10 Activity Theory in the Learning Technologies

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Activity theory is a social psychological framework that grew out of two theoretical pillars of Soviet psychological thought in the 1920s and 1930s: Vygotskian cultural-historical psychology and praxis-focused Marxist materialism. Activity theory, also sometimes called Cultural Historical Activity Theory (or CHAT) seeks to create an account of human cognition in which people, their intentions, tools, culture, and encompassing social structures are all considered as inherently inseparable components of human activity which constitute thought. Within educational technology and the learning sciences, hereafter referred to as the "learning technologies," CHAT is used in many ways. Most often, learning technologists have used third-generation CHAT (identified with the Scandanavian school) as a guiding theoretical framework to understand how technologies are adopted, adapted, and configured through use in complex social situations.

Thus, this chapter provides a brief historical account of how CHAT originated and was taken up by learning technologists, and then we use brief examples from our own work to illustrate its application. We argue that within learning technologies, CHAT has been primarily used as an analytic tool for understanding human activity in a manner that honors human agency (consistent with constructivism) that accounts for how people think *with* tools (such as models, simulations or games), and examines learning within social and cultural contexts (such as schools or gaming guilds). A key feature of CHAT, we argue, is that it treats people working with these tools within social contexts for particular purposes (individual and collective) as the minimally meaningful unit of analysis. In other words, we cannot understand cognition (and hence learning) without considering these components of human activity that comprise it. Admittedly, this chapter is not a thorough review of the nuances of CHAT, nor does it explore more cutting-edge developments within the community of scholars, practitioners, and theoreticians pushing the paradigm forward. We have made many simplifications to CHAT in an effort to make it readable (relying heavily on Cole, 1996, and Engeström, 2001) and hope that those interested in this intellectual tradition will pursue it further.

For general readers of this volume, we hope to convey an appreciation for what kinds of problems CHAT might illuminate, the theoretical traditions underlying it, and some of its limitations.

We begin by providing a historical overview of the evolution of CHAT from first- and second-generation activity theory. This overview is strongly indebted to a number of rich, existing histories of the evolution of CHAT, notably those provided by Engeström (2001), Cole (1996) and Nardi (1996b), and traces the evolution of CHAT over three-quarters of a century. We continue by laying out the basic characteristics of CHAT as a framework, outlining what we see as the most salient features, characteristics and caveats of the model. Finally, we describe many examples of the use of CHAT in the learning technologies, and detail the implications of CHAT for the design and analysis of learning technologies.

First Generation CHAT: Origins in Vygotskian Social Psychology

Engeström (2001), among others, notes that CHAT is rooted in Vygotskian social psychology, which might be loosely described as the psychological tradition that treats human activity as socially, culturally and historically situated. First, Vygotsky (1978) famously argued that human thought was not simply a matter of a response in reaction to a stimulus, but that thinking is inherently *mediated* by abstract symbols and physical objects, like language, tools, numbers and signs. To use a mundane example, the existence of an axe deeply alters our experience of trees, as we can cut them and use them for various purposes (or study their inner rings). Similarly, cultural tools such as language color our experience; consider the equally mundane example of the watch:

> They (children) name things, denoting them with expressions established earlier in human history, and thus assign things to certain categories and acquire knowledge. Once a child calls something a "watch" (chasy), he immediately incorporates it into a system of things related to time (chas); once he calls a moving object a "steamship" (parovoz), he automatically isolates its defining properties – motion (vozit') by means of "steam" (par). Language, which mediates human perception, results in extremely complex operations: the analysis and synthesis of incoming information, the perceptual ordering of the world, and the encoding of impressions into systems. Thus words – the basic linguistic units – carry not only meaning but also the fundamental units of consciousness reflecting the external world.
>
> (Luria, 1976, p. 9)

In this way, *mediation*, the idea that tools (physical and cultural) mediate our experience and understanding of phenomenon, was a primary contribution of Vygotsky to understandings of human thought

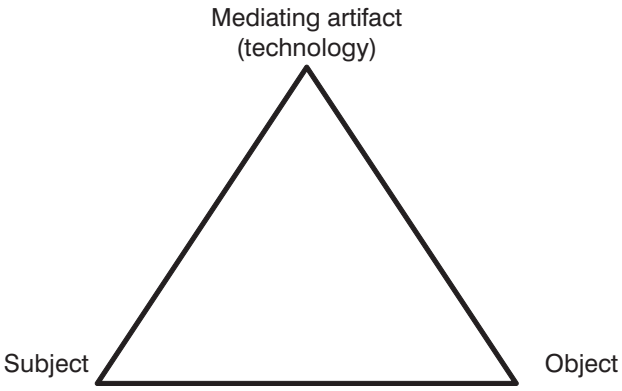

Figure 10.1 Vygotsky – tools as mediational means

and cognition (see Figure 10.1). These mediated abstractions, which are inherent in "higher-order" mental processes, Vygotsky argued, serve to allow for greater freedom in thought and expression. Vygotsky emphasized this point in his examination of the fundamental psychological differences between primates and young children:

> One important manifestation of this greater flexibility is that the child is able to ignore the direct line between actor and goal. Instead, he engages in a number of preliminary acts, using what we speak of as instrumental, or mediated (indirect), methods. In the process of solving a task the child is able to include stimuli that do not lie within the immediate visual field. Using words (one class of such stimuli) to create a specific plan, the child achieves a much broader range of activity, applying as tools not only those objects that lie near at hand, but searching for and preparing such stimuli as can be useful in the solution of the task, and planning future actions.
>
> (Vygotsky, 1978, p. 26)

Objects in the world fundamentally mediate – that is influence and shape – how people think and act. These objects, which include both physical tools like a measuring cup and sign-representations like symbolic variables in elementary algebra, are often integrated into a person's internal patterns of thought. A child learning how to subtract fractions, for instance, initially relies upon external representations like groups of blocks, but soon internalizes those representations and is able to perform such operations in her or his head.

CHAT (particularly as described later by Leontiev, 1978) emphasizes how objects and language are tied to broader collective action; indeed, particular notions of time (and watches) are tied to broader socio-cultural

institutions that created the notion of a "second" and manufactured watches and steamships. In a related manner, Vygotsky argued that human thought is fundamentally a social phenomenon that achieves structure in children through the internalization of social norms and cultural practices. This social view of cognition was encapsulated by a famous Vygotskian formulation:

> Any function in the child's cultural development appears twice, or on two planes. First it appears on the social plane, and then on the psychological plane. First it appears between people as an interpsychological category, and then within the child as an intrapsychological category.
>
> (Vygotsky, 1981, p. 163)

Thus, Vygotsky points to social *interaction* between humans as the location of learning, rather than the lone, isolated individual. Learning, from this perspective is usually studied in "natural" situations, such as parent–child interactions rather than "constructed" environments, such as schools (acknowledging that parent–child interactions are also constructed). An important, related concept in Vygotsky's cultural historical psychology is the notion of the *zone of proximal development* (or ZPD), which is,

> The difference between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under … guidance or collaboration with more capable peers.
>
> (Vygotsky, 1981, p. 86)

Restated, ZPD is the theoretical range of what a performer can do with competent peers and assistance, as compared with what can be accomplished on one's own. A classic example of the ZPD is considering how parents engage in joint activity with children that are on the upward edge of their competence (including conversation). Parents quite naturally adjust tasks, guidance, and feedback so that children are constantly achieving success, and gradually learning to function independently (Conner, Knight & Cross, 1997; Gauvain, 2001).

Second-Generation CHAT

The "second generation" of work in CHAT was in fact the period in which activity theory became distinct from traditional cultural-historical psychology. The Kharkov school of Russian psychology, a group of Vygotsky's students led after his passing by A. N. Leontiev, began to revise the extant understandings of Vygotskyan psychology with an eye

toward a) understanding human thought in *practice*; and b) producing a more *materialist* account of human thought (Leontiev, 1978). Leontiev, like Vygotsky, considered himself a Marxist, and accordingly wanted to produce a framework for understanding cognition that accorded with Marx's emphasis on both the objective, material nature of the world and the way in which human thought is fundamentally linked to human *practice* (see Marx & Engels, 1998). Note that for Engeström (and indeed most activity theorists) second wave activity theory is an extension of Vygotsky's work (and perhaps an acknowledgment of themes that existed). Leontiev, in this way, sought to produce a material psychological account that understood human thought as a "social object" that is fundamentally part of the subjective practice of human activity.

Thought and cognition, in Leontiev's understanding, should be understood as a part of social life – as a part of the means of production and systems of social relations on one hand, and the intentions of individuals in certain social conditions on the other (Leontiev, 1978). Many contemporary frameworks like behaviorial and Pavlovian psychology understood mental processes only in terms of an immediate mental stimulus and an immediate response, ignoring the role that the social world and social history played in structuring thought. Activity theory, as Leontiev understood it, presented an alternative to the stimulus-response model. Leontiev argued that activity facilitated a dialogue between interior mental processes and the real, external social world, a theory he clearly and forcefully articulated in a short paper called "Activity and Consciousness":

> Thus in dealing with the problem of how consciousness is determined we are confronted with the following alternative, either to accept the view implied in the "axiom of immediacy", i.e., proceed from the "object-subject" pattern (or the "stimulus-response" pattern, which is the same thing), or to proceed from a pattern which includes a third, connecting link – the activity of the subject (and, correspondingly, its means and mode of appearance), a link which mediates their interconnections, that is to say, to proceed from the "subject-activity-object" pattern.
>
> In the most general form this alternative may be presented as follows. Either we take the stand that consciousness is directly determined by surrounding things and phenomena, or we postulate that consciousness is determined by being, which, in the words of Marx, is nothing else but the process of the actual life of people.
>
> (Leontiev, 1977, pp. 2–3)

Leontiev, then, understood thought and cognition as mediated not just by signs and objects, but also by the larger structures of activity in which they are embedded. Activity in such a framework should be the primary focus when studying human thought and cognition.

Yrjo Engeström (1987) articulated the clearest distinction between classic Vygotskian psychology, which emphasizes the way semiotic and cultural systems mediate human *action*, and Leontiev's second-generation CHAT, which is focused on the meditational effects of the systemic organization of human *activity*. CHAT is marked by an explicit emphasis on how collective activity – including the social institutions that co-constitute actions – characterizes experience (and hence thought and learning). Engeström writes,

> The second generation of activity theory derived its inspiration largely from Leont'ev's work. In his famous example of "primeval collective hunt" Leont'ev (1981, pp. 210–213) explicated the crucial difference between an individual action and a collective activity. The distinction between activity, action and operation became the basis of Leont'ev's three-level model of activity. The uppermost level of collective activity is driven by an object-related motive; the middle level of individual (or group) action is driven by a conscious goal; and the bottom level of automatic operations is driven by the conditions and tools of the action at hand. However, Leont'ev never graphically expanded Vygotsky's original model into a model of a collective activity system. Such a model is depicted in figure 2.
>
> (Engeström, 1987, p. 78)

Engeström's now famous graphic depiction of second-generation activity theory expands the unit of analysis to include collective motivated activity toward an object (or goal), which makes room for understanding how social groups (collective action) mediates activity.

Engeström's graphic depiction of Leontev's theory (Figure 10.2) has become so synonymous with CHAT more generally (perhaps because it provides a useful graphic organizer for crystallizing mulit-layered, complex phenomena) that it is worth explicating further. A key addition to understanding how it builds on Vygotsky's socio-cultural model of learning is how it transforms the notion of *object*. The object in CHAT is profoundly historically and culturally situated. Rather than describing the chopping of trees in abstract terms, activity theorists are very interested in human collective action in particular cultural and historical terms (the C and H in CHAT). For an activity theorist, how and why forests are being cleared are crucially important for understanding it as goal-directed action, and thus, a meaningful unit of analysis might be logging practices in Eastern Tennessee in the mid-19th century. This object (transforming the landscape) would be understood in terms of particular subjects

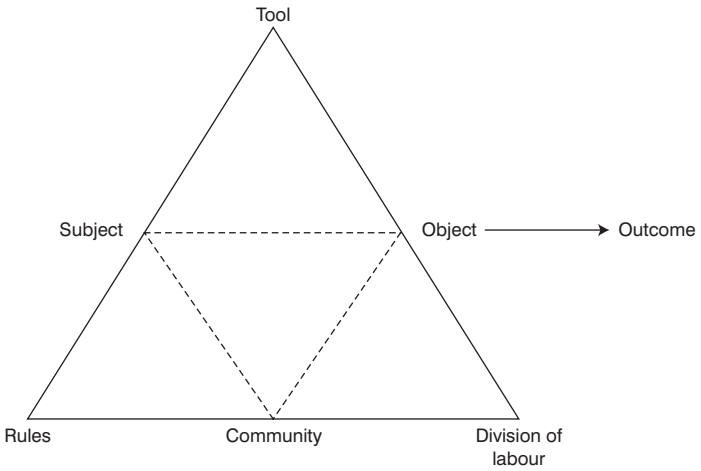

Figure 10.2. Engeström's (1987) diagram of second-generation CHAT

(logging companies and loggers, more about contradictions between such groups in third-generation CHAT), tools they employ, and the broader social context.

This social context, or notion of the collective and how it mediates activity is a second profound evolution in second-generation CHAT. The social layer of mediation tries to capture: 1) how social structures – including formal and informal rules (logging regulations or local customs about trees) mediate activity, and 2) how divisions of labor mediate activity. In the case of logging, today we primarily have lumberjacks and truck drivers, but mid-19th-century American logging might have included increased specialization such as whistle punks, buckers, and fallers. In both cases, one might also include various industrialists, bankers, lobbyists, and so on who mediate activity. The result of this collective activity is a transformation of the object, which leads to *outcomes* (wood, deforested land, perhaps profit).

One of the strengths of CHAT is how it enables researchers to look for *contradictions* in an activity system that will drive its evolution. To extend our logging example, one might imagine how new transportation devices such as gas-powered vehicles transformed logging, enabling loggers to access new lands. One can use this notion of contradictions to examine how new tools (like chainsaws, steam engines and gas-powered vehicles) transform formal and informal rules (such as leading to legislative restrictions on how areas are clear cut or how industrial waste is disposed of) and new divisions of labor as new technologies make old jobs like muleskinners obsolete.

How and why logging has anything to do with learning may seem opaque, but consider how such an analysis might be turned toward a

classroom or school. An analyst might examine a high school in Madison, WI, and see that the object is to transform subjects (students) to becoming adults prepared to enter the workforce, college, and participate in a democratic republic. The *outcomes* might be graduation rates (or perhaps even learning). *Tools* (textbooks, chalkboards, tables, desks, paper, pencils) might be employed to facilitate this transformation. *Formal and informal rules* (attendance and grading policies, as well as informal rules such as ways of denoting respect toward teachers) mediate these outcomes, as do *divisions of labor* (teachers, administrators, school boards, students).

These components of an activity system are all dependent upon the hierarchical structure of activity that Leontiev described. Any activity system, in other words, is composed of three different levels of scales of activity-related processes: activity, actions and operations (Leontiev, 1978). These three levels of a system can be described thus:

> Activities are oriented to motives, that is, the objects that are impelling by themselves. Each motive is an object, material or ideal, that satisfies a need. Actions are the processes functionally subordinated to activities; they are directed at specific conscious goals. According to activity theory, the dissociation between objects that motivate human activity and the goals to which this activity is immediately directed is of fundamental significance. Actions are realized through operations that are determined by the actual conditions of activity.
>
> (Kaptelinin, 1996, p. 55)

CHAT attempts to capture how these components and levels of an activity system all evolve in coordination with one another, driven by systems' inherent need to resolve *contradictions*. Thus, one can see how CHAT provides one set of analytic tools for understanding how the American High School has largely been so resilient (see Tyack, 1974), despite attempts to introduce new tools (televisions, computers) or divisions of labor (reading specialists, class sizes) without fundamentally rethinking the activity system.

Third-Generation CHAT

Attempting to apply a CHAT analysis to a school reveals a limitation of second-generation CHAT: from whose perspective is the system being analyzed, how are boundaries around activity systems conceptualized, and how do we reconcile these without reifying problematic power relations? Returning to the example of school, who defines the object of the activity system? How do students conceptualize the object? How do teachers or parents, and how do we reconcile how one group might state the goals of a system (participate in a democratic republic) with what *actually* occurs? These questions lie at the heart of the field of inquiry know as third-

generation CHAT, which is the generation in which the use of the term CHAT first emerged (see Engeström, 1987; Kuutti, 1996; Kaptelinin, 1996; Nardi, 1996b; Cole & Engeström, 2007). Engeström (1987) describes the contradictions *between* constituents in an activity system as secondary contradictions (as opposed to the primary contradictions between the components of an activity system). Because the determination of whose voices are heard in an analysis has deep ethical and cultural implications, the third generation of CHAT is focused on developing "conceptual tools to understand dialogue, multiple perspectives, and networks of interacting activity systems" (Engeström, 2001, p. 135).

A second, related important characteristic of third-generation CHAT is a deeper move toward the social and cultural. Rather than talk about "a high school in Madison, WI", third-generation CHAT has begun to describe a particular high school (such as Madison High East) at a particular time (say the spring of 2011) with a specific set of social norms and cultural practices. Grounding an analysis in particular time, place and sociocultural context enables CHAT researchers to make much more specific claims about constituent groups, and even for constituent groups to co-define them themselves. This approach, which we call the *deep historical approach* is typified by Engeström and Middleton's (1998) work examining health facilities or office environments, Brown and Cole's (2002) work with the 5th Dimension in libraries and schools, or even Etienne Wenger's analogous work with communities of practice among claims workers (Wenger, 1999), which is not strictly activity theory but shares deep affinities with the core approach. Researchers conducting such studies employ ethnographic data collection methods such as interviewing and observations, as well as historical methods of document gathering and analysis to understand the particulars of an activity system from multiple perspectives.

CHAT: Characteristics and Caveats

This third generation of activity theory has been the generation in which most work employing learning technologies has been done, and will subsequently be the basis for the remainder of the chapter. As Engeström describes, the bulk of this work has applied the CHAT framework through empirical studies, using it to illuminate findings about human activity systems, and adjusting the underlying theory accordingly. Before turning to such an analysis, we highlight five characteristics of CHAT as a theoretical foundation of learning environments to guide the reader. CHAT is unusual in that it is not a learning theory (per se), not an instructional theory, and certainly not an instructional-design theory. Rather, researchers employing CHAT use it as a tool for understanding learning, refining instruction, and suggesting directions for instructional

design. We return to these in the conclusions, but present them here so as to circumvent any potential misunderstandings.

1. *CHAT is an analytic tool, not a prescriptive theory that prescribes particular forms of instruction*. As an outgrowth of Vygotskian social psychology, CHAT makes particular claims about learning, namely that we learn through social interaction, and thus learning is most powerful when people are engaged in joint activities with peers (especially when using a variety of tools and resources while engaged in activities of ever-increasing complexity). For this reason, many CHAT researchers are not especially interested in school-based learning. Schools traditionally sequester learning (students working independently), and operate according to a logic of *content* flowing from increasing layers of authority (federal government à state standards à textbooks à teachers) to students, who then re-present the information back up a chain of increasing authority culminating in validated tests (see Lemke, 1990; Leander & Lovvorn, 2006). Indeed, CHAT can be used to illuminate issues in such systems, such as that learning technologies like constructionist tools that require individual autonomy and value creative expression will be rejected from the system because they contradict the object of the system (and everything else in it, see Barab *et al.*, 2002; Collins & Halverson, 2009). Thus, CHAT does not necessarily prescribe how to design instruction, but is an analytic framework that can be applied to workplaces, schools, digital gaming communities, and so on.

2. *CHAT does not prescribe any particular research method, although as a theoretical tradition, CHAT's methods are often deeply cultural and historical*. CHAT is theoretical framework, or a set of assumptions that a researcher makes that points his or her analytic lens toward particular phenomenon (such as the contradictions in an activity system) and away from others (such as the mental inner workings of a student). CHAT does not, in and of itself prescribe any particular research method or methodology, and researchers such as Michael Cole, Jay Lemke, Yuro Engeström, Bonnie Nardi, Sasha Barab, and ourselves have employed a variety of research techniques within CHAT studies. However, because CHAT involves understanding the interplay among subjects, tools, communities and the objects they transform, CHAT analyses typically employ cultural methods such as ethnography (participant observation, interviews, interaction analysis) and historical analysis (oral histories, document analysis, archival analysis).

Many affiliated scholars are hostile to the notion of prescribing or standardizing methods for CHAT-based research, because of their deep belief that research methods need to emerge from the context being studied. Drawing on Hegel's work on the phenomenology of mind, Engeström argues that "the substantive theory and the methods of study are genetically intertwined, not separate. Methods should be developed or `derived' from the substance, as one enters and penetrates deeper into

the object of study" (Engeström, 1993, p. 99). In other words CHAT scholars commonly hold that there are no "silver bullet" methods that can be applied to any context, but rather that the methods used have to suit both the question being asked and the context in which it is asked. As such, there are many methods like ethnography and formative experiments that are commonly used in CHAT research, but none that are formally prescribed or recognized (Kaptelinin & Nardi, 1997). CHAT is not, however, a methodological free-for-all, as there are shared methodological beliefs in most CHAT research. For example, Nardi (1996b) describes some of the key methodological implications of CHAT for the study of human–computer interaction:

- A research time frame long enough to understand users' objects, including, where appropriate, changes in objects over time and their relation to the objects of others in the setting studied.
- Attention to broad patterns of activity rather than narrow episodic fragments that fail to reveal the overall direction and import of an activity.
- The use of a varied set of data collection techniques including interviews, observations, video, and historical materials, without undue reliance on any one method (such as video).
- A commitment to understanding things from the users' points of view, as in, for example, Holland and Reeves (this volume). (Excerpt from Nardi, 1996b)

As such, although CHAT endorses a methodological pluralism, as a theory it has methodological commitments that are shared across the field of researchers. These methodological commitments grow out of CHAT's emphasis on the systematic nature of activity, historicity, multi-vocality, and dialogic processes (Engeström, 2001).

3. *CHAT, as a research approach, is a structured and ideationally-driven approach in the sense that researchers use theoretical assumptions to understand human activity*. CHAT shares affinity with critical design ethnography (Barab *et al.* 2004), both of which bring strong theoretical frameworks to inquiry and use them to illuminate issues, in direct contrast to approaches like grounded theory, which seek to *remove* pre-existing models and find theory "in the data" (cf. Glaser & Strauss, 1967). Activity theory is strongly driven by the existing theoretical constructs and models that are used to describe systems of activity, actions and operations (Bakhurst, 2009; Engeström, 2001). Engeström (2001) for example, prescribes a fairly specific approach to understanding activity and expansive learning (see Figure 10.3), detailing a matrix for analyzing learning that touches on different precepts in activity theory.

Engeström here prescribes a framework for analyzing learning and activity, instructing researchers to focus on activity systems as a unit of

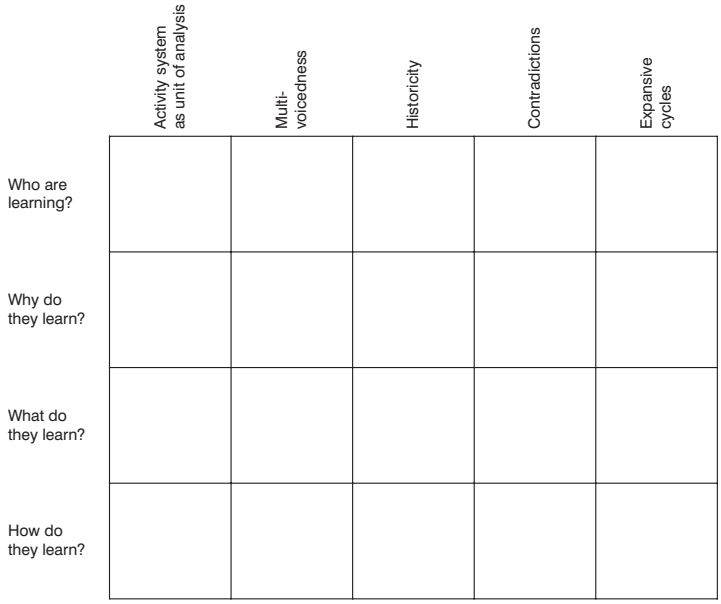

Figure 10.3 Matrix for the analysis of expansive learning (Engeström, 2001)

analysis, the multivoicedness and historicity of those activity systems, the contradictions embedded within them that exist in a dialectic relationship, and the cycles of expansive and transformative learning that take place. In such a way, Engeström, like most third-generation CHAT theorists, has a strong theoretical model that he brings to analysis, unlike methodologies that strive to avoid generalizable theories and models (e.g. Garfinkel, 1967; Glaser & Strauss, 1967).

Engeström's emphasis on the importance of general theoretical models is almost universal in the CHAT literature. Time and again, CHAT scholarship emphasizes the importance of building general analytic tools and models of activity to use in different settings, while acknowledging the importance of context to adjusting those tools and models. In a paper introducing CHAT to scholars in computer-supported collaborative work (CSCW) and human–computer interaction (HCI), for example, Kuutti and Arvonen (1992) provide a strongly prescriptive model for understanding the relationship between actors (e.g. software users) and information technology "support systems" (see Figure 10.4). This typology of the relationships between actors and support systems is characteristic of the strong emphasis on hypothesis and shared theoretical frameworks in CHAT. In these respects, CHAT is closely related to positivist positions in the social sciences, as its research questions are driven by theory, and seek to improve upon theory, although positivists may or may not acknowledge their ideologies and governing assumptions.

Area of support	Role of a person towards the support system in an an activity: Pre-determined	Active	Expansive
Instrument	Routine automation	Tool	Automation or tool construction
Rules	Control	Shared meanings	Rule construction, negotiation
Divsion of labour	Fixed, 'forced coordination'	Mutual coordination	Organizing work
Subject 'thinking'	Triggering of a predetermined action	Searching information	Learning, understanding
Object	Data	Shared material	Object construction
Community	Fixed hierarchy/ network (invisible)	Malleable visible network	Community construction

Figure 10.4 The range of relationships between an actor and a support system in an activity (Kuutti & Arvnonen, 1992, p. 236)

4. *Underlying CHAT is an interactionist epistemology, meaning that for CHAT researchers, learning and knowledge are inseparable from context*. For a CHAT researcher, the minimal meaningful unit of analysis is a person engaged in an activity with tools and resources in some social context. With roots in Vygotsky, knowing is, for CHAT researchers, *action* (to quote Wertsch, 1998), meaning that knowledge arises through an interaction among tools, resources, people, and extant social structures (including everything from language to cultural models to overt rules). Building on the work of Hutchins (1995), and Pea (1993), for CHAT theorists and researchers, knowledge is stretched across material tools (such as notes) and conversations (which trigger different situations and ways of being). CHAT researchers generally reject the symbolic, information-processing model of the mind, which assumes that information can be "stored" free from language, culture, or situation, and can be "recalled" reliably independently of situation. More often, CHAT researchers embrace metaphors of the mind as a rhizome (see Cunningham, 1998) semiotics, as a neural network (see Gee, 1992), or as simulator grounded in embodied experiences (Barsalou, 1999; Gee, 1992; Glenberg & Robertson, 2000). Regardless of which metaphor one employs, many CHAT researchers come from the non-symbolic processing tradition, maintaining that

knowing is action, manifests itself through social activity, and is co-comprised of tools, language and social interactions.

5. *Finally, embedded within CHAT is a* conflict-driven theory of change *in which evolution occurs through* contradictions *embedded in a system*. CHAT is grounded in the intellectual tradition of dialectical materialism, with its notions of change driven by contradictions owing much to the German philosophers Hegel and Marx. One of the core principles of CHAT is the "central role of contradictions as sources of change and development", which are defined as "historically accumulating structural tensions within and between activity systems" (Engeström, 2001, p. 137). While contradictions lead to conflicts and perturbations within activity systems, they also lead to innovation in and transformation of the activity system. To be sure, it is beyond the scope of this introduction to provide a thorough accounting for the nature of contradictions in CHAT or to trace the notion of contradictions through Hegelian and Marxist philosophical thought. However, we argue that central to CHAT is this notion that through tracing contradictions, one can trace the evolution of historical systems and identify ways in which they are coming-to-be. We find this notion of contradictions to be quite useful irrespective of CHAT or Marxist thought more generally, however researchers should be aware that this approach differs from the utopian or other theories of social change.

CHAT in Learning Technologies

Vygotsky was responding to behaviorism and the traditional psychoanalysis / introspection, both of which treated the individual (or arguably the person plus stimulus) as the meaningful unit of analysis, but in the late 1980s, Vygotsky's social psychology gained renewed attention for its capacity to respond to new critiques of cognitive science's view of the mind. The symbolic processing model, which largely dominated the first 30 years of cognitive psychology, treated knowing as a process of information inputs (through the senses), information processing (in the brain), information storage (knowing is a function of memory), and then information retrieval and recall (see Derry & Steinkuehler, 2006; Gardner, 1987). Several inter-related changes in understandings of the mind led to this so-called "social turn", including the realization that the senses actively construct information (see Gibson, 1979); that knowledge is profoundly embodied, tied to our senses and experiences (see Glenberg & Robertson, 2000); that knowledge is constructed individually and uniquely through experience (von Glasersfeld, 1996); that knowledge is co-constituted by tools (material and cultural, see Gee, 1992; Pea, 1991); that knowledge is created through social processes (particularly communities that legitimize ways of knowing; Scardamalia & Bereiter, 1994); and that knowledge is reconstituted through social practices that are tied to broader social, cultural, historical (and thus inherently

political) concerns (Lave & Wenger, 1991). In short, old models viewed the mind as a digital computer, and a wave of cognitive science research demonstrated the shortcomings of this view.

As cognitive scientists (and later learning technologists) adopted what might be broadly described as a *socially-situated* view of cognition, Vygotsky's socio-cultural psychology provided an intellectual tradition in which learning is studied not only through laboratory experiments, but also through investigating learning in complex, everyday environments (see Anderson, Reder & Simon, 1996; Derry & Steinkuehler, 2006; DeVane *et al.*, 2009; Gee, 2000/2004; Greeno, 1997; Hutchins, 1995; Kirshner & Whitson, 1997; Moss, Pullin, Gee, Haertel, & Young, 2005; Wertsch, 1998). As Cole (1996) described, this movement toward Vygotsky's cultural psychology sought to return culture back to the center of the study of human cognition, as it was for Vygotsky (and perhaps Dewey). A host of groundbreaking studies typifying this approach emerged from this period such as Walkerdine's (1990) study of Mexican chiclet salespeople, Goody et al.'s (1977) study of learning through apprenticeship among Vai tailors, or Lave's (1988) study of weight watchers' participants. Lave and Wenger's (1991) *Legitimate Peripheral Participation* synthesized these studies and described learning through the metaphor of participation (as opposed to acquisition), arguing that in much of human activity, learning occurs through social processes in which newcomers become increasingly central to legitimate social practices.

Within this context, CHAT gained popularity as a framework for conceptualizing learning in such spaces. Michael Cole's 5th Dimension project, an after-school technology-enhanced learning environment, is one of the most influential examples of a Vygotskian-inspired learning design in which CHAT was used to iteratively understand and refine the program (see Cole, 2006). In the 5th Dimension, children voluntarily attend after-school computer clubs designed to support literacy development (defined broadly). The 5th Dimension is a network of activities ranging from digital games to reading stories, tied together through a fantastic maze that embeds curricular goals within it. By design, 5th Dimension is decentralized, non-linear, designed to appeal to broad tastes, and meant to facilitate learning through interaction. Also by design, 5th Dimension sites pull in community members (particularly pre-service teachers) to serve as peers and mentors for children.

5th Dimension: CHAT-Based Design

The 5th Dimension (5thD) is one of the most thoroughly researched learning technology interventions to date, with perhaps over 100 publications on it performed with a variety of approaches (see Cole, 2006; Mayer, Schustack & Blanton, 1999). Many insights were gained from this body of research, but one of the most important from a CHAT perspective

was the limitations of a particular intervention (such as 5thD) to create its own unique activity system. As one of the local enactors of 5thD described,

> The original 5thD was developed by adults who had a strong theory about learning and development, strong culturally-based views of what children should learn, and well established patterns of interacting with children and with other adults. Other adults in other environments have different views, different goals, different theories. At the (local) YMCA it seems important to the adults (parents, directors, counselors) that children learn manners, deference, obedience. It is important that they use tools and other equipment "the right way".
>
> (Brown & Cole, 2002, no page)

This analysis is a classic kind of CHAT analysis; one group of subjects (Cole and colleagues who designed 5thD) envisioned learners and mentors working together with adults in joint activity in open-ended tasks that honored their interest. In contrast, local subjects enacting the program held a model of childhood in which children need to be inculcated with values (the object of the activity system). Understanding these contradictions among different subjects and objects enabled researchers to understand how the program should evolve.

A finding from these 5thD enactments is that an intervention alone does not constitute its own new activity system (or at least 5thD did not). Rather educational interventions (from Read 180 to Digital Games) are more akin to tools that subjects appropriate in their effort to transform objects. Note, however that the arrows between components in activity systems go both ways, suggesting that tools can under certain conditions create contradictions that push activity systems toward new objects. Elsewhere, we have argued that mobile phones may be one such tool (particularly if students come with them to school, see Squire & Dikkers, in review). However, the idea of creating entirely new activity systems within broader nested systems (such as after school clubs) has proven to be thus far unattainable (cf. Squire, et al., 2003). Rather, through cycles of design à research à redesign that identify contradictions and introduce changes that might resolve them (ranging from tools to new divisions of labor), learning technologists might be able to better understand activity systems and how to design new ones more in accordance with their goals.

CHAT as a Framework when Redesigning a University Course

Barab and colleagues (2002) used CHAT in a similar vein to examine students' learning in the Virtual Solar System (VSS) Project. VSS investigated what happens when instructors, researchers, and learning scientists collaboratively redesigned a lecture-based university course, *Introduction to the Solar System*, to emphasize learning astronomy through

developing 3D models. Researchers observed and video-recorded students throughout the duration of the course, enabling researchers to make more robust claims about the inter-relationship between *individual actions* and *collective activity* over longer timescales. For example, using micro-level analyses, researchers demonstrated how concepts such as scaling, which was an object of early activity, was produced and then mobilized as a tool. Theoretically, this study contributed an understanding of the *fractal* nature of actions and activities within activity systems, suggesting how educational researchers can connect individual and group action to collective activity to show how understandings emerge in situ and then are mobilized as tools for future action.

Yet, as in Cole's 5thD work, the analytic power of CHAT may be in its capacity to illuminate *contradictions* that drove change in the system. Early in the course, a contradiction between learning to build 3D models vs. learning astronomy arose as a primary contradiction within the *object* of the activity system. Students and instructors alike wanted activity to focus on transforming participants' understandings of astronomy, but the opacity of the 3D modeling tools made *learning to build 3D models* the object driving activity. When presented with this analysis, instructors created new initial assignments (formal rules) that introduced the tool more gradually, which enabled the system to evolve toward *learning astronomy*. Other contradictions were noted in *divisions of labor*. Students were required to work in groups, but the instructor and university grade individually (with grades being consequential toward other activities). Further, resources such as the instructor that were not directly useful for transforming the *object* (whether it be learning the tool or building models) were rejected for tools that did. For example, the instructor delivered many thoughtful mini-lectures on the history of astronomy, which, while researchers found them quite fascinating, students who were consumed with building models rejected as less useful.

It is worth pausing to ask what analytic power CHAT might purchase a researcher that simple case studies do not. After all, if a complex 3D modeling tool is introduced into an astronomy course, is it not commonsensical that problems would arise? Is it not understood that grading systems need to be designed to balance learning, group dynamics, and broader concerns?

Indeed, CHAT is not the only method that could detect such patterns nor suggest solutions to them, but (part of) its analytic power is in providing a ready framework for detecting, describing, anticipating, and considering the ramifications of them. In the case of the complex 3D modeling tool, CHAT encouraged researchers to frame the problem *not* simply as a matter of the tool being too *complex*, but as a mismatch among current assignments, rules, and tools. Perhaps more importantly, it asks researchers and instructors to *embrace* such contradictions as the drivers of change in a system. Rather than "throw out" the program because

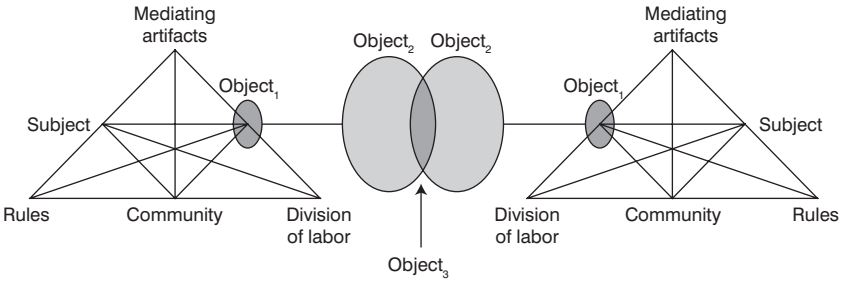

Figure 10.5 Activity systems in dialogue (Engeström, 2001)

of conflicts, or even look for simple answers, it requires researchers to step back and examine the system as a whole, which includes considering the object of the system as it was designed and as it was experienced for various subject groups. CHAT provides researchers – particularly design researchers – with an analytic lens for stepping back and examining their designed educational interventions as a whole to understand their quality and to suggest modifications. Critically, it requires researchers to examine not only their own goals as subjects in the system, but also different constituent groups, including different groups of students, administrators, teachers, and so on. Engeström (2001) seeks to capture this idea in Figure 10.5, a depiction that shows how CHAT researchers must examine how at least two different subject groups experience activity systems.

After the first full iteration of the Virtual Solar System Project, Barab and colleagues note several driving contradictions (see Figure 10.5) that characterize the course, and once again highlight the difficulty of introducing novel technologies with different embedded values into an activity system *even when the entire course was redesigned with the new pedagogy in mind.* Truly embracing a modeling-based curriculum meant several changes. The first was setting expectations of students-as-subjects. Most students entered the course expecting to be relatively passive recipients of information and expecting to transform their transcripts to have more credits that meet the university science requirements. Many students had some curiosity or interest in science, but even then, they were not expecting to be involved in an active model building community in which they learned in a self-directed manner through building and testing understandings. Similarly, this shift toward a modeling-based community drastically changed aspects of course participation that instructors had not intended. For example, Barab and colleagues found that whichever participant created the group inscriptions that specified how their model would be built generated the deepest understandings, because other participants were relegated to roles in which they implemented findings. Barab concludes by questioning the possibility of transforming such introductory classes given their function of generating revenue and sorting students within the broader university system.

CHAT Applied to Digital Media

Within the nascent field of digital media and learning, the role of CHAT is adapting, as researchers seek to understand how digitally-mediated affinity spaces function, and then design learning environments based on them. Within this paradigm (see Steinkuehler, Squire & Barab, 2011), the idea is that digital affinity spaces, such as video game communities are important sites of learning because 1) learning is interest (or passion) driven (Gee, 2003); 2) learning is driven by closed and open problem solving rather than memorization (Gee, 2005; Steinkuehler, 2006); 3) learners interact with peers of different ages and ability levels, enabling the broadening of weak social ties (Steinkuehler, 2005); 4) learners marshal a variety of tools in the service of game play (Steinkuehler & Duncan, 2009); and 5) learning is supported through robust networks of just-in-time learning (DeVane *et al.*, 2010). Although few researchers have formally applied third-generation CHAT as Engeström or Barab might, games researchers such as Gee, Steinkuehler, or Squire have used case study or discourse methods to employ socio-cultural similar analyses.

As an example of what such a research paradigm might look like, consider Apolyton University, an online community of digital game players nested within the Apolyton.net community. This brief description draws from more in depth, previously published research articles (Squire & Giovanetto, 2008; Squire, 2011). Apolyton University is an online informal "university" started by players of the game *Civilization III* in the early 2000s. *Civilization III* (or *Civ3*) is a popular digital turn-based strategy game in which players lead a civilization for 6,000 years by gathering resources, building cities, and negotiating with other computer-controlled players. The University formed when Theseus, a veteran player, wanted to sharpen his skills, find a community to learn with and from, and prepare for an upcoming expansion pack which would enable online collaborative and competitive play.

The core community came from the Apolyton.net site. They had previously participated in a "best of the best" activity in which players used stock editing tools to "rewrite" the rules so as to produce the most playable, accurate, well-balanced game possible. In short, they were unsatisfied with the stock game as it came "out-of-the-box" and wanted to fix it. The fact that *Civ3* ships with an editor that enables players to rewrite its rules made this possible.

Within a few weeks, the community grew to a few hundred player-students. Players designed courses around themes, such as "Give Peace a Chance," the course that requires players to win without waging war. In each course, players downloaded a common saved game file (created with the editor), took notes on their play, took screenshots illustrating their play, and posted these notes and screenshots in the form of During-Action-Reports. Most reports followed a format of posting a short narrative to

recap the action, posing a question to the community of players related to what they were working on, and reporting the basic descriptive statistics from their game (rate of population and economic growth, and so on).

Soon, dozens of courses emerged. The University formed its own curricular committee to establish core courses and identify what needed to be learned. Soren Johnson of Firaxis games, who was the lead programmer on *Civ3* joined and posed new challenges to the community, such as reverse engineering the algorithm behind barbarian uprisings. They even went so far as to elect a Dean.

After about 18 months, interest in the University waned. In part, the community had exhausted *Civ3*'s possibilities. There was, in one participant's words, not much else to learn. But also, the community dispersed in part because they were recruited to help build *Civ4*, the sequel to *Civ3*. Soren Johnson, now the lead designer of *Civ4* was so impressed with Apolyton that he recruited about 100 "beta testers" to create their own "best of the best" activity in which they would improve *Civ4* just as they had *Civ3*. Eventually several players were hired to work full time at Firaxis.

If we apply a cursory CHAT analysis, we might consider students such as Theseus as *subjects* who participated in this activity so as to transform themselves into more adept Civ players in order to experience pleasure, be challenged, develop skills, and perhaps expand their social networks (see Figure 10.5). They employed a variety of *tools* to do so, including the game and its editor, but also a variety of modding tools developed by the community, such as the Civ3MultiTool (developed by Gramphos) which enables players to edit saved games, fan-generated tutorials which explain how to edit the game's rules or graphics, and fan-generated art packs (created with a variety of tools such as PhotoShop). The community also developed *conceptual tools*, such REXing, or Alex's Archer Rush, which were known strategies developed by the community and employed in various situations. The community created a glossary to explain knowledge learned in the community that had been codified into new terminology. These physical and conceptual tools were *outcomes* of the activity system that were continuously fed back into the system.

The community, although emergent, generated *formal* and *informal rules* to mediate participation. They created formal processes for proposing and approving courses, although they remained quite open, in that *anyone* could propose or participate in a course. Informal rules emerged governing how participants interacted. Most posts were responded to within 2–5 hours. Informal rules governing behavior, such as a reluctance to discuss current events or politics, emerged as well, as this International community of players held divergent views toward current events such as the Iraq War. As a result, players tended to discuss the game as a game within Apolyton without using it as a tool to talk through current events (although many were eager to do so in private). Using the game to talk

about history was more common, although many players drew sharp distinctions between historically accurate scenarios (which many of them built) and the entertainment play at Apolyton. Even within this voluntary, ad hoc organization, labor was divided among Committees and Deans helped tend to the overall health of the community, tending to requests for content, tools, or new experiences. In the course of our year-long study, 174 players participated in the University.

Through this brief account, we get a snapshot of Apolyton University as an activity system. Contradictions drove activity in the space – players' desire to improve their skills and improve the game led to the creation of new mods and new structures, until players felt as if they were complete. At the end, as players themselves transformed, many entered new activity systems, namely beta testing the game design, and in the case of some, securing new employment as full-time game-designers. As learning technologists, we were intrigued by the rapidity with which new knowledge and *tools* were generated and fed back into the system (as well as into other game communities) and the degree to which players transformed themselves as *objects*. In comparison to school, the enterprise appeared quite *generative* in that the system generated new outcomes that fed back into other systems. This generativity was born out of a dialectical relationship between the community of users on the Apolyton forums, the tools (message board systems, game modding tools, game system, etc.) that were used to support the activity of the community, the object of the community's activity, and the acts undertaken by the individual subjects within that community. Outside the immediate scope of the activity system, this generativity was also born out of the dialogue that this activity system entered into with a number of other activity systems. Learning and activity in Apolyton resulted from the activity of a community working with a specific set of tools toward agreed-upon ends.

Conclusion: Using CHAT to Design Learning Technologies

At the most basic level, CHAT forwards that "an activity is a form of doing directed toward an object and activities are distinguished from one another by their objects" (Kuutti, 1996, p. 26). Activity, in other words, consists of a person or persons doing something toward some end. Learning, accordingly, is strongly linked to this doing, the end to be accomplished in the doing, the tools used in the doing, and the social system in which the doing takes place. Learning technologies, according to CHAT, are not a medium that unproblematically transmits knowledge to a user, but rather a tool that structures and mediates the learning accomplished through activity. CHAT views learning technologies not as "teaching machines" but as a "support system" for learning through doing (see Kuutti & Arvonen, 1992). Learning is not only accomplished by

observing, but also by doing, and learning technologies serve to support and structure that doing.

From its inception in the activity theory of Leontiev and the Kharkov school, CHAT has always sought to understand human thought not just as an abstract and symbolic phenomenon, but also as a thing that takes place – that is practiced – in the real everyday world. Its study of cognition in the world – in classrooms, in workplaces, in hospitals – leads it to understand both the importance of tools to learning activities and the importance of activity systems in shaping how tools and technologies help people learn. Neither learning nor learning technologies were understood as abstract and self-contained, but rather as phenomena with rich cultural histories of use that are embedded in larger social systems and undertaken/used by persons with different intentions and goals. Activity theory, in short, embraces understanding the complex and messy reality of learning with tools and technologies, rather than an idealized and formulaic abstraction that occurs in a laboratory.

Perhaps the most important benefit of activity theory is not that it situates learning technologies in ecologies of activity, but rather that it gives teachers, designers and scholars a systematic way to understand learning technologies as they function in the complexity and untidiness of the real world. Many an educator or instructional designer has come to the conclusion that the success of learning technologies depends on how they are actually used in a learning context, but it is often difficult to image what conclusions to draw from this understanding. What does it mean for the design of a learning technology that its success depends upon how, where and why it is used? Who cares if learning with technology is a messy real-world process if such a realization does not help its users learn? Activity theory answers these questions by providing learning technologists with a structure for understanding how learning with technology occurs with activity – its utility lies in its ability to provide a formal grammar for understanding the "buzzing, blooming confusion" (James, 1981, p. 462) of learning in the real world.

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