchored in the theoretical frameworks described in the previous section and illustrating it in specific domains: (1) the design of the CreativeIT Wiki; (2) an empirical study of the SAP Community Network (SCN); and (3) an analysis of Massive Open Online Courses (MOOCs).

A Spectrum of Interesting Examples

Table 1 provides an overview of a sample of environments created by mass collaboration with unique features. These systems (at least in principle) engage the talent pool of the whole world to make contributions and thereby have potentially millions of developers.

Table 1: Environments of Mass Collaborations with Unique Features

Site	Objectives and Unique Aspects
Wikipedia	web-based collaborative multilingual encyclopedia with a single, collaborative, and verifiable article; authority is distributed (http://www.wikipedia.org/)
iTunes U	courses by faculty members from "certified institutions"; control via input filters; material can not be remixed and altered by consumers (http://www.apple.com/education/itunes-u/)
YouTube	video sharing website with weak input filters and extensive support for rating (http://www.youtube.com/)
Encyclopedia of Life (EoL)	documentation of the 1.8 million known living species; development of an extensive curator network; partnership between the scientific community and the general public (http://www.eol.org/)
PatientsLikeMe	collection of real-world experiences enabling patients who suffer from life-changing diseases to connect and converse (http://www.patientslikeme.com/)
Instructables	socio-technical environment focused on user-created and shared do-it-yourself projects involving others users as raters and critics (http://www.instructables.com/)
Scratch	learning environment for creating, remixing, and sharing programs to build creative communities in education (http://scratch.mit.edu)
Stepgreen	library of energy saving actions, tips, and recommendations by citizen contributors for saving money and being environmentally responsible (http://www.stepgreen.org/)
SketchUp and 3D Warehouse	repository of 3D models created by volunteers organized in collections by curators and used in Google Earth (http://sketchup.google.com/3dwarehouse/)
Innocentive	unleashing human creativity, passion, and diversity — http://www.innocentive.com/
Open Source Software	software developed in a public, collaborative manner with its source code made available and licensed [Raymond & Young, 2001]
CreativeIT	wiki to foster collaboration between all researchers interested in "Creativity and IT" — http://l3dswiki.cs.colorado.edu:3232/creativit
SAP Community Network	used by software users, developers, consultants, mentors and students to get help, share ideas, learn, innovate and collaborate — http://scn.sap.com/
MOOCs	courses offered for free for everyone — http://www.mooc-list.com/

Our own research activities that have been focused on different aspects of the three environments mentioned at the bottom of this table will be briefly described in the following sections. Issues

related to Wikipedia are discussed in Chapter 6 "Individual vs. Collaborative Information Processing: The Case of Biases in Wikipedia" by A. Oeberst).

The CreativeIT Wiki: Supporting Distributed Scientific Communities

We have designed and seeded a wiki-based socio-technical environment to support the (mass) collaboration between scientists, artists, and students in the application area of "Creativity and Information Technology"), specifically in the context of the NSF research program "Creativity and Information Technologies" (http://www.nsf.gov/pubs/2009/nsf09572/nsf09572.pdf).

The unique challenges of supporting this specific community are that people working in interdisciplinary projects or in niches of their disciplines are often isolated in their local environments unaware of relevant work in other disciplines.

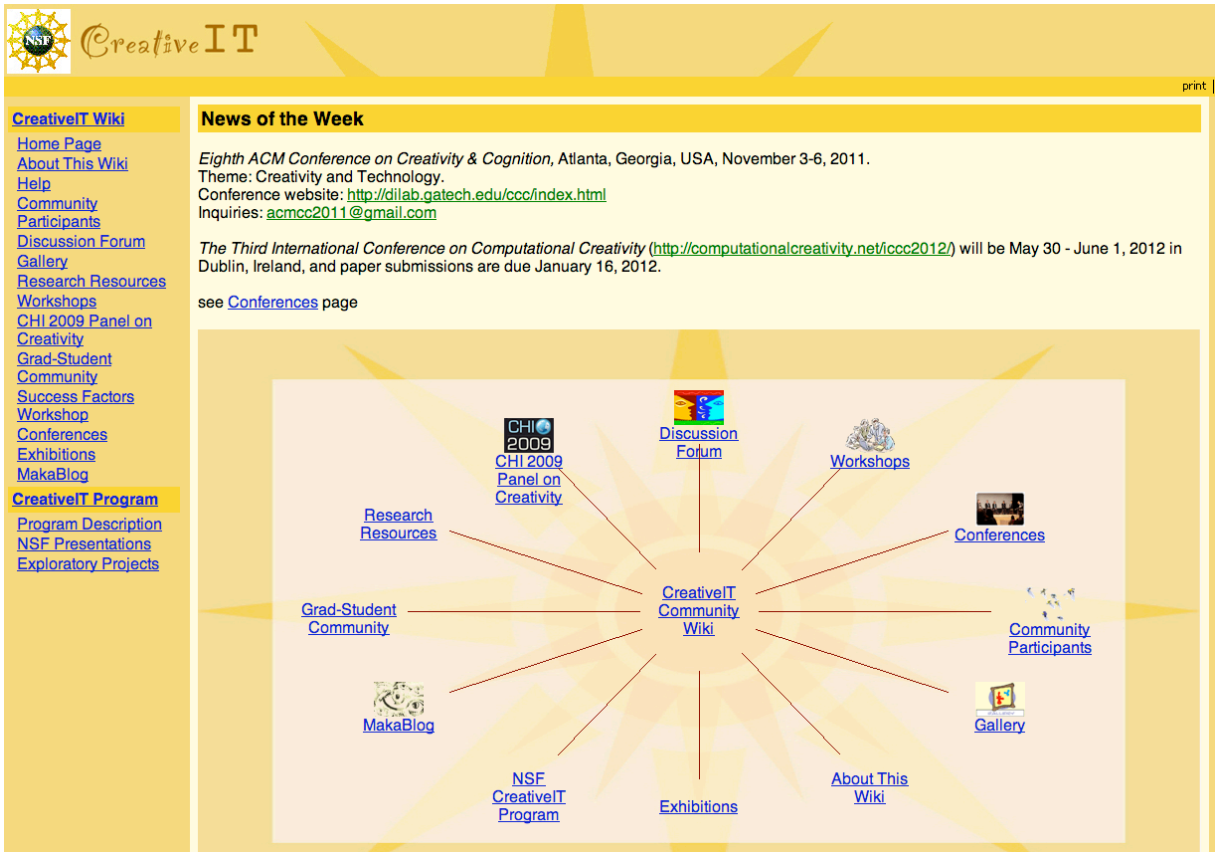

Fig. 6: A Screen Image of the CreativeIT Wiki

The prototypes developed in this research project [Dick et al., 2009] (see Figure 6 for an example screen image) had some success as a content management system (marked by the creation of 290 pages, 80 literature references contributed by community members, workshop proceedings published as part of the wiki, a gallery of project exemplars, and hosting over 100 registrants). It fell short in creating and fostering an active community. Despite our best efforts to seed the wiki and to provide support mechanisms, we were unable to engage "masses of people" to participate and collaborate and our prototype did not reach the *"tipping point"* [Gladwell, 2000].

As a result of our research with the CreativeIT Wiki, we articulated a set of requirements (based on a deeper understanding of how technical and social environments can be changed through

design interventions) that should be further explored as design foundations for social production and mass collaboration, including:

- provide *awareness mechanisms* that will give participants better overviews over ongoing activities and changes taking place in the wiki;
- integrate *events (taking place insight the wiki or links to outside events) to provide specific objectives for participants to collaborate;*
- create *social support tools* that support participants to find and connect to other participants, represent themselves to other researchers, and create networks of interests can influence user activities;
- explore different design trade-offs for the *social environment* (e.g.: making the environment more *permissive* and unstructured versus more *prescriptive* and structured) and their influence on participation and collaboration; and
- assess whether *rating systems* will increase the trust and interest in existing content.
- support *paths* for contributors to migrate towards increased involvement (see Figure 3).

SAP Community Network (SCN): Studying Mutual Learning in Communities of Practice

We have studied the *SAP Community Network (SCN)* (http://scn.sap.com/) [Gorman & Fischer, 2009] as an example of a successful socio-technical environment consisting of more than one million registered users forming a highly active online community of developers, consultants, integrators, and business analysts building and sharing knowledge about SAP technologies via wikis, expert blogs, discussion forums, code samples, training materials, and a technical library. We have collected a comprehensive data set that includes all of the posting activity of more than 120,000 users from June 2003 through May 2008.

To get a better understanding of processes and dynamics in a culture of participation such as SCN, we have developed an initial analytic framework to measure a number of factors, including attributes such as (1) *responsiveness* (how often and quickly members get responses to their requests), (2) *engagement intensity* (how many helpers and responses are required to answer questions); and (3) *role distribution* (the ratio of users who ask questions to those who answer questions). Our analysis allowed us to find patterns in the data that hint toward an environment that is supportive of mass collaboration. In addition to a *quantitative* analysis, we have engaged in a limited *qualitative* analysis to understand the impact of incentive systems on participation. SCN uses a point system to *reward users* for their participation, but these features can have negative effects. Points are highly valued, and some users resorted to "gaming the system" to earn points.

Our analysis allowed us to identify patterns in the data relevant for a deeper understanding of different aspects relevant for mass collaboration. SCN provides good support and motivation for users to contribute (that we measured by the time it took users to receive a response to their post which is significantly less than in other environments we analyzed for comparison). In addition to such *quantitative* analyses, we also did preliminary *qualitative* analysis to understand the impact of incentive systems on participation. SCN uses a point system to reward users for their participation, but these features can have negative effects. Points are highly valued, and some users did resort to "gaming the system" to earn points. Data sources like this will contribute to create better frameworks to understand and design effective means to support intrinsic motivation with appropriate incentives in mass collaboration.

Massive Open Online Courses (MOOCs): Enriching the Landscapes for Learning and Education

MOOCs are Higher-Ed courses with massive enrollments that promise *"Education for Everyone and for all Interests"*. They have generated enthusiasm, excitement, and *hype* worldwide and recently increasing *skepticism* [Fischer, 2014]. They are being broadly discussed in the major news media. Rapidly increasing numbers of MOOC providers, MOOC courses, and articles, discussion groups, and blogs discussing MOOCs are indicators of the involvement of many stakeholders. Most of these analyses and developments are based on *economic perspectives* (such as scalability, productivity, being "free") and *technology perspectives* (including platforms supporting large number of students in online environments, enrichment components such as forums, peer-to-peer learning support, and automatic grading). Few contributions analyze MOOCs from a *learning science perspective* and put them into a larger context with other approaches to learning and education. Our research has been focused on conceptualizing MOOCs as one component in a *rich landscape of learning*. We are particularly interested to explore MOOCs as a forcing function to identify to core competencies of residential, research-based universities [Eisenberg & Fischer, 2014].

Fig. 7: A Common Images Illustrating the World-Wide Participation in a MOOC

While MOOCs attract masses of learners who sign up for them (see Figure 7 for the geographical distribution of learners in a specific MOOC), the meaning of "participation" and "collaboration" needs to be better understood and analyzed in the years to come. The nature of MOOCs, being instructionist and supporting primarily a one-directional information flow from teacher to learners, enables the scaling-up of participants to very large numbers leading to an extremely low teacher/student ratio.

Signing-up for MOOCs is trivial (it requires often not more than providing a few information items) and it is free. Many people are signing up without any intentions to participate in the course as a whole (they may use MOOCs as the textbooks of the 21st century). This is a simple explanation why MOOCs have often extremely low completion rates. Educationally important objectives leading to collaboration including (1) feedback from instructors, tutors, and teaching assistants; (2) virtual forums; (3) local meet-up groups;

(4) peer-to-peer collaboration (such as mutual criticism, feedback, and grading) are possible within the MOOC framework but up till now play a minor role in almost all MOOCs.

A research agenda for MOOCs is discussed in Chapter 15 by J. Moskaliuk.

Research Challenges

Understanding and fostering mass collaboration requires paying attention to factors from political, economical, and social domains [Benkler & Nissenbaum, 2006]. This section takes a brief look at a few of those factors.

Distances and Diversity in Mass Collaboration. By bringing together large numbers of participants, *distances* (spatial, temporal, and technological dimensions) and *diversities* (bringing stakeholders together from different cultures) are important factors influencing and determining mass collaboration. Table 2 provides an overview of the major distances and diversities.

Table 2: Differentiating Distances and Diversity

Distances and Diversities	Rationale	Addressed by	Challenges
spatial	participants are unable to meet face-to-face; low local density of people sharing the same interests	computer-mediated communication	achieve common ground; involve large communities
temporal	support long-term, indirect communication and meta-design	design rationale, building on previous work	motivate efforts to document design decisions for others
conceptual within domains	shared understanding	communities of practice (CoPs),	avoid group-think
conceptual between domains	make all voices heard	communities of interest (CoIs); boundary objects	establish common ground; integration of diversity

These distances and diversities are double-edged swords for mass collaboration: if dealt with and exploited in the right way, they can provide interesting opportunities that participants can learn from each other and their collaborations result in more creative artifacts [Fischer, 2005].

Motivation for Collaboration. Human beings are diversely motivated beings. We act not only for material gain, but for psychological well-being, for learning personally meaningful information, for social integration and connectedness, for social capital, for recognition, and for improving our standing in a reputation economy. In most application areas, mass collaboration relies on intrinsic motivation for participation and it has the potential to influence this by providing contributors with the sense and experience of joint creativity, by giving them a sense of common purpose and mutual support in achieving it, and in many situations by replacing common background or geographic proximity with a sense of well-defined purpose, shared concerns, and the successful common pursuit of these.

Control. Meta-design supports users as active contributors who can transcend the functionality and content of existing systems. By facilitating these possibilities, *control* is distributed among all stakeholders in the design process. The willingness to share control is a fundamental challenge in mass collaboration. The promise of sharing control is a gain in creativity and innovation: *"Users that innovate can develop exactly what they want, rather than relying on manufacturers to act as their (often very imperfect) agents."* [von Hippel, 2005].

To increase social creativity requires: (1) *diversity* (each participants should have some unique information or perspective); (2) *independence* (participants' opinions are not determined by the opinions of those around them) [Surowiecki, 2005]; (3) *decentralization* (participants are able to specialize and draw on local knowledge) [Anderson, 2006]; and (4) *aggregation* (mechanisms exist for turning individual contributions into collections, and private judgments into collective decisions). In addition, participants must be able to express themselves (requiring technical knowledge how to contribute), must be willing to contribute (motivation), and must be allowed to have their voices heard (control).

Quality of the Artifacts. Many teachers will tell their students that they will not accept research findings and argumentation based on articles from Wikipedia. This exclusion is usually based on considerations such as: *"How are we to know that the content produced by widely dispersed and qualified individuals is not of substandard quality?"*

The online journal *Nature* (http://www.nature.com/) has compared the quality of articles found in the *Encyclopedia Britannica* with Wikipedia and has come to the conclusion that *"Wikipedia comes close to Britannica in terms of the accuracy of its science entries."* This study and the interpretation of its findings has generated a controversy, and Tapscott and Williams [Tapscott & Williams, 2006] have challenged the basic assumption that a direct comparison between the two encyclopedias is a relevant issue: *"Wikipedia isn't great because it's like the Britannica. The Britannica is great at being authoritative, edited, expensive, and monolithic. Wikipedia is great at being free, brawling, universal, and instantaneous."*

There are many more open issues to be investigated about quality and trust [Kittur et al., 2008] in cultures of participation, including: (1) errors will always exist, resulting in learners acquiring the important skill of always being critical of information rather than blindly believing in what others (specifically experts or teachers) are saying; and (2) ownership as a critical dimension: the community at large has a greater sense of ownership and thereby is more willing to put an effort into fixing errors. This last issue has been explored in open source communities and has led to the observation that *"if there are enough eyeballs, all bugs are shallow"* [Raymond & Young, 2001].

A Long-Tail Framework and Mass Collaboration. The *Long Tail theory* [Anderson, 2006] postulates that our culture and economy is increasingly shifting away from a focus on a relatively small number of "hits" (mainstream products and markets) at the head of the demand curve and toward a huge number of niches in the tail. Information technologies have greatly enhanced the ability to take advantage of the Long Tail by exploiting niche markets and connecting people with communities and products of interest. We have been exploring the implications of the Long Tail theory for *learning and education* [Collins et al., 2009] by focusing on two of its transformational aspects: (1) learning about exotic topics outside the mainstream education curriculum, and (2) the opportunity to communicate with people who share similar interests somewhere in the world on a regular basis. The web (specifically the Web 2.0 supporting cultures of participation) gives children and adults the ability to pursue topics they are

particularly interested and feel passionate about. These are topics learners never encounter in school unless they pursue them later in college.

Schools, however, have moved in the opposite direction. Even as computers become more ubiquitous in schools, curriculum standards and mandated assessments (based on frameworks such as cultural literacy [Hirsch, 1996]) have exercised a conservative force against the proliferation of idiosyncratic interests and passion by emphasizing that everyone should learn the same thing at the same time, as measured by the same standards. Similarly, the education establishment has tried to control what people learn by defining the curriculum in schools. The dramatically increasing amount of non-mainstream knowledge indicates a gap between the world we live in and the formal education, where the latter focuses mainly on limited amount of knowledge.

Measurements and Data. While some aspects determining cultures of participation can be easily measured, e.g.: (1) how many learners have signed up for a MOOC; (2) how many and how often people visited a particular site (see Table 1) and (2) how well does a site live up to certain usability and sociability factors [Preece & Shneiderman, 2009], other aspects are much more difficult to assess and measure. Some researchers have great hopes that data gained from *learning analytics research* (http://www.solaresearch.org/events/lak/) will provide many new and interesting insights into learning processes. Mass collaboration (as it is conducted mostly inside computational environments in which activities can be tracked) provides rich data sets about interactions, collaborations, and engagement that computational processes can exploit.

The following issues related to learning analytics should be pursued and investigated:

- what are the fundamentally new aspects of learning analytics research in the context of mass collaboration? The idea of collecting data about student behavior and actions is not new: it has been pursued with dribble files in LOGO, user modeling in intelligent tutoring systems, and artifact analysis in designing activities;
- how valuable will the insights be that learning analytics environments are able to collect and analyze? how can we infer from low-level, quantifiable events (such as material looked at, how long and how often, errors made, help requested) the intentions, problems encountered, and objectives of the learner?
- while learning analytics may provide insights to understand the past and the present ("how things are"), how much will it help to envision and design alternatives to learning and education ("how things could/should be")?
- are the potential misuses and privacy violations of the data gained with learning analytics? Some MOOCs companies plan to sell data about their students to companies as part of their business model to make money.

Identifying Drawbacks of Mass Collaboration. Mass Collaboration opens up unique new opportunities for education and learning in the 21st century, but as with all major innovations, some potential drawbacks should not be overlooked. One such drawback is that participants may be forced to cope with the burden of being active contributors in *personally irrelevant activities.* This shift provides power, freedom, and control to learners, but it also has forced them to act as contributors in contexts for which they lack the experience that teachers and professionals have acquired.

More experience and assessment is required to determine the design trade-offs for specific contexts and application domains in which the *advantages* of mass collaboration (such as extensive coverage of information, creation of large numbers of artifacts, creative chaos by making all voices heard,

reduced authority of expert opinions, and shared experience of social creativity) will outweigh the *disadvantages* (accumulation of irrelevant information, wasting human resources in large information spaces, lack of coherent voices, and participation overload). The following research questions need to be explored:

- Under which conditions is a *fragmented culture* (with numerous idiosyncratic voices representing what some might characterize as a modern version of the "Tower of Babel" and others as refreshingly diverse insights) better or worse than a *uniform culture* (which is restricted in its coverage of the uniqueness of local identities and experience) [Lanier, 2006]?
- If all people can contribute, how do we assess the *quality and reliability* of the resulting artifacts (an interesting analysis comparing Wikipedia with Britannica is documented in [Giles, 2005], a summary of criticism by different authors is compiled at http://en.wikipedia.org/wiki/Wikipedia:Criticisms; and a specific critique by Nicholas Carr can be found at: http://www.roughtype.com/?p=110)?
- How can curator networks effectively increase the quality and reliability? The mass collaboration taking place in the Encyclopedia of Life (see Table 1) has develop an interesting and extensive framework to engage and support curators to increase the overall quality and quantity of content on the EOL site (http://eol.org/info/255).
- What is the role of *trust, empathy, altruism, and reciprocity* between participants and how will these factors affect mass collaboration [Benkler & Nissenbaum, 2006]?

Conclusions

Mass collaboration in the networked information economy [Benkler, 2006] provides opportunities that masses of people can engage as active contributors and collaborate with each other in numerous human activities, including: (1) participation is invited, supported, encouraged, and valued rather than prohibited; (2) creative contributions and innovations are decentralized and extended and artifacts are developed as open, evolvable seeds rather than finished products (facilitated by meta-design and *MODEL-DEMOCRATIC*); (3) new relationships between the individual and social and new control regimes between teachers and learners are established; and (4) the focus of education is shifted from teaching to learning.

The *theoretical frameworks* described in this article address some important aspects of mass collaboration and can be applied to *different domains, contexts, and tools* (as illustrated in the example section). The briefly described *research challenges* outline a research agenda to gain a deeper understanding of the opportunities and pitfalls associated with mass collaboration.

Mass collaboration in education (and beyond in numerous other human affairs) represents a new paradigm. While new technologies play an important facilitating role, the most important impact will be in fundamentally new opportunities for thinking, learning, working, and creating artifacts.

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