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Why *All* CSL is CL: Distributed Mind and the Future of Computer Supported Collaborative Learning

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Abstract. In this paper, we argue that this distinction between CSCL and HCI is based on a particular understanding of the relationship between humans and computers—and more generally between humans and their tools in activity systems. We draw on work by Shaffer and Kaput (1999), Clark (2003), and Latour (1996a; 1996b; 1996c) to conduct a thought experiment, extending the analytical reach of *activity theory* (Nardi, 1996b), *mediated action* (Wertsch, 1998) and *distributed cognition* (Pea, 1993) by adopting a stronger form of the concepts of *distribution* and *mediation* in the context of cognitive activity. For rhetorical purposes, we posit this stronger form of the distribution of intelligence across persons and objects as a theory of *distributed mind*. Our purpose in describing a theory of distributed mind as an extension of (but not replacement for) extant sociocultural theories on this 10th anniversary of the International Conference on Computer Supported Collaborative Learning is to problematize for the field its current focus on *human* collaboration as supported by computers. We are concerned that a field focusing on the interactions of humans will overlook the ways in which meaningful cognitive (and therefore pedagogical) activity is distributed among human and non-human agents within activity systems. We argue that *all* computer-supported learning is fundamentally collaborative—whether or not the computer is supporting the interaction of persons in the learning process. The consequences of such a move are a call for a tighter integration of the fields of CSCL and HCI, and a more powerful framework to help guide pedagogical choices in an age marked by rapid expansion of powerful cognitive technologies.

Keywords: Sociocultural theories, activity systems, distributed mind, virtual culture

INTRODUCTION

Over the last decade, work in computer supported collaborative learning (CSCL) has focused predominantly on ways in which computational media make possible new modes of interaction between people in the pursuit of understanding. That is, work on CSCL has focused on how computers support human collaboration. Over roughly the same period of time, work on human computer interaction (HCI) has focused on ways in which people communicate with computers and other computational devices in the pursuit of meaningful goals—including the development of understanding.

In this paper, we argue that this distinction between CSCL and HCI is based on a particular understanding of the relationship between humans and computers—and more generally between humans and their tools in activity systems. We draw on work by Shaffer and Kaput (1999), Clark (2003), and Latour (1996a; 1996b; 1996c) to conduct a thought experiment, extending the analytical reach of *activity theory* (Nardi, 1996b), *mediated action* (Wertsch, 1998) and *distributed cognition* (Pea, 1993) by adopting a stronger form of the concepts of *distribution* and *mediation* in the context of cognitive activity. We suggest that new computational tools problematize the concept of thought within current sociocultural theories by challenging the traditional position of privilege that humans occupy in sociocultural analyses. For rhetorical purposes, we posit this stronger form of the distribution of intelligence across persons and objects as a theory of *distributed mind*.

Our purpose in describing a theory of distributed mind as an extension of (but not replacement for) extant sociocultural theories on this 10th anniversary of the International Conference on Computer Supported Collaborative Learning is to problematize for the field its current focus on *human* collaboration as supported by computers. In an era of increasingly powerful computational games, simulations, and the virtual worlds they create, we are concerned that a field focusing on the interactions of humans will overlook the ways in which meaningful cognitive (and therefore pedagogical) activity is distributed among human and non-human agents within activity systems. We argue that *all* computer-supported learning is fundamentally collaborative—whether or not the computer is supporting the interaction of persons in the learning process.

The consequences of such a move are a call for a tighter integration of the fields of CSCL and HCI, and a more powerful framework to help guide pedagogical choices in an age marked by rapid expansion of powerful cognitive technologies.

BACKGROUND

The dilemma of action

To illustrate the issue at hand, we begin with a contradiction. In *Mind As Action*, Wertsch (1998) offers a historical review of research on human action, describing a moment in Kenneth Burke's theorizing when Burke contrasts the actions of persons with the "sheer 'motions' of 'things'" (p. 12). Burke claims that he is "not pronouncing on the metaphysics of this controversy," for "the distinction between things moving and persons acting is but an illusion." However, Burke adds: "Illusion or not, the human race cannot possibly get along with itself on the basis of any other intuition" (p. 13). For Burke, humans need to remain at the center of activity because it is too disconcerting to think otherwise.

Computation media problematize this basic intuition because modern computers—and equipment controlled by computers—act independently in ways that traditional tools do not. Thought and action are no longer the sole property of humans: computers and other digital tools exhibit significant kinds of thinking and important forms of independent activity. They create a variety of situations in which people clearly think *with* rather than *using* tools.

In what follows, we argue that although existing sociocultural theories of cognition assign an essential role to objects in their frameworks for studying action, in a sense, Burke's center still holds. Computational media thus provide both a means and a motive to push beyond current theory. We ground this claim about the significance of computational media in understanding thought using the theory of *virtual culture*.

The evolution of virtual culture

A number of theorists, including Dewey (1991), Clark (2003), and Bateson (1972) have written about the co-evolution of tools, culture and cognition through which, as Donald (1991) suggests, "the individual mind has long since ceased to be definable in any meaningful way within its confining biological membrane" (p. 359). Building on a large body of prior work on the development of writing (Schmandt-Besserat, 1978, 1992, 1994), Donald argues that with the development of extended societies within a mythic culture, the record-keeping needs of commerce and astronomy led to the creation of external symbol systems, of which mathematical notations were probably the first (see also Kaput & Roschelle, 1998). Donald suggests that these external records led to the development a *theoretic culture* based on written symbols and paradigmatic thought characteristic of scientific disciplines. DiSessa (2000) describes historically powerful representational and inscriptional tools such as writing and mathematical notation as *infrastructural*. In a theoretic culture, such tools play a leading role in cognitive activity and thus in formal education. Schooling in a theoretic culture focuses on learning to access parts of the cultural record and manipulate them through writing and mathematical notation (Donald, 1991).

Writing and mathematical notations are, of course, static representational systems, and therefore thinking in a theoretic culture can be reasonably characterized as the result of human agency mediated by cultural tools. Computational media, however, are inherently dynamic representations (Kaput, 1986, 1992, 1996a, 1996b; Kaput & Shaffer, 2002; Papert, 1993, 1996; Shaffer & Kaput, 1999), and thus suggest a different relationship between tool and person. Building on Donald's framework, Shaffer and Kaput (1999) describe computational media as a new transformative tool, one in the process of creating a new cognitive culture. They argue that just as theoretic inscription systems such as writing and mathematical notation externalize human memory, computational media make it possible to externalize well-formed algorithms. That is, computers make it possible to create artifacts that take a particular form of thinking (understanding that can be expressed in the form of a finite state algorithm) and allow it to be carried out independent of any person. Computation thus makes it possible to develop simulations that dynamically enact and reenact parts of the way we understand our world. Shaffer and Kaput argue that if written symbols led to a theoretic culture based on external symbolic storage, then computational media are in the process of creating a virtual culture based on the externalization of symbolic processing.

Theories of Mediational Means, Activity Theory, and Distributed Cognition

A broad range of recent work in psychology and anthropology supports the basic contention that the relationships among thought, action, and technology are essential in understanding learning. This body of work examines the problems with analyzing thought and action from the perspective of an individual without taking into account the context of tools and social interactions in which thinking and acting take place. In addressing this concern with context, theories of mediation means, activity theory, and distributed cognition in particular have attempted to grapple with the role of technology in thinking:

Each of these theories begins by positing that activity necessarily takes place in the context of mediating tools. Wertsch (1998), argues that thinking always emerges through action with mediational means—that is, with tools—and thus learning is not the acquisition of isolated skills that transfer to from one context to another, but rather the *mastery and appropriation of cultural tools*. In activity theory, this premise is represented by Vygotsky's (1978) model of mediated action, which relates subject, object, and mediating artifact (Engestrom, 1999). In distributed cognition, Norman (1993) describes a similar framework for analysis as an equation, with the system of activity composed of a person and an artifact. There are important distinctions in how these theories frame the issue. But they all suggest that the appropriate unit of analysis for thought and action is the interaction of people and tools in social context, rather than the level of either persons or tools in isolation.

One important issue these theories address is the relationship between artifact and person within this unit of analysis. Activity theory proposes explicit linkages among individual actors, tools, confederates, and the norms of action within a social context (Engestrom, 1999). In so doing, it provides a descriptive framework for clarifying the unity of consciousness and activity by positing that consciousness is located in practice, which is, in turn, embedded in an historically-developed social matrix of people and artifacts. Distributed cognition similarly proposes that knowledge resides in people, in tools, and in cultural settings in which people interact with tools without being locatable exclusively in the heads of individual persons or in the design of specific artifacts; that is, the parts of the system have knowledge, but the system as a whole is more knowledgeable than the sum of its parts (Hutchins, 1995). Distributed cognition analyzes the persistence of knowledge in such systems, both in the form of physical artifacts and in the processes through which the system perpetuates its norms and functions (Nardi, 1996a).

However, all of these theories posit an asymmetrical relationship between persons and artifacts. This distinction is explicit in the case of activity theory, which identifies three levels of means as *operation*, *action,* and *activity,* with the corresponding ends of *instrumental conditions, goal*, and *motive* (Engestrom, 1999). The later (motive) is ascribed only to human beings (Kaptelinin, 1996; Nardi, 1996a), and thus the structure of the highest level in the operation/action/activity framework is by definition determined by the human agents in the system. In distributed cognition, the asymmetry is less explicitly drawn. Both humans and artifacts are referred to as *agents* in the system. However, theorists of distributed cognition such as Solomon, Perkins, and Globerson (1991) make the distinction between the things a person can achieve *with* a tool, and the effects *of* that tool on his or her thinking in other contexts—that is, without the tool. While Pea (1993) rejects this formulation, he does assert that "the primary sense of distributed intelligence arises from thinking of people in action," and adds in a footnote, "I take the work of Leont'ev on activity theory as arguing forcibly for the centrality of people-in-action, activity systems, as units of analysis for deepening our understanding of thinking" (p. 49). And elsewhere: "I use the phrase 'distributed intelligence' rather than 'distributed cognition,' because people, not designed objects, 'do' cognition" (p.50). Wertsch's conception of the relationship of persons to objects is implied in his construal of mediated action as meaning "agent-acting-with-mediational-means." Wertsch (1998) explains, for example, that "the task of a sociocultural approach is to explicate the relationships between human action, on one hand, and the cultural, institutional, and historical contexts in which this action occurs, on the other" (p. 24). From the standpoint of these frameworks, activity systems are something to be analyzed by focusing on human action. Each thus reinscribes Burke's center: it is people who are do the acting.

The problem this poses from the point of view of virtual culture is that when we use the general category of human action to analyze activity, focusing on the person using the tool obscures the active role tools play. This may not have posed a significant problem in analyzing the static inscriptional systems of a theoretic culture. But in a virtual culture based on the offloading of symbolic processing, we may need to end—or at least reconceptualize—the analytic privilege we accord humans in the process of thinking and acting. In the next section we describe work by Latour as a basis for orienting to objects and humans as more genuinely equivalent participants in activity systems—and thus, by extension, in cognitive activity.

Latour's translation model of action

Latour (1996b; 2000) describes how objects, by virtue of their being in the world in some form (physical artifacts in the physical world and informational artifacts which are represented in speech, text, or in action on a computer screen) *push back* in their interactions with humans. A thought, once instantiated in an object, is no longer exactly that thought, for it now has an independent existence in the world. It is a *something* situated in the world. We can *fold ourselves into* an object, but the object always expresses our thoughts, values, intentions, and norms with its own “timings, tempos, and properties” (1996a, p. 268)—that is, in its own particular form. Latour gives the example of delegating to a wooden fence the task of containing sheep. He asks, “Are the sheep interacting with me with when they bump their muzzles against the rough pine planks?” And answers, “Yes, but they are interacting with a me that is, thanks to the fence, disengaged, delegated, translated, and multiplied. There is indeed a complete actor who is henceforth added to the social world of sheep, although it is one which has characteristics totally different from those of [human] bodies” (1996a, p. 239). The fence enacts Latour’s intention to keep the sheep all together in one place to make sure that none wander off. His action is folded into the nature of the fence; but if one looks for a “mind” in this situation, it is as much in the head of Latour, who is now freed up to read a book, as it is in the fence that enacts a particular way of thinking (keep the sheep together), a way of valuing (although they might not like it much, it is more important for sheep to be penned up than for them to roam free), and a way of interacting (now the sheep interact with the fence rather than with Latour). The relation between humans and technology is thus best conceived not as humans *using* objects, but rather as humans *interacting with and through* objects.

From this perspective, action has no point of origin; rather action is a moment of translation in which *actants* (things and people) come together to share in action, which is mutually distributed between them. Latour argues that “to act is to mediate another’s action” (1996a, p. 237). Both humans and objects mediate, and one can only proceed to action by mediating another’s action. As a result, this conception of action does not grant analytic priority to humans, since action is a moment of mutual mediation between actants, “no one of which,” Latour explains, “ever, is exactly the cause or the consequence of its associates” (1996a, p. 237). In developing the concept of distributed mind, we take as a premise for our thought experiment that persons and artifacts are equivalent actants in this sense: persons and artifacts engage in mutual mediation, and the actions that result are not ascribable more to one than the other.

FROM TOOLS AND THOUGHTS TO TOOLFORTHOUGHTS

A virtual cognitive ontology

Latour’s model of action reorganizes our thinking about cognition by challenging the idea that humans have a privileged position in action. Seeing action as an association of multiple mediating actants pushes us out of the western anthropological schema which, Latour (1996a) suggests, “always forces the recognition of a subject and an object, a competence and a performance, a potentiality and an actuality” (p. 237). If objects were only the reified intents or concretized designs of their makers, it would make sense to orient to them, as Pea (1993) suggests, as things that *have intelligence* but cannot *do cognition*. The structuring effects of objects designed to shape action (and thus also thought) would be principally relevant to our understandings of activity. Yet, as is often noted, objects have a way of exceeding or changing the designs of their makers (Postman, 1993; Tenner, 1997). To the extent that a tool *expresses* desires, intentions, and meanings, the desires, intentions, and meanings that the tool enacts are never precisely those of any single individual. A tool has its own characteristics and properties that shape action in ways that are influenced by, but not reducible to, the initial inputs of its designers and users.

Instead, we suggest that just as tools are externalizations of human designs, thoughts are similarly internalizations of our actions with tools—both physical tools, such as Latour’s fence, cultural tools, such as language, and social tools, such as the system of property rights that makes it possible to Latour to erect a fence on “his” land around “his” sheep. All thoughts are connected to tools, and all tools are connected to thoughts: every time we consider a thought (since it is an internalization of action with a tool) it is inextricably linked to a tool, and every time we consider a tool (since it is an externalization of a thought) it is inextricably connected with a thought. In this view, tools are not distinct from thoughts; rather, both are poles in the back and forth movement between tool and thought. The reciprocal relation between tool and thought exists in both. We thus suggest that rather than seeing tools as static thoughts—objects distinct from human subjects—we grant tools and thoughts the same ontological status. That is, we posit that tools and thoughts are fundamentally the same kind of thing. Put another way, the concept of persons and objects as equivalent actants removes Vygotsky’s (1978) distinction between *sign* and *tool*. Vygotsky argues that both are mediators of activity, but since signs orient internally and tools orient externally, “the nature of the means they use cannot be the same” (p. 55). Positing symmetry between persons and artifacts argues that all activity is simultaneously internal and external, and that the processes involved are therefore not ontologically distinct—different in specific properties, perhaps, but not in their fundamental nature.

Toolforthoughts defined

In this ontology, then, there are no tools without thinking, and there is no thinking without tools. There are only *toolforthoughts*, which represent the reciprocal relation between tools and thoughts that exists in both. When we say that something is a *tool for thought* (as separate words) this might suggest that *thought* is the broader category and that tools are something that help people think. Or it might imply that *tool* is the broader framework and persons are agents who use both thoughts and physical artifacts as tools. To avoid these difficulties, we connect the nouns *tool* and *thought* in order to suggest how toolforthoughts are the outcome of a process of tools existing in a reciprocal relation with thoughts.

Whether they are internalizations of social interaction (Vygotsky, 1978), or externalizations of cognitive processes (Shaffer & Kaput, 1999), toolforthoughts are templates for action: reifications of patterns of social action that arise from an ongoing historical dialectic between tool and thought.. We refer to these reifications as templates because they have a particularity to their form. This particularity does not ensure that toolforthoughts enact the social organizations that their inventers intend—a toolforthought is a social pattern, and no one would expect that intent is equivalent to outcome in a social setting. The particularity of a toolforthought does imply, however, that when a toolforthought participates in action, the action is inflected by the pattern of the template: some actions, while perhaps still possible, are less likely to emerge than others; other actions, while perhaps not inevitable, are more likely to emerge. Toolforthoughts collaborate in some ways better than other ways, creating a set of constraints and affordances for any toolforthought (Gibson, 1986; Norman, 1993). Any action that unfolds with a toolforthought unfolds in some particular way, rather than in another way; thus all toolforthoughts are inherently ideological. As Postman (1993) argued, every tool implies "a predisposition to construct the world as one thing rather than the other, to value one thing over another" (p. 13).

Toolforthoughts as objects of study

As understood in the context of theoretic culture, tools and thoughts divide the space of mediation and activity: as an artifact, a tool mediates but does not act; as an agent, a person has thoughts, but does not mediate. The construct of toolforthought, in contrast, preserves the unity of action and mediation. Toolforthoughts are the cognitive instantiation of Latour's mutually mediating mediators. Toolforthoughts neither act nor are acted upon; rather, they interact to produce a model of thinking that goes beyond current conceptions of mediated action, activity systems, and distributions of intelligence or cognition. In this model, biological cognition itself is a form of mediation, with the same ontological status as that of other mediators, and thinking, in the words of Latour (1996c), involves "constantly shifting from one medium to the other," with work divided between "actors in the setting, either humans or non-humans" (p. 57).

We refer to this as a theory of *distributed mind*, and we suggest that while extant theories, such as actor network theory, activity theory, and theories of mediational means and distributed cognition contain elements of this theoretical stance, a theory of distributed mind is distinct in its explicit emphasis on the ontological equivalence of tools and thoughts—and their linkage in the concept of toolforthought as the fundamental unit of analysis for cognition. In such a framework, the appropriate unit of analysis is not a system *comprised* of human beings and tools, but rather *systemic effects of individual toolforthoughts* and the particular forms of social interaction they foster. For each toolforthought, the task is to understand its particular constraints and affordances—and to uncover how the linkages between the two participate in particular kinds of social interactions at the expense of others.

EXAMPLES

Toolforthoughts in mathematics

Not long ago, solving many mathematical problems necessarily meant representing them in algebraic notation and solving a system of equations. For example, the motion of a ball after it is thrown was determined by representing the motion with equations $x_t = x_0 + v_{xo}t$ and $y_t = y_0 + v_{yo}t - ½gt^2$. The same problem can now be solved with a variety of new quantitative modeling toolforthoughts. Papert, for example describes how even very young students can use a similar process to solve complex problems of projectile motion by creating a simulation in a LOGO microworld (Papert, 1980). Such methods provide a range of techniques for solving interesting and important problems that cannot be addressed in the traditional mathematics curriculum.

The point that new tools open new avenues for solving problems has been made many times before (see, for example, Kaput, 1986; 1992; Papert, 1980, 1993, 1996; Resnick, 1991, 1994a, 1994b; Shaffer & Kaput, 1999; Shaffer & Resnick, 1999). However, the concept of toolforthoughts changes our understanding of the implications of this expansion. One might defend the primacy of algebra in the curriculum by arguing that only when using algebra are students really *doing*, and thus really *understanding*, mathematics; it is the spreadsheet, or modeling environment that is solving the problem when a student uses a computer. But this argument is only sustainable when cognition is taken to be a certain kind of action that can only take place in certain kinds of activities—in this case something happening in the head that is only manifest in symbolic manipulation. If we define mathematics as computation using particular techniques then, indeed, when these become externalized in a new tool, the original endpoint of instruction has been taken over by the tool.

The theory of distributed mind, however, focuses on the outcomes of interacting toolforthoughts. It emphasizes how new tools lead to new kinds of actions, and thus to new modes of thought. In this view, the reason for introducing new technologies into the classroom is not to recreate existing activities, but rather to allow more compelling possibilities that new toolforthoughts provide. Because there are no thoughts independent of tools (or tools devoid of thought), intelligence is always the collaboration of toolforthoughts. Pedagogy *does* sacrifice understanding is when a toolforthought is being used to do the thinking (a type of action) that is already folded into it. However, the understanding being sacrificed is not *what has been folded into the toolforthought*. That understanding is still present but has been relocated. The understanding being sacrificed is the understanding that comes from *actions that are only possible with the aid of the toolforthought*. Using a calculator to add 2+2, does not sacrifice the ability to add. That capacity is still present in the person-calculator system. What is sacrificed is the understanding that would come from working with the calculator to do something we cannot do with pencil and paper alone.

In other words, it is not new toolforthoughts that potentially diminish understanding, but rather curricula—or, more precisely, a poor match between toolforthought and activity. Thus, Pea's (1993) suggestion that we have to balance between "deeper understanding" and "engaging in meaningful whole-task problem solving" (p. 74) is a dilemma that only arises from a particular way of thinking about technology, cognition, and learning. In the theory of distributed mind, all thinking is a tool-thought combination. Understanding mathematics does not depend on mastering traditional mathematical toolforthoughts. It means being able to interact with a suite of powerful toolforthoughts to accomplish meaningful mathematical ends.

From this perspective, algebra is not inherently more powerful than other mathematical modeling systems, other than the power it has by virtue of its place in the historical development of mathematics. It may be more powerful. But now that case needs to be made through an analysis of its constraints and affordances, and their resulting social consequences. It is not enough that algebra has traditionally been a dominant toolforthought, because algebra has also traditionally disempowered a wide range of students—and many important problems are beyond the scope of traditional algebraic techniques. New toolforthoughts potentially let more students work with complex mathematical relationships than the mathematics curriculum of theoretic culture (Kaput & Shaffer, 2002; Papert, 1980). These new possibilities for mathematical understanding depend not on mastery of the traditional forms of theoretic culture, but rather on learning to collaborate with a system of mathematical toolforthoughts to achieve meaningful ends.

Toolforthoughts in literacy

Bolter (1991) describes a *writing space* as the interplay of writing materials and techniques of inscription used to produce literacy objects. Not surprisingly, paper is the dominant writing material in a theoretic culture, and symbolic text is the dominant technique of inscription. Theoretic writing spaces thus emphasize print literacy, and theoretic schooling emphasizes the production and consumption of symbolic text as a primary literacy activity. That is, school focuses on learning to read and write words on paper.

Writing in a virtual culture, however, increasingly means collaborating with a range of toolforthoughts: artifacts that represent new and expanded access to traditional forms of writing (the Web), but also modes of communication that were not previously available (interactive multimedia), or were available but not in the form of writing technologies (immersive role playing simulations). Forms of representation that are not considered writing in a theoretic culture—for example, movement through space and situational gestures that are all but unwritable in pen and ink—are critical elements of writing in virtual media such as videogames.

The basic cognitive engine of virtual culture is the externalization of symbolic processing: the instantiation of dynamic transformations in new toolforthoughts. These externalizations in virtual worlds make it possible to extend and recombine physical forces and responses such as gravity, agility, and location, to create new ways of being in the world. In videogames and other computational spaces, we "read" concepts in more experiential (Norman, 1993), more embodied ways (Gee, 2003). This experiential aspect of virtual writing spaces makes possible new ways of knowing and new modes of understanding. In a theoretic culture it is possible to conceive of literacy as an interaction between tool and person: between the text and the reader or writer. However, new forms of reading and writing such as we find in videogames and other simulations require a degree of projection (or inhabitance) that makes it increasingly difficult to analytically separate person from tool. Indeed, what is the ubiquitous avatar if not a representation of the tight coupling between computationally literate person and computational literacy object?

The potential consequences of this increased embodiment are profound. In theoretic culture, writing is used to create a *world on paper* (Olson, 1994). Understanding a world on paper requires experience of the real-world contexts to which the text refers (Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, in press). In virtual culture, writing both creates a *world on the computer* and provides the experiences needed to understand that world. In video games and other computational spaces, we have the potential to dwell in the virtual world through a new form of direct experience. As a result, the lengthy cognitive apprenticeship in the dominant symbolic systems of theoretic culture are no longer required to have meaningful experiences in complex cognitive domains. Papert (1980) famously suggested that computers make it possible to learn mathematics by living in Mathland as one can learn French by moving to France. Similarly, more people can learn French by playing a massively multiplayer online computer game conducted in French. Learning in digital worlds means developing an understanding of the world from the inside, for it is through one's own action in digital worlds that they take on meaning. In other words, virtual literacy makes existing forms more widely accessible at the same time it gives us access to new worlds—social, conceptual, and material.

Digital worlds thus support a view of learning which foregrounds having particular kinds of experiences and accomplishing meaningful ends. We evaluate toolforthoughts in virtual literacy by the interactive, communicative, interpretive, and expressive ends that students can accomplish in collaboration with them. Think, for a moment, of students who come to know Hamlet through multimedia projects (Murray, 1999)—or some day perhaps through a Prince of Denmark video game. These students may not be facile at translating words reprinted from Shakespeare's Folio or Quarto into a personally-relevant interpretation of the dilemmas that face the troubled prince. But that was, after all, not Shakespeare's intent in writing the play. Hamlet was written to be seen, not read. More to the point: from experiencing the play through a range of literacy toolforthoughts, more students will be able to interact with the themes of Hamlet, the nuances of Shakespeare's dramatic skill, and the relationship between performance and interpretation that the play represents.

Video games as toolforthoughts

We close this section with a specific example that exemplifies the power of new toolforthoughts as interactive learning environments, and the challenges they propose to traditional notions of CSCL. *Full Spectrum Warrior* (Pandemic Studios, for PC and Xbox) is a video game based on a U.S. Army training simulation. But *Full Spectrum Warrior* is not a mere first-person shooter in which the player blows up everything on the screen. To survive and win the game, the player has to learn to think and act like a modern professional soldier. (For a more detailed discussion of the game, see Gee, in press.)

In Full Spectrum Warrior, the player uses the buttons on the controller to give orders to two squads of soldiers, as well as to consult a GPS device, radio for support, and communicate with rear area commanders. The Instruction Manual that comes with the game make it clear from the outset that players must take on the values, identities, and ways of thinking of a professional soldier to play the game successfully: "Everything about your squad," the manual explains, "is the result of careful planning and years of experience on the battlefield. Respect that experience, soldier, since it's what will keep your soldiers alive" (p. 2).

In the game, that experience—the skills and knowledge of professional military expertise—is distributed between the virtual soldiers and the real-world player. The soldiers in the player's squads have been trained in movement formations; the role of the player is to select the best position for them on the field. The virtual characters (the soldiers) know part of the task (various movement formations) and the player knows another part (when and where to engage in such formations). This kind of distribution holds for every aspect of military knowledge in the game. However, the knowledge that is distributed between virtual soldiers and real-world player in this game is not a set of inert facts; what is distributed are the values, skills, practices, and (yes) facts that constitute authentic military professional practice. This simulation of the social context of knowing allows players to act as if in concert with (artificially intelligent) others, even within the single player context of the game.

In so doing, *Full Spectrum Warrior* shows how games take advantage of situated learning environments. In games as in real life, people must be able to build meanings on the spot as they navigate their contexts. In Full Spectrum Warrior, players learn about suppression fire through the concrete experiences they have had while playing. These experiences give a working definition of suppression fire, to be sure. But they also let a player come to understand how the idea applies in different contexts, what it has to do with solving particular kinds of problems, and how it relates to other practices in the domain, such as the injunction against shooting while moving.

Video games thus make it possible to "learn by doing" on a grand scale—but not just by doing any old thing, wandering around in a rich computer environment to learn without any guidance. The fruitful patterns or generalizations in any domain are the ones that are best recognized by those who already know how to look at the domain and know how complex variables in the domain interrelate with each other. In *Full Spectrum Warrior* the player is immersed in activity, values, and ways of seeing. But the player is guided and supported by the knowledge built into the virtual soldiers and the weapons, equipment, and environments in the game.

DISCUSSION: COLLABORATIVE LEARNING IN A VIRTUAL CULTURE

We began this essay by arguing that current thinking and theorizing about tools is based on an assumption about agency: that humans have it and tools don't. As a thought experiment, we replaced this postulate with an alternative borrowed from Latour: that neither tools nor humans have agency in the traditional sense; rather action always emerges from the collaboration of mutually mediating actants, which can be human or non-human. That is, we posited an ontological equivalence between *inter*activity and *intra*activity in thinking. Positing such equivalence, we argue, requires creating a new analytic category of toolforthoughts: a view from virtual culture of the relationship between technology and cognitive activity. For rhetorical purposes we describe this as a theory of distributed mind. However, we want to emphasize that our goal is not to supplant existing sociocultural theories of cognition, nor to recreate actor network theory, but to extend these theories to account more robustly for thought and action in an era of new computational toolforthoughts.

A theory of distributed mind extends current thinking about CSCL in two ways. First, if tools and persons are equivalent actants, then thinking and acting always mean learning to collaborate with valued toolforthoughts. This means that in a very important sense, all *computer-supported activity* is inherently *collaborative* activity. In an age of powerful computational toolforthoughts, this is not merely a rhetorical claim, as the example of *Full Spectrum Warrior* shows so vividly. We are constantly in collaboration with valued toolforthoughts, and even toolforthoughts designed to support human-to-human collaboration are, in fact, examples of *human-computer-human interaction* rather than computer-supported collaboration.

The second point, which follows from this first, is that as it enters its second decade of formal existence, the field of CSCL may need to broaden its mandate to focus more directly on the *ends* of human-computer-human interaction rather than its current emphasis on the *means* of using computational toolforthoughts to support human collaboration.

Our current educational system writ large is grounded in an assumption that thinking is something that goes on inside the head of a person using tools, and that what matters, in the end, is the thinking and not the using of the tools. This view privileges the use of abstract formalisms and the classes of problems those formalisms were developed to solve—neither of which have been empowering historically for students from less advantaged backgrounds. Building on work of sociocultural theorists, CSCL has expanded this view of cognition by focusing on things students can accomplish in collaboration with other students in computer-mediated social settings. But as we argue above, this step, though important, may not be sufficient.

In a theoretic culture marked by a relative paucity of powerful toolforthoughts, the most significant of which were static inscriptional systems, the goal of education was to master existing cultural tools. Accordingly, sociocultural theories have emphasized, generally, the development and use of infrastructural tools (diSessa, 2000), such as traditional mathematical notations and print literacies, within relatively stable (albeit evolving) cultures of practice. In a time of rapid and fundamental technological change it is easier to see that which toolforthoughts are valued in this sense is inherently ideological. As diSessa (2000) argues, tools become infrastructural when they support a nexus of uses that are seen as valuable and necessary in a given social context—a move that always depends on the size and power of the social niches they serve. By conceptualizing tools as participants in, rather than merely mediators of, cognition (and contrariwise by conceptualizing persons as mediators rather than agents), a theory of distributed mind prepares us for a virtual culture marked by a multiplicity of cognitive toolforthoughts. It provides perspective on the inevitable panic that arises in our theoretic frame of mind when young people begin using new and more powerful toolforthoughts: the panic that our children are no longer *learning how to think*. A theory of distributed mind foregrounds instead consideration of the kinds of actions we want students performing: Should they answer problems that computers can now easily solve? Or should they be working on problems that have not yet been solved, but that can now be approached in collaboration with a combination of able peers and new toolforthoughts? The question we ask about new toolforthoughts can no longer be: "Will these tools help students to collaboratively learn traditional mathematical, scientific, social, historical, and print literacies?" Rather, we have to ask: "Who will be able to collaborate with these toolforthoughts, and what will they be able to accomplish?"

A theory of distributed mind reminds us to be wary of the naturalistic fallacy of mistaking *what is* for *what ought to be*. The particular set technologies we have inherited—pens, papers, books—does not define a fixed and immutable realm of what it cognitively possible or desirable. So pedagogical choices are not, as Pea (1993) suggests, about balancing deep understanding and engaging tasks. Nor are they about deciding whether to emphasize "solo performance" (with or without toolforthoughts) or work "in collaboration with others." Rather, learning is always collaborative. Learning always means doing particular kinds of things in collaboration with particular kinds of toolforthoughts. Therefore all meaningful actions with toolforthoughts can lead to an experience of deep understanding. What matters are the actions we value—a value defined in relation to our understanding of the things worth doing and issues worth addressing with a given set of toolforthoughts. This decidedly preliminary examination of a theory of distributed mind thus suggests that new educational toolforthoughts cannot be evaluated in isolation; rather, they need to be understood as fundamentally changing how we think. In particular, the perspective of toolforthoughts highlights the extent to which all thinking is a collaborative enterprise, and therefore all learning—particularly computer-supported learning—is collaborative learning. Examining toolforthoughts in a virtual culture thus raises profound questions: How will we decide what activities we value? What frameworks will we use to weigh the constraints and affordances of competing toolforthoughts? And, as we move into the second decade of work in CSCL, how can we conceptualize computer-supported collaboration as being more than merely computer-supported *human* collaboration?

Eventually, of course, these questions must be developed in such a way as to be addressed by specific hypotheses that can be subjected to empirical study. Our goal here has been to provide an ontological argument for the value of such questions to the CSCL community—and to suggest that the effort of addressing them will be advance our understanding of the role computational media can and should play in collaborative learning.

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