

Re-thinking the ‘thing’: Sociomaterial approaches to understanding and researching learning in work

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Abstract

Purpose: This article compares theoretical conceptions that reclaim and re-think material practice – ‘the thing’ in the social and personal mix – specifically in terms of work activity and what is construed to be learning in that activity.

Approach: The article is theory-based. Three perspectives have been selected for discussion: cultural-historical activity theory (CHAT), actor-network theory (ANT), and complexity theory. A comparative approach is used to examine these three conceptual framings in context of their uptake in learning research to explore their diverse contributions and limitations on questions of agency, power, difference, and the presence of the ‘thing’.

Findings: The three perspectives bear some similarities in their conceptualization of knowledge and capabilities as emerging - simultaneously with identities, policies, practices and environment - in webs of interconnections between heterogeneous things, human and nonhuman. Yet each illuminates very different facets of the sociomaterial in work-learning that can afford important understandings: about how subjectivities are produced in work, how knowledge circulates and sediments into formations of power, and how practices are configured and re-configured. Each also signals, in different ways, what generative possibilities may exist for counter-configurations and alternate identities in spaces and places of work.

Value: While some dialogue has occurred among ANT and CHAT, this has not been developed to compare more broadly the metaphysics and approaches of these perspectives, along with complexity theory which is receiving growing attention in organizational research contexts. This article purports to introduce the nature of these debates to work-learning researchers and point to their implications for opening useful questions and methods for inquiry in workplace learning.

Keywords: activity theory, actor-network theory, complexity theory, sociomaterial, work-learning

In social sciences interested in enactments of work activity, politics and knowledge, and the flows among them, a prominent shift has occurred that invites attention from work-and-learning researchers. Evident in perspectives such as science and technology studies, actor-network theory, complexity theory and new cultural geographies, this shift counters theoretical positions that assume the social/cultural and the personal to be the defining parameters of what it means to learn. It challenges the centering of human processes in learning (often conceived as consciousness, intention, meaning, intersubjectivity and social relations) derived from perspectives associated with phenomenology and social constructivism, and foregrounds the material.

The material includes tools, technologies, bodies, actions, and objects, but not in ways that treat these as ‘brute’ or inherently distinct from humans as users and designers. The

material also includes texts and discourses, but not in ways that focus on linguistic, intertextual and cultural circulations that preoccupy post structural analyses. Overall, this shift is away from a primary preoccupation with human meaning including meanings attributed to such objects, as we see in hermeneutic, narrative or symbolic interactionist approaches. The shift is also away from analysing such objects as traces of something assumed to be ‘culture’, as we see in conventional anthropological accounts.

Instead, among perspectives that seem to be part of this pervasive shift¹, the material world is treated as continuous with and in fact embedded in the immaterial and the human. Therefore in this discussion, the term ‘sociomaterial’ is used to represent perspectives that are argued to form part of this shift. But why this focus on the material? What can it bring to work-learning studies?

The first answer is perhaps an obvious one. Work life is fully entangled with material practice, technologies, vehicles, architectural spaces, roads and roadblocks, nature and objects of all kinds, in ways that are often not even acknowledged in the preoccupation with understanding human activity and meaning-making.

The second answer is that attention to the sociomaterial can help reveal the dynamics that are actually constituting what comprises everyday life, including learning. Humans and what they take to be their ‘learning’ and ‘social’ processes do not float, distinct, in ‘contexts’ of work that can be conceptualized and dismissed as a wash of material ‘stuff’ and spaces. The things that assemble these contexts, and incidentally the actions and bodies including human ones that are part of these assemblages, are continuously acting upon each other to bring forth objects and knowledge. These objects might be taken by a casual observer as natural and given – things comprising a ‘context’. But a more careful analysis notes that these objects, including objects of knowledge, are very messy, slippery and indeterminate. Indeed some sociomaterial analyses accept the simultaneous existence of multiple ontologies that can be detected in the play of objects. This has enormous implications for understanding worklife and the processes of learning.

A third answer to ‘why sociomaterial?’ is its ability to unsettle categories that have become problematic conventions in work-learning analyses, despite critique that by now is well-worn. Such categories include informal and formal learning, individual and collective learning, and workplace learning and organizational learning. These categories are unhelpful because they suggest that such things exist as knowable and distinct, when research has struggled with the inseparability, uncertainties and fluidities of the

¹ It is dangerous to try to categorize theoretical or philosophical perspectives, particularly when diverse writers and positions are called into presence under one transcendent term that may fit uneasily with their particular projects. This short paper attempts mainly to show certain broad similarities of realist perspectives that foreground material concerns as well as multiplicity, and to suggest possibilities of these approaches for work-learning research. It does not argue for a new grand ontology, nor for replacing other perspectives with those interested in the socio-material. Exclusions are necessary given the limited scope here, but important literature for work-learning researchers that could be considered socio-material analyses include feminist technology studies (e.g. Bray, 2007), speculative realism (e.g. Harmon 2009; Nancy, 2000), Knorr-Cetina’s (1997) work on object-relations in professional knowledge, mobility studies (e.g. Sheller and Urry, 2006) and many others.

phenomena which such categories are intended to describe. In a summary of the contributions of science and technology studies (STS) to organizational research, Woolgar *et al.* (2009: 19-21) shows the general value of sociomaterial perspectives to work-learning research:

(1) a propensity to cause trouble, provoke, be awkward; (2) a tendency to work through difficult conceptual issues in relation to specific empirical cases, deflating grandiose theoretical concepts and claims (and even some ordinary ones); (3) an emphasis on the local, specific and contingent in relation to the genesis and use of science and technology; (4) caution about the unreflexive adoption and deployment of standard social science lexicons (e.g. power, culture, meaning, value); (5) reflexive attention to the (frequently unexplicated) notions of our audiences, value and utility... Consistent with the premise that users are performed, enacted, and configured (Woolgar, 1991a), for a whole range of cultural artefacts, this style of STS maintains an active interest in the transposition of social science research across sometimes challenging social-organizational boundaries. This we construe as a radical intellectual challenge, not merely a political preference or a practical obligation.

A range of conceptual and methodological framings employing sociomaterial analysis, or what Law (2009) suggests we call ‘material semiotics’, has commanded recent attention in the social sciences more broadly. However, this range is less evident in studies of workplace learning. Apart from the relative prominence in work-learning studies of cultural-historical activity theory or CHAT (e.g. Engstrom; Sawchuk 2003; Unwin/Fuller 2004) and a few analyses informed by actor-network theory (ANT) (e.g. Edwards/Nicoll 2007; Fox 2000; Mulcahy 1999/2007), there does not yet exist a vibrant conversation about and among sociomaterial conceptions.

The purpose of this paper is to open a dialogue that compares theoretical conceptions that reclaim and re-think material practice – how *matter* comes to matter in the social and personal mix – specifically in terms of work activity and what is construed to be learning in that activity. Three perspectives have been selected for comparison: CHAT, ANT, and complexity theory. The three bear some similarities in their conceptualization of knowledge and capabilities as emerging - simultaneously with material elements, identities, policies, practices and environment - in webs of interconnections between heterogeneous entities, human and nonhuman. Each illuminates very different facets of the sociomaterial that can afford important understandings related to conceptions of ‘learning’ and knowledge in work-based practice: about how subjectivities are produced in work, how knowledge circulates and sediments into formations of power, and how practices are configured and re-configured. Yet each perspective is itself a slippery, heterogeneous and contested site of inquiry².

² Important critiques – and responses – have been generated as these theoretical conceptions have proliferated in a range of uptakes across the social sciences, including education and organization studies. Issues of subjectivity, ethics, dangers of totalization and formulaic models, researchers’ presence, representation of absence and multiplicity, etc have been widely debated within each conception. While

This discussion employs the terms work and learning cautiously. Conceptions of ‘work’ across different fields are multiple and resist synthesis. Work has been analysed as paid and unpaid, linked to the formal economy or not, visible and invisible, based in organizational action, household chores, caregiving, or individual reflection, distributed across multiple sites and even continents, virtual or continuously mobile. Enactments of work and their effects, such as forms of oppressions and privileges, vary profoundly depending on particulars: geographic regions; public, private, domestic or not-for-profit settings; or on whether we are referring to tradesworkers or managers, self-employed professionals, farmers, indentured labourers, academics, bloggers, and so on. Any generalized theory of work must ignore all the exceptions or distort them to fit a singular pre-conceived model. Similarly in discussing ‘learning’, a term which has come to be applied to a vast range of processes from information transmission to individual development to emancipatory transformation, there is no unitary definition that can adequately represent the multiple and contested perspectives. Here, learning is treated differently in each conception and no attempt will be made to synthesize them in one transcendent pronouncement.

In the following discussion these three conceptual framings are compared in context of their uptake in work-learning research. Both their diverse contributions and their limitations are explored on questions of power, difference, and the material: how and why *matter* matters in the processes of becoming and knowing that constitute the worlds of work.

Socio-material perspectives on learning and knowledge in work

Practices of work, including practices conceived as ‘learning’, are most often discussed in social and cultural terms. Overly psychologized and acquisitive perspectives of learning in work as confined to the personal and the individual have gradually given way to more collective or participative understandings of knowledge construction (Fenwick 2008). Often these notions of participation are confined to human interactions, focusing on social relations and cultural forces and the ways in which humans ‘use’ tools or move through ‘contexts’. In such conceptualizations, the very processes of materialization that designate these different entities and their possibilities for interaction become obscured.

Sociomaterial accounts, what some might call posthumanist perspectives, claim that matter is a critical force in the constitution and recognition of all entities, their relations, and the ways they change (or ‘learn’). Sociomaterial perspectives not only question the acceptance of differential categories such as individual/organization and binaries of subject/object, knower/known etc, but also challenge the givenness of fundamental distinctions between human and non-human. The assumption that entities are anterior to their representation is refuted, to focus on the material and discursive practices through

such debates cannot be addressed satisfactorily in this brief overview, interested readers might start by consulting Sawchuk et al (2005), *Educational Philosophy and Theory* Vol 40 No 1 (2008) (special issue on complexity and education), Osberg and Biesta (2009), Law and Hassard (1999), and Fenwick and Edwards (2010 forthcoming).

which entities and their interactions are enacted into being. Sociomaterial accounts also examine how the differential boundaries separating entities are stabilized, and destabilized. The point is not to reify or bring into focus ‘things’. The point is in fact to contest the notion that things (including objects, texts, human bodies, intentions, concepts etc) exist separately and prior to the lines of relations that must be constructed among them, and to examine the dynamic process of materialization – including material and discursive practices – through which things emerge and act in what are indeterminate entanglements of local everyday practice.

In such accounts, all entities are understood to be mutually constituted - in their distinct boundaries, properties, directions of action, and relations with other entities – simultaneously with the constitution of the dynamic phenomena and events in which they are implicated, within and through the ongoing flux of multiple interactions and connections. As Barad (2003: 817) puts it, “The world is an ongoing open process of mattering through which “mattering” itself acquires meaning and form in the realization of different agential possibilities”. Different theoretical accounts conceptualize and name this mutual sociomaterial constitution differently. Complexity theory talks about co-specification (Varela et al 1991) where two entities become attracted and, through their association, begin to imitate one another and to link together. A series of dynamic, nonlinear interactions produce ‘emergence’ (Davis/Sumara 2006), the understanding that in (complex adaptive) systems, phenomena, events and actors are mutually dependent, mutually constitutive, and actually emerge together in dynamic structures. Actor-network theory talks about ‘translation’ (Latour 2005), the process by which entities, human and nonhuman, come together and connect, changing (‘translating’) one another to form links that bring forth networks of coordinated action and things.

These themes are taken up to a greater or lesser extent in the three sociomaterial perspectives selected for discussion here: complexity theory, cultural-historical activity theory, and actor-network theory. Each is rooted in different, often contested, positions about the nature of knowledge, being, agency, practice, and the relations of knower with known and subjects with objects. However, each has been employed by analysts to interrogate phenomena associated with what some call ‘learning’ in work contexts. This discussion is limited to a brief comparative overview of these perspectives, as an extended dialogue among them is not possible within the confines of this paper.

Learning as emergence of collective cognition and environment: complexity theory

‘Complexity theory’ is actually a heterogeneous body of theories originating in evolutionary biology, mathematical fractals and general systems theory, and including enactivism, cybernetics, chaos theory, autopoietic theories, and so on. The present discussion draws from analysts who have theorized complexity theory in terms of human and organizational learning (e.g. Davis/Sumara 2006; Osberg/Biesta 2007; Stacey 2005). Complexity theory provides one approach to understanding learning processes in a system such as a work organisation. The first premise is that the systems represented by person and context are inseparable, and the second that change occurs from emerging systems affected by the intentional tinkering of one with the other. The key theme is *emergence*, the understanding that in (complex adaptive) systems,

phenomena, events and actors are mutually dependent, mutually constitutive, and actually emerge together in dynamic structures.

Davis and Sumara (2006) among others have applied these concepts to human learning, showing how environment and learners emerge together in the process of emergent cognition. Elements that come to comprise a system interact according to simple rules that are recursively re-enacted. Elements often couple, in a process of co specification (Varela et al 1991). As each element interacts and responds within the activity, the overall shape and direction of the system shifts, as does the emerging object of focus. Other elements are changed, the relational space among them all changes, and the looping-back changes each element's form and actions. The resultant coupling changes or 'co-specifies' each participant, creating a new transcendent unity of action and identities that could not have been achieved independently. These interactions are recursive, continuing to elaborate what is present and what is possible in the system. They also form patterns all by themselves – they do not organize according to some sort of externally imposed blueprint – so complexity theorists describe such systems as *self-organizing*. That is, through the ongoing processes of recursively elaborative adaptation, the system can maintain its form without some externally-imposed discipline or organizing device, such as hierarchical management.

In work organisations, people constantly influence and adjust to each other's emerging behaviours, ideas, and intentions - as well as with objects, furniture, technologies, etc - through myriad complex interactions and fluctuations. A whole series of consequences emerge from these micro actions. Most of this complex joint action leaks out of individual attempts to control what they are doing. No clear lines of causation can be traced from these interactions to their outcomes, because at any given time among all these interconnections, possibilities are contained in the system that are not visible or realized. This means, among other things, that humans are fully nested within and interconnected with many elements of the systems comprising them and in which they participate. They are not considered to be autonomous, sovereign agents for whom knowledge can be acquired or extracted.

And yet, in our observation and recall of such occurrences, the tendency is to focus on the (human) learning *figure* and dismiss all these sociomaterial complex interactions within which the figure becomes visible as 'background'. Complexity science urges a refocusing on the relations that produce things, not the things themselves. Out of these continuous and non-linear interactions emerge dynamic wholes that exceed their parts. Osberg and Biesta (2007) call this 'strong emergence': conditions where the knowledge and capability that emerges is more than the sum of its parts, and therefore not predictable from the 'ground' it emerges from. Johnson (2001) shows that this emergence is enabled in systems characterized by diversity, decentralisation, redundancy, open constraints and feedback.

Overall, in complexity theory knowledge and action are understood as continuous invention and exploration, produced through relations among consciousness, identity, action and interaction, objects and structural dynamics. New possibilities for action are constantly emerging among these interactions of complex systems, and cognition occurs in the possibility for unpredictable shared action. Knowledge or skill cannot be contained in any one element or dimension of a system, for knowledge is constantly emerging and spilling into other systems. No actor has an

essential self or knowledge outside these relationships: nothing is given in the order of things, but performs itself into existence. In human resource development applications of complexity theory, attention would be drawn to the relationships among learners and the environment. For example, an organizational change initiative would focus on enabling connections instead of training individuals to ‘acquire’ understanding of the new policy – connections between this initiative and the many other initiatives likely to be lurking in the system, between parts of the system, between the initiative and the system’s cultures, and between people, language and technologies involved in the change. It would encourage experimentation among people and objects involved in the change, and would focus on amplifying the advantageous possibilities that emerge among these connections as people tinker with objects and language involved. Learning is defined as expanded possibilities for action, or becoming ‘capable of more sophisticated, more flexible, more creative action’ (Davis/Sumara2006).

Learning as expansion of objects and ideas: cultural-historical activity theory

Cultural-historical activity theory (CHAT), by now well-known to analysts of work-based practice and learning, analyses these ongoing dynamic interactions with an “expansive” view of learning (Engeström 2001; Fuller/Unwin 2004). Derived from activity theory with Marxist roots, CHAT focuses on activity as the unit of analysis. It highlights the sociomaterial interactions particularly among artefacts, system objects and patterns, individual/group perspectives, and the histories through which these dynamics emerged. Material artefacts (objects, tools, technologies, signs) are considered a primary means of transmitting knowledge, for artefacts are understood to consolidate knowledge, mediate social interaction and the negotiation of knowledge, and suggest alternative modes of operation (Miettinen et al. 2008). CHAT studies examine a system’s historical emergences and relations among these material artefacts as well as divisions of labour, cultural norms and perspectives enmeshed in the system: “how things came to be as they are, how they came to be viewed in ways that they are, and how they are appropriated in the course of developmental trajectories” (Sawchuk 2003). Close attention is given to the system’s “objects” (the problem spaces at which action is directed). Emphasis is placed on the contradictions inherent within organizations, such as the common tension between emphasis on competency and control and injunctions for innovation involving risk and experimentation. When these contradictions become sufficiently exacerbated or questioned through actors’ negotiations, ‘learning’ occurs – where learning is viewed as collective ‘expansion’ of the system’s objective and practices.

From a CHAT perspective then, expansive learning is fundamentally a mediated process, explained as the “construction and resolution of successively evolving tensions or contradictions in a complex system that includes the object or objects, the mediating artifacts, and the perspectives of the participants” (Engeström 1999: 384). As various forms of contradiction are partially or wholly resolved, the system’s learning, knowledge, ‘objects’ and related practices become expanded. Thus expansive learning involves shifts in the system’s activity purposes and processes, in the problems that are framed and the knowledge that becomes visible: it is particularly useful for understanding innovation or the uptake of knowledge-creation in organizations (Engeström 1999) What becomes distinguished as novel or useful depends on what problems become uppermost in a

particular activity system, what knowledge is valued most there, and indeed what knowledge is recognized and responded to by the system elements.

Sawchuk's (2003:21) study of technology learning among workers showed how people's participation in computer learning practices was inseparable from sociomaterial dynamics: "integrated with everyday life and mediated by artifacts including computer hardware and software, organizational settings, oral devices, class habitus, trade unions, and working-class culture". He analysed encounters among participants to reveal how their "patchwork" of learning opportunities unfolded in informal networks across overlapping systems of activity - on the job as well as at home with the kids, fixing a car with buddies, struggling in computer labs,. The material dynamics of these systems - their artifacts and the histories and cultures embedding these artifacts in practices - are as important as the social dimensions of community, language, routines and perspectives in tracing the knowledge that is produced and the changes in people and practices that emerge through contradictions.

Learning as 'translation' and mobilization: actor network theory

Actor-network theory (ANT), claim its continuing proponents, is not a theory but a sensibility - indeed, many diffused sensibilities that have evolved in ways that eschew its original tenets. Their shared commitment is to trace the process by which elements come together - and manage to *hold* together - to assemble collectives, or 'networks' in ANT-ese. These networks produce force and other effects: knowledge, identities, rules, routines, behaviours, new technologies and instruments, regulatory regimes, reforms, illnesses and so forth. No anterior distinctions such as 'human being' or social 'structure' are recognized. Selected concepts of this field that have been most frequently applied to questions of learning, knowledge generation and practice include central notions of: *symmetry* - that objects, nature, technology and humans all exercise influence in assembling and mobilizing the 'networks' that comprise tools, knowledge, institutions, policies, and identities; *translation* and *stabilization* - the micro-negotiations that work to perform networks into existence and maintain them while concealing these dynamic translations; the processes of *enrolment and mobilization* that work to include and exclude; and the *fluid objects* and quasi-objects produced by networks that perform themselves as stable, even 'black-boxed', knowledge and bodies (Fenwick/Edwards forthcoming).

ANT takes knowledge generation to be a joint exercise of relational strategies within networks that are spread across space and time and performed through inanimate - e.g. books, mobile phones, measuring instruments, projection screens, boxes, locks - as well as animate beings in precarious arrangements. Learning and knowing are performed in the processes of assembling and maintaining these networks, as well as in the negotiations that occur at various nodes comprising a network. ANT studies are particularly useful for tracing the ways that things come together. It can show how things are invited or excluded, how some linkages work and others don't, and how connections are bolstered to make themselves stable and durable by linking to other networks and things. Further, and perhaps most interesting, ANT focuses on the minute negotiations that go on at the points of connection. Things - not just humans, but the parts that make up humans and nonhumans - persuade, coerce, seduce, resist, and compromise each other as they come together. They may connect with other things in ways that lock them into a

particular collective, or they may pretend to connect, partially connect, or feel disconnected and excluded even when they are connected.

Gherardi and Nicolini (2000) studied how cement-laying workmen learn safety skills, using actor-network theory to examine how knowledge is 'translated' at every point as it moves through a system. Safety knowledge was embedded throughout the system: in safety manuals, protective equipment that workers were required to wear and use, signs reinforcing safety rules, and inspectors with lists of specific safety practices. However at each node within this system, safety knowledge was continually being modified or even transgressed. For example, one workman would show another how to change a new safety procedure to make a task easier, or two together would modify a tool to solve a problem, depending on who was watching, of course. At other points in the system, the crew foreman negotiated the language of the safety assessment report with the industrial inspector. Deadlines and weather conditions caused different safety knowledge to be performed and different standards of evaluation. The equipment itself, and the crew's culture, embedded or 'grounded' a history of use possibilities and constraints that influenced the safety skills performed by those who interacted with the equipment. No skill or knowledge had a recognizable existence outside its use within the sociomaterial networks of the inter-connected networks. In ANT readings, nothing is given in the order of things, but performs itself into existence.

Discussion: sociomaterial perspectives of learning

All three perspectives - complexity theory, cultural-historical activity theory and actor-network theory - while deriving from very different theoretical roots and premises, bear commonalities. First, all three take the *whole system* as the unit of analysis, appreciating human/nonhuman action and knowledge as entangled in systemic webs, and acknowledging the processes of boundary-making and exclusion that establish what is taken to be a 'system' and its 'elements'. Second, they all focus on closely tracing the formations and stabilization of elements - all bodies including knowledge - that are produced, reinforced or transformed by subjects that emerge with/in a particular activity. That is, they all trace *interactions among non-human as well as human* parts of the system, emphasizing both the heterogeneity of system elements and the need to focus on relations, not separate things or separate individuals. Third, they all understand human knowledge and learning in the system to be embedded in *material action and inter-action (or intra-action)*, rather than focusing on internalized concepts, meanings and feelings of any one participant. In other words, they do not privilege human consciousness or intention, but trace how knowledge, knowers and known (representations, subjects and objects) emerge together with/in activity.

More perhaps than the other perspectives, complexity theory provides a rich analysis of the *biological* (as well as social, personal, cultural) flows inherent in materialization processes, the elaborate intertwining of human/nonhuman elements, and the non-linear simultaneous dynamics and conditions which produce *emergence*. The 'system' in complexity theory is an effect produced through self-organization via these dynamics and is continuously adaptive, so studies are able to model system patterns in various scalar spaces as they interact, shift and change. Knowledge (e.g. new possibilities, innovations, practices) emerges along with identities and environments when the system affords sufficient diversity, redundancy and multiple feedback

loops. Diversity is not to be ‘managed’ towards producing greater homogeneity, as some approaches to workplace learning might advocate, but to be interconnected. In elaborating this point, Davis (2006) explains that difference in an identified system needs ways to become visible – the conditions must enable the enactment of difference - which it often is not. As diverse elements become enacted they must also be able to interconnect through overlap. In classrooms or organizations, emergence can be enabled where there is diversity and constraints (purposes and rules of engagement) through: amplifying difference and perturbations, decentralizing organizing processes, encouraging continuous interaction, and ensuring ongoing feedback among various elements/sites (Davis/Sumara 2006; Stacey 2005).

By contrast, in cultural-historical activity theory, organizations are viewed as sites of central contradictions and ideological struggle between those who control the means of production and those whose labour and knowledge are exploited. These are the Marxist roots of this theory, although it moves well beyond binary conceptions of organizations as sites of class struggle between dominant and oppressed groups, where ‘learning’ is conceived as either reproducing given power relations or transforming them through collective politicization and resistance. The Marxist notion of systemic ‘contradictions’ is central to CHAT, and individual perspectives and interests are constantly at play in negotiating these contradictions. In these features, CHAT retains a more humanist orientation than either complexity or ANT. This human-centric analysis is also evident in the clear delineation of non-human ‘artefacts’ as bounded, distinct from humans, and while embedding cultural histories, are relegated to the role of mediating human activity. CHAT also foregrounds a socio-political analysis of human activity, including constructs such as ‘division of labour’ and ‘community’ (and even social class, prominent in many CHAT analyses), which is anterior to the emergence of elements that may or may not comprise a ‘system’. However, CHAT affords a rich approach to analysing precisely these political dynamics that are so important to workplace organizations while insisting that these dynamics intermingle the material with the social. Complexity theory can only address the political through severe (and some would argue inappropriate) stretching of its constructs. CHAT also theorizes the historical emergence of the socio-cultural/material in activity systems in ways that complexity theory cannot.

ANT approaches have been compared to CHAT although they share little in their ontological assumptions (for an extended comparison from an activity theory perspective working with early ANT accounts, see Miettinen 1999). ANT (including the many *after*ANT commentaries) offers the most radical material challenge to understandings of learning, work and organization. When anyone speaks of a system or structure ANT asks, How has it been compiled? Where is it? What is holding it together? All things are assemblies, connected in precarious networks that require much ongoing work to sustain their linkages. ANT traces how these assemblages are made and sustained, how they order behaviours as well as space and objects, but also how they can be unmade and how ‘counter-networks’ or alternative forms and spaces can take shape and develop strength. ANT has also challenged the tendency to seek ‘relations’, showing that the relative stability of certain networks occurs not through their coherences but through their incoherences and ambivalences. ANT commentators play with scale, and reject dualisms of local/global or micro/macro. There are no supra-structural entities, explains Latour (1999:18), because “big does not mean ‘really’ big or ‘overall’ or ‘overarching’, but

connected, blind, local, mediated, related". ANT also shows how knowledge is generated through the process and effects of these assemblages coming together. ANT offers us, finally, a way to challenge notions of 'learning' as a process occurring in individuals' conscious minds. In ANT, all things are network effects: a concept, a text, an organizational routine or breakdown, an oppressive regime, a teacher, worker or manager. In fact any thing or human being, human intention, consciousness, desire, etc emerges and oscillates through various translations at play in material network effects, sometimes appearing simultaneously as multiple ontologies. ANT focuses on the circulating forces and minute interactions that get things done through the networks/*assemblages* of elements acting upon one another. As Latour (2005: 44) wrote:

Action is not done under the full control of consciousness; action should rather be felt as a node, a knot, and a conglomerate of many surprising sets of agencies that have to be slowly disentangled. It is this venerable source of uncertainty that we wish to render vivid again in the odd expression of actor-network.

And what about theorization of work³ in each perspective? Clearly, CHAT focuses explicitly on work in Marxist terms, as a specific societal activity where workers are alienated from work while induced to engage it as meaningful. These terms pre-configure particular concepts of society and the social, as well as particular forms of activity called 'work' and human bodies in distinct roles as 'workers'. These terms also are linked to concepts of value (use and exchange), capital and ownership, creating windows of analysis that shape observation of organizational activities, including whatever is construed to be work and learning activity. In complexity theory, 'work' is not distinguished from other activities comprising the emergence of a system, as an economically structured set of relations and activities. Nor does complexity theory equate an organization or other site of work to a complex adaptive system. Boundaries are conceptualized as emerging through self-organizing processes. However, organizational theorists such as Stacey (2005) have shown how complexity theory can illuminate the emergence of novel forms of order in (work) activity, the uncanny ways that a system self-modifies regardless of efforts to manipulate it (e.g. through labour strikes, technological implementations, or managerial interventions), and the importance of micro-interconnections among people and things that can create massive and unpredictable changes. Actor-network theory also does not explicitly differentiate 'work' from any other activity, and indeed invites us to consider how we might argue for a sensible distinction. Nonetheless, ANT is closely attuned to the politics through which particular practices and purposes (that some may associate with 'work') come to be assembled and extended to translate a range of identities, behaviours, bodies, commitments, and so forth. ANT's particular interest in how heterogeneous things, human and nonhuman, came to be connected to form these practices, and the quantities of work that hold them together in the face of blockages and counter-networks, is useful for showing how powerful, entrenched networks emerge and are sustained, as well as for glimpsing openings within such networks for alternate possibilities. Neither ANT nor complexity theory accepts anterior constructs such as 'work' and 'alienation', or 'structure' and 'agency', as they begin from different understandings of what constitutes reality. One difficulty of reading these three perspectives against each other is maintaining faith in their own distinct metaphysics.

³ I am indebted to an anonymous reviewer who suggested that CHAT is the only perspective of the three to explicitly theorize work. While this may be true, CHAT's analysis of 'work' emerges from a particular metaphysics that other perspectives do not share, based on anterior constructs and generating normative assumptions about what comprises work, the 'worker', and society.

To impose the constructs of one upon another to evaluate its capacity for robust analysis is to commit an error of the fold: insisting on ontological singularity and folding all perspectives into one which is granted a transcendent status.

For all three perspectives, questions of interest are around how disparate elements and their linkages are performed and reconfigured through local practices of materialization. All three examine how practices become fixed and durable in time and space, and seek out the ambivalences, uncertainties and contradictions – the openings. A key contribution of them all is to de-couple learning and knowledge production from a strictly human-centered socio-cultural ontology, and to liberate agency from its conceptual confines as a human-generated force. Instead, agency as well as knowledge is understood as *enacted* in the emergence and interactions – as well as the exclusionings - occurring in the smallest encounters. In these material enactments, this ‘material-discursive agency’, boundaries and properties of elements come into being, subjects and objects are delineated, and relations are constituted that appear to glue them together. Nothing is determined, and (unknown) radical future possibilities are available at every encounter.

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