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Research Articles

Socio-Technical Systems:
A Meta-Design Perspective

Gerhard Fischer, University of Colorado, USA

Thomas Herrmann, University of Bochum, Germany

ABSTRACT

Meta-design of socio-technical systems complies with the need to integrate two types of structures and processes: technical systems, which are engineered to provide anticipatable and reliable interactions between users and systems, and social systems, which are contingent in their interactions and a subject of evolution. Meta-design is focused on objectives, techniques, and processes to allow users to act as designers. It provides, rather than fixed solutions, frameworks within which all stakeholders can contribute to the development of technical functionality and the evolution of the social side, such as organizational change, knowledge construction, and collaborative learning. This paper combines the theoretical framework of meta-design and its underlying principles with the consideration of methodological aspects and practical cases. Five different principles are explored: (1) cultures of participation, (2) empowerment for adaptation and evolution, (3) seeding and evolutionary growth, (4) underdesign of models of socio-technical processes, and (5) structuring of communication. Design collaboratories and knowledge management are used as examples to analyze meta-designed systems representing socio-technical solutions as well as frameworks within which socio-technical solutions can be developed. The combination of theoretical and methodological considerations leads to a set of practical guidelines for meta-designers.

Keywords: Collaboration, Cultures of Participation, Evolutionary Growth, Knowledge Management, Meta-design, Participatory Design, Reseeding Model, Semi-structured Modeling, Socio-Technical Systems (STS)

INTRODUCTION

New technologies and new media are important driving forces and prerequisites to address the complex and systemic problems our societies face today. But technology alone does not improve social structures and human behavior, making the design of *socio-technical systems (STSs)* a necessity rather than an academic luxury.

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A unique challenge faced in focusing on STSs is that that they combine two types of fundamentally different systems:

- *Technical systems* that are produced and continuously adapted to provide a reliable, anticipatable relationship between user input and the system's output. This relationship is engineered to serve the needs of users and is—at least incrementally—preplanned.

- *Social systems* that are the result of continuous evolution including emergent changes and behavior. The development of their characteristics cannot be planned and controlled with respect to the final outcome; the changes within STSs are a matter of contingency (Luhmann, 1995) and can only—if ever—be understood afterward and not in advance; social systems mainly serve their own needs and not those of others.

The strength of STSs is that they integrate these different phenomena so that they increase their performance reciprocally. Even more important, the integration of technical and social systems helps them to develop and to constitute each other, for example, the interaction among community members is supported by technical infrastructure, and the members themselves can contribute to the development of the infrastructure, as is typically demonstrated by open source communities. However, the relationships between the development of the social and the technical are not deterministic but contingent. For example, developing software for specific organizations does not deterministically change them but only influences the evolution of their social structures. Software designers can be reflective with respect to the impact of a software system on its social context, and they can make their assumptions about the expected evolution of the social system explicit and a matter of discourse, but they cannot control the organizational change.

One emerging unique opportunity to make a systematic and reflected contribution to the evolution of social structures in STSs is *meta-design* (Fischer & Giaccardi, 2006), representing a design perspective supporting the evolution of systems that have contingent characteristics. Whereas many design activities aim to develop concrete technical solutions, meta-design provides a *framework* within which STSs can be developed. Fischer and others (Fischer & Giaccardi, 2006) have outlined a variety of important characteristics of meta-design. The most important principles characterizing a meta-design framework for the development of STSs are (Fischer, 2010):

1. Support for *cultures of participation* that put the owners of problems in charge and give them control of how technical systems are used and which functionality is underlying the usage. In this context, an ecology of roles (Preece & Shneiderman, 2009) will develop including developers, co-developers, consultants, facilitators, and curators (see the section, "Cultures of Participation").
2. Mechanisms to support *empowerment for adaptation* and *evolution at use time* by offering functionality for *tailorability*, *customization*, and user-driven adaptability (Mørch, 1997) (see the subsection "Empowerment for Adaptation and Evolution").
3. A procedure model that includes the phases of *seeding*, *evolutionary growth*, and *reseeding* (Fischer & Ostwald, 2002), in which the seed represents a result of underdesign—it represents basic structures and is in accordance with the relevant standards but it leaves space and options for the development of concrete details (see the subsection "Seeding, Evolutionary Growth, and Reseeding Model").

Herrmann et al. (2000, 2004) have conducted several *empirical studies* in which they have analyzed the relevance of communicational practices in the course of developing STSs. Herrmann (2009) describes a list of practical cases that support the methodological consideration in this paper. Based on an action research approach, Avison et al. (1999) have gradually developed methodological concepts that comply with the principles of socio-technical meta-design:

4. *Semi-structured modeling* to support and accompany the communication during the evolution of a socio-technical system. The models document requirements, plans, technical specifications, business

STSs, and processes on the one hand, and the specification of details on the other hand (see the subsection "Underdesign of Models of Socio-Technical Processes"). Semi-structured modeling is closely related to underdesign, which is an important principle of meta-design (Fischer, 2003).

5. *Walkthrough-oriented facilitation* as an example for the structuring of communication. It supports the integration of various perspectives, the negotiation of design decisions, the building of commitments about how technology will be used and adapted, and the evaluation of prototypes (see the subsection "Structuring of Communications").

The goal of this paper is to integrate these five conceptual principles under the perspective of meta-design of STSs. Focusing meta-design on the development and evolution of STSs gives the opportunity for a more detailed reflection of methodological implications and guidelines. Meta-design of STSs leads to new considerations that go beyond traditional participatory design, end-user-programming, or previous principles for the design of STSs (Cherns, 1976; Eason, 1988).

In our analysis, we draw on a body of literature that contributes to the clarification of socio-technical phenomena (Checkland, 1981; Mumford, 1987, 2000; Trist, 1981; Whitworth, 2009). Our analysis is based on a variety of concepts that stem from an interdisciplinary background, such as the interdependence between technology and organization (Orlikowski, 1992); sociological systems theory (Luhmann, 1995); wicked problems (Rittel & Webber, 1973); scenario-based design (Carroll, 1995); contingency (Pedersen, 2000); and participatory design (Kensing & Blomberg, 1998). This paper does not describe a complete set of tools and methods for the meta-design of STSs but rather describes the background of a meta-design methodology as well as examples of methods.

The theoretical background of STSs and meta-design are described in the next section. The third section gives a detailed description of the five principles of meta-design as they are listed above. These theoretical considerations are complemented with insights, as they can be derived from concrete empirical examples. The fourth section elucidates that there is a wide spectrum of software for which meta-design can be applied, and it continues by focusing on two typical areas of socio-technical meta-design, collaboratories and knowledge management (KM).

- *Collaboratories*, which have a clear location, include various competences and perspectives and various roles with respect to the development of technology, commitments, and organizational structures.
- *Knowledge management* within companies and communities includes various possibilities to build knowledge, to integrate it, to develop social relationships, and to identify appropriate technical support etc.

Based on the theoretical analysis and the reflection of practical cases, the fifth section provides a list of guidelines for the practice of meta-design. The concluding section summarizes the reasons for a meta-design approach in the context of socio-technical systems.

SOCIO-TECHNICAL SYSTEMS

Characteristics of STSs

Socio-technical systems can be understood as the systematic integration of two kinds of phenomena that have very diverging, partially contradictive characteristics. STSs are composed *both* of computers, networks, and software, *and* of people, procedures, policies, laws, and many other aspects. STSs therefore require the *co-design* of social and technical systems.

Whereas *technical systems* are purposeful artifacts that can reliably and repeatedly be used to support human needs and to enhance human capabilities, *social systems* are dedicated to purposes that lay within themselves and are a matter of continuous change and evolution, which makes their behavior difficult to anticipate. Social structures can be identified on several levels: communicative interaction between people or in small groups such as families or teams, organizations or organizational units, communities, or social networks. The reactions of social systems to their environment are contingent—they are not independent from external stimuli, but they also are not determined by them. As opposed to necessity, universality, constancy, and certainty, *contingency* (Pedersen, 2000, p. 413)

- Refers to variability, particularity, mutability, and uncertainty;
- Implies that the system creates its own necessity in its pattern of reactions toward events (Kirkeby, 2000, p. 11); and
- Provides a basis for continuous evolution, including opportunities for emergent changes.

How new phenomena will emerge in social systems cannot be predicted or made the result of a well-planned, algorithmically organized procedure; they depend on coincidences and are context related in the sense of situatedness (Suchman, 1987). Technical systems may also react contingently toward their users, but the more mature a technical system has become, the more one will expect that it is reliable for the users, predictable, and noncontingent. Obviously, the socio-technical perspective covers more aspects than the viewpoint of human-computer interaction (HCI): it is about the relationship between technical infrastructure as a whole and structures of social interaction, which cover organizational and coordination issues, sense making and common ground as a basis for communication, power relations, negotiation, building of conventions, and so forth.

It is not unlikely that formal communication, anticipatable procedures, scripts, and prescriptions may be empirically observable within in social systems. For example, workflow management systems (Herrmann & Hoffmann, 2005) demonstrate the managerial attempt to implement scripts and institutionalize plan-oriented behaviour in the context of organizations. However, it is a social system's dominant characteristic that rules and routines can be revised and become subjects of negotiation, and it cannot be predicted whether and when anticipatable behavior is no longer sustained but becomes a subject of evolutionary or emergent change.

By contrast to those researchers who assume that complex human activities can also be assigned to technical systems (Latour, 1999), we suggest that the crucial characteristics of social versus technical systems point in two opposite directions (Table 1). The basic differences outlined in the table also apply to artificial intelligence applications and large networks of autonomous agents. The strength of socio-technical systems results of the integration of these two kinds of different phenomena.

Beyond Coincidental Connectedness: The Need for Systematic Integration

STSs are more than a coincidental connectedness of technical components and people. ".. STS research is not just applying sociological principles to technical effects (Coiera, 2007), but [it explores, G.F., T.H.] how social and technical aspects integrate into a higher-level system with emergent properties" (Whitworth, 2009, p. 4).

The synergy between technical and social systems can be achieved only if both parts are closely integrated. One of the important theoretical challenges with respect to STSs is to explain how this integration can happen, by which factors it is influenced, and how it can be observed. Sociologists such as Luhmann (1995) and Habermas (1981) identify *communication*, amongst all kind of human activities, as the most relevant constituent of social systems. Our research emphasizes the role of communication when we try to understand the integration between social and technical structures. The degree of integration between social and technical structures increases with the extent of the following factors.

Table 1. Main characteristics of technical and social systems

	Technical systems	Social systems
Origins	Are a product of human activity; can be designed from outside.	Are the result of evolution, cannot be designed but only *influenced* from outside.
Control	Are designed to be controllable with respect to prespecified performance parameters.	Always have the potential to challenge control.
Situatedness	Low: preprogrammed learning and interaction with the environment.	High: includes the potential of improvisation and nonanticipatable adaptation of behavior patterns.
Changes	Are either preprogrammed (so that they can be simulated by another technical system) or a result of intervention from outside (so that a new version is established).	Evolutionary: gradual accumulation of small, incremental changes, which can lead to emergent changes (which, however are not anticipatable). There is no social system that can simulate the changes of another social system.
Contingency	Are designed to avoid contingency; the more mature a version is, the less its reactions appear as contingent.	The potential for change and evolution is based on contingency.
Criteria	Correctness, reliability, unexpected, unsolicited events are interpreted as malfunction.	Personal interest, motivation; in the case of unsolicited events, intentional malpractice may be the case.
Modeling	Can be modeled by describing how input is processed and leads to a certain output.	Models can only approximate the real behavior and have continuously to be adapted.
Modus of development	Is produced or programmed from outside.	Develops by evolution that is triggered by communicative interaction.

- Communication that uses the *technical systems as a medium* helps to convey communicational acts and shapes them.
- Communication *about the technical system* includes how it is used, how it has to be maintained, how it could be adapted to the needs of an organization and its users, how its effects can be compared with other technical systems, and so forth. This kind of communication leads to what we can call the appropriation of the technical system (Pipek, 2005) by the social system. The communication mirrors the organization's understanding of the technical structures.
- Content or social structures (e.g., responsibilities or access rights) *regulating communication* are being represented within the technical system as well as the social structures.
- Self-description describes and constitutes the characteristics of the STSs and can be found in the oral communication and in the documents of the social system as well as in the technical system's content and structures (Kunau, 2006).

With respect to the integration between technology and social structures, it is important to understand that technology is not mainly represented by artifacts such as hardware but by methods and procedures that are connected with these artifacts. These procedures and methods build the bridge between technology and communications in social interactions. The invention of writing is a typical example: the method of how to write is the dominating aspect compared with the means that help to make the written durable. Thus, the social impacts—such as shift of power and control, distributed cognition, shift in tasks, and so forth—are caused much more by the methodological aspects of writing than by its physical materiality.

The need for seamless socio-technical integration is emphasized by many authors and approaches—for example, by Eason's (1988) or Cherns' (1976) principles of socio-technical design, by Kensing et al.'s (1996) MUST-Method, or Wulf and Rohde's (1995) approach of integrated organization and technology development.

The relevance of socio-technical integration can be observed in many areas, for example, knowledge management or computer-supported collaborative learning (CSCL); it is definitely insufficient just to introduce a document management system or to provide all schools with Internet access. Introducing a technical system is a necessary but not sufficient measure to be taken. They have to be complemented with interventions that aim on organizational as well as mental changes to promote the appropriation (Pipek, 2005) of the technology. Employees will not be willing to share their knowledge with others without role models and facilitation support, students will not learn more or be more motivated, and teachers will not teach better, as long as CSCL systems are not accompanied by new forms of educational experience.

Within the large set of areas where socio-technical integration takes place, this paper focuses on the design of technical systems that are related to information processing and software development. To determine a clear focus with respect to the social structures into which technical systems are integrated proves difficult. The classical socio-technical literature (Trist, 1981) usually addresses the meso-level, concerning such organizations as companies, administrations, and nongovernment organizations (NGOs) or their subunits. However, with the emergence of the web, and in particular Web2.0 and social software, phenomena have to be taken into account such as virtual communities, which form larger units between the meso- and the macro-level where individuals and/or several companies are interacting within new social structures that became possible only by new types of technical infrastructure. The new phenomena that emerged in the context of the web and Web2.0 also gave new reasons for intensifying socio-technical analyses and approaches. It also became obvious that socio-technical phenomena cannot always be appropriately described by the concept of "system" as it is defined by older (von Bertalanffy, 1973) or newer (Maturana & Varela, 1980) systems theory. By contrast, it can be more adequate to focus the analysis on *socio-technical environments* (Carmien et al., 2005) within which the integration of technical and social structures can develop. Such a socio-technical environment is less the result of engineering or design activities and more a framework within which design takes place and is intertwined with the evolutionary growth of social structures (see the *intermediate level* of Table 2).

With respect to their evolution, socio-technical systems integrate two characteristics: on the one hand, they are the result of such human activities as design, engineering, managing, and communication; on the other hand, they serve on a higher level as the environment or framework within which these kind of human activities take place. Therefore we argue that the concept of "meta-design" is more appropriate to describe how socio-technical systems or environments are developed and do develop.

A CONCEPTUAL FRAMEWORK FOR META-DESIGN

Meta-design (Fischer & Giaccardi, 2006) is an emerging conceptual framework aimed at defining and creating socio-technical systems or environments and at understanding both as living entities. It extends existing design methodologies focused on the development of a system at design time by allowing users to become co-designers at use time. Meta-design is grounded in the basic assumption that future uses and problems cannot be completely anticipated at design time, when a system is developed (Suchman, 1987; Winograd & Flores, 1986). At use time, users will discover mismatches between their needs and the support that an existing system can provide for them. Meta-design *extends boundaries* by supporting users as active contributors who can transcend the functionality and content of existing systems.

Table 2. A three-level model of meta-design

	Abstract description	Examples
Meta level Beliefs and concepts of meta-design	Meta-design provides a philosophy—a set of beliefs and guidelines—that helps to select appropriate methods and procedures. It is substantiated by theoretical insights and by concrete empirical examples.	Orientation on a culture of participation, concept of impreciseness of modeling methods, basic requirements for end-user programming (e.g., critiquing systems, programming by example).
Intermediate level A framework being meta-designed in accordance with the concepts and beliefs of the meta level. It serves as an environment within which STSs are developed and do develop.	People (designers, managers, etc.) who are committed to meta-design will help to establish a framework within which various concrete socio-technical solutions can develop. This framework can include concrete software-developing tools, technical building blocks, modeling methods, organizational rules of participation, description of roles and tasks, and selection of personnel.	A KM environment established in a company to improve knowledge exchange by offering technical means and promoting appropriate social conventions. This environment can include a modeling method to specify process-oriented knowledge management. A CSCL environment as it might be introduced by a university's administration with which several concrete courses can be organized. A set of patterns of how concrete courses can be run may be included.
Basic level Socio-technical solutions as they are developed within the framework.	A concrete socio-technical solution as it exists during a certain period of time and will be a subject of continuous maintenance and adaptation.	A concrete document management system implemented to support a project. It includes categories of content and access rights; concrete rules and roles for its usage are specified. A concrete course for which students are assigned and instructed so that they can use the CSCL system.

By facilitating these possibilities, *control* is distributed among all stakeholders in the design process (Fischer, 2007b).

Meta-design provides frameworks, which comprise objectives, techniques, representations of concepts, boundary objects, and processes for creating new media and environments that allow "owners of problems" as members of a social system to act as *designers*. A fundamental objective of meta-design is to create STSs that empower all relevant stakeholders of groups, communities of practice, communities of interest, and organizations to engage actively in the *continuous development* of a concrete socio-technical solution rather than being restricted to a prescribed way of interacting with the technical system or with its users.

The crucial aspect of meta-design, which leads to its name, is that of "*designing design*" (Fischer & Giaccardi, 2006). This refers to the concept of higher-order design, and the possibility of a malleability and modifiability of structures and processes as provided, supported, or influenced by computational media. It is a design approach that focuses on a framework of general structures and processes, rather than on fixed objects and contents.

Meta-design covers the *whole period of creative drafting of a solution*: specifying concrete concepts and plans (about technical infrastructure as well as organizational rules); introducing a technical system; experience with a first usage and feedback; the process of appropriation; and metamorphoses of the software system (Orlikowski, 1996) or the project goals (Herrmann & Hoffmann, 2005), including redesign. Therefore, meta-design is concerned with models of cyclic improvement and adaptation of socio-technical systems; these models can comprise shorter and longer cycles of adaptation.

The higher-order concept of designing design becomes apparent by the three-level model of Table 2. The meta level contains the assumptions and orientation of how socio-technical meta-design should be organized as they are a matter of research; these are explained in the following sections. With these orientations, frameworks can be developed with which and within which concrete solutions can develop. These frameworks represent the intermediate level and combine technical and social issues to a socio-technical environment. On the basic level are the concrete socio-technical systems that develop or are developed with the help of such a framework.

Most powerful are those phenomena that serve as an example on all three levels. Wikipedia represents a very prominent example: on the basic level, it is a concrete solution for exchanging encyclopedic content; with respect to the intermediate level, it has emerged to a framework within which new tools are permanently adopted and social conventions assume increasingly more differentiated shapes; additionally, Wikipedia has inspired concepts on the meta level such as the belief that it is reasonable to support the role of *prosumers* in the web.

Meta-design can be characterized by the following five principles, which are discussed in detail and explained with concrete examples in the next section.

1. *Cultures of participation* (Fischer & Giaccardi, 2006) are concerned with the way in which designers and users can *collaborate* on the design activity, both at design time and at use time. Therefore, meta-design supports a culture of participation by which people with various and varying competences on the technical or domain level can contribute to shape a socio-technical solution. It puts *owners of problems in charge* and promotes a new distribution of control in socio-technical systems by establishing a culture of participation. Methods and techniques of participatory design are provided for all kinds of stakeholders (e.g., end-users, managers, consultants, software developers, those who are responsible for quality management or privacy issues) to be involved. They all must have a chance to initiate the emergence of a socio-technical system or its appropriation and adaptation.
2. *Empowerment for adaptation and evolution*. The cultural and organizational framework being provided by cultures of participation has to be completed by specific methods and tools that especially empower end-users so that they can either partially take over the role of designers or can explain their needs to others who are able or have the right to adapt the features of a socio-technical system. End-users can benefit from critiquing methods and techniques (Fischer et al., 1998), from functionality for end-user programming, from descriptions explaining the rules and processes of a socio-technical system, from procedures of how others can be asked for help, from concrete examples of how a socio-technical system can be adopted, from all kinds of material with which they learn how to appropriate a socio-technical system, and so on. This kind of end-user support has to be provided by meta-design. For the context of socio-technical systems it has to be emphasized that end-users should be empowered not only to adapt the technical system but also to contribute to the development of social conventions, organizational rules, and definition of tasks, as well as other contributions.
3. *Seeding, evolutionary growth, reseeding.* The seeding, evolutionary growth, reseeding (SER) model is a typical principle of meta-design. Seeds or impulses can be represented by prototypes; by introducing new technology for a so-called pilot group within an organization; by an information campaign that prepares the implementation of a new system (e.g., KM); and by making people aware of their learning capabilities, of needs for change, and of conflicts to be solved. If meta-design delivers concrete systems, these are meant only as examples and as seeds. They will always be accompanied with a frame of methods and tools

that support development of these seeds and their evolutionary growth.

4. *Underdesign.* An important aspect of meta-design is *underdesign* (Fischer, 2003), which means that the structures and processes of an STS should be only partly specified; only those structures are determined that are indispensible to meet legal norms, security requirements, and basic economical needs. Therefore, it acknowledges the necessity to *differentiate between structurally important parts* for which extensive professional experience is required and therefore cannot easily be changed (such as structure-bearing walls in buildings) and *components users should be able to modify* to their needs because their personal knowledge is relevant (Habraken, 1972).

To support flexibility, underdesign includes examples of how things can be but need not be done; it provides maps instead of scripts (Schmidt, 1999), many options among which one can easily make a choice, and gaps to be filled in as well as guidance on how these gaps can be completed. This type of specification fulfills the need that everybody who is included can contribute to the completion of the design. It offers users (acting as designers at use time) *as many alternatives as possible*, avoiding irreversible commitments they cannot undo (one of the drawbacks of overdesign) (Simon, 1996). Underdesign is grounded in the need for *"loose fit"* in designing artifacts at design time so that unexpected uses of the artifact can be accommodated at use time (Henderson & Kyng, 1991); it does so by creating contexts and content-creation tools rather than focusing on content alone (Fischer & Giaccardi, 2006).

5. *Structuring of communication* for "*designing the in-between"*(Fischer & Giaccardi, 2006). Meta-design pursues the dual objective to support existing social networks and to shape new ones. It delivers methods of *appropriate communication support*—for example, strategies and methods for running participatory workshops, for facilitating discourses among stakeholders with differing perspectives (their needs and their ideas are collected and integrated), for enhancing social creativity, and for accompanying processes of the appropriation and adaptation of a certain technology. Meta-design aims to provide technology and methods that help to build social relationships, which mediates communication and supports negotiation among various perspectives. Promoting relationships among people includes affecting each other and being affected by social interaction. *"Methodologically, the third level of meta-design defines how co-evolutionary processes and co-creative, behaviors can be sustained and empowered on the basis of the way in which people relate"* (Fischer & Giaccardi, 2006). Both, artifacts as well as plans can serve as boundary objects (Star, 1989) that mediate the social interaction during design. Meta-design is concerned with the *identification and evolution of boundary objects* which help to connect the perspectives of a variety of stakeholders and to run as a thread through the whole life cycle from the idea of a new technology to its implementation into a socio-technical system and its appropriation. This life cycle can be methodologically accompanied by opportunities of facilitated discourses and reflections. A method of how such a discourse can be organized for the involved stakeholders is exemplarily outlined by the description of the socio-technical walk-through at the end of the next section.

FIVE PRINCIPLES FOR META-DESIGNED STSS

Cultures of Participation

To support "designing together," meta-design facilitates cultures of participation that are different from the traditional *participatory design* (PD) approach (Kensing & Blomberg, 1998).

Meta-design is based on the principles of PD, but it transcends them by taking into account new developments, such as (1) mass collaboration (Tapscott & Williams, 2006); (2) possibilities for end-user development (Lieberman et al., 2006; Pipek et al., 2009); and (3) agile software development (Cockburn & Highsmith, 2001; Fowler, 2001), in which customers and developers tightly collaborate.

The basic idea of PD is to allow all stakeholders to influence design-related decisions and give a voice specifically to those people who have in many case no influence because of imbalanced power structures; lack of knowledge, experience, or information; restricted communication capabilities; and/or technical reasons.

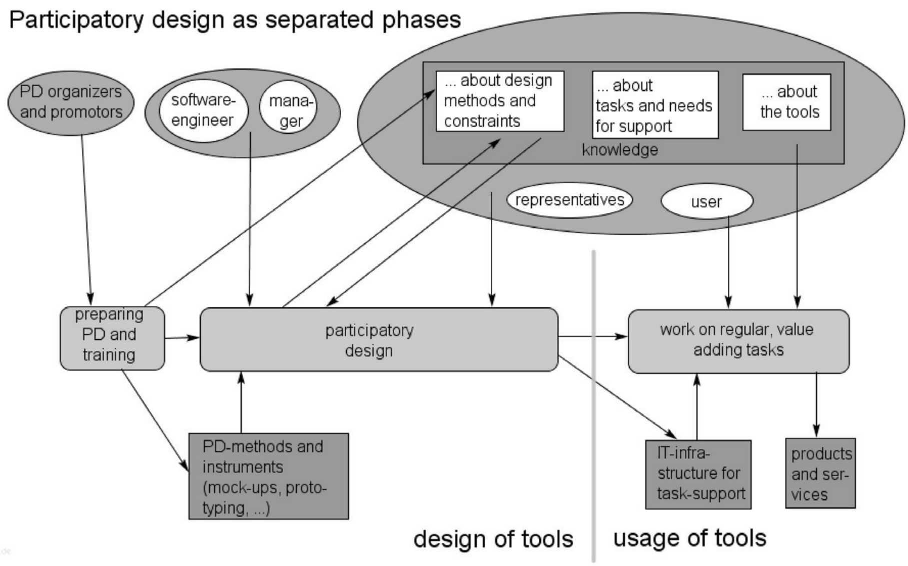
Meta-design transcends the traditional PD approach (Figures 1 and 2 illustrate the differences). Traditional PD usually aims at providing opportunities by which workers in a company can influence the design of tools that they will use afterwards to carry out their daily jobs. The relevant activities (from left to right in Figure 1) start with preparing and training stakeholders who will have to participate in decision making but are not used to doing so. These can be future users or their representatives, as displayed with the roles (ovals on the right side in Figure 1). They develop knowledge about the methods and tools (rectangle within the oval) which are used in the activity *participatory design*. This activity follows on "*preparing PD*" and employs typical PD-methods (left rectangle at the bottom). The phase of design is clearly separated (with a gray line in Figure 1) from the phase of the usage of the designed tools. In the case of traditional PD, design happens in workshops or meetings while employing the tools happens at the workplace; this is expressed with the activity "*work on regular, value-adding tasks*" in Figure 1. Traditional PD is grounded in a division of labor among managers, software engineers, and users. In this context, managers are in power on the social side, and engineers or developers are the power holders on the technical side (see role ovals in Figure 1).

By contrast, meta-design seeks to establish a culture of participation directly at the workplace combined with ongoing learning (see Figure 2) so that design can continue during the run time of a hardware/software system. Consequently, work on regular tasks and work on the employed infrastructure for these tasks are integrated. Meta-design promotes the quality that the set and the characteristics of the involved roles are highly dynamic: new roles emerge such as power users or co-developers (Nardi, 1993), and the traditional roles can continuously achieve and lose competencies that are needed to contribute to the development of their tools. Meta-design promotes a rich *ecology of participation* (Fischer et al., 2008; Preece & Shneiderman, 2009), which includes a broad variety of roles with varying characteristics, as shown in the elliptical symbol in Figure 2. The semi-circle in the role oval indicates that the list of roles is not complete. Meta-design tries to build a socio-technical environment (left rectangle at the bottom of Figure 2), which promotes the dynamic natures of roles.

Web2.0 (O'Reilly, 2006) cultures are role models of how traditional roles (e.g., producers versus consumers) are dissolved and new roles, such as *prosumers* (Tapscott & Williams, 2006), are created. They demonstrate one of the essential strengths of cultures of participation: they have the potential to integrate a huge variety of different backgrounds, perspectives, and experience. The different roles are offered a variety of tools and activities, such as blogging, tagging, rating, and contributing.

Whereas traditional PD differentiates between clearly defined roles, meta-design aims on establishing a variety of roles and smooth transitions among them. This includes shifting "*some control from designers to users and empowered users to create and contribute their own visions and objectives*" (Fischer, 2007b, p. 197). In the course of the evolution of an STS, developers and those who are originally responsible to maintain the system "*must accept a role in which they create mechanisms*

Figure 1. Traditional participatory design



allowing users to act as designers and modify systems, thereby providing them with new levels of personal control" (Fischer, 2007b, p. 202). This includes the fact that participation is not necessarily centrally organized; such a government can evolve if needed but is not a prerequisite of a culture of participation (Forte et al., 2009).

Table 3 represents the differences between traditional participatory design and establishing a culture of participation by meta-design.

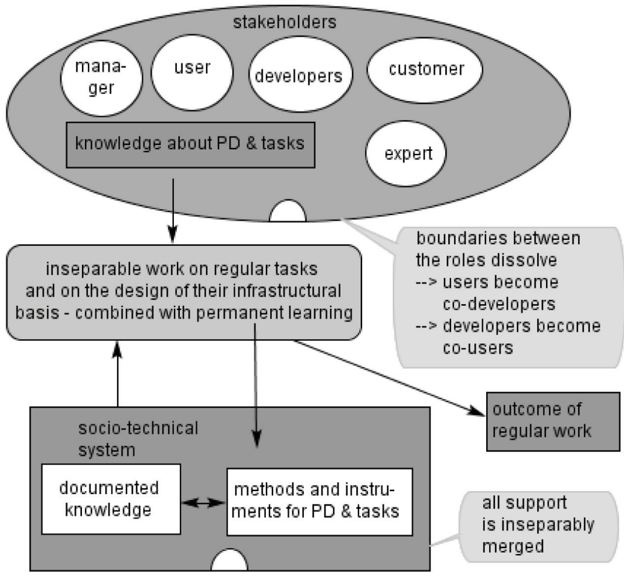
People who are allowed or encouraged to participate are not always motivated to do so. Therefore, meta-design is also concerned with overcoming motivation barriers, with systems of rewards and incentives, and with promoting participation by methods such as facilitation or scaffolding. Users accept and exercise opportunities for participation only in the case of *personally meaningful problems* (Fischer, 2002). This paper mainly points out why the participation of various stakeholders in many roles leads to an improvement of STSs. However, this potential benefit is usually insufficient to motivate people to think continually in a design mode in addition to the other tasks in which they are involved. Deliberate research is needed to understand why and how people can develop the motivation to contribute to design instead on relying on fixed out-of-the-box solutions.

Empowerment for Adaptation and Evolution

Within socio-technical systems, users are not only those who directly interact with a technical system but all who benefit from the system as a whole when pursuing their interests or carrying out tasks. The permanent evolution of socio-technical systems is at least partially driven by their users, who share a wide range of possibilities for participation. Cultures of participation have to be complemented by tools and methods that help users perform in the role of designers.

Adaptability of socio-technical systems by their users is different from the possibilities of *end-user development* (Lieberman et al., 2006). Even if the software system is almost not adaptable by a single end-user, it can become highly adaptable due to the self-adaptability of the socio-technical system as a whole. For

Figure 2. Cultures of participation—design in use



example, the social system can develop and provide certain roles (e.g., support teams that can immediately react to the wishes of end-users if they need to modify their systems). Therefore, incremental improvement combined with intensive interaction with the users can take place. Meta-design of STSs is not focused on the software's adaptability by end-users (this is only one part of meta-designed features) but is concerned with the adaptability and means for the evolution of the STS as a whole. This includes possibilities to contribute to the evolution of organizational rules, social conventions, the culture of an organization, and so on. It is an important part of meta-design to differentiate among those cases for which

- Software is directly adapted by end-users, either individually or in cooperation with other end-users;
- End-users closely collaborate with software developers, who immediately adapt the technical system; and
- Not (only) the software, but other structures or processes of the STS, are adapted.

As already pointed out in the previous section, meta-design aims at the evolution of an ecology of various and varying roles. These roles are also engaged in various ways and forms of collaboration in the adaptation of the STS. Therefore, a meta-designed framework has to provide a variety of tools, methods, processes, and strategies that supports all kinds of roles to take part in the adaptation and evolution of the various aspects of an STS.

Table 4 presents an overview of the aspects by which end-user development and meta-designed possibilities for the adaptation of the STS differ. It focuses on collaborative adaptation within socio-technical systems. Early studies (Nardi, 1993) already identified that end-user development is more successful if supported by collaborative work practices rather than focusing on individuals. The studies observed the emergence of "gardeners" and "local developers" who are technically interested and sophisticated enough to perform system modifications that are needed by a community of users, but other end-users are not able or inclined to perform.

Table 3. Participatory design and meta-design

	Participatory design	Culture of participation within a meta-design framework
Focus	Design time	Design *and* use time
Time line	The phase before the outcome of design is implemented; opportunities (e.g., workshops) are provided where participation takes place.	Design continues indefinitely, requiring active participation by users.
Tools and tasks	First, designing the tool; then carrying out tasks with the tool.	Working on the task and designing the tools needed for these tasks are intertwined.
Collaboration	The team that designs tools (technical infrastructure) and the team that collaboratively carries out the tasks with the technical infrastructure are separated.	The team that designs tools (technical infrastructure) and the team that collaboratively carries out the tasks with the technical infrastructure are overlapping or even inseparably merged.
Roles	Clearly separated roles such as workers, managers, developers, users, user advocates.	The boundaries between the roles dissolve, new roles emerge (co-developers, power users, prosumers), and the roles are highly dynamic.
Content	Information as content, on the one hand, and tools for information processing, on the other hand, are separated.	The development of the tool and the content are intertwined.
Application environments	Focused on work in companies with specific stakeholders, such as managers, developers, users.	Communities of interest and practice, open source communities, NGOs.
Regulations	Clear regulations about who is allowed to take part in decision making on what level.	Flexible degrees of involvement in decision making with the tendency to shift control from developers to users as co-developers.

Seeding, Evolutionary Growth, and Reseeding Model

The SER model (Fischer & Ostwald, 2002) (see Figure 3) was developed as a descriptive and prescriptive model for creating software systems that best fit an emerging and evolving context. In the past, large and complex software systems were built as complete artifacts through the large efforts of a small number of people. Instead of attempting to build complete systems, the SER model advocates building seeds that change and grow, and can evolve over time through the small contributions of a large number of people. Therefore, these seeds play the role of *boundary objects* (Star, 1989), to which the communication between involved people can refer. SER postulates that systems that evolve over a sustained time span must continually alternate between periods of planned activity and unplanned evolution, and periods of deliberate (re)structuring and enhancement. It is apparent the the procedural model of SER also serves as guidance within meta-designed frameworks for the development and evolution of socio-technical systems. In STSs, seeds need to be available for the technical components as well as the social structures and processes.

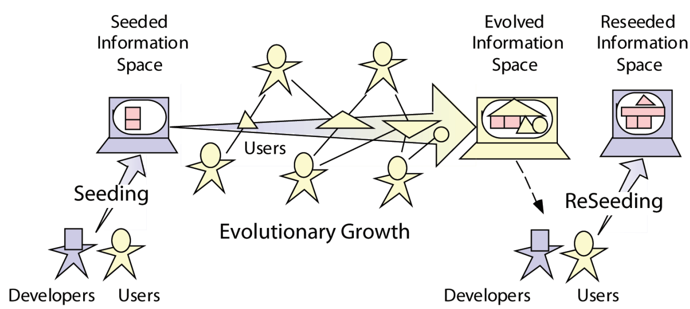
The SER model encourages system designers to conceptualize their activity as meta-design, thereby aiming to support users as active contributors. The feasibility and usefulness of the SER model for reflective communities has become apparent in the context of several areas (see the next section).

Meta-design provides methods and practices that support seeding and evolutionary growth. SER works only in the context of the other principles of meta-design such as participation, underdesign, and empowerment for

Table 4. End-user development and usage-oriented development and adaptation in STSs

End-user development	Usage-oriented development and adaptation in STSs
Adaptation mainly by programming, parameterization, configuration, etc.	Adaptation by communication in the course of incremental cycles of demand—getting it programmed, testing it, new demand—with minor parts of programming by the user.
Mainly individual development with some collaboration between end-users and involvement of experts.	Collaborative developing is shared among various roles.
Individual learning by the end-user.	Collective learning of people in various roles of the socio-technical environment.
Gentle slopes of increasing complexity.	Gentle slopes of involving more and more parts of the socio-technical environment.
The user interface is decisive to make end-user development possible.	The interfaces to others is decisive, to make communication for cycles of agile development possible.
The system shows the end-user how its features can be modified.	Others show end-users how they can modify their systems.
The offered functionality mainly aims on the adaptation of software.	The adaptation refers to technical as well as social, and organizational structures and processes of carrying out tasks, learning, etc.

Figure 3. The seeding, evolutionary growth, and reseeding (SER) model



adaptation. Similar to action research (Avison et al., 1999) or the behavior of reflective practitioners (Schön, 1983), phases of experimenting and practicing have to alternate with phases of reflection during the evolutionary growth. Transferring the SER model to STSs implies that seeds are built not only for technical features but also for social structures and interactions. The growth of the seeds (for both the technical and social dimensions) cannot be anticipated at design time. How seeds will evolve or are used is situated in future uses at use time and cannot be sufficiently planned at design time.

Underdesign of Models of Socio-Technical Processes

Underdesign can refer to either concrete artifacts or plans of how the artifacts should be designed. It can also refer to either how the design project will be organized or how the usage of the artifact is coordinated among several people for collaborative tasks. A subset of these plans may be represented by graphical models for software-design (e.g., with the unified modeling language, or UML) or for process management; others may be checklists, Gantt charts and so on. The modeling method SeeMe represents a special approach with which flexible degrees of under design can be chosen by varying the degree of completeness and preciseness.

As previously pointed out in the subsection, "A Conceptual Framework for Meta-Design," underdesign in the context of STS not only refers to hardware and software but also to the plans that describe how the technology will be used and how the collaboration of the users is coordinated. The most prominent examples of representing this kind of plan are process models. They can be overdesigned, as in the case of models that are developed to program workflow management engines. Preprogrammed workflow management systems force the users into inflexibility, which presents problems in handling exceptions or improvising a solution, for example (Thoresen, 1997). Conversely, it is not reasonable to go without explicit process models (Schmidt, 1999) because they help people within an STS explain the need for changes to others, introduce newcomers to the STS, or document changes that have taken place so that evolutionary growth is supported. The solution is a modeling method incorporating underdesign with flexible degrees of incompleteness and impreciseness.

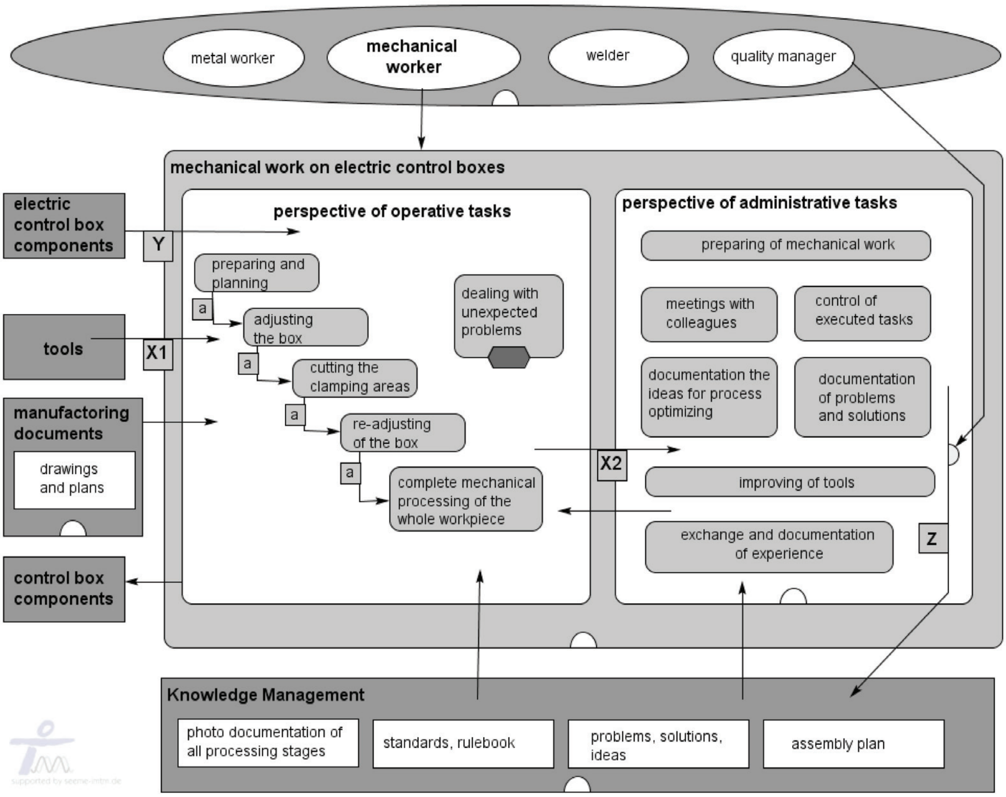
The modeling method SeeMe (semi-structured, socio-technical modeling method) has been developed to represent concepts and processes of socio-technical systems and also to articulate incompleteness, uncertainty, informalities, and freedom of decision. Therefore, SeeMe offers the possibility to represent vagueness explicitly and to choose flexible degrees of underdesign (Goedicke & Herrmann, 2008). The method aims to the integration of technical and social aspects as well as formal and informal structures. Therefore, it visualizes the complex interdependencies among different people, between humans and computers, and among technical components.

The concept of SeeMe and examples of its usage have been described in several papers (Herrmann & Loser, 1999). Therefore, the following explanation focuses on the relationship between SeeMe and underdesign. The model in Figure 4 represents the basic concepts of SeeMe by displaying a real example from a KM project of a manufacturing company that produces electric control boxes for the mining industry. Within this context, the diagram displayed in Figure 4 is a concrete example of an initial seed that had structured the discussion about a KM system and helped to evolve the descriptions of the needs and requirements that were assigned to the new system (see the subsection "Knowledge Management" later in this paper). The diagram in Figure 4 contains the three basic elements of SeeMe: roles, such as "mechanical worker"; activities, such as "mechanical work on electric control boxes" or "preparing and planning"; and entities such as "electric control box components." These elements can be embedded into each other. Relations are represented with arrows, which express that one activity is followed by another, that roles carry out activities, or that entities are used or modified, among other relations.

Figure 4 focuses on the tasks of the role of "mechanical worker" but shows them in the context of other roles. On the left side of the diagram, the already available tools are displayed, and at the bottom, the components of the KM system are only roughly outlined. It turned out that focus on KM needs to consider the administrative tasks in more detail. Therefore, the activity "mechanical work on electric control boxes" is represented with two perspectives, operative versus administrative. Figure 4 includes a specific relation that points from "quality manager" to relation "Z." This specific relation expresses that the quality manager is interested in activities that lead to entering information into the KM system. Interests are a typical phenomenon that characterizes social interactions.

Figure 4 shows some central examples for methodological aspects to support underdesign:

Figure 4. Knowledge management in the context of manufacturing



- **Incomplete specification of subelements.** The listed roles, the manufacturing documents, the administrative tasks, and the KM components are only incompletely specified. This is expressed by semicircles. For instance, in the case of the administrative tasks, the involved discussants were not sure whether they had mentioned all the important activities. By contrast, the operative tasks have been considered as the only example where an activity can be completely specified because the mechanical work appeared as well specified due to the clear definition of the outcome that had to be achieved.
- **Freely sequenced and overlapping activities versus determined sequence of activities.** A further contrast between these two perspectives refers to the sequencing of activities. The relations of type (a) in the operative tasks activity expresses that the displayed sub-activities (preparing, adjusting the box, etc.) are strictly sequenced, whereas such a sequencing is not obvious for the adminstrative tasks. The graphical concept of embedding activities (Harel, 1987) helps to express that the employees can freely decide by themselves how the activities are sequenced: whether they want to proceed in a certain sequence, whether this sequence changes from case to case, or whether they work simultaneously on some of the included subactivities. If it turns out after a while that it is reasonable to carry out some activities in a prespecified sequence, the model could be changed afterward and the knowledge management could be adapted to support this sequence.

If a sequence of administrative tasks were sequenced at the beginning of the project, this would have been an example of overdesign.

- **Predetermined decisions versus freedom of decision.** The activity "dealing with unexpected problems" is annotated with a hexagon, which usually expresses that this activity takes place only under certain conditions. However, the hexagon is empty in this context—the conditions under which a problem is considered as exceptional (e.g., the customer requires changes after the beginning of the production) are not explicitly listed. Subsequently, the employees decide whether they consider a problem as exceptional or as routine.
- **Unspecified transitions and relations.** The relation labeled X1 cuts into the entity of "tools." This means that only a subset (not all) of the tools are used, and that it is not reasonable to specify this subset in advance. Therefore, the cutting arrows are another possibility for underdesign. Similarly, the relation X2 expresses that it is not appropriate to specify the operative subtasks from which administrative tasks are exactly initiated. Therefore, this specification is left to the workers when they start to document the handling of a case. The administrative tasks can start before the operative tasks are completed. Such a constellation is typical for everyday work practice—one manager has described this configuration as "diagonally parallel" activities. By contrast, the left side of the relation labeled Y expresses that all the components of the electrical box have to be objects of the mechanical work since it is not cutting into this entity.
- **Meta-relations.** Beside what is displayed in Figure 4, SeeMe offers the possibility of a meta-relation that helps to express that the diagram includes activities or roles that are able to change the structures currently represented in the diagram. The meta-relation has a self-referential meaning and is closely related to the intentions of meta-design. The meta-relation usually points from activities or roles to the structures that can be modified. For example, meta-relation can be used to express that a project manager determines which roles or persons will participate in a project team.

There are, in principle, two possibilities to deal with incompleteness, which are indicated in SeeMe diagrams: it can either be eliminated and replaced by more complete specifications in the course of design and usage, or the incompleteness remains and opens a space for free decisions that are "taken on the fly" and depend on the context where, for example, a software system is used. It has to be emphasized that even if parts of a diagram are completely specified this does not necessarily imply that the real processes will run exactly as specified. The models are only a first approach to understand or to plan what happens in reality, and they have to be negotiated and adapted continuously. SeeMe is not the only modeling method to document the planning of socio-technical processes. Others also pursue this purpose, but only few support explicitly dealing with vagueness, such as i* (Yu & Mylopoulos, 1994), which differentiates between hard goals and soft goals identified during the requirements analysis.

Structuring of Communication

The modeling method SeeMe supports design on the level of planning. Whether and how the specifications of a plan are brought into reality is by no means determined by the plan itself, but depends on communication processes and how the people within a socio-technical environment are related to each other. So although software can be programmed and configured, the implementation of new organizational structures and processes is a matter of complex communication.

Meta-design can help to support this communication by certain interventions, such as bringing people together by organizing workshops and facilitating them. We propose a method called the *socio-technical walkthrough*

(STWT) (Herrmann, Kunau, Loser, & Menold, 2004), which has matured in the course of several cases (Herrmann, 2009). The STWT consists of a series of workshops. In every workshop, a model of the STSs—such as SeeMe diagrams—is discussed, completed, and negotiated. The facilitation of these discourses is walkthrough-oriented: "structured walkthrough" (Yourdon, 1979); "cognitive walkthrough" (Polson et al., 1992); or "groupware walkthrough" (Pinelle & Gutwin, 2002). The STWT can be characterized by its facilitation strategy:

- *Getting started*: The facilitator usually prepares a diagram representing the plan of a STS. It is reasonable to begin with an overview diagram and to have a strategy of how to walk through the diagram step-by-step.
- *Asking prepared questions*: With every step, the facilitator focuses on parts of the diagram and, for every step, applies one or two prepared questions, such as: "Which kind of information is needed or produced here?" or "How can the information processing be technically supported?" The stakeholders are encouraged to respond to these questions.
- *Collecting contributions*: The facilitator collects the answers, hints, proposals, comments, references to further documents, and so forth. It is important that the stakeholders contribute their varying, and potentially conflicting, viewpoints and make comments.
- *Focusing on the diagram*: The diagram serves as a "boundary object" (Star, 1989), which integrates the varying perspectives of the participants into a larger picture. Therefore, the facilitator makes sure that the collected contributions are inserted into the diagram. The diagram's growth mirrors the ongoing discourse. Everybody's contributions are valued and must leave traces in the diagram. This does not necessarily imply that every proposal shapes the outcome of the design, only that it has a chance to do so.
- *Dealing with conflicts*: making differing *positions comparable* and visible helps to deal with conflicts and to "*support congruence"* (Cherns, 1987, p. 158*)*. Depending on the social context, the eventual solution to a conflict is found by negotiation or by a decision of the management. These decisions can also be postponed until the first practical experience with the socio-technical solution has been made.

Between the workshops, the resulting diagrams can be discussed with others who have not participated in the workshop, they can be compared with the reality of everyday practice, they can be reconsidered by experts, and their appearance can be improved to increase their comprehensibility.

Therefore, the STWT is a method to support participation and to give users the opportunity to decide how a technology will be shaped and collaboratively used. The STWT offers users possibilities for permanent learning and a means to express themselves so that they can document their ideas and demands for adaptation, communicate them to others, learn how to bring them into reality (by themselves or with the help of others), and finally check whether the outcome of adaptation complies with their goals. The diagrams and the technical artifacts to which they refer can be considered as seeds; the STWT workshops provide a place where the evolutionary growth of these seeds can take place (with respect to the diagrams) or be reflected (with respect to the technological change that is mirrored in the diagrams).

SeeMe diagrams are only one example of the type of artifacts that can be used for the STWT. Other kinds of artifacts may be scenarios (Carroll, 1995), UML-based use case descriptions, or presentations of personas (Grudin & Pruitt, 2002). The indispensable characteristics are that they can be inspected step-by-step, that they support underdesign, and that they serve as boundary objects that can be understood and shaped from the background of various perspectives and therefore serve as a seed for the evolution of an STS. A STWT is usually centrally organized by a facilitator. However, within a culture of participation, the role of the facilitator can be taken by varying stakeholders.

EXAMPLES OF META-DESIGNED STSS

Relevance of Meta-Design for a Broad Spectrum of Applications

Meta-design provides *conceptual frameworks* (e.g., contexts for creating content; see the subsection "Cultures of Participation"), *processes* (such as the SER model; see the subsection "Seeding, Evolutionary Growth, and Reseeding Model"), and *tools* (such as SeeMee; see the subsection "Underdesign of Models of Socio-Technical Processes"). It provides a fundamentally different *design methodology* for a broad spectrum of application areas, including:

- *Software design*, with a focus on customization (Henderson & Kyng, 1991); personalization, tailorability (Mørch, 1997); design for diversity (Carmien & Fischer, 2008); and end-user development (Lieberman et al., 2006);
- *Architectural design*, with a focus on underdesign (Brand, 1995; Habraken, 1972);
- *Urban planning*, with a focus on land use, public transportation, and flood mitigation (Fischer, 2006) as pursued by the Envisionment and Discovery Collaboratory (EDC; see the discussion later in this section);
- *Teaching and learning*, with a focus on learning communities (Rogoff et al., 1998), courses-as-seeds (dePaula et al., 2001), and negotiation of concepts (Carell & Herrmann, 2009; Herrmann, 2003);
- *Living information repositories*, with a focus on organizational memories (dePaula, 2004) and community digital libraries (Wright et al., 2002);
- *Interactive art*, with a focus on co-creation by putting the tools rather than the objects of design in the hands of users (Giaccardi, 2004);
- *Web2.0-based cultures of participation*, with a focus on informed participation (Brown et al., 1994); collaboratively constructed artifacts (Scharff, 2002); and social creativity (Fischer, 2007a); and
- *Knowledge management*, with a focus on bottom-up–oriented knowledge contribution (Diefenbruch et al., 2000; Herrmann et al., 2003a) (see the discussion later in this section).

In the following subsections, two types of frameworks (collaboratories and KM) that have a twofold character with respect to meta-design are described in more detail. These are socio-technical systems that are meta-designed and are frameworks where design takes place.

Collaboratories

A *collaboratory* (Finholt & Olson, 1997) is a place where people come together to work on such tasks as design, planning, developing visions, and solving concrete problems, and are willing to collaborate, to learn from each other, and to permanently reflect and improve the tools and methods they use. The constituents of a collaboratory are not only the technical infrastructure; they also include

- People who dynamically share various roles and tasks as well as their social interaction; they are users of the collaboratory;
- Places where results are documented and archived;
- Properties of the collaboratory, such as subjects of reflection and making proposals for improvement; and
- Some people who prepare sessions in the collaboratory and maintain it, some who have the task to develop visions of how the collaboratory can evolve, and some who work on adapting the technology and contributing to incremental improvement.

Collaboratories are places where heterogeneous perspectives are melted, transdisciplinary cooperation takes place, and learning is continuously going on. They are special but typical examples of STSs, and their properties and constellation are very flexible and include a wide range of possibilities for further development so that they can be considered as the typical outcome of meta-design. This can be outlined by the concrete examples of two collaboratories, ModLab and the EDC.

ModLab: A Facilitation Collaboratory

The ModLab was developed to facilitate design-oriented communication among various stakeholders and to support collaborative creativity (Herrmann, 2010). Its centerpiece is a large, high-resolution interactive wall (4.80 m × 1.20 m; 4,320 × 1,050 pixels, which seamlessly integrates three rear-projection boards (see Figure 5). Touches are recognized via six cameras that view the reflection of infrared light caused by fingers or pens. The angles of view of the cameras overlap to support uninterrupted dragging actions over the entire wall. Data can be entered and manipulated directly on the screen or via laptops connected via WiFi. At the moment, mainly three types of software are available: the Microsoft™ Office suite; an editor for process diagrams (www.seeme-imtm.de); and the SMART™ software, which is used to control the interaction with the board but also provides means for notetaking, handwriting recognition, annotations on PowerPoints, and so forth. Furthermore, we identified some web applications (e.g., Google Docs, Mindmeister) that support collaboration within and between meetings. This collaboratory is frequently used to run workshops where brainstorming is conducted or socio-technical processes are designed. Recent examples include a workshop on the development of tagging mechanisms for process models (Prilla, 2009) and a meeting for identifying useful services that can be offered to elderly people (Carell & Herrmann, 2010).

The project leaders who organize the meetings in the collaboratory continuously try to find new tools that can be used in the lab, ask other people who are responsible for the maintenance of the lab to install these tools, and test them. Users who visit the lab have to get used to the new types of technologies, develop preferences and reservations, and make proposals for improvement.

The Envisionment and Discovery Collaboratory

The EDC (Arias et al., 2000) is a long-term research platform that explores conceptual frameworks for new paradigms of learning in the context of design problems. It represents a STS 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, the support of reflection-in-action as a problem-solving approach (Schön, 1983) and an open architecture supporting meta-design activities.

The EDC brings together participants from different domains who have different knowledge and different contributions 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 (Rittel & Webber, 1973).

The EDC 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. The exchange of information is encouraged by providing stakeholders with tools to express their own opinions, requiring an open system that evolves by accommodating new information. The information is presented and handled in a way that it can be used as boundary objects. 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) to describe a situation from their points of view. Figure 6 shows the EDC in use, illustrating the following features.

Figure 5. ModLab—a facilitation collaboratory at the University of Bochum

- The pane at the bottom shows a table-top computing environment that serves as the action space: the stakeholders engage in determining land use patterns as a collective design activity in the context of an urban planning problem.
- The left pane at the top is the associated reflection space in which quantitative data (derived dynamically from the design moves in the action space).
- The right pane at the top visualizes the impact of the height of new buildings (sketched by the stakeholders in the action space) on the environment by using Google Earth.

We have begun to include mechanisms within the EDC to allow participants to inject content into the simulations and adapt the environment to new scenarios. The next steps include creating ways to link to existing data and tools so that participants can draw on information from their own areas of expertise to contribute to the emerging, shared model. By exploring these different approaches, the EDC has given us insights into collaboration that draws on both individual and social aspects of creativity.

A META-DESIGN PERSPECTIVE ON THE COLLABORATORIES

Both ModLab and the EDC are specific examples of STSs that have a number of characteristics in common. These commonalities illustrate the following aspects of meta-design:

Technical Infrastructures and Social Interactions of Various Roles Are Intertwined

Bringing the technical infrastructure of the collaboratories into existence was constitutive for the development of a community that integrated technicians, researchers, and users of the collaboratories. After such a community had evolved, it started to make design proposals for enhancing the collaboratory's technical components. In this way, the technical infrastructure and its community of users, technicians, and researchers (with a core group of about 10 people) evolved itself as a socio-technical unit.

Most of the new technical features that were implemented in a collaboratory (e.g., the usage of gestures on the interactive wall; the

Figure 6. The envisionment and discovery collaboratory

activation of commands by positioning objects on the table top) didn't work very reliably in their starting phase as prototypes. The reactions of these new features appeared as contingent with respect to the input actions of the users. Therefore, a phase of maturing was triggered by the technicians to eliminate contingent reactions (cf. Table 1; control), and to make HCI sufficiently reliable. The more reliably it worked, the more the community was able to let new ideas emerge, which inspired the ongoing design of the collaboratory's infrastructure (e.g., developing a game that helps newcomers become familiar with the technological support). Those types of contingency that were based on technical malfunction motivated the technical staff to eliminate them, and they also were inspiring the users to develop new ideas. The collaboratories are a place where people start to "play around"—either in reality or in their imagination—with the available features. This was also a source for inspiration (cf. Table 1, situatedness, contingency). Actually, the collaboratories were not built to continue the design of their own infrastructures but to support design in other areas, such as urban planning or service engineering. However, working in these design areas did incidentally contribute inspirations for the improvement of the collaboratories themselves.

Collaboratories Evolve in Cultures of Participation with a Variety of Participants in Various Roles

Whereas traditional PD (see Table 3) would have emphasized the phases of drafting and planning of a collaboratory such as the Modlab, the main participation of the collaboratory at the University of Bochum started only after it was established. A collaboratory is such a complex phenomenon that it is difficult to imagine its possibilities before its features and potential are experienced by being inside. According to Table 3, the phase of usage itself was most important for the development of a culture of participation (see the subsection "Cultures of Participation"). There is also no definite point of time when the design of a collaboratory's infrastructure comes to an end; in contrast, it seems to go on indefinitely (see Table 3, time line). An ecology of roles (see Table 3, roles) has evolved during the evolution of collaboratories (Fischer et al., 2008), such as:

- A *project leader*, who is responsible for the overall design and the usage of the collaboratory;
- One or more *chief technicians*, who solve technical problems and evolve the infrastructure;
- *Personnel (e.g., students)*, who maintain the hardware and software to develop new features;
- *Domain experts*, who solve problems of their domain with the help of the collaboratory;
- *Scientists*, who use the collaboratory as members of research teams;
- *Students and teachers*, who use the collaboratory for learning and knowledge construction; and
- *Typical test-persons*, who detect every problem with a technical feature by their experimental usage behavior.

In the case of a traditional PD, one would have tried to clearly define the competencies of the involved roles so that their responsibility and authority can be made visible for all participants. By contrast, in the case of an evolving culture of participation, the tasks, activities, and competences of these roles can overlap: The technical infrastructure can be considered as a domain itself, and problems of this domain are discussed and partially solved by everybody in the collaboratories; the experts of other domains can contribute with proposals for technical improvement; and users become co-developers and developers become co-users. Users start to observe the troubleshooting routines of the technicians and begin to solve little technical problems by themselves. Teams of technicians and users cooperate very closely (see Table 3; collaboration). The social system as a component of the socio-technical collaboratory continuously evolved. This was also triggered by the integration of new personnel, who contributed new perspectives and knowledge domains.

Adaptation of the Technical Infrastructure Is User-Driven

The technical infrastructure has been continuously adapted to the needs of the people. This did not happen mainly by employing mechanisms of end-user programming. In contrast (cf. Table 4), the users either delegated certain tasks (mainly adding new features to the collaboratory) to the technicians, and the technicians explained how the users could handle technical problems by themselves.

A typical example is the calibration of the touch screen in the ModLab. Adaptations are carried out or promoted by those who maintain the collaboratory (see the subsection "Empowerment for Adaptation and Evolution"). The users develop new ideas of how they can convey or present their information and they start by trying out various possibilities of new information exchange; this inspires them to ask the technical staff to provide them with new features (such as wii-controlled interaction, touch-based rating mechanism, etc.). Once again, these proposals inspire the technicians to develop and implement their own ideas for improvement. Mutual learning and collaboration are the bases for the ongoing adaptation and maintenance where people increase their availability to take over the viewpoints of others.

In the course of this collaboration, not only technical infrastructure was adapted but also the social system, for example, by integrating new people into the staff who maintain the collaboratory. These newcomers brought in new perspectives and ideas of how the collaboratory could be enhanced and used. An important prerequisite for the continuous development of a collaboratory is to design it as an assembly of building blocks or components that can be flexibly and experimentally combined (Mørch et al., 2004). Examples for these building blocks are software features, web applications, and hardware devices, among others.

From the perspective of meta-design, collaboratories are self-referential socio-technical systems: they are designed to evolve, they are the place where this evolution takes place, they provide the infrastructure that supports this evolution, and they provide the context that represents the common ground on which this evolution is driven by the communication between problem owners.

Knowledge Management

KM has a twofold character in the context of socio-technical meta-design: on the one hand, STSs are designed to support knowledge exchange, and on the other hand, knowledge exchange and integration (Herrmann et al., 2007) are needed in the course of the development of an STS. KM strategies have developed in companies that pursued the goal to be aware of the firm's knowledge resources, to continuously evolve them, and to make them mutually accessible (& Leidner, 2001). Therefore, technical systems were employed to store the knowledge and to distribute it. Additionally, it was intended to integrate the various sources and repositories of electronic documents. Strategies of KM are also applied for the knowledge exchange between companies and within communities. Web2.0 paradigms (O'Reilly, 2006), especially the emergence of Wikipedia, had a tremendous influence on KM-strategies in firms where one attempts to copy the success of bottom-up–oriented knowledge exchange and users are empowered to contribute and adapt content (see the subsection "Empowerment for Adaptation and Evolution"). Wikipedia is an example of how people who don't have an official status as experts in an certain area can contribute to an encyclopedia, and it demonstrates mutual collaboration where expert status and power relations have at least secondary relevance (Benkler, 2006).

In many cases, KM projects tried to develop and introduce a concrete technical system, for example, BSCW (Appelt, 1999) and Answer Garden (Ackerman, 1998), to support KM for a certain purpose, such as project management or support of a hotline, and certain conventions, such as how, when, and where documents have to be stored. This kind of socio-technical solution represents an STS. However, this solution never stands alone but has to work in the context of other systems that are used for KM activities and have either been developed systematically or emerged in the wild. In companies as well as on the web, there is not just one type of system or application which supports knowledge exchange and not only one type of behavior for distributing and integrating knowledge, but a whole variety of them that build a socio-technical framework (see Table 2, intermediate level). It can be considered a task of meta-design to provide such a framework where concrete solutions can develop that cover:

- Plans and strategies of how knowledge exchange can be improved;
- Technical applications that are used to collect, structure, and distribute knowledge;
- Processes and conventions of how knowledge will be documented and used;
- Content representing the relevant knowledge;
- Support of learning in the context of knowledge construction and knowledge application; and
- Meta-knowledge that represents information about the value of knowledge, how it is structured and used, etc. (Herrmann, Kienle, & Reiband, 2003).

A meta-designed KM framework is an STS in which various roles collaborate in a culture of participation (see the subsection on cultures of participation), and concrete plans, technical features, commitments, and so forth can be considered as seeds (see the subsection on the SER model) that are adapted step-by-step and help to evolve and initiate new habits of knowledge exchange.

A SeeMe diagram similar to that shown in Figure 4 was developed at the start of a

KM project for a manufacturing company and served as an initial, underdesigned plan (see the subsection "Underdesign of Models and Socio-Technical Processes")—a seed that grew over a period of six STWT workshops (see the subsection "Structuring of Communication"). The final result contains about six times more elements than that shown in Figure 4. The roles displayed in Figure 4 as well as a project leader were involved in the STWT. The content of the KM and the first experiences with it were discussed in the workshops, which were also used to train the usage of the system and to initiate organizational change. The most relevant aspect of the project was that the participation of the workers has been introduced as a sustainable element of continuing reflection and continuous improvement—this can be interpreted as an initiation of a culture of participation. The discussion about what the KM system should offer already helped them to develop a better understanding of their own work and their collaboration.

Another example deepens our considerations on the relationship between meta-design and cultures of participation. We helped to introduce a KM solution for central consumer counseling in North Rhine Westphalia, Germany, which supports more than 50 local advice centers (Herrmann, Hoffmann, Kunau, & Loser, 2004, p. 18). The basic idea behind the project was to provide and distribute information needed to help people to make their decisions when they buy products or services. They can also seek the help of professional counselors for these decisions. Their work has to be supported by the KM project. A system was introduced that provided documents and the latest news about products and services available on the German market. Due to legal reasons, the information flow was only in one direction: from the central organization to the local advice centers. The central organization was legally responsible to make sure that the distributed information was correct. Therefore, local agents were not allowed to enter information into the system, although they gained a lot of experience and would have preferred to document these data in the KM system. Therefore, the motivation to work with the system was not very high—paper-based documents, to which additional information could easily be annotated (e.g., with post-its), were still more favored three years after the system's introduction. Furthermore, the one-directional flow of information was even fixed by the type of technology itself because the central organization had purchased only a few software licenses to allow the users to enter information; most of the licenses were valid only for a read-only access. It is apparent that a meta-design approach could have helped to overcome some of these problems, as outlined below.

- It would have promoted a much more flexible technical solution by which the access rights could have been flexibly adapted.
- A continuous process of negotiation and adaptation would have been implemented whereby the conflicting needs of adding personal information, distributing it, and delivering legally secured information could have led to a solution that presented appropriate compromises; the quality ensuring and rewarding procedures of Wikipedia could serve as a role model in such a case (Bryant et al., 2005).
- The continuous learning by the employees about what is possible with the system would have accompanied the continuous process of adaptation.

GUIDELINES FOR THE META-DESIGN OF STSS

This section describes *guidelines* (Fischer et al., 2009) derived from our conceptual considerations (see the sections on meta-design and practical experiences) with the development of STSs. These guidelines transcend the principles and propositions for socio-technical design as proposed by Cherns (1987) and Eason (1988):

- "Principle 1: Compatibility … Members must reveal their assumptions and reach decisions by consensus … Experts are needed … they, too, are required to reveal their assumptions for challenge" (Cherns, 1987, p. 154f).

- "Principle 2: Minimal Critical Specification. … no more should be specified than is absolutely essential … requires that we identify what is essential" (Cherns, 1987, p. 155).
- "Proposition 3: The effective exploitation of socio-technical systems depends upon the adoption of a planned process of change" and
- "Proposition 9: The exploitation of the capabilities of information technology can only be achieved by a progressive planned form of evolutionary growth" (Eason, 1988, p. 46f).
- "Proposition 6: The specification of a new socio-technical system must include the definition of a social system which enables people in work roles to co-operate effectively" (Eason, 1988, p. 47).

These principles and propositions suggest that mainly needs an actor is necessary (a manager or designer) who can recognize a certain principle (e.g., that members reveal their assumptions), outline a plan (how things should evolve), or define a social system as it should be—and this is sufficient to bring a successful socio-technical solution into reality. By contrast, meta-design aims to provide the basis on which STSs can develop with respect to the goals that are behind the above-quoted principles.

Provide Building Blocks

From a technical point of view, a meta-design framework should include components and building blocks for HCI, software functionality, and content. These are hardware devices, software features, documents, presentations, web applications, web sites, etc. as they are used in STSs, such as the described collaboratories and knowledge management solutions. The users of an STS can freely combine, customize, and improve these components or ask others to do so (see the subsection "Empowerment for Adaptation and Evolution"). It is not reasonable to provide a complete, integrated set of components as a final technical solution to which a social system should adapt. By contrast, the meta-designed framework may include only complex technical solutions if they are meant as examples of how the components can be integrated, but not as prescriptions. These examples should have the role only of seeds, which inspire the evolutionary growth of a new assembly of components that fits into the STS. Meta-design must be continuously aware of new technological trends, and the meta-designed framework must be flexible enough to integrate these trends by providing new building blocks. They must be suitable as seeds that give impulses for new directions of evolutionary growth (see the subsection on the SER model) in concert with the already existing components.

Underdesign for Emergent Behavior

Systems need to be *underdesigned* so that they are viewed as *continuous beta* that are open to facilitate and incorporate emergent design behaviors during use. Underdesign is not less design but more design because a meta-designed framework provides meta-tools, meta-methods, and meta-knowledge to allow people with various and varying competences to collaboratively design socio-technical solutions. A meta-designed framework establishes a corridor within which participatory design can develop without re-inventing the wheel or violating such constraints as legal norms, ethical restrictions, and the like. Underdesign helps to answer the question of how complex the technical building blocks that are provided by a meta-designed framework should be: On the one hand, they should integrate enough functionality so that a useful and reasonably usable unit is offered. On the other hand, they should not be too complex or they would have to be "disassembled" if someone wants to combine them with other building blocks. Underdesign has also to be applied to planning. In contrast to Eason's propositions, we do not assume that the evolution and change within STSs can be fairly planned. Therefore, methods of documentation have to be employed for the planning of an STS that allows for incompleteness and impreciseness (see the subsection on underdesign). Plans are meant as seeds (see the subsection on the SER model). They neither completely describe what should or will be nor do they completely match all aspects of the reality of an STS.

Establish Cultures of Participation

People should be enabled and attracted to bring their competences and perspectives into the development of socio-technical systems. Therefore, a transparent policy and procedure is needed to incorporate user contributions. To attract more users to become developers, the meta-designed framework must offer “gentle slopes” (see Table 3) of progressive difficulty and incremental extension of the included design aspects so that newcomers can start to participate peripherally and move on gradually to take charge of more difficult tasks. Important relevance has the structuring and facilitation of communication (e.g., by walkthrough orientation; see the subsection “Structuring and Communication”) so that all kind of participants are encouraged to make their contributions and can realize that these contributions are recognized and become part of the decision-making process. Rewarding and recognizing contributions is an essential prerequisite of fostering intrinsic motivation. Roles and their rights and duties must not be fixed for the period of an STS’s evolution but should be part of this evolution so that domain experts can become co-designers, new roles can be integrated and control can be shifted in accordance with increased competencies (see the subsection “Cultures of Participation”).

Share Control

A further crucial precondition for fostering participation is sharing control among the involved people (Fischer, 2007b). The roles that users can play vary, depending on their levels of involvement (Preece & Shneiderman, 2009). When users change their roles in the community by making constant contributions, they should be granted the matching authority in the decision-making process that shapes the system (Benkler & Nissenbaum, 2006). Responsibility without authority cannot sustain users’ interest in further involvement. Giving people some authority is a further source of intrinsic motivation because it will attract and encourage new users who want to influence the system’s development to make contributions.

Promote Mutual Learning and Support of Knowledge Exchange

Users have different levels of skill and knowledge about the system. To get involved in contributing to the system’s evolution or using the system, they need to learn many things. Peer users are important learning resources. A meta-designed socio-technical environment should be accompanied by knowledge sharing mechanisms that encourage users to learn from each other. Therefore, a knowledge management infrastructure (as described previously) can be a STS by itself as well as a meta-tool to support the evolution of all kinds of STSs. For example, in open source software projects, mailing lists, discussion forums, and chat rooms provide important platforms for knowledge transfer and exchange among peer users (Ye & Yamamoto, 2007).

Structure Communication to Support Reflection on Practice

Communication support has to be offered, which helps to combine usage of technical systems, collaboration, and design activities with mutual reflection. To fulfill Chern’s (1987) principle that participants must reveal their assumptions, an appropriate communication structure is necessary. A facilitated communication that leaves enough time for reflection (e.g., by proceeding step-by-step), offers opportunities for the exchange of backgrounds and assumptions. Furthermore, within a culture of participation, users need to continuously see that their contributions make a recognizable influence on the system.

Therefore, a communication procedure, such as the STWT (see the subsection "Structuring of Communication"), is feasible and makes the design artifacts (plans, models, etc.) continuously visible together with the improvements or proposals that are annotated by involved people. Considering an underdesigned plan of the socio-technical design step-by-step gives the participants sufficient time to reflect on it and to make their comments.

Complex design problems require more knowledge than any single person possesses. Therefore, knowledge exchange and construction among many domain experts must be fostered. Creating a shared understanding among domain experts requires facilitation so that different and often controversial points of view are brought together and lead to new insights, new ideas, and new artifacts.

CONCLUSION

New media and new technology provide new possibilities to rethink learning, working, and collaborating. In this article, we argue that new media and new technology on their own cannot support and transform these activities to meet the demands of the future, but that they have to be integrated into STSs.

Our analysis differentiates between a highest level of meta-design considerations, which cover a theoretical framework and its scientific substantiation, and an intermediate level that is represented by a meta-designed framework that includes concrete tools, procedures, methods, knowledge, and so forth. Within these frameworks, concrete socio-technical systems of a certain type can and do develop. They represent the basic level. The highest level—or meta level—is needed because it is not possible to provide a list of all concrete methods and tools that represent meta-design.

Socio-technical phenomena are self-referential: on the one hand, they are the outcomes of design and evolution, and on the other hand, they have the potential to support their own evolution. Collaboratories and knowledge management environments are typical examples. The strengths of socio-technical systems result from the integration of deterministic structures and processes and the contingency of social systems. Meta-design aims to support this integration.

Therefore meta-design offers a corridor by which the evolution and continuous adaptation, as is typical for social systems, can take place. Meta-design gives people who participate within a socio-technical system an opportunity to contribute to its evolutionary growth and to promote the evolution of their own social interactions. Therefore, the participant's work should be organized around seeds that represent boundary objects to which design can refer during use time. To avoid misunderstandings, we stress that the goal of meta-design is not to let untrained people develop and evolve sophisticated software systems, but to put *owners of problems* in charge. By contrast, the critical challenge is the creation of STSs that achieve the best fit between the technical components (mainly software and hardware) and their ever-changing context of use, problems, domains, users, and communities of users. Meta-design creates inherent tensions between *standardization* (which can suppress innovation and creativity) and *improvisation* (which can lead to a Babel of different and incompatible versions), and the success criteria for meta-designed frameworks is whether they can balance this tension.

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Building Industrial Clusters in Latin America: Paddling Upstream

Carlos Scheel, Tecnológico de Monterrey, Mexico

Leonardo Pineda, Universidad del Rosario, Colombia

ABSTRACT

Analysis of more than 20 projects for clustering small and medium enterprises and supporting organizations in different Latin American countries has uncovered a number of barriers, activities, structures, strategies, policies and procedures that impact competitiveness. These factors mean that there are different appropriate industrial cluster and industrial business models appropriate for the social, economic, and business conditions of the Latin American region. It is difficult to transfer successful practices from industrialized countries to developing regions with a light adaptation, because it is impossible to have "clustering readiness" when resources are scarce, regional and industrial conditions are hostile, and associated capabilities of the participants of clustering are poor or nonexistent. These conclusions are supported by applying a methodology designed by the authors to identify global opportunities and formulate viable cluster structures, capable of converting isolated scarce resources in difficult situations, into world-class regional value propositions.

Keywords: *Cluster Barriers, Clustering Strategies, Industrial Clusters, Latin American Competitiveness, Sociocultural Impacts*

INTRODUCTION

From the analysis of numerous successful cases in industrialized countries, we have found that most of them have been strongly supported by well articulated clustering organizations and a proper governance of effective national innovation systems. Is this organizational structure working on the Latin-American industrial environment?

Since the publication in 1990 of Michael Porter's book, *The Competitive Advantage of Nations*, the cluster approach has been broadly spread and applied in two particular directions. The first one is on the academic world because it has served as a new label for older concepts like the economy of agglomeration. The second one is oriented toward policy circles as an instrument for supporting industrial sectors and regions (Maier, 2007). However, as the term is openly extended, a universal definition doesn't exist. Thus, for the purposes of this article, we define a cluster as a "spatial agglomeration of similar and related economic and knowledge creating activities" (Teigland, Lindqvist, Malmber, &

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Waxell, 2004), or as "poles of competitiveness" (Cohen, 2007) using the French approach.

It should be recognized that the cluster approach is based on four broad assumptions. First, in today's economy, the ability to innovate is more important than cost efficiency in establishing the long-term ability of enterprises to grow. Innovation is defined broadly here as the ability to develop new and better ways to organize the production and marketing of new and better products and services (Grant, 1996; Lundvall, 1992; Nelson, 1993; Nonaka, 1994; Porter, 1990). This does not mean that cost considerations are irrelevant, but simply, that the combined forces of market globalization are enhancing the real impact of knowledge as an intangible resource and learning as a production process.

Second, innovations frequently occur as a result of a linked interaction between multiple elements, rather than an effort of an isolated individual (Håkansson, 1987; von Hippel, 1988; Lundvall, 1992). This fits with a Schumpeterian view of innovation as a new mix of already existing knowledge with organizing production process and entering new markets in unconventional ways by improving or redesigning goods (Schumpeter, 1934). All of this confirms not only the statement that organizations can't compete as lone agents but also that system interaction is needed in order to shape the innovation process. This is a key factor regarding the interaction of different players and regional conditions on a cluster organization.

Third, geography is an important factor because agglomeration empowers face-to-face interaction, trustful relations between various actors, easy observations, creation of a brand and the possibility to perform immediate benchmarks (Malmberg & Maskell, 2002). Furthermore, spatial proximity enhances innovation interaction, learning process and value creation, where it has to be recognized that the empowerment drivers for these phenomena are participants such as universities, research centers and new venture capitals.

The fourth and final implication is that local industrial structures with many firms tend to activate processes which create not only a dynamic flexibility, but also a learning process and innovation. In such environment, chances are greater for an individual company to get in touch with agents that have developed new technology. Furthermore, the flow of industry related information and knowledge is to the advantage of all firms involved (Malmberg & Maskell, 2002). Moreover, Malmberg and Maskell (2002) foster the impression that reasons exist to believe that the knowledge structures of a given geographical territory are at the same level of importance than other characteristics, such as raw material input supplies, production costs, regulations, etc., when it comes to determine where we should expect economic growth in today's world economy.

When it comes to observe the four broad assumptions explained above, but within the Latin American (LA) environment, economic acceleration of value due to industrial clustering is not taking place. After analyzing more than twenty projects implemented in the past 15 years for the clustering of small and medium enterprises and supporting organizations, in different countries of the region, both practitioners and the authors, have arrived at some very discouraging conclusions.

Even though it is possible to find some exceptional cases, they are more the outcome of corporate successes, rather than of *regional competitive industry clusters*, according to world class best practices. The observed cases in the Latin American region show very few examples of true clustering synergies among the main players which are the entrepreneurial community, the academia, the government and the social communities.

The reasons for this lack are multiple and complex. Most businessmen blame local and federal governments and their politicians. Others confirm that reasons are the: financial costs; strong cultural isolation of the companies; total misalignment of the public policies with the industrial strategies; low competitiveness and poor innovation of most small and medium enterprises (SME); lack of research and development; a poor system of transferring the results to industry; reduced connectivity infrastructures and e-readiness. Also the insufficient technical, technical and innovation training systems, as well as obsolete regulatory frameworks and an obscure biased rule of law, which is one of the strongest inhibitors for clustering among industrial participants.

Based on these situations, we have formulated a series of questions to establish the causes of this poor performance on developing competitive clusters of the region. All the indicators and procedures for clustering readiness, cluster performance, and cluster implementation have been extracted from the Compstrac© Methodology (2003) that has been used in several cases in Latin America.

The main questions are:

a) What are the cluster-readiness conditions that are required to incubate industrial poles of competitiveness?
b) What are the barriers for an effective c-readiness in the Latin America region?
c) Is there a feasible and effective road map for achieving regions capable to support an effective clustering among all participants?
d) What is the missing link in the Latin-American productive chains which would enable successful clusters to occur?

How World Class Regions Compete

In well-developed countries, industrial structures include highly collaborative and complex organizations of clusters and related industries. The dynamics of this complex system of innovations is non-linear and uncertain, because the interactions among the organizations can sometimes exceed the borders of the countries (Meyer & Leidesdorff, 2003). Moreover, the participants maximize the benefits of flexibility, share the advantages of belonging to effective networks and generate increasing economic returns (Porter, 1998) which are redistributed among all stakeholders through dynamic and sustainable network mechanisms.

Natural associations of local competitive companies (mainly SMEs), which have high performance leverages, may easily attract foreign direct investment (FDI), and develop partnerships to cover worldwide markets. As a result of their immersion in industrial infrastructures and political and social environments, they are integrated into networks of increasing economic returns where the companies, industrial sectors and indeed entire regions are all winners.

These associations have competitive infrastructures (transportation, broadband connectivity, ports, universities, research centers, etc.), e-readiness regions, aggressive new venture capitalists, highly skilled human resources, effective national innovation systems, incubators of technically enhanced spin-outs and spin-offs, research and development centers and high-tech export programs, etc.

Their competitiveness depends on the construction of unique, differentiable and sustainable capabilities to create appropriate enabling clustering-conditions (i.e. e-environments, e-business, e-government support systems, effective access, enabling policies, etc.), which are invaluable sources of competitive advantages. Porter (1990) stated that there are two types of factors, the basic ones which includes the natural resources and the advance ones that are "created" in order to obtain advantages. Therefore, economic competitiveness resides in forming enabling capacities that may generate the factors that provide differentiating core competencies, accessibility of key resources and the best practices of the industry.

These world class regions have tremendous capacities (not only within their territories, but wherever the resources exist, using the best local-regional advantages), to generate high added differential value by stimulating the competitiveness development of their companies at all levels. Also, they have formed strong synergies of all stakeholders from their environments, productive engines, complementary and supporting activities, and innovative processes. Furthermore, most of them have learned to align the enterprise microeconomic cycles with the *meso* and macroeconomic environments (and vice versa), obtaining impressive levels of competitiveness and practices.

However, this is not the case of developing countries (DCs) where we have found that *all* of these conditions must be created, they are not natural. Therefore, in these cases, a robust methodology must be developed and applied. Due to these hostile conditions for clustering, in 1994 one of the authors decided to design a methodology for preparing (c-readiness) and assembling cluster configurations. Sponsored by a UNIDO program for promoting competitiveness and the UNDP, the Compstrat© methodology was developed. This is procedure for entrepreneurial competitiveness strategies and subsequently, a more comprehensive version named Compstrac© for clustering strategies for regions with scarce resources, hostile industrial and regional conditions and poor associability levels was formulated.

The Compstrac© approach is structured in three phases. A first phase is designed to find if a determined region has the capabilities to support associativeness, or clustering readiness. A second stage has the objective to know not only where the conditions of the industrial factors are determined but also where all the required relationships are developed, in order to craft the associative process and the assembling of the constituents of the cluster. A third stage, which is the cluster performance phase, is related to all the parameters needed to measure the impact of the cluster and the benefits that an organizational structure of this type generates for the region.

This procedure has been applied to more than 20 cases in different countries and several industrial sectors (such as software, metal-mechanic, flowers, health, tourism, aeronautical parts, tropical fruits (mango), textiles, leather, fish, etc), with a variety of supporting institutions that depend on the case and country, such as local governments, industrial chambers or federations, research centers, etc. Each case has been different and some of the results and experiences are discusses in this paper.

In order to benchmark the cluster readiness capabilities, Table 1 identifies some main features and key outcomes of the best practices of industrialized countries.

As we can observe, if a region offers these characteristics to support a clustering environment, the companies do not compete as isolated small producers, but as part of a large network. Furthermore, they do not only compete with good quality products, or with an effective business model, but with high value, differentiated and world-class processes, as well as innovative effective industrial and regional models working on a unique well tuned network economy. In summary, "*clustering is a systemic organization*."

Innovation Approach as a Driver for Industrial Clustering

Porter (1998) showed that in a global economy with high speed communication, fast transportations and accessible markets, the competitive advantages are not only affected by the intra-organizational conditions but also by environment drivers outside the enterprises or their "externalities" ; i.e. their surroundings which characterizes the co-operation among other enterprises, support agencies (*meso* institutions such as chambers of commerce and industry, technology centers, new venture capitalists, etc.) and public players. This standpoint led to a shift in the priorities of regional development policy. Nowadays, individual enterprises are no longer at the centre of the industrial structure, but rather they have become *networked enterprises* that strengthen their relationships with suppliers, customers and public policies as well.

Pioneering studies in this context were done in the early nineties, Lundvall (1992) argues that the uncertainties involved in innovation and the importance of learning implies that the process would need a complex communication between different parties. It should be noticed that for him, two of the factors involved, are interactive learning and collective entrepreneurship, because these allow the introduction of a

Table 1. Key outcomes of best practices

MAIN FEATURES OF WORLD-CLASS CLUSTERS	KEY OUTCOMES OF CLUSTER STRUCTURES
o Reliable national system of innovation, associated to robust research and development state policies. o Trust and confidence in basic institutions (privacy, physical security, legal security, political continuity). o Transparent, timely and effective legal frameworks. o Enterprise, government and intra-industry alliances, and strong social and cultural collaboration schemes. o Higher education research centers linked to industry needs and government programs. o Strong and wide-area connectivity capabilities, high-quality linkages and viable access (e-readiness). o Modern business, industry, and regional models (i.e. e-regions, e-business). o Wide and effective use of enabling technology resources (i.e. ICT). o Effective producers of high value and differentiation. o Effective and aligned (companies, academy, government banking) public policies. o Steady, effective financial and social capital markets, as well as robust venture capital instruments. o Transparent and coordinated public administration mechanisms at the three levels of government (i.e. aligned e-governments at national-state-municipal levels). o Available human capital that is trained and educated in the specialized fields of knowledge that the cluster requires and with the supporting of educational institutions to further develop the work force.	o Sustainable poles of competitiveness (with world-class practices) competing for high-value global markets. o Specialization on high value increasing returns. o Global delivery of products to markets without restrictions (space and time). o Wide coverage of markets of highly skilledtalents (quantity and quality). o New venture capital strategies to support high-risk investments. o Highly supportive and world-class infrastructures (public, physical, etc.). o Flexible and vibrant industries with continuous mobility and global resource allocation management (wherever the best practices are located). o Global Producer Networks (GPN) of highly productive companies. o Empowered environments capable of transforming innovation, research and development, into strong and sustainable system of capitals (economic, social, environmental and public) o Strong networkedeconomies.

process of innovation that goes from individuals towards collective efforts.

When analyzing the types of approaches in innovation theories like that mentioned above, it can be seen that innovation is no longer described as a linear process. It is more oftem argued that innovations represent the result of interactions and feedback processes by various different players (firms, knowledge producers, technology transfer institutions, incubators) in so-called innovation systems. The empowerment of a region (within a country) is based on the innovation strength of networks which are characterized by self-steered processes, co-operative exchange structures and dynamism among all stakeholders.

Therefore, supporting the development of enterprise networks promises to be an efficient instrument for structural SME-oriented innovation policies. However, empirical experience shows that cluster policy is not a panacea for regional policies. The skill of identifying and initiating clusters which are likely to be successful, as well as motivating enterprises, meso institutions, public players and possibly research organizations to work together, must be developed first by those directly responsible for the clustering process and implementation.

The main features of the world class regional competitive industries and the different initiatives created to develop them identified above, provides enough reasons to believe that the success of innovation occurs precisely in the interaction between global and local processes. Successful regions understand how to network intelligently local and regional players such as enterprises, universities, research institutions, associations, policy makers and administration in order to bundle and augment the knowledge distributed among individuals and to transform it into new products, processes and services (clusters) capable of undertaking world-class opportunities.

What are the Cluster-Readiness Conditions Required to Incubate Industrial Centers of Competitiveness?

After analyzing the key outcomes emerging from the discussion above, it can be inferred that the clustering procedure is concentrated on shifting from total firm isolation, to an industrial association, then to a club of sharing entrepreneurs, to a chain of suppliers, to a cluster of enterprises and finally to a center of competitiveness.

From the above we may also conclude that one of the basic enabling conditions to become an attractive center is to have an empowering networked environment, capable of articulating all the necessary and sufficient participants required to achieve a strongly interacting competitive region.

We have divided the required enabling conditions into three basic groups. The regions must: (1) be electronically prepared (e-readiness), (2) have a high capacity to support and capitalize innovation (i-readiness) and (3) be able to break the inhibiting barriers of isolation and achieve strategies and policies of effective clustering (c-readiness).

Here we describe the main elements for each empowerment situation (Scheel, 2006).

A region is e-ready when it has fulfilled the NRI metrics established in the World economic forum (2003):

1. Technology Infrastructure, which means to have a sufficient network access;
2. Business readiness for adoption of ICT benefits, and being part of an effective and robust network economy;
3. Legal and policy environments, capable of supportive public policies of inclusion and networking;
4. Network learning (Social, Human and Cultural Capital); And
5. A well connected, fully empowered, and social responsive entrepreneurial sector.

A region is ready to develop and maintain clusters (c-readiness) when it has developed special capabilities such as:

1. Substantial market conditions, necessary to induce cluster integration.
2. Structural drivers (connectivity and technology infrastructure), for clustering stakeholders' hard infrastructures: IT and connectivity, airports and other transportation facilities.
3. Economic and financial enablers that supports world-class trade. Existence of robust extended value systems of suppliers, customers, and wealth producers.
4. Public policy and legal enablers for effective clustering.
5. Social and cultural environments that leverage the clustering process.
6. Regional attractiveness enablers.
7. Industrial competitiveness enablers.
8. Entrepreneurial productivity and business environment enablers.

As stated before, innovation is a key player in the process of clustering. Therefore the regions must be creative, innovative and capable of transfering *local knowledge*, technology and science, into economic value added, directly imbedded into substantial benefits for the community. This innovation-readiness (i-readiness) (Scheel, 2003) exists when the following conditions are present in the region:

1. The region has a systemic approach to regional problems, based on a natural local empowerment, trust, transparency networking capabilities and well supported associativeness capabilities and partnership culture.
2. The region considers all institutions as a whole (family, church, police, wealth,

schools, etc), and when there is a citizen's council that integrates all these institutions, with a major leader (a champion).

3. A Rule of Law and enforcement exists at all levels of accountability and governance.
4. The region maintains a political stability, freedom, equality, inclusion, and basic freedoms for all to participate.
5. Talent is based on the ability to attract, recruit, train/educate, and retain world-class talented intellectual capital and major technology companies.
6. The region has a robust and sustainable soft infrastructure: schools, libraries, educational opportunities at all levels, scientific prominence in technology based research, and the existence of a market for talent.
7. The region has developed Science and Technology research excellence on specific sectors of technology, linked to at least one top academic and research University.
8. The region is i-ready when a robust Regional Entrepreneurship Infrastructure exists promoting: Social awareness and appreciation for innovation; Entrepreneurship and risk-taking; Financial, tax incentives and new venture capitalists. Additionally there needs to be a simultaneous global and local vision of regional development so that there is strong regional collaboration between: Academia, Business and all levels of Government; Strong partnerships among R&D, entrepreneurial structures, and social demands; and coherent civic, social, and technology entrepreneurship thinkers, doers and catalysers; as well as a large immigrant entrepreneurship Diaspora.
9. And finally, all these requirements and activities must be governed under an effective and sustainable Regional Innovation System (RIS), with the ability to convert innovation on a social capital benefit, capable to create a disruptive innovation cycle, coherent with wealth producers (resources), external drivers (value accelerator processes), and with social benefits (social welfare value) attached to the individuals and their communities.

In summary, a region is *i-ready* when it maintains a vibrant industry, and a fluent transference of R&D into successful business, a social coherent capital, and a high quality of life, a kind of constructive capitalism

Of course, not all success cases have required all of the conditions we propose. We have observed that a success center has at minimum an adequate electronic network readiness, a strong capability to associate all stakeholders, a mayor research center (or university) and all of them have effective regional innovation systems, with a functional governance. However, when we have tried to transfer and implement these enabling environments, relationships and capabilities in some developing regions, we have encountered barriers.

Our main hypothesis that has been supported in most of the implemented cases within the Latin American region is that *if a determined region does not have the clustering-readiness, an effective connectivity (and some other e-readiness characteristics) and it is not supported by an effective national innovation system, the cluster concept probably will not be successful, at least as a critical mass structure with a powerful impact on the regional GDP.*

What is the Competitiveness Situation of the Latin American Region?

One of the most relevant issues, when discussing Latin America competitiveness is the complexity of the Region, both in terms of national economic and social structures and in terms of their international capabilities to be integrated into global markets.

Countries like Chile and Brazil are far beyond the national standards of other economies, while others like Colombia, Venezuela and Peru are still based in commodities such as petroleum exploitation and coal mines, with a manufactured sector still lacking technical modernization. Therefore, one of the flaws currently seen in the literature about the LA region is to assume that all the countries require and currently have, equal conditions, even in the absence of standard comparison parameters.

According to the Latin America Competitiveness Review 2009-2010 (World Economic Forum, 2009), Chile confirms its superior economic performance within the region by ranking 30th in the overall sample of 134 countries covered in the GCI (Global Competitive Index) and surpassing all its regional neighbors by a wide margin. Chile is ahead of 16 of the EU's 27 members. Moreover, countries like Costa Rica, Brazil, Panama, Mexico, Uruguay and Colombia surpass the EU's weakest performer which is Bulgaria. Nevertheless, Costa Rica, second in the region and 55th in the world, is twenty five places behind Chile. Not only does Chile continue to benefit from remarkably competent macroeconomic management but, it also operates in an institutional environment characterized by transparency, openness, and predictability.

The remaining Latin American and Caribbean countries are spread over the lower half of the Index range. Paraguay, Bolivia and Nicaragua are the least competitive economies in the region and are also among the weakest performers of the 134 countries covered by the Index.

This situation is understandable since the GCI (Global Competitiveness Index) is composed of the so called *Twelve pillars of competitiveness*, as it states: "The measurement of competitiveness is a complex undertaking. One cannot simply pinpoint one or two areas as being critical for growth and prosperity" (Blanke & Mia, 2006). In this light, the GCI captures this open-ended dimension by providing a weighted average of many different components, which are grouped into *pillars* (of competitiveness). According to the World Economic Forum, each of these pillars reflects one aspect of the complex concept of competitiveness, and they have been identified as: Institutions; Infrastructure; Macroeconomic stability; Health and primary education; Higher education and training; Goods market efficiency; Labor market efficiency; Financial market sophistication; Technical readiness; Market size; Business sophistication and Innovation (Schwab, Sala-i-Martin, & Greenhill, 2009).

Therefore, we propose to investigate whether these twelve pillars are also a coherent set for the "clustering" of productive sectors as a pre-condition for becoming competitive in international markets.

A first approach is given by the WEF Report. It underlines that the Survey results indicate that clusters are relatively numerous and well developed in the region, and this is reflected in the good results on the vertical linkages, with Chile, Costa Rica and Brazil as top innovation performers within the region (Schwab & López-Claros, 2006).

However it is not whether the clusters exist, but rather to determine their capability to compete with similar ones of other geographical regions that is required.

The case of salmon farming in Chile could be considered as a real and successful cluster (Schwab & López-Claros, 2006). Furthermore, the categorization of this case helps to realize that in other Latin American locations, the reference to "hundreds of smaller agglomerations" is not a clear cut indication that there are clusters, it rather could be just companies that come to work together "mainly driven by price competitiveness". They are just a bundle of players trying to form *critical masses to achieve* certain group benefits.

Beyond question, the shoe manufacturing cluster in Sinos Valley in Brazil, the garment manufacturing cluster *Complejo Gamarra* in Lima, Peru, and the software cluster SINERTIC in Bogotá, Colombia and many others are interesting examples. However, a systematic assessment of the performance of clusters in the region carried out using the methodology Compstrac© (Scheel, 2003) shows that they have difficulties concerned not only with innovating and moving up within the value chain, but also with the absence of enabling environments, and existence of cultural barriers, which will be further elaborated in this paper.

Empirical evidence applying Compstrac© sheds light about the conditions which face the enterprises in some productive sectors when they want to exploit their opportunities of being organized as a specialized clusters. Around 25 industrial sectors have been assessed in order to learn in detail the main reasons to success as organized world class clusters.

The foremost outcome of some of the cases reviewed, indicating the key issues hindering the cluster development, as well as some main factors that can potentially encourage the clustering development are summarized in Table 2.

Analyzing the results of all the cases where in the Latin-American region that are documented (at least internally) as above, it is clear that each case depends on the industrial sector, on the regional clustering characteristics and on the local public policies. Additionally, they have commonalities, such as lack of trust of supporting institutions; lack of association amongst peers; poor knowledge of the externalities of industrial sectors; a divergence between the public policies and the economic drivers; an historical determinism of the region that maintains some companies in an incompetent comfort band; a slow reaction from public policies (social and economic drivers moving faster) against global drivers.

Further analysis of the production chains indicates that global competitors are also jeopardizing the competitiveness capabilities even within internal markets. As an example, in the case of leather shoes and products the aggressive strategies pursued by China are eroding prices, and there is a suspicion of price dumping. A similar situation is found in the garment and clothing sector. Under these conditions the main question remains open, "…whether Latin American countries can overcome these threats in these productive sectors by means of assembling industrial clusters or not"…, as happened on the cases of the Emilia Romagna (Resenfeld, 3-23) in dairy production, or the wool industry of Prato (Owen & Jones, 2003) in Italy.

To answer this question, we need to be aware of both local and external conditions that influence the behavior of firms. Under open market conditions, SMEs are exposed to competition and therefore need to be more actively involved in defining innovation strategies in products, process, services, business and industrial models, and capable of differentiation for competitive strategy.

Some Possible Interpretations for the Latin American Situation

Observing the world-class players' performances against the current situation of the LA region, we conclude that the panorama is not encouraging. There is no simple and fast track formula. The barriers are many and complex; they start at the lower levels of business culture and include the regional industrial structure.

Considering the few successful cluster formations in the region - such as the automotive cluster in Mexico (Palacios, 2001), the electronic cluster in Costa Rica (World Bank, 2006) and the software-informatics cluster in Curitiba, Brazil (Bortagaray & Tiffin, 2000) - the necessary condition to start a cluster seems to be the existence of a robust and sustainable industry, with a well structured chain of suppliers. This means, that it is vital to have in existence highly productive companies structured as value chains with extended value systems of companies bonded to suppliers, supplier chains, and customer chains, all of them linked to an extended network of supporting and complementary organizations and institutions in an effective and attractive region. Alternatively, as in the case of Intel in Costa Rica, a cluster can form when the federal government is involved. Here they provided policies directly from the Office of the Presidency, designed to create the necessary conditions for Intel to prefer Costa Rica, over other Latin-American countries. Additionally, the cases of the electronic-software cluster in Jalisco, Mexico and the software-informatics cluster in Curitiba, Brazil, demonstrate that the existence of an established value chain developed over decades, is a major enabler for well-structured clusters.

The following are the most significant practices we have found, that *inhibit* the process of clustering companies, supporting industries, institutions, etc., in Latin America:

Table 2. Examples: Key issues and main factors encouraging clustering

Cluster	Inhibitors	Enablers
Leather products (Colombia) **Status:** design is the key factor in niche markets. (Cámara de Comercio de Bogotá, 2006)	• Quality of inputs, namely hide and skins. • Tannery process highly pollutant. • Mostly microenterprises belonging to the informal economy.	• Top class design. • Handicraft with good capabilities. • Medium and large enterprises with good foreign technology. • Diversity of market niches.
Fruits and legumes (Colombia) **Status:** organic products with promising perspectives. (Cámara de Comercio de Bogotá, 2006)	• Production mostly concentrated in very small farms • Lack of good practices in agriculture. • Lack of traceability labs to secure food safety according to international standards. • Large fragmentation of distribution channels.	• Exotic products for international market niches. • Biotechnology developments for healing purposes nutraceutics. • High demand for agricultural organic products. • Package and packaging for long term product durability and conservation. • R&D results available for commercialization purposes.
Women's underwear **Status:** under consolidation as a key player in international markets. (Colombia) (Cámara de Comercio de Bogotá, 2006)	• The raw material, namely fabrics of low quality. • Lack of skilled labor in the integration process. • The current structure of enterprises - organized as single workshops. • Strong unfair competition among large and small enterprises.	• Top class design. • Very good exposure to international markets. • Brand name positioning in neighbor countries.
Software development **Status:** still learning, but good perspectives. (Colombia) (Cámara de Comercio de Bogotá, 2005)	• Number of developers available. • Lack of quality assurance, testing and metrics. • Poor command of the English language. • Developers without reliable certification.	• Government policy to foster software development as a key sector. • Cluster of enterprises already available. • European Software Institute ESI branch in Colombia.
Health and medical services **Status:** positioning in cosmetic surgery. (Colombia) (Cámara de Comercio de Bogotá, 2006)	• Unfair competition among different services in regions. • No focus oriented services. • Large service dispersion • No international certification available.	• Strong research capacity at university and clinic levels. • Some services already considered of world class: ophthalmological, deontological services and cosmetic surgery. • Relatively competitive costs compared to international standards.
Metalworking industries **Status:** losing competitiveness, due to technical downgrading. (Colombia) (Agenda Interna para la Productividad y la Competitividad, 2007)	• Technical obsolescence of workshops and of the production process. • Inputs from iron and steel of poor quality. • Production costs not competitive neither locally nor internationally.	• Specialization in products and segment markets, associated with the construction industry. • Redeployment of the enterprises to free trade zones near to ports to reduce transportation costs.
Jewelry and bijouterie **Status:** very informal sector, only large enterprises with positioning capacities. (Colombia) (Centro de Información y Asesoría en Comercio Exterior, 2006)	• Value added chain disintegrated with small merchants. • Social problems arising from informal sector. • Production process still very artisanal. • Low application of advanced technologies for environmental protection purposes.	• Local endowment of key inputs from mining: gold, platinum, and emeralds. • Top class design. • Positioning of individual enterprises in international markets.

continued on following page

Table 2. Continued

Shoe industry **Status:** losing competitiveness due to strong competition from China. (Colombia) (Agenda Interna para la Productividad y la Competitividad, 2007)	• Small workshops without formal structure. • Quality of inputs very poor. • Obsolescent production processes.	• Only large enterprises able to compete with foreign products. • Mass production at very low price in market niches.
Business tourism **Status:** good recovery although country image still affecting the sector. (Colombia) (Such, Zapata-Aguirre, Risso, Brida, & Pereyra, 2008)	• Image and reputation of cities. • Few bilingual personnel. • Local transportation infrastructure.	• Cultural attractiveness of specialized events: music, theatre, dance and disco. • World class lodging and hotel facilities.
Wool fabrics and garments **Status:** most enterprises disappeared. (Colombia) (Jara, 2008)	• Complete integration of production process from fabrics to garments. • Production processes expensive due to technical obsolescence of equipment and machinery. • Low buyer bargaining power. • Low negotiation capabilities with large foreign customers. • Difficult financial position.	• Enterprise experience of more than 50 years. • Specialization in wool garment of high quality. • Design a key competitive success factor. • Good skills in traditional practices. • Wide knowledge of technical and management processes. • Good branding (inside the country). • High response quality. • Sufficient manufacturing capacities.
Software development (Nuevo Leon, Mexico) **Status:** pending, looking for core competencies of the region. (Instituto Mexicano para la Competitividad, 2008)	• Lack of sufficient specialized human resource. • No critical mass of human resources on specific high value areas for large projects. • Weak public policies to prioritize the sector. • High labor costs compared to other LA competitors. • Lack of branding in Software industry. • Existence of a strong organizational culture of individuality among SMEs in the sector • Few SMEs take advantage of the federal supports for entering global arenas.	• The Government has the largest software development capacity in the country. • Important experience in BPM off-shoring processes. • A growing strategy of e-readiness infrastructure in the country. • Competitive adjusted cost Vs risk software projects against international competitors. • Geographical closeness for off-shoring processes. • Cultural and business affinity with global customers. • Strong industrial sectors that are high consumers of embedded software and IT services (i.e. autoparts, manufacturing, financial industry, food industry, health). • Low country geopolitical risk (lately affected by violence and insecurity).
Biotechnology (Nuevo Leon, Mexico) **Status:** pending a planned growth strategy driven by the research centers, looking for host companies. (Instituto Mexicano para la Competitividad, 2008)	• Non-existence of host companies • Still not a priority area for federal government policies. • Non-existence of new enterprises (start ups). • Strong legislation against new uses of biotechnology products.	• Development of two large research and development centers on medical applications. • Well known schools of medicine with large investments on research. • Private investment ready to leverage new venture projects.
Furniture (Coahuila, Mexico) **Status:** most of the producers almost disappeared due to Chinese penetration in Mexico. (Instituto Mexicano para la Competitividad, 2008)	• Lack of integration of entrepreneurs. • Legacy strategies completely out of modern competitiveness focus. • Threat of Chinese imported goods due to NAFTA. • Impossible to arrive to common agreements between producers. • Strong culture of isolation.	• The Chinese imports have generated some late reactions of the local producers.

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Table 2. Continued

Mango (Ecuador) **Status:** Some of the largest producers adopted suggested strategies, others continued on a low profile basis. (ITESM-Sede Guayaquil & Corporación Las Cámaras, 1999)	• Low performance per hectare. • Highly fragmented producer network • There is not an association of producers dedicated to branding, specialization, exports, etc. • Has a very large competitor, but different months of production. (Mexico) • Lack of technology development centers. • No certificates and quality protocols. • No unique (national) branding identity. • Delivery times depend on other products (shipping by sea i.e. banana, shrimps). • High rejection levels (paid by producers). • May become a commodity fruit with low prices in a near future. • High bargaining buyers power (mainly of Europe and Japan). • There is no State Plan for development.	• Has almost a unique window of production with the highest prices for the main buyers. • Due to other tropical fruits from Ecuador, may cover the USA market with greater frequency. • Highly demanded exotic fruit. • Non-saturated production capacities. • Has modern packing practices and logistics between packers and shipping ports. • Highly skilled entrepreneurs.
Aeronautical industry (Nuevo Leon, Mexico) **Status:** Stand-by for government decisions (Inst. Mex. Para la Comp, 2008)	• Lack of research centers. • No legacy industry. • Difficult to transfer expertise from other industries (i.e. auto parts). • Expensive land (for airports).	• Well positioned auto industry. • Strong legacy of metal-mechanical industry in the region.
Printing industry (Costa Rica) **Status:** Largest producers adopted the suggested strategies, others continued on a low profile basis. (PNUD Program for National Competitiveness, 1994)	• Poor financial tools for modernization and growth. • High bargaining power of suppliers (highly dependent on imported resources). • Due to old equipment, costs are difficult to reduce. • Limited exports capabilities. • Government is the main consumer.	• Good geographical position for fast delivery in Central America. • High skilled working labor capacity. • High quality at low costs products.

(1) Generalized distrust among institutions, enterprises, social groups, and individuals,
(2) Generalized production and trade of low-value products or goods,
(3) Operating in a low competition but survival comfort band,
(4) Low levels of technical skills and non-existent trade associations (as distinguished from trade unions),
(5) Incompetent (corrupt and biased) legal framework (rule of law) for industrial policies,
(6) Lack of capacity for networks at all levels (regional, industrial, enterprise, entrepreneurs, chambers),
(7) Poorly linked (or non-existent) inter-governmental (municipal, state, federal) industrial policies,
(8) Unbalanced and unfavorable rules of competition,
(9) Slow and inadequate structural reforms,
(10) A rejection of, or inability to implement innovative models of businesses, industries and regions,

(11) A common aversion to risk taking,
(12) An inability to collaborate for synergies and their enhancement among all stakeholders,
(13) A growing gap between the richest and the poorest,
(14) A weak infrastructure and general low “e-readiness” levels,
(15) Obsolete enabling technologies that are not fit for the international markets,
(16) Lack of rules of compatibility (worldwide class standard processes and metrics of quality),
(17) Lack of investors and inadequate support of the private banking system because of perceived high risk,
(18) Low productivity metrics and lack of specialized human resources,
(19) Lack of strategic thought, a focus on the daily operation of the business rather than on the long-term performance, and
(20) One of the most important barriers at the enterprise level – neither the enterprises nor the institutions have been designed for cluster readiness. They have conventional organizational structures totally adverse to the c-readiness environments.

With all these barriers, without the proper industrial and clustering enabling-conditions, and effective resource management, it is quite probable that the LA region will not succeed in implementing a well planned inter-regional clustering strategy on the short-term horizon.

The Latin American region is not naturally ready to incubate industrial clusters. Therefore, in order to develop the basic structural enabling conditions, the model we suggest can develop the competitive capabilities of the enterprises and the relationships among supporting institutions so that they can be prepared for developing “clustering-readiness” and will become capable of incubating and operating world class centers of competitiveness.

Road Map for Building a C-Readiness Region

…what we have is tremendous business isolation instead of

enterprise cooperation as a landmark in the Latin America business environment…

Opinion of a famous Latin American entrepreneur.

Gereffi (2001) argues that the current international success of companies is based on their strategic location in global networks that enable them to have access and interactions with leading world-class enterprises. Birkinshaw, Morrison and Hulland (1995) also note that, industry structural characteristics as well as the competitive factors of a company, have an influence in the formulation of global strategies within an industry. They argue, that the impact of these two groups of factors is different and varies from one industry to another. In this sense, the analysis and study of Industrial Clusters is fundamental to understanding the Latin American business environment.

Morosini (2004) argues that an industrial cluster is a “socioeconomic entity characterized by a social community of people and a population of economic agents localized in close proximity in a specific geographic region. Within an industrial cluster, a significant part of both the social community and the economic agents work together in economically linked activities, sharing and nurturing a common stock of products, technology and organizational knowledge in order to generate superior products and services in the marketplace”.

Bell and Albu (1999) suggest that research on industrial clusters in developing countries is increasingly concerned with how their competitiveness evolves and changes over time.

Based on the experiences on cluster incubation in Central and South America, we have found that industrial clusters in Latin America have a pattern that repeats over and over again: a lack of integration among the companies; no shared consensus; no common visionary perspectives; no strategic alignment with the environment in order to impact in the performance of organizations (Venkatraman & Presscott, 1990); inability to effectively joint complementary industries; an atomized and quite limited vision of global environments; incapability to identify opportunities of "outside" players and to identify current or future customer demands. In short, a lack of *vision and culture of collaboration and trust among stakeholders.*

Schmitz and Nadvi (1999) mention that there is increasing agreement that clustering helps small enterprises to overcome growth constraints and compete in distant markets but there is also recognition that this is not an automatic outcome. In an effort to try to transform the *isolation paradigm* of these regions, the Wealth Creation Group (based on Innovation and Enabling Technologies – the WIT Group of the Monterrey Institute of Technology), has applied the Compstrac© (2003) framework to identify and create the enabling conditions capable for *perfect competitiveness*, and the necessary environments and their relationships (networking) required for incubating and operating industrial clusters and centers.

This environment is built on three basic concepts: (a) network economy mechanism; (b) value accelerating environment strategy; (c) and systemic association.

In industrialized countries this environment is effective, sustainable, and an important driver for success; however, in developing regions this value accelerating environment must be created, it is not natural. This artificially created environment must offer substantial value added and differential alternatives and it must provide associated relationships and a cultural platform that takes advantage of the benefits of grouping together. This is a very slow process of cultural change, from traditional hierarchical and isolated structures to an empowered network of companies and complementary industries and institutions. Gadde, Huemer and Hakansson (2003, p. 357) emphasize that "from the standpoint of a single company, strategizing from an industrial network perspective implies that the heterogeneity of resources and interdependencies between activities across company boundaries, as well as the organized collaboration among the companies involved, must be considered simultaneously". According to these authors (2003, p. 357) "in order to enhance its performance, a company must relate its activities to those of other firms, and it is through the continuous combining and recombining of existing resources that new resource dimensions are identified and further developed within business relationships". Bell et al. (1999) argue that for building a cluster s longer-term competitiveness, as well as technical learning in large-scale firms, we need to focus on systems of knowledge accumulation, rather than just production systems.

In order to create these "c-readiness conditions", the framework must develop accurate enabling *conditions*, competitive *capabilities* and strong value added *relationships*, in regions with hostile conditions, scarce resources and weak networking cultures.

A conceptualized road map to develop industrial clusters

Below we develop a conceptualized road map for the process of enabling conditions for industrial cluster creation. Using the analogy of the creation of a new residential community (Scheel & Ross, 2007) we must prepare an initial design must be made, the land must be surveyed and prepared, financing must be found, the infrastructure installed, the buildings constructed, the residents brought in, the community connected with its neighbor communities and, in later stages, the community must be extended vertically and horizontally with the rest of the region and the world. Translated to the "c-readiness" concept, the activities would be:

Design conception. A regional preparation for assembling clustering conditions must be deliberately conceived. It will not just "happen"; industrial development policies must be established with the intention of developing the appropriate conditions and promoting specific clusters that can benefit the region and obtain concomitant benefits. Although initial mid-term and long-term goals must be established, they must be formulated with sufficient flexibility that they can be reviewed and adjusted. The design must consider regional competencies and enabling conditions in order to select and attract the appropriate clusters.

Preparation of the enabling environment. The preparation phase is continuous and extends throughout the regional development process. The objective is to prepare the environment by modifying the behavior of the participants, both current and future, so as to develop a culture that will support the networked requirements of the clustering process. The business community must understand and adopt the collaborative culture and skills they require to lead the cluster creation, while the public and community organizations must understand their supportive role of insuring the proper environment for a successful wealth creation and distribution.

Financing sources. The most important financial activities in preparing a region for clustering are to ensure that the appropriate mechanisms and organizations are present and are attracted to the region that is being prepared for clustering. Whether they are local or extra-regional financial institutions, they need to have confidence in the regional development capabilities, a strong and effective legal framework to protect their investments and stability in the long-term design of the project. Government financing should focus on private enterprise projects to develop businesses that create differentiation products and services that will be globally competitive.

Creating the infrastructure. The activities related to infrastructure creation and development deal with physical infrastructure such as logistics infrastructure and telecommunications and also with intangible but measurable infrastructure such as skills and knowledge. The planning activities should identify the requirements on a stage-by-stage basis (Predevelopment, Introductory, Functional, and Advanced) and these should then be matched with current capabilities and each stage's requirements. Government policies must be established to support the "*e-, i-, c-readiness*" infrastructures, as well as direct support for creating infrastructure and indirect stimuli such as fiscal benefits for business coming in to the region.

Assembling the cluster. The creation of regional clusters is based on previous preparation and is stimulated by both market conditions in the industry, local attractions for the clustering enterprises, and a state policy nurturing the networking concept, whether they are local or global firms. Both conditions – market and regional attractiveness – need to be aligned. Important participants, besides the clustering firms, are governmental institutions that can stimulate the development of techno parks and research facilities, and academic institutions that can offer innovation projects and a skilled workforce.

Populating. The acid test comes when the initial clustering conditions are set and the region must attract individual businesses and investors, whether they are local or global players, to set up operations and begin the clustering process. Facilitating the creation and operation of industry associations, insuring the existence of adequate support products and services such as logistics and telecom, insuring appropriate labor conditions and support, and solving startup situations are all key success factors to sustaining growth of the business population in the region.

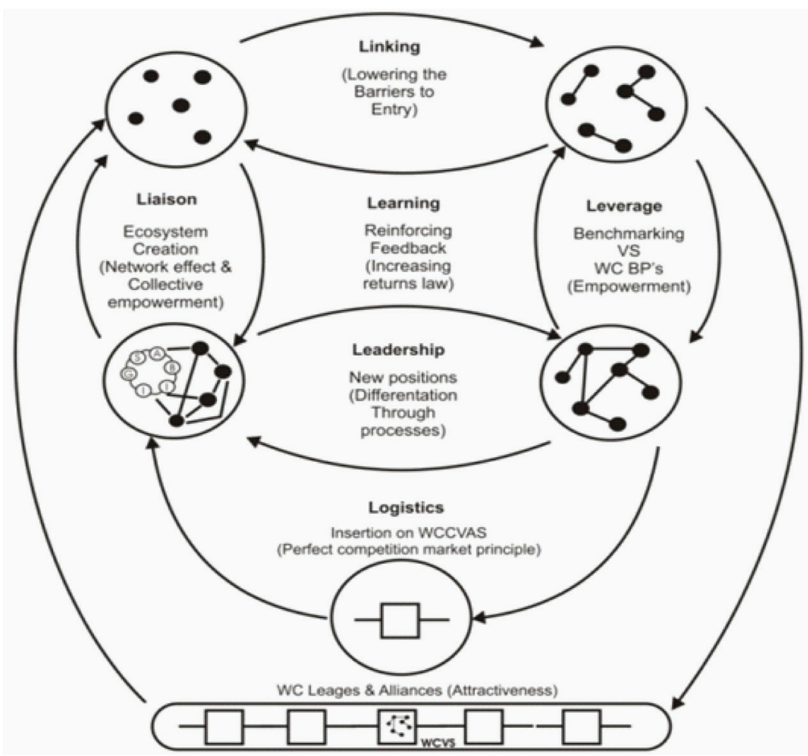
Networking. In order to attract global players of an industry, the region must develop and maintain world-class networking mechanisms to insure the regional integration to global markets. This means not only the physical networking of infrastructure, such as logistics and telecom, but also business networking of local suppliers (small business networks) with global sources, and all of these integrated into global service and supply networks. This networking is a constant and cross-functional process of integrating regions and specific industries to assemble successful clusters.

Extending clustering attributes. The major activities mentioned above to develop "c-readiness" are executed in a both sequenced and parallel manner as the cluster develops. As this happens, the design is reviewed and new opportunities are identified to extend regional clusters, either by adding complementary clusters to the region, or extending the regional cluster to other regions.

Here we summarize a mechanism we call the Seven Loops Model (Scheel, 2005) designed to develop local (regional) competitive clusters into world-class value systems. In Figure 1 we show these loops in action and demonstrate how they link to each other and re-combine.

Once we have identified the regional target e.g. to develop a Center of *Software* manufacturing and development which could increment regional GDP by x% and would promote an increment of thousands of new jobs; or to create a Center of Biotechnology research and development built to attract an important anchor or control company into the region, and which would promote the generation of new entrepreneurs and start up organizations, we start to *link*

Figure 1. The Seven Loops Model for developing clusters into world class value chains



the essential players, lowering the barriers so that all the local necessary and sufficient agents are included. If this is not sufficient to jump start the process, then we need to add external drivers and initiate specific alliances or *liaisons* with academic resources; banking instruments; complementary and support industries; specific infrastructures; and Government supports; all of which ensure Social Capital development.

During the execution of the model loops benchmarking is performed continuously against best practices until a pre-determined *leverage* position of the cluster is achieved and a *leader* positioning is maintained. Once the conditions, capabilities and relationships are assembled and the cluster has achieved the proposed goal, it is ready to be inserted into world class value chains, and a *logistics* mechanism is implemented to provide this. A parallel process of *learning* is performed along all the cycles of empowerment, benchmarking and establishing liaisons with partners and stakeholders, until the cluster is included and maintained naturally as part of world class performing *leagues*. Iammarino and McCann (2006) argue that clustering dynamics imply a combination of knowledge, technology and structural change. Following this dynamics, it should be possible to generate the necessary and sufficient enabling conditions, capabilities and relationships, to have a value accelerating environment, capable of empowering a network of local companies and complementary industries and institutions, to ensure a competitive environment that is linked to a global networked economy.

CONCLUSIONS AND RECOMMENDATIONS

We have described in this paper the most common Latin American scenarios, with their drawbacks and barriers that prevent effective incubation and operation of industrial clusters at high levels of competitiveness. The significant results of our surveys imply the conclusion that the region is still lagging far behind world class best practices, as far as clustering of enterprises and complementary drivers is concerned.

Over a number of years and through examining the different situations within Latin America we have found that historical determinism, which has predominated for several decades in this region, has obstructed the development of well-recognized centers of competitiveness on the region.

From our perspective, the most common issues surrounding the Latin American region include the fact that there has been no explicit cluster policy initiative for business network creation in Latin America. Cluster policy is not actually a priority in the region - although several policy makers use this as a political platform when talking to the industrial community. Additionally, the barriers to the design and implementation of cluster policies in Latin America include the fragmented nature of the national economies, which consist of very small enterprises with limited sectorial concentrations and specializations.

It is important to note that there are new policies currently being adopted by some Governments focusing on industrial specialization within the framework of technology parks and technology based incubator initiatives to promote high technology and innovation start-ups. However, there are no explicit criteria to determine short term impacts. The government programs aim to address some of the structural deficiencies of the manufacturing sector and intend to encourage entrepreneurial activities with higher value added in order to enhance the overall competitiveness of the economy, but more in a generic sector than as a cluster oriented approach. 'Policy push' in identifying the needs for the establishment of clusters is estimated as being a key success factor in Latin America, as mentioned in several studies, such as the UN Economic Commission for Latin America ECLAC, and the Andean Finance Corporation CAF. In Latin America there are no real clusters of firms, excepting those already mentioned such as the strong supply chains mainly found on the auto industry in Mexico;

the aeronautical industry in Brazil; electronic and software industries in Jalisco Mexico; the salmon industry in Chile; and the extended SME chain linked with anchor companies in Costa Rica, as no industrial sector is sufficiently important to constitute a minimum critical mass of specialized firms, complementary industries, supporting organizations, etc. As we stressed above, the present situation in the productive sector in Latin America shows fragmented efforts on a great number of locations. Current developments need rather to coordinate activities and arrive at a "*shared vision*" forming common strategies among the academic, and business community, in collaboration with government bodies and local authorities. The success of such a plan lies in the coordination among various parties and state commitment in facilitating these visions utilizing funds and drafting policies to frame these efforts, and this has not yet happened.

These conclusions have provoked some isolated initiatives within the LA region, based on creative formulas, on new models and frameworks built under scarce resources and hostile conditions; some centers starting from a copy-paste from successful cases that work under empowered enabling conditions, specialized competitiveness producers and strong network economies.

Therefore, the LA region requires context sensitive models for clustering, empowerment and developing valuable clusters and including them in world class systems. These models need to be capable of capitalizing on global opportunities and transforming them into tangible advantages with high economic value-added, differentiation, specialization, and branding, all of which aligned to a sustainable and well distributed social welfare.

It is time to break the paradigm by proposing a holistic approach, where all the participants of large economic networks are winners, where any clustering project or center building program becomes economically attractive, socially inclusive, and politically effective. In the meantime, Latin American policies seem to be a paddling upstream, with few opportunities to consolidate world class clusters of enterprises into a *sine qua non* for the modernization of the productive sector.

We also observed that in order to develop successful clustering strategies, it is necessary to have a proven methodology applied in similar regional circumstances. It is impossible to transfer successful practices from industrialized countries to developing regions with just light adaptation of the recipes, for the simple reason that it is impossible to have "clustering readiness" when the resources are scarce, the regional and industrial conditions are hostile, and the networking capabilities of the cluster participants are poor or inexistent.

Finally, while we realize that for the Latin American region, the assembling and operation of "centers of competitiveness" is a titanic task and a possibly a very discouraging journey; we expect that the success of few specialized subsectors, in venues like Chile (salmon), Costa Rica (electronic-software), Brazil (aeronautical, energy), Colombia (clothing), and Mexico (automobile); may be reproduced in other sectors and different locations, if they rely on a systemic and context specific framework that can take advantage of the *local richness based on resources, values, principles and relationships.* This must all be *aligned* and *shared* toward the dynamic and substantial global business opportunities available expressed as practices that ensure the development of the economic, the social and the environmental meta-systems toward a common goal: that is the sustainable growth of the developing regions.

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Carlos Scheel is full professor Monterrey Institute of Technology (from Jan 1973) Mexico. He is currently working on a framework based on "techno-economic-social-environmental Ecosystems" designed from a systemic perspective for wealth creation for regions with scarce resources, hostile conditions and poor associative characteristics, that need to compete on world class environments, maintaining low impact of their ecological life cycle assessment. He is author and co-author of more than 50 papers published in Technical Magazines and/or International refereed reports; and he has written 12 books in diverse areas of Innovation and Technology.

Leonardo Pineda is an economist, (Ph.D) Cum Laudae, University of Goettingen, Federal Republic of Germany. He was a former staff member of the United Nations Industrial Development Organization UNIDO in Vienna, Austria, as well as Vice-President for Cooperation and Development of the Colombian Federation of Chambers of Commerce. He is a recognized international Consultant on Strategic Management of Technology, Innovation and Knowledge and MBA guest professor at several national and international universities. He is keynote speaker to various international forums on issues related to technology clusters, innovation poles, and knowledge enterprises. He has extensive international experience in technical cooperation projects for international organizations. At present he is holding a chair at the Business School of the University El Rosario in Bogotá, in the research area on the impact of technological change and strategic innovation in enduring organizations.

Review of Regional Workplace Development Cases:

A Holistic Approach and Proposals for Evaluation and Management

Arto Reiman, University of Oulu, Finland

Seppo Väyrynen, University of Oulu, Finland

ABSTRACT

The labour-intensive manufacturing industry faces many working-life challenges in the rural, sparsely populated northern areas of Finland at both operational and strategic levels. These challenges vary, being in interaction with both technical and social systems and their combinations. In this paper, the authors review and evaluate needs, actions and results carried out to improve work and productivity in three regional industrial development cases. The actions discussed in this paper, such as work environment management, change management in general and the sociotechnical approach, are essential for the success of enterprises. Using the results of this research as a basis for developing design knowledge, two guidelines for strategic management purposes are proposed. These guidelines implement sociotechnical aspects into the work environment and its management, and recognise that it is important to focus on human and organisational factors in addition to technical end environmental aspects. A proposal for a specific, unique self-assessment tool for evaluating the level of the quality of the work environment in SMEs is also suggested.

Keywords: *Macroergonomics, Organisational Ergonomics Productivity, Quality of Working Life, Safety, Work Environment*

INTRODUCTION

Traditional management systems have not always been profound enough to understand the complex varieties of organisational life, such as quality, ergonomics, safety, marketing, purchasing and human resource management, which often result from the complex and conflicting needs of the stakeholders involved. Therefore, it is important to create and introduce management systems that combine and accommodate all these elements (Dzissah et al., 2000).

In a work organisational context, technology, tools, environment and persons all affect each other. This whole entity is called a work system - a composite of people, procedures and equipment that are integrated to perform a specific operational task or function within a specific environment (Carayon & Smith, 2000; European Committee for Standardization, 2004; Roland & Moriarty, 1983; Smith

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& Carayon, 1995, 2000). Work systems are in this study considered as sociotechnical systems, as Hendrick (2002) for example, emphasises.

Macroergonomics is one framework for combining the above-mentioned issues. Macroergonomics is a top-down sociotechnical approach to work design. A macroergonomic view is holistic, contextual and organisational in comparison to microergonomics. Macroergonomics focuses on systemic issues, general relationships and interactions (Hendrick, 2002; Kleiner, 2000) and is also concerned with organisational issues such as the optimisation of sociotechnical systems (International Ergonomics Association, 2008).

Often work system components have been treated as independent entities with no relationship to each other, while macroergonomics considers them to be interdependent. The primary methodology of macroergonomics is participatory ergonomics, which involves all organisational levels in the design process (Hendrick, 2002; Kleiner, 2000). Macroergonomics pools joint design in which technological subsystems and personnel subsystems are jointly designed for a humanised task approach, and integrates the organisation's sociotechnical characteristics into the design. Macroergonomics systematically considers the workers' professional and psychosocial characteristics in designing the work system (Hendrick, 2002; Kleiner, 2000).

The first aim of this study was to summarise and analyse specifically both the micro- and macroergonomic needs and learning issues of the cases. The second aim was to widen and develop design knowledge by proposing specific and common guidelines for diagnosing needs and implementing development actions on the grounds of the cases and literature. The emphasis on implementation plays a key role in these cases. As one of the few disciplines that can take a sociotechnical view of implementation, ergonomics can assist in the establishment of an implementation strategy that facilitates organisational change and human learning as well as technical change (Eason, 1990). Hence, sociotechnology seen from the ergonomists' point of view can in essence be like the general design structures in Table 1.

This article is structured as follows. First, the concepts of strategic management, risk management, and sociotechnical systems and their relations to work systems, are explained. Secondly, in the empirical section, three cases are presented and discussed.

LITERATURE REVIEW

Strategic Management

Enterprises should set up targets and goals for their performance in both the short and long terms. Enterprises should also select methods and means for advancing their goals and set up intermediate goals to measure the extent and pace of their progress (Kaplan & Norton, 2001).

Strategic management is a proactive process that involves creating and moulding the future along with making sense of the past. Most important in selecting strategies is to select a strategy that helps the specific organisation learn, develop, and ensure the future (Kaplan & Norton, 2004). Strategic management is also about developing the capability for long-term

Table 1. Eason's (1990) temporary design structures for system implementation as carefully but quite implicitly followed socio-technical principles within the cases

Temporary organisational structures for managing the change process	
Technical roles	*User roles*
Technical system implementors	Senior user champions
Trainers	User representatives as local user support
Ergonomists	Local user decision-making

flexibility (Eden & Ackermann, 1998) and it should be incorporated into everyone's objectives and actions (Kaplan & Norton, 2004).

The relationships between humans, technologies, and environmental aspects should be understood in order to be able to make comprehensive strategic choices. Besides tools and techniques, also employees, their needs, knowledge, and organisational reward and authority structures, should be recognised and utilised (Coakes & Coakes, 2009). This kind of sociotechnical approach is an important aspect in many fields such as occupational safety (Waterson, 2005).

The opportunity to participate in decision-making provides the employee with a psychological feeling of responsibility that often leads to an improved work motivation and satisfaction (Nagamachi, 2002). All employees within an enterprise have unique experiences and expertise of their own, thus they are capable of giving a special contribution and taking part in decision-making about diverse items in workplaces. A mutual understanding about attitudes and values needs to be found (Brown, 2002; Hughes & Ferrett, 2003). The climate for participation should be encouraging and support should exist throughout the organisation and among other stakeholders (Wilson, 2005). User participation can be emphasised on many levels, and often the best results are achieved when development work is done with the user (Osvalder, Rose & Karlsson, 2009).

Strategy development is undertaken to enhance the competitiveness of enterprises of all sizes. Larger enterprises typically have a much greater variety of possibilities to guarantee the expertise of development actions and to orientate and train chief executives, job-site managers, foremen and workers than do smaller and medium-sized enterprises (SMEs). On the other hand, in SMEs the members of the organisation typically know each other better and communication links are often direct, informal, and spontaneous (Kjellén, 2000; Väyrynen, Hoikkala, Ketola & Latva-Ranta, 2008).

Work System Management

Human behaviour and technology are interrelated. Changes in technologies affect social relationships, attitudes and feelings about work (Hatch & Cunliffe, 2006). A work system is traditionally seen as a microergonomic system that focuses only on persons and technologies, i.e. on an individual person and tools or some other technological artifact. When implementing new devices, technologies or ways of work, it should be recognised that the work system evolves continuously even though planning and education are involved. This may be because users may explore new ways of using the technology or because the demands on the work system from its environment continue to change (Eason, 2009).

Kleiner and Hendrick (2008) discuss the same concepts within a sociotechnical work system framework. They describe a work system as a combination of:

- A technological subsystem (the things needed to perform the work);
- A personnel subsystem (people needed to do the work);
- An environmental subsystem (elements outside of the work system focused upon);
- An internal environmental subsystem (for example, cultural and physical characteristics);
- An organisation subsystem (for example, organisational structure and processes).

All these separate work systems operate within a larger "systems of systems". Systems are also engaged in transactions with other systems. Managing this complexity is a challenge (Eason, 2005; Kleiner & Hendrick, 2008).

Safety Management

It is reasonable to make enhancements to all levels of the work system to gain maximum profit. The work system needs to be in balance. Some parts of the work system might be affected very easily, but some parts are not so definite. A balanced work system "produces" desired, and also undesired, events such as accidents and material and environmental losses. For example, desired events are promoted by applying ergonomics knowledge to guarantee a high level of usability of tools and workstations. Therefore, it is important to discuss and analyse how these elements should be balanced and managed so that production would be satisfactory for the person doing it (Carayon & Smith, 2000; Smith & Carayon, 1995) and as productive, safe, and of as good quality as possible (cf. Väyrynen, Röning & Alakärppä, 2006). When a balance is not achievable by minimising the negative aspects of an element, the whole system balance should be improved by enhancing the positive aspects of other elements (Smith & Carayon, 2000).

All the components of the work system are potential objects of losses. Humans can be injured through accidents and occupational diseases. Absences from work and too early retirements cause considerable losses to individuals, enterprises and society. According to the principles of occupational risk prevention, the person has to be protected within the whole entity. On the other hand, the person often plays a key role when deviations and disturbances occur within the system, causing losses to the person, outside persons or other components, including the environment (Väyrynen et al., 2006). To achieve success in risk control and prevention, many, often synergic, efforts against various losses are needed (Brauer, 1994; Kjellén, 2000). All accidents, occupational diseases and production, and environmental problems can be predicted and thus avoided through good work system design (Kjellén, 2000).

On the whole, it is wise to link things so that one can speak about a holistic safety, health, environment and quality (SHEQ) system, as do many modern enterprises (Hutchison, 1997). Safety management accentuations and practices are most efficient in a comprehensive management system. In this kind of total quality management (TQM) system, quality management, safety management, and environmental management are all connected by the general management of the enterprise (Väyrynen, 2003; Zülch, Keller & Rinn, 1998). These management areas should, however, be discussed as separate entities, still seamlessly belonging to the TQM system. These systems should all be important and recognised elements in enterprises' strategy work (Cecich & Hembarsky, 1999; Dzissah, Karwowski & Yang, 2000).

The above can imply the need for Integrated Management Systems (IMS) (Wilkinson & Dale, 2007). IMS assures customers that products and services satisfy quality requirements. Further, responsible organisations also have to be concerned about the well-being of their employees, their working environment, the impact of operations on the local community, and the long-term effects of their products while in use and after they have been discarded.

Evaluation of Development Actions

Development actions are needed in order to succeed in strategy work. The aim of development activities in enterprises is to increase productivity, shorten time-to-market, simplify processes, facilitate information and knowledge sharing and also increase employee well-being. In organisational development activities the characteristics of the organisation are not always fully taken into account and development processes are implemented without a deeper understanding of the culture (Järvenpää & Eloranta, 2000).

Usually it takes time to see what kinds of benefits and cost savings are gained through different development actions and improvements. Kaplan and Norton (2004) state that benefits and cost savings are typically realized in 6-12 months from improvements in operational processes, in 12-24 months from enhancements in customer relationships, and in 24-48 months from change in innovation processes and regulatory and social processes.

Benchmarking is one strategy for executing changes in organisations. Systematic comparisons with the activities and operations of other enterprises increase knowledge of one's own actions and result in proposals for improvement. Experiences can be both negative and positive. It is possible to learn from errors and mistakes. Comparisons can be made within and between enterprises from different industries, not only from similar industries (Freytag & Hollensen, 2001). Product or service output can be measured daily, for example by the amount created. Likewise, it is easy to continuously measure and improve quality initiatives.

Development actions should also be evaluated. Evaluation provides feedback for managers and other stakeholders in their strategy work (Wholey, 1991). Measuring different kinds of parameters is important in completing learning forms. Different parameters can be compared both internally and externally within and between enterprises (Freytag & Hollensen, 2001).

Measuring the work environment has traditionally concentrated on retrospective assessments of chemical and physical risk factors and accident statistics. However, these kinds of retroactive measures do not reveal how to create new values. It is important to note that safety is not about numbers. Safety is about people and protecting them from injury. Safety is measured in order to understand whether implemented efforts actually prevent accidents and illnesses. Ultimately, numbers and parameters indicate whether these efforts are effective (Toellner, 2001). Safety affects both production and quality, so it should be managed and measured accountably. Lost man-hours, increased insurance premiums and other related costs affect the economics of an enterprise in a variety of ways, just like production and quality. In order to manage and measure safety, it is important to know the initial state, objectives and possible reasons for underachievement (Cohen, 2002; Health and Safety Executive, 2004).

RESEARCH METHODOLOGY

This study is composed of three separate cases (I-III). These cases comprise a review of workplace development actions that have been executed during 2001-2007 in the main cities of the Bothnian Arc area in northern Finland. The cases were primarily separate studies, but they also have many similarities (Table 2). Open cooperation between the enterprises and the members of their value chain is pertinent in every case.

The large industrial plants and the supplier SMEs in Cases II and III are in practice quite the same. Some of the SMEs in Case I also function as supplier SMEs in other cases. Hence, this whole case entity constitutes a large enterprise network in working life development issues in northern Finland. Still, there are some definite - mainly methodological - differences between the cases. Also, the case-specific aims varied between the cases. In Cases II and III the overall aim was to create procedures and models for cooperation, whereas in Case I enterprise-specific microergonomic issues were emphasised more.

A constructive design science research approach (Järvinen, 2004) was utilised in the cases to formulate proposals for common and specific guidelines. The first aim was to evaluate the needs and learning issues of the cases. The guidelines were built on the basis of the case-specific data and literature. Each of the cases had their own procedures for data collection (Table 2). Both qualitative and quantitative data were collected inside the cases.

The design science research approach was combined in this study with the general model of planned change (Cummings & Worley, 2004) (Figure 1). This procedure of planned change was utilised in all the cases. The development process began with a formal contract and followed with diagnosing, planning and implementation, and planning and institutionalising phases. Phases 1, 2 and 3 were performed continuously within different micro- and macroergonomic issues. Additionally, the fourth phase of planned change was based on the cumulative data and experiences of the first three development phases of the cases. The design knowledge in this study was comprised of three different design approaches (Järvinen, 2004), which were:

Table 2. Introduction of the Cases (I-III) in this study

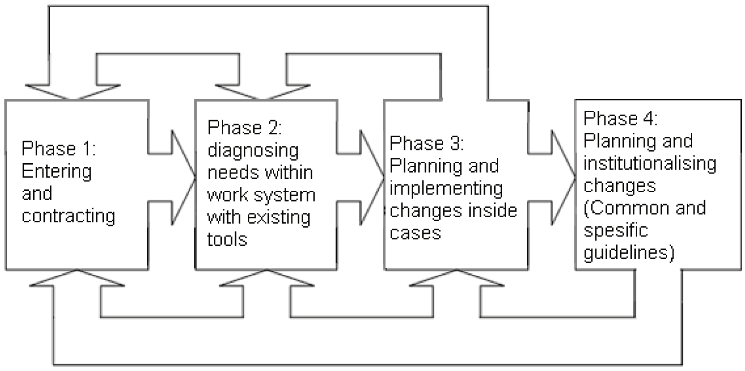
	I SME development and cooperation	**II Supply chain network cooperation**	**III Shared workplace cooperation**
Subject enterprises	18 metal industry SMEs.	11 large process industry plants and 15 supplier SMEs.	15 large process industry plants and their key supplier SMEs.
Aim	To develop the work environment inside the enterprises and to share good practices with peer enterprises.	To develop safety at work, cooperation and safety management within the supply chain network.	To develop safety at work at common workplaces and to study the implementation and impacts of the occupational safety card (OSC).
Methodology in the cases	Separate sub-case studies and a design science research approach to the whole entity (Kisko & Rajala, 2004; Kisko & Reiman, 2008).	Macroergonomics, Total quality management and Integrated Management System (IMS model) (Sinisammal, Väyrynen, Latva-Ranta & Ketola, 2007; Sinisammal, 2008).	Macroergonomics and quality management style (Niemelä & Latva-Ranta, 2009; Väyrynen et al., 2008).
Main data collection methods	Enterprise-specific material from microergonomic issues. Focus groups, observations, questionnaires and interviews	Focus groups, observations and questionnaires	Focus groups, questionnaires, interviews and statistical data analyses
Years	2001-2006	2002-2006	2003-2007
Place	Raahe	Oulu, Raahe, Kemi and Tornio	Oulu, Raahe, Kemi and Tornio
Main financier	The Finnish Work Environment Fund and the European Social Fund.	Workplace Development Programme TYKES and the enterprises involved in the projects.	The Finnish Work Environment Fund and the Centre for Occupational Safety.

- Object design knowledge where actions were designed to be used in the cases (phases 1 and 2);
- Realisation design knowledge where plans and implementations of actions were executed in the cases (phase 3); and
- Process design knowledge where proposals for guidelines for solving problems were formulated (phase 4).

The first three phases responded to the first aim of what kinds of needs there were before the execution of the cases and what the enterprises had learned from the cases. The data collection (Table 2) was executed by means of different kinds of interviews, questionnaires and focus group meetings (Langford & McDonagh, 2003) for the representatives of the enterprises internally and between enterprises. The fourth phase of planning and institutionalising changes resulted from the second aim of this study, that is, to widen and develop new design knowledge by proposing specific and common guidelines for diagnosing and implementing development actions.

An open coding (Järvinen, 2004) approach was utilised to summarise and synthesise the case-specific data. Hence, this study is qualitative and interpretative in nature. Nonetheless, some detailed issues, such as the coefficients of the criteria in the specific guideline consisted of quantitative evaluations by the representatives of the enterprises. According to Järvinen (2004) and Ramstad and Alasoini (2007), these kinds of social and theoretical innovations, such as the guidelines in this study, also belong to the design science framework.

Figure 1. General model of planned change that was used in the cases (adapted from Cummings & Worley, 2004)



RESULTS

Three regional cases were reviewed and analysed. The cases were executed separately, but there were many similarities in them. The development work began with identification of actual and detailed microergonomic needs. These needs also involved macroergonomic approaches especially in participation and co-operation procedures, internally and between the enterprises. The enterprises were mostly competitors in the same area, but they still understood the macroergonomic participative approaches and the benefits of cooperation procedures in the development processes of working life.

The actions differed from each other quite significantly on the micro level. Nonetheless, macroergonomics and organisational ergonomics issues were emphasised in every case. The cases had their own objectives, results and outcomes (Table 3). These were mainly related to improvements in microergonomic issues, safety and quality management, participatory work design and intra- and interorganisational communication and cultural issues. The socio-technical needs and challenges were addressed by optimising and introducing new forms of organisational structures and cooperation between different enterprises, personnel-level participation, and HSEQ procedures and processes by different means. The case-specific needs and learning issues (Table 3) were analysed from the results later on by the researcher.

A close work system is important, and so is the role of a certain kind of self-managing of hazards and enhancing their control. These cases emphasised new levels of a safety culture which are achievable only by involving everyone from top management to white-collar and blue-collar employees. Further, these cases were intended to be a framework for positive cooperation at the enterprise level between personnel groups and other stakeholders.

Self-Assessment Tool

As a more specific result, a guideline for evaluating the quality of the work environment was created in Case I. Participants from ten enterprises took part in the design process. The guideline is a *self-assessment tool (SAT)* (Figure 2) for managers use. The structure of the self-assessment tool is largely analogous to the Excellence Model from the European Foundation for Quality Management (EFQM) (EFQM, 2003). Performance is assessed both by the results and by the quality of the processes and systems developed to achieve them.

The self-assessment tool is divided into criteria and sub-criteria, as is also the EFQM model. There are altogether five sections (I-V) in the self-assessment tool. These sections are

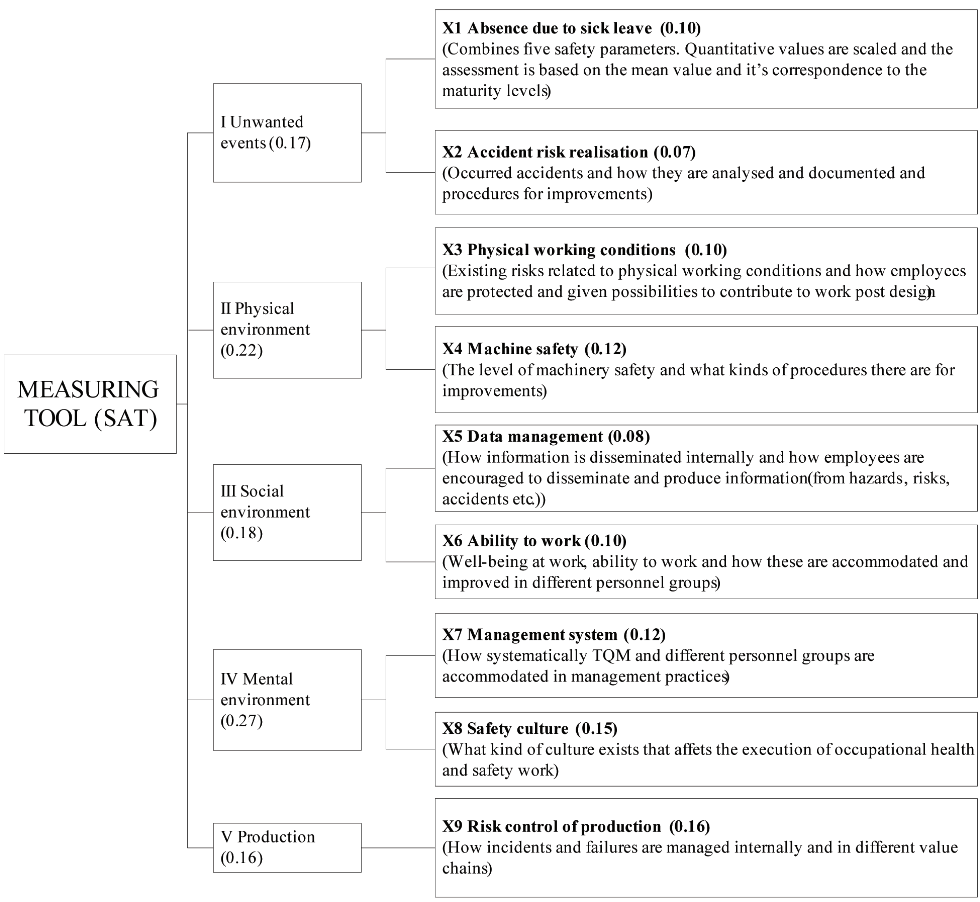
Table 3. Evaluations of the needs and learning issues in the cases in sociotechnical, HSEQ and participatory issues

	I SME development and cooperation	II Supply chain network cooperation	III Shared workplace cooperation
Actions and methods in the cases	Various microergonomic methods, depending on the needs of the enterprises. Especially bench learning, focus groups, interviews, questionnaires and safety checklists.	Participative observations. benchmarking and bench learning. Spreading of good practices and focus groups.	Focus groups, questionnaires, interviews and statistical methods for measuring and studying the impacts of OSC.
Effects on sociotechnical system integration	*Needs:* Microergonomic approach in several case issues and macroergonomic approach jointly with SMEs. *Learning:* Macroergonomic cooperation between peer enterprises and also inside enterprises within different personnel groups concerning e.g. ways of work and layout solutions.	*Needs:* Interorganisational HSEQ performance in macro- and microergonomic work systems. *Learning:* System thinking is feasible and useful to achieve common goals within the network.	*Needs:* Boosting education and training of personnel within macro- & microergonomic work systems. *Learning:* Large-scale efforts are possible beyond complying with government regulation.
Effects on HSEQ	*Needs:* The managers of the enterprises allocated as most desired development needs: unwanted events and their removal, physical, social, and mental environment and production. The employees allocated the needs into organisation, physical environment and different single, strenuous tasks. *Learning:* New methods of HSEQ management implemented into daily use. A new assessment tool developed and implemented into use.	*Needs:* Building and sharing intra- and interorganisational HSEQ requirements and assessment models and building a new HSEQ index for benchmarking and competition purposes (Award). *Learning:* New HSEQ practices implemented and evidence of positive effects gathered.	*Needs:* To emphasise the individual's role within HSEQ thinking embedded in one's own everyday work system. *Learning:* Spreading and broad implementation of the occupational safety card (OSC) and it's affects on the TQM.
Effects on participation between different stakeholders	*Needs:* New methods for broad participation between different personnel groups inside enterprises and between enterprises. *Learning:* New methods broadly adapted and implemented especially in enterprises' inner use. Also some participative procedures between the enterprises introduced and utilised.	*Needs:* Common building and agreeing on IMS-style HSEQ management. Increasing and measuring HSEQ performance in process industry and supplying SMEs. *Learning:* Regional HSEQ assessment system can be participatorily built, implemented and maintained.	*Needs:* Collaboration procedures with enterprises, unions, authorities and other stakeholders. *Learning:* Nationwide new good practices can be achieved. As in this case, a package of essential health and safety knowledge and skills for every individual at workplaces.
Concrete outputs	Enterprises learned several new methods and participative procedures. A specific self-assessment tool (SAT) for assessing the quality of the work environment was created and implemented into use.	Widely recognised assessment and auditing system. Forum for discussions and arranging competitions (Award). Efforts towards nationwide system assessment.	Material for educational institutions and databases, etc. about OSC. OS card is largely implemented into use in workplaces in Finland.

divided into nine sub-groups (X_1-X_9) which form the criteria of SAT (Figure 2). The amount of sub-groups was based on traditional guidelines for product design (Pahl & Beitz, 1986), which state that the amount of assessment criteria should be quite moderate - commonly from 8 to 15 criteria. A specific coefficient for every criterion was calculated using the average values of the managers' (n = 10) assessments of importance.

The assessment criteria are given and explained within a specific questionnaire. The assessment questionnaire was formed for every criterion on the basis of the performance maturity levels presented in the EN ISO 9004 (European Committee for Standardization, 2000) standard. Sub-group X_1 is calculated and scaled from a mean value of five quantitative indicators: accident frequency, absence due to an accident, absence per employee, absence percentage and the average length of workplace accidents. The assessment for sub-groups (X_2-X_9) is made subjectively on a scale from 0 to 4 by utilising maturity level definitions in the questionnaire. The total score is calculated as a mean value of these nine subgroup assessment values. The level of performance for every criterion is annually evaluated by a representa-

Figure 2. SAT, also containing coefficients and explanations, which elements are assessed in the sub-groups (X_1-X_9). Every sub-group is assessed on a scale from 0 to 4 (adapted from Reiman, 2008)



tive of the company's management level. These assessment values are comparable between enterprises (Reiman, 2008).

The participants (n = 10) also made a SWOT analysis for the SAT. According to the analyses the SAT is a rapid feedback assessment tool that provides a good basis for bench learning by giving the enterprise a concrete follow–up and measuring tool with certain parameters for performance-oriented comparisons inside and between enterprises. In particular, inter-enterprise assessments and follow-up possibilities were highlighted. There were also some weaknesses. These mostly consisted of the subjectivity of the assessments, and hence reliable comparability between enterprises.

DISCUSSION

General Discussion

The main objective of this study was to review and analyse three regional industrial development cases where quality of working life (QWL) and productivity have been improved and to give guidelines for strategic management purposes. In addition to QWL and productivity, the key focal points in the development were comprised strongly of the approaches of ergonomics and occupational risk prevention (ORP). Both technical and sociotechnical issues existed. In particular, continuous development procedures and processes, and safe use and implementation of technologies, work environments, and knowledge and other management systems, were emphasised in the cases.

Eason's (1990) temporary design structures for system implementation were the main sociotechnical, though very general, principles (see Table 1) followed as such in the cases. Table 4 shows that, according to the authors' opinion, more detailed principles, like the one of Clegg (2000), were not totally met in these diverse cases. The approaches, as the descriptions show, were perhaps in part "too straightforward". Thoughts on TQM, safety management and safety culture, as well those on regional networks were emphasised largely and in a simple way, which weakened some sociotechnical ideals. Nonetheless, quite often the sociotechnical "paradigms" allow "flexibility" and "no necessity for hard and fast rules and guidelines" (Waterson, 2005). On the other hand, this article could at least tentatively add some "working" proposals to be included in, and tailored to be compatible with, the mainstream of sociotechnical approaches and examples.

Enterprises, especially SMEs, need a more comprehensive hold on their strategic long-term management practices. There are numerous different systems (i.e. social, cognitive, economic, software and hardware systems), which depend on the viewpoints that need to be maintained and improved. They all affect each other in many ways (Whitworth, 2009). Organisations should become more like learning organisations that have the possibility to continuously develop their ability to create their own future (Senge, 1990).

More strategic and system-wide changes (Badham, 2000) need to be undertaken in the face of increasing rates of change in external business and social environments. Managing any change requires problem-solving. Within difficult and complex problems, the interactions between psychological, economic, technical, cultural and political factors need to be recognised (Mumford, 2003).

The work system should be managed by taking into account the above-mentioned elements of business and working life itself. Work systems should be taken into account in enterprises' visions and strategies, and managed as a part of total quality management. All losses should be seen as affecting humans, environment and economics, and thereby total productivity and quality. The work system is measurable in many ways and it affects:

- National health work;
- Health, safety and well-being at work;
- Activities of local occupational safety and health (OSH) authorities;
- Actions of employers, entrepreneurs, labour unions and other stakeholders;

Table 4. Compared with the holistic contemporary sociotechnical design principles of work systems (Clegg 2000; Waterson, 2005), the cases showed "slightly mainly" good accordance with them

Principle	Emphasis in the cases
Meta-principles	
Design is systematic	Enough
Values and mind-sets are central to design	Enough
Design is socially shaped	Too little
Content principles	
Systems should be simple in design and make problems visible	Too little
Design entails multiple task allocations between and among humans and machines	Too little
Problems should be controlled at their source	Enough
Process principles	
Evaluation is an essential part of design	Enough
Design involves multidisciplinary education	Enough
Resources and support are required for design	Too little

- Strategic management, productivity, competitiveness of enterprises and other work organizations;
- Bench learning within networks;
- Innovation and developing activities within work organizations;
- Research & development (R&D) in general;
- Education and training.

Proposals for Guidelines

As a specific guideline for work environment management, a self-assessment tool (SAT) for managers' use was introduced. The SAT was created in cooperation with the managerial level of ten machine workshops. Accordingly, the SAT is therefore, at the present time, mainly designed for use by similar enterprises. However, the structure of the tool permits modifications. For example, the coefficients could be redefined for different branches, if needed. Naturally, then they are not comparable with former results.

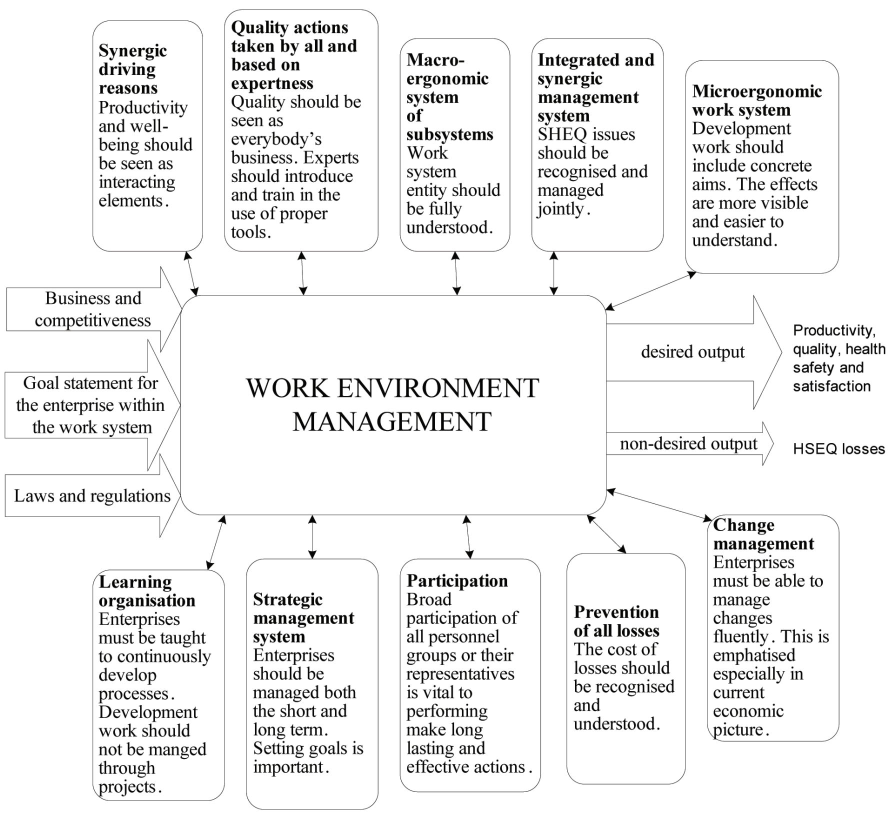
The SAT is a follow-up instrument for intermediate goals. The SAT is based on subjective assessments. Its validity and reliability have not yet been discussed. There might be a chance that the management is willing to give a better picture than it actually is. One way to resist that would be to allow representatives of other personnel groups to participate in the assessment processes. A discussion and a comparison of the results would then be made after the assessments. One way to execute the assessment rounds in the future could be by using it as a web tool. The SAT could also serve as a tool for measuring the effects and influences of different actions taken in the enterprises. The tool or its enterprise-specific adaptations are in use in most of the enterprises that were involved in the design process. Further development of the SAT has been now been undertaken within transportation enterprises (Reiman, Pekkala & Väyrynen, 2010).

According to this study, work environment issues, QWL, ORP and ergonomics should all be combined and given a connective definition for their development and strategic management. This study connects these in a process design way as a common guideline to be used to design the solution to the problem. As a result of the theoretical basis of this article and the cases, and in another response to the study's second aim a *general approach and theory model (GAT* *model)* for controlling *work environment management (WEM)* is proposed besides the SAT (Figure 3). Its role is to act as a guideline for experts in developing issues that both promote production and prevent occupational and other risks. It consists of ten different approaches and theories that should be emphasised when planning and executing development actions. It combines the goals of well-being and productivity at both the individual and organisational (enterprise) levels.

The GAT model and the SAT should both be integrated into, and synergic with, the whole management system. Usually, enterprises' own risk management processes can be improved within a one-year timescale, but to have more long-lasting effects, different work systems, work environments, customers, other stakeholders and other relevant elements should also be taken into account more profoundly. These elements and also regulatory and social process systems should all be catered to more or less simultaneously when planning and executing development actions.

Organisations and enterprises need these kinds of development projects and participative approaches and tools described above. Sociotechnical issues should be emphasised more and more, especially nowadays with the economic challenges that enterprises all over the world are facing. The guidelines presented in this study are usable and concrete proposals

Figure 3. Basic criteria affecting WEM according to the cases and the literature review, which forms the GAT model. These should all be taken into account more or less simultaneously when planning and executing development actions in the regional multi-criteria QWL, ORP and productivity approach.



for strategy work and development actions and evaluations. The more specific SAT is in use in enterprises involved in the design process, and efforts are being made to implement it also in other branches. The GAT model is a more theoretical proposal that needs more testing in actual working life.

CONCLUSION

Employers and employees should both be able to adapt to changing circumstances and optimise the fit between the social and technical aspects of the workplace. Looking back to the years 2008 and 2009 and the economic challenges influencing the operating environment of enterprises both regionally and globally, it can be seen that the kinds of actions discussed in this article, such as work environment management, change management in general and the whole sociotechnical approach, are essential for the success of the enterprises. According to this study it is important to also focus on human and organisational factors in addition to technical end environmental aspects. As a conclusion of this study, two unique proposals for common and specific guidelines for strategic management purposes were given on the grounds of the cases and literature. These proposals also implement sociotechnical aspects into the work environment and its management.

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Arto Reiman received his MSc in process engineering from the University of Oulu, Finland in 2005. His MSc thesis was concerned with work environment and quality issues in metal industry SMEs. At the moment, he is working as a researcher at the University of Oulu in Department of Industrial Engineering and management and is continuing with doctoral studies. He has worked with various projects concerned with ergonomics, work environment, safety and management. In his doctoral studies, he is interested in work environment management in the transportation branch and especially in cases where single employee's work environment often changes.

Seppo Väyrynen is a Professor of Work Science at the University of Oulu, Oulu, Finland since 1989. Before that, he mainly worked for the Finnish Institute of Occupational Health. He has Master's (1974) and Doctor's (1986) degrees in Mechanical Engineering, the theses for which were dealing with working environment and ergonomics development, being linked to engineering design and management. In addition to heading a unit at the Department of Industrial Engineering and Management, he is teaching various courses in ergonomics and safety engineering, supervising doctoral students, and directing a research group with many R&D projects. His research interests include ergonomics, user-centred design, participative design, safety-conscious design, risk control, safety management and usability engineering. He has published more than 300 scientific or professional articles and book chapters.

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