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Activity Theory and Context-Based Design

Introduction

A significant evolutionary shift has occurred in human-computer interaction (HCI) design. Prior to this shift, computer software designers tended toward a computer-centered design approach that at best assumed and at worst ignored the needs and preferences of end users. This approach prioritized the attributes of the technology itself and often resulted in design solutions that were in search of problems. Its limitations gave rise to a human-centered design in which users articulated their needs and developers observed or listened to users and then addressed various needs in their designs. Unlike the technology push of computer-centered design, human-centered design emphasizes human needs and objectives and the technology that serves these purposes.

Another shift has begun now—to a context-based design where the use, design, and evaluation of technology are socially co-constructed and mediated by human communication and interaction. Context-based design builds on human-centered design by positioning the interactions between users and mediating tools within the motives, community, rules, history, and culture of those users. In addition, context-based design calls for designers and evaluators to reflect on the elements of their own context and on the way that this space interacts with the space of technology use.

This book uses activity theory as an orienting framework for context-based design. In our work on human-computer interaction, we attempt to explicate the workings of communicative tools, spaces, and practices and thereby raise numerous questions regarding the activity of design. How do tools mediate activities? Do different kinds of tools mediate differently?

How do we make visible and represent multiple, simultaneously occurring processes? As in any mediated sociocultural context, the relationship between the activity and the tool is a reciprocal one. Activities shape the requirements of particular tools, and the application of the tool begins to reshape dimensions of activity. We use the concepts of activity theory and related theories to help ground and illuminate this ongoing interaction between the uses of computer systems, the practice of design, and the evaluation of designs produced.

Activity Theory: An Overview

Activity theory draws inspiration from the work of the Russian semiotician and psychologist Lev Semenovich Vygotsky (1962), who argued against artificial separations between mind and behavior and between mind and society. Contrary to the dominant mentalist tradition of his time, Vygotsky posited the unity of perception, speech, and action. In addition, he emphasized the centrality of mediating devices, such as language and other symbols or tools, in the development of mind and thought. The emphasis on meaning through action, the connection between the individual and the social, and the role of mediating tools provide the kernel around which activity theory has developed.

Building on these principles, Alexei N. Leont'ev (1981) created a formal structure for operationalizing the activity system as a complex, multilayered unit of analysis (figure 1.1). His model is less a representation of reality than a heuristic aid for identifying and exploring the multiple contextual factors that shape or mediate any goal-directed, tool-mediated human activity.

As indicated by Engeström's (1999a) model, an activity system consists of people, artifacts, an object or motive, sociocultural rules, and roles (Kaptelinin, Nardi, & Macaulav, 1999). Kari Kuutti (1996, p. 27) has characterized *activity* as "a form of doing directed to an object." For these authors an activity is the highest-level objective where the motivations behind the activity and the ultimate objectives or desired outcomes are the same. Within this activity system, multiple actions are performed to reach the overall objective. Each action is driven by a conscious intentional goal. Finally, operations represent unconscious, often routine actions carried

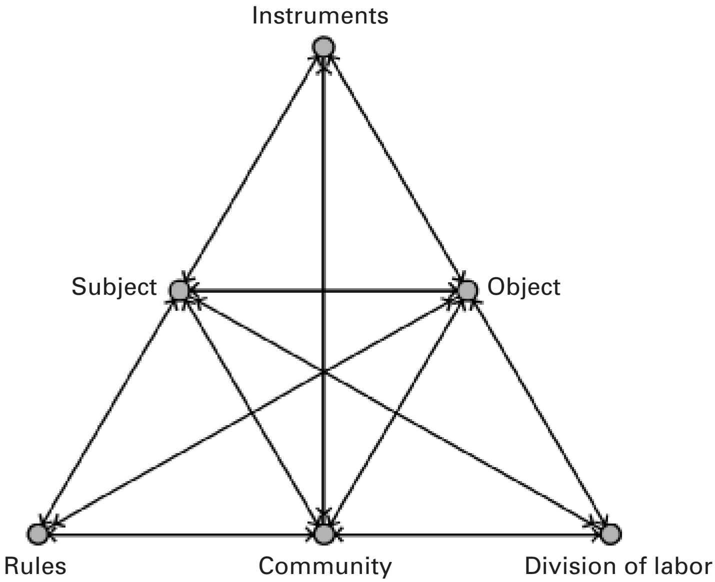

Figure 1.1
Engeström's analysis of activity and mediating relationships

out automatically in the service of other goal-oriented actions. Therefore, the composition of an activity system consists of the activity (the system itself), actions, and operations. Breaking down the system of activity into component parts is useful for identification purposes; however, the system is not reducible to isolated actions or isolated relationships between subjects and tools.

A simple example of the hierarchical structure of activity systems is the activity of "Mark is driving to Aunt Sally's house." The motivation and outcome are for Mark to end up at Aunt Sally's. To realize this outcome, a number of actions might take place: calling Aunt Sally to see when she's available for a visit, checking the weather, printing out driving directions, filling up the car with gas, and so on. On the drive itself, a number of unconscious operations are performed, such as applying the brakes at red lights and using directional signals before changing lanes or making turns. Collectively the motives and actions add up to the final destination. The hierarchy of actions and the identification of the different components of an activity system provide helpful guideposts for articulating and examining the complexity of context. The multilayered nature of activity theory identifies the actions involved in an activity and assesses how these actions relate to each other.

Activity Theory and HCI

The explanatory potential of activity theory lies in the attention that it gives to multiple dimensions of human engagement with the world and in the framework that it provides for configuring those dimensions and processes into a coherent "activity." Critical to understanding these processes of engagement for use in the field of HCI is the mediating role that is played by cultural artifacts or tools and their transformative power. The researchers working at the Human-Computer Interaction Group at Cornell University have focused primarily on mediating devices for communication and learning (figure 1.2). Our research questions have explored how these devices affect outcomes (such as what kind, if any, of communication or learning occurs), process (how does communication or learning occur? what facilitates or inhibits the engagement? who is involved and not involved?), and motivation (how do our notions of communication or learning change? what are our expectations of communication or learning?). Fundamental to the activity theory approach is that humans develop and learn when, in collaboration with others, people act on their immediate surroundings.

Activity theory shares much in common with anthropological, ethnomethodological, and other sociocultural approaches, such as Trevor Pinch and Wiebe Bijker's "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other" (1987) and Jean Lave and Etienne Wenger's "Legitimate Peripheral Participation in Communities of Practice" (1991). In our work at the HCI Group, we have been drawn to these theories for their common focus on dynamic change, tool mediation, and social construction of meaning. For a more thorough treatment of activity theory history, its recent developments, and its relationship to other sociocultural theories, we refer the reader to a number of excellent sources (e.g., Engeström, 1999a, 1999b, 1999c; Kaptelinin, 1996; Kuutti, 1996; Nardi, 1996a, 1996b). Here we elaborate only on the principles of activity theory that are

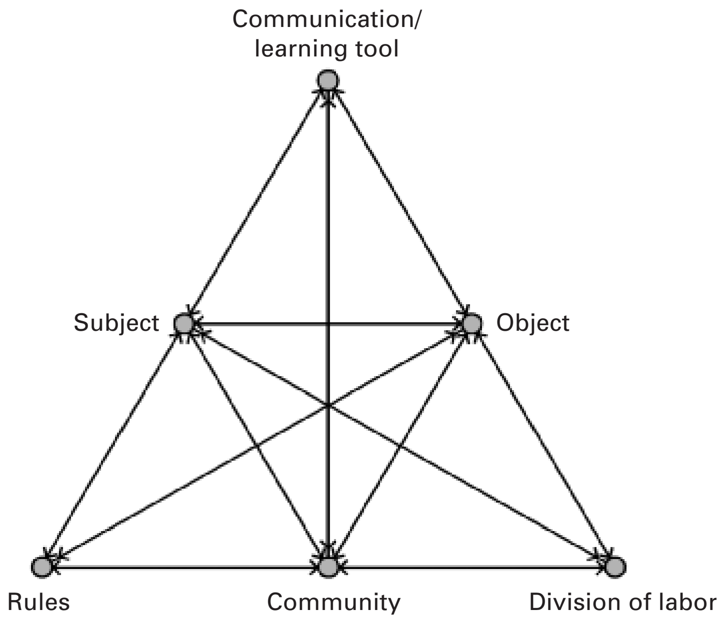

Figure 1.2
Application of Engeström's activity analysis to communication and learning

recurring themes in later chapters—namely, the concepts of mediation, object orientedness, and disturbance.

Mediation
An individual's relationship with and orientation toward an objective is mediated by the tools that are used to attain the objective, the community that participates in the activity, and the division of labor that exists in that community (Engeström, 1999a). In the models of an activity system described above (see figures 1.1 and 1.2), bidirectional arrows indicate multiple mediating relationships within a complex integrated system. Victor Kaptelinin (1996) specificly addresses the mediating effects of computer activity on consciousness, learning, and development. For him, computer technologies have the power to enable and transform activities through the actions, goals, and social relations of individual agents. Our own evaluations of computer mediation confirm these effects, as we describe in later chapters. We emphasize two main insights regarding mediation—the

bidirectionality of effects (of the perceptions, motivations, culture, and actions that shape the tool and that are shaped by the tool) and the need for sustained longitudinal studies to reveal how these mediating relationships develop and change over time.

Object Orientedness

In the activity theory model, *object orientedness* (Kaptelinin, 1996, p. 107) refers to humans' engagement with objects (and objectives). Activity theorists ascribe object status to physical, social, and cultural phenomena, including nonmaterial phenomena such as expectations and affinities. The purpose, intent, or motivation of acting on an object or working toward an objective is the foundation of the activity system, and acting on an object is the orienting space of the action.

The HCI Group has identified two important subcategories within the concept of object orientedness: (1) psychological and social objects can be ranked at the same level of importance as physical objects, and (2) artifacts can be transposed into object status and vice versa. An artifact or tool in the primary activity system framework (see figure 1.1), for example, may simultaneously be an object in another system. As a subject interacts with a word-processing program to write a paper, the object is the completed paper, and the artifact or tool is the software program. However, if the program breaks down, the software becomes the object in a new activity of troubleshooting. Likewise, the word-processing program is both a tool for the human subject who uses it and the object of usability research for the designer.

Disturbance

The relationships among the various elements in the activity-theory model are flexible and ever-shifting. In a general account of how activities develop, Yrjo Engeström (1999b) makes the point that activity systems support development and goal attainment but also produce disturbances. In the example of the word-processing program that shifts from being a tool to being an object, this transformation occurs at a breakdown or disturbance. Frank Blacker, Norman Crump, and Seonaidh McDonald (2000) identify other disturbances, such as incoherencies, tensions, and inconsistencies among various components in the system. Engeström (1999b) argues that relationships within activity systems are made orderly only by the determination that people show as they engage with the objects of their activity. As disturbances become evident within and between activity systems, participants may begin to address the underlying issues and change their situations, their activities, or themselves. We have found that disturbances can be informative in the design process as signposts for uncovering why the disturbance materialized, why it did not exist until a given point in time, what the effects of the disturbance might be, and how the disturbance is resolved.

Adding to Activity Theory: An Ecological Perspective

The model of activity theory that is referred to throughout this chapter (that is, the subject, object, and tool relationship) has traditionally been understood as a synchronic, point-in-time depiction of an activity. It does not depict the transformational and developmental processes that provide the focus of much recent activity theory research. In this section, we link activity theory to an ecological perspective to examine another viewpoint and conceptualization of the interplay between systems and the adaptive transformation of systems across time. We are not the first to draw on ecological perspectives for HCI work. Probably the best-known application of this approach is Donald Norman's appropriation of James J. Gibson's (1977, 1979) ecological theory of perception. We turn to ecological theories for two reasons. First, the focus on adaptive systems works well with activity theory and with examining human-computer interaction in context. Second, the ecological metaphor guides our reflection on the evolution and adaptation of our theories and practice of design. Like their biological counterparts, ecologies of ideas (such as activity theory and our application of this theory and related ideas) evolve within complex systems that are novel, are interrelated, and seek to sustain the delicate and necessary balance between the need for stability and the need for change.

In Urie Bronfenbrenner's formulation (1979) of an ecological systems theory of human development, development is a joint function of person and environment. By carefully examining the person within various processes and contexts and asking challenging questions about the nature

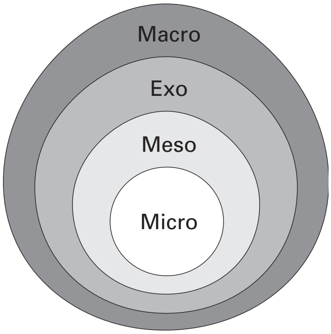

Figure 1.3
Urie Bronfenbrenner's model of an ecological systems theory of human development

of the interaction, researchers can increase the explanatory power of their results. Bronfenbrenner's theory posits an ecology of nested environments or systems—micro, meso, exo, and macro (figure 1.3).

Microsystems, according to Brofenbrenner, consist of "a pattern of activity, roles, and interpersonal relations experienced by the person in a given setting with particular physical and material features and containing other persons with distinctive characteristics of personality and systems of belief" (Bronfenbrenner, 1989, p. 226). Mesosystems "comprise the linkages and process taking place between two or more settings containing the person" (for example, relations between home and school and between school and work) (Bronfenbrenner, 1989, p. 227). Exosystems "encompass the linkage and processes taking place between two or more settings, at least one of which does not ordinarily contain the person, but in which events occur that influence processes within the immediate setting that does not contain the developing person" (for example, for the child, the relation between home and the parent's workplace) (Bronfenbrenner, 1989, p. 227). Macrosystems "consist of the overarching pattern of micro-, meso-, and exosystems characteristic of a given culture, subculture, or other broader social context with particular reference to the developmentally instigative belief systems, resources, life styles, and opportunity structures and patterns of social interchange that are embedded in each of these systems" (Bronfenbrenner, 1989, p. 228). In other words, the macrosystem is the social blueprint for particular cultures, subcultures, or other broader social contexts.

In sum, the micro level of function refers to the individual (plant, animal, and so on) environment and its functions, the meso level refers to interactions of micro environments, the exo level is an outer level that operates indirectly on the environment, and the macro level is the outermost level that defines the global contexts and functions of the system (Engeström, 1999c). Within this ecological model, the issues most relevant for HCI revolve around looking for interaction and interdependence among the levels and the primacy of time and space.

Interaction and Interdependence

Systems do not exist in a vacuum but rather are situated in a broader context of networks of interacting systems. Design questions and practices revolve around the interactions and interdependence of these nested environments. These interactions and their interrelatedness constitute the complexities of design.

Component systems within ecological systems are characterized by progressive, mutual accommodation and extinction throughout the life of the system; these interactions are dynamic processes in and of themselves. As is also true with the principle of disturbance in activity systems, ecological systems are not always harmonious and functioning but have constant tensions, discontinuities, and breakdowns that are necessary for survival and adaptability. The tensions and breakdowns can be used as points of reference for understanding and describing design activity, for example.

Mutual accommodations among system elements shape the relationship among these components, which is interdependent. Changes in any part of a system or among contextual levels have the potential to affect any or all of the other related systems. The developments, tensions, and interrelationships in these systems should be studied in the context of these accommodation processes. As the ecological approach and the process, person, and context model are explored, we describe and account for the transformative power of seemingly ubiquitous artifacts such as language and pervasive computing devices. When an activity system is analyzed at one particular level or context, its relations with activities at other contextual levels (educational systems government, state and local processes) should also be taken into account. This approach reflects what Andrew Pettigrew (1990, p. 269) calls the "importance of embeddedness or studying change in the context of interconnected levels of analysis."

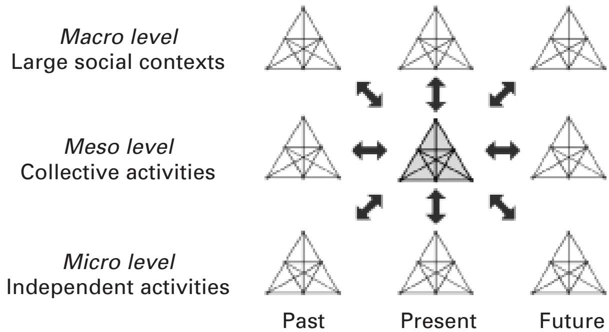

Figure 1.4
Temporal interconnections and "situatedness" of an activity (adapted from Boer, van Baalen, & Kumer, 2002)

Primacy of Time and Space

In addition to the physical network of activity systems, their temporal interconnectedness needs to be examined (Pettigrew, 1990). Activities develop through time, stimulated by the tensions that develop within and between them at various levels (Leont'ev, 1978). "Processes observed at different contextual levels of analysis are often observed to have their own pace and rate" (Boer, van Baalen, & Kumar, 2002, p. 92). Activities from the past are alive in the present and also help shape the future. An activity system is not static, and the developments and changes within the system need to be described and analyzed by locating changes in the past, present, and future (Boer et al., 2002). The dynamic nature of ecological systems hinges on their situatedness in time and space (figure 1.4). Thus, parameters of time and space are the initial critical contexts to which designers need to attend.

Integration of Activity Theory and Ecological Principles

Integrating activity theory with ecological principles involves understanding an outcome (such as a specific technology or user need) at a particular point in time in the context of interacting systems (micro, meso, exo, and macro). The primacy of time and space is particularly crucial because all systems evolve over time and understanding occurs in both historical and contemporary contexts. Activities are "multilevel, multidimensional, dynamic, collective, context-sensitive, and mediated by cultural artifacts" (Boer et al., 2002, p. 8).

The interaction between actors in an activity system is mediated by the object of activity, by language and tools, by a division of labor, by conventions, and by social rules. Participants are involved in a social process as they attempt to accomplish some goal or objective and as they use diverse combinations of signs and tools to create meaning. An activity system can be decomposed into a network of several detailed activity systems—the original setting and increasingly broader contexts (Boer et al., 2002). For example, when analyzing how distributed work teams collaborate on a design project, researchers would look at the history of the work teams and also zoom out to the organizational settings, social settings, and larger social contexts and levels in which these distributed teams operate. The activity system is not only "affected by activity systems at other contextual levels but also exerts influence on them itself. In fact, an activity system can be conceived as a system of distributed cognition" (Boer et al., 2002, p. 6).

The iterative design cycle that is shown in figure 1.5 illustrates the cyclic process of change that is anticipated by activity theory. First, researchers and designers must examine current practices and activities. Needs are identified through scenario-based design techniques, interviews, and observations. Next, tensions, controversies, and conflicts within and between activity systems are identified. Then a period of search and questioning begins as new models and metaphors are considered and new solutions and designs are developed. After the initial series of trials and testing of designs in actual settings, new priorities and approaches emerge, followed by periods of reconceptualization, revision, and redesign. Ultimately, the entire cycle is repeated until some resolution, new stability, or closure is achieved. Increasing agreement among the groups is indicated by a narrowing of disagreements during each iteration, with the resulting central point representing a shared conceptualization or closure (Pinch & Bijker, 1987).

As people begin to address the tensions, conflicts, and breakdowns that are features of their activity systems, they begin to create a collective force for change and innovation (Blacker, Crump, & McDonald, 1999). These breakdowns as well as points of change and development can be used to study activity. The activity-theory approach emphasizes the incoherencies,

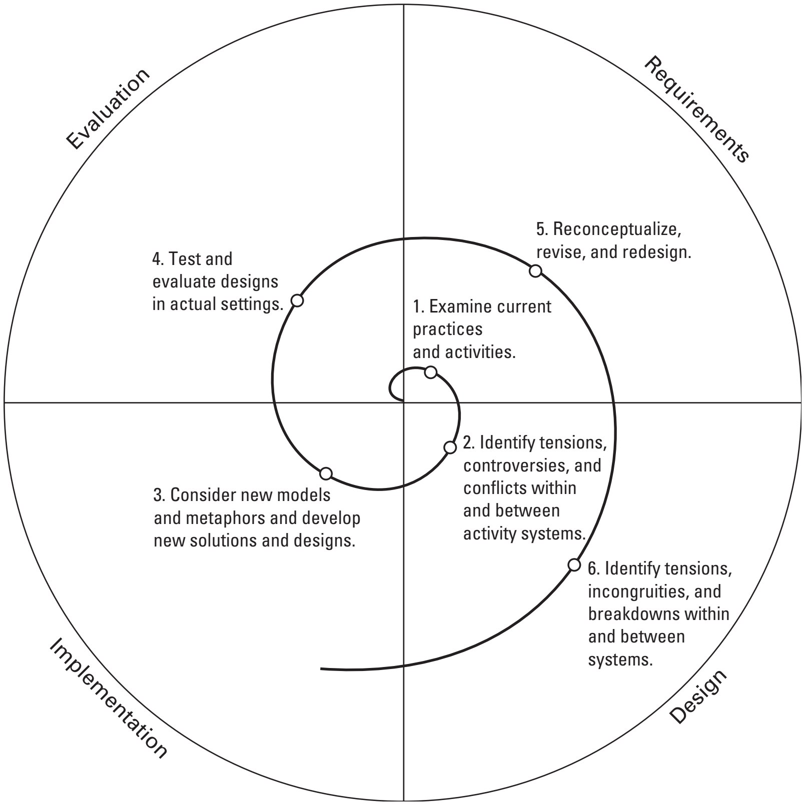

Figure 1.5
An iterative design cycle

tensions, controversies, and conflicts that exist among components in the system (Blacker et al., 1999).

Activities such as technology construction should not be perceived as statically structured entities but rather as dynamic processes that are characterized by ambiguity and change. Construction and renegotiation reoccur constantly within the system. The entire iterative design process rests on dynamic interactions between order and chaos, steady states and breakdowns, harmony and controversy. The activity system is constantly working through tensions within and between its components (Blacker et al., 1999). The tensions and breakdowns that occur within activity sys-

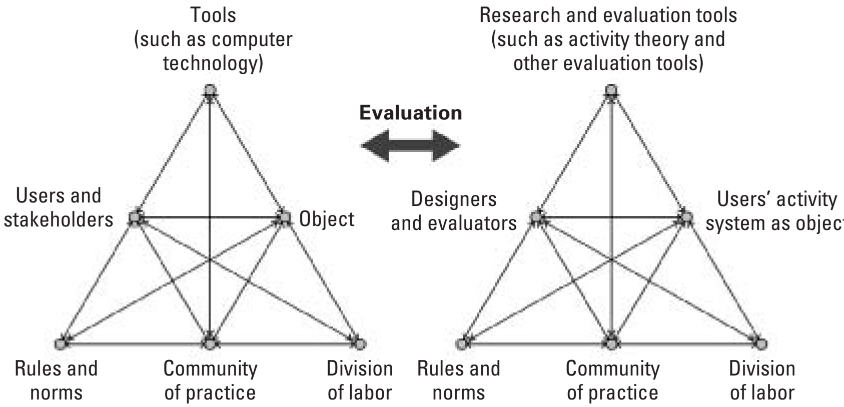

Figure 1.6
The mediating role of evaluation in technology design

tems can be used as points of reference for studying the social construction and design process (Boer et al., 2002).

Within these nested environments are systems that function dynamically and thus enable us to examine how they change over time. Within any design ecology, some systems are perceived as stable and thus require less attention from the designer, while others are perceived as being in flux and become the focus of design research or development. When a new tool is introduced, for example, designers usually focus on user requirements for design (at the micro level), establish these requirements, and then move on to understand the interactions between the new tool and practices in a larger context (meso level).

Toward Reflection in Action

Activity theory cautions us that any tool has the potential to transform the activity in which it is used and, reciprocally, that tools have the potential to be transformed as they are used. Responsible evaluation professionals need to reflect on those potentials and on the ethical considerations that are involved in assessing tool designs, user programs, and evaluation instruments (figure 1.6). Evaluators and designers need to document and analyze uses of technology in program settings and in evaluation activities to understand the mediating functions of different technologies and tools—or, to paraphrase Bonnie Nardi and Vicki O'Day (1999), to engage thoughtfully with technologies as they are used in various contexts.

Evaluation activities are embedded in complex technosystems and cannot be isolated from the system under study. Looking at evaluation as part of the technology design system has transformed how evaluations themselves are designed and conducted (see figure 1.6). In the next few chapters, we describe how we use computer technologies and their multimedia functionalities to collect (multimedia) data, to organize and analyze that data, and to present research findings. These tools can disclose behaviors and social phenomena that have remained hidden and unexamined, even unimagined, because no technologies existed to reveal them. Because new technologies enable new ways of knowing, new ways of evaluating, and new ways of representing and reporting knowledge, they pose methodological, social, and ethical challenges that evaluators need to reflect on and address. Various applications, such as Lotus Notes or concept mapping, can facilitate collaboration among evaluators and stakeholders and offer new ways of conducting evaluations and reflecting on the design process through evaluation activities.

In conclusion, the main contention of this volume is that computer-mediated activity and design need to be understood within their relevant contexts. Activity theory is a holistic approach that can accommodate complexity and diversity by integrating multiple levels of analysis, diverse and multidimensional activities, and various contextual features of computer-mediated communicative practice into a coherent model of human-computer interaction (Nardi, 1996a, 1996b; Engeström, Miettinen, & Punamäki, 1999).