Chapter 5
Matterings of Knowing and Doing: Sociomaterial Approaches to Understanding Practice

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Introduction

'Practice', both as an enactment of and a medium for learning, has been argued throughout this volume to weave knowledge together with action, conversation and affect in purposeful and regularized orderings of human activity. Most educators who would describe their orientation to learning as 'practice-based' would likely agree in principle with Schatzki's (2001) definition of practice as 'embodied, materially mediated arrays of human activity centrally organized round shared practical understanding' (p 2). However, the 'embodied, materially mediated' dimensions of practice tend to remain somewhat under-theorized. What comprises materiality, exactly? How do material phenomena become interlaced in practice, and how do they affect learning and action? What are the architectures and flows of material elements in practice, what force can they exert and how do they change or become reconfigured? The 'embodied' dimension of practice, too, invites closer analysis. What or whose bodies, how are they mobilized and how are they distinguished in practice? What constitutes a 'body'? The purpose of this chapter is to open a dialogue among theoretical conceptions that reclaim and rethink material practice—how *matter* comes to matter in the social and personal mix—specifically in terms of practice and what are the relations of learning to practice.

First, however, let us look more closely at certain under-theorized aspects of practice-based learning in terms of what may be gained through closer attention to materiality. One of these is the different *kinds* of practice that are at play, often simultaneously, in many organized human endeavours such as work activity. These include codified approved practices such as professional standards, everyday

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routines that are collectively recognized but may or may not be codified and adaptive practices such as workarounds and rule bending that are often engaged to make codified practices work. But beyond the more explicit practices comprising a recognized collective activity, there are many practices that are more implicit, practices that are widely understood and that support and even frame the more explicit practices. These include particular knowledge practices of sorting, interpreting, coding, etc., memory practices, tool practices and conversational practices that may be so taken for granted. They are no longer visible, at least until they are specially foregrounded. There are also transgressive practices, of imagination or disruption, that emerge and gain force in entirely different ways. Finally, there are practices through which a practice is assembled, such as literacy practices and particular organizing practices. What diverse material processes, connections, stimuli and forces are at work in generating, expanding and sustaining—or constraining—these multifarious forms of practice?

A second under-theorized issue in discussions of practice is that of *participation*. 'Participation' is prevalent in learning literature as a contrast to 'acquisition' views of learning as cognitive, conceptual and individual. In this representation, participation is often equated unproblematically with activity, or with 'engagement' with an emphasis on 'doing'. Materially speaking, both activity and participation offer different views on the complex transaction of humans and the objects comprising their environments. The relative lack of robust analysis in practice-based learning of the complexities of participation can perhaps help to explain why the concept of 'legitimate peripheral participation' (Lave and Wenger 1991), originally set forth to explain apprenticeship of novices, was so quickly adopted to explain participation in communities more generally—despite the problems of so crudely representing participation-for-learning as a movement from margin to centre. Material considerations of participation foreground not only the material dimensions of human activity and human bodies but also the non-human participants in a practice: texts, instruments, technologies, furniture, weather, etc. What different forms of participation (and partial or non-participation), on the part of both human and non-human actors, are possible in holding together a practice? What forms of participation bring about change or dissolution of a practice? What different modes of participation are linked with different forms of learning? How do different locations of participation, from outside or inside a practice, affect learning? Taken further, the question of participation's relation to practice invites questions about the distinction between a *practice*, the process of *practicing* and the state of being *practiced*: What does it mean to participate in these different modes, and what are the implications for learning?

A third question is about how practice actually becomes *reconfigured* or transformed. The 'community of practice' concept popularized by Wenger (1998) has been critiqued for its inherent processes of reproduction. Once a practice has become stabilized, new adherents are inducted into its routines and objects in ways that do not necessarily enable, or even endorse, transformative energies of resistance, creative adaptations or subversion. The whole orientation of 'practice-based learning', then, could be criticized for promoting what is essentially a highly conservative, a-critical direction where what is valued as the most important knowledge and skill is simply

that which ensures the continued dominance of historical routines and hierarchies. A practice in itself does not necessarily embed the seeds for change, either through innovation or self-critique—or does it?

Theories that specifically trace the material aspects of practice can be helpful in beginning to address such questions. Materiality includes tools, technologies, bodies, actions and objects, but not in ways that treat these as 'brute' or inherently separate and distinct from humans as users and designers. Materiality also includes texts and discourses but not in ways that over-privilege linguistic, intertextual and cultural circulations. Overall, a foregrounding of materiality helps to avoid putting human actors and human meaning at the centre of practice. It avoids treating material things as mere appendages to human intention and design, or as traces of human culture. Among perspectives that seem to be part of this pervasive shift, 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.

A range of conceptual and methodological framings foregrounding this sort of sociomaterial analysis and its relations with social relations has commanded prominent attention in the social sciences broadly. In learning studies, three materially oriented theoretical perspectives are particularly prevalent: cultural-historical activity theory or CHAT, actor-network theory (ANT) and complexity theory.[1] 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 non-human. Each illuminates very different facets of the sociomaterial that can afford important understandings related to conceptions of 'learning' and knowledge in practice: about how subjectivities are produced in practice, how knowledge circulates and sediments into formations of power and how practices are configured and reconfigured. However, it is important to note that within each perspective there range a diversity of orientations, strong contestations and lively critical debates which have been discussed at length elsewhere.[2] In fact, more disparity than resemblance may appear evident among the educational studies conducted in the name of CHAT, ANT or complexity. Of course, this phenomenon is not atypical of any theoretical field that expands and diversifies over time and is adapted for various applications: witness the proliferations in education of Marxist analyses, some more relevant or rigorous than others, some directly opposing one other's assertions and some creating downright absurd or simplistic accounts. The problem is the attempt to represent such diversity and critique—a necessarily reductionist and even presumptive activity when any single account such as this will be framed and limited by one author's particular perspective. Indeed, some registers of these perspectives resist representation of any kind, aiming to open questions and sensibilities meant to interrupt authoritative theoretical narratives rather than to erect new ones. Furthermore, this chapter is a very small space in which to unfold such expansive theoretical complexity. The most that may be done is to offer a few introductory comments about each perspective. These are but provisional and partial comments that can only gesture to, rather than explicate, possibilities that may be afforded

through these perspectives. The following discussion, therefore, gestures to the possible insights afforded by CHAT, ANT and complexity for practice-based learning: how and why *matter* matters in processes of becoming and knowing.

Sociomaterial Perspectives on Practice and Learning

Sociomaterial accounts, what some might call post-humanist 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 exist prior to their representation is rejected. Instead, inquiry begins by wondering what sorts of material and discursive practices enact entities and their connections into existence. Sociomaterial accounts also examine how the different boundaries separating entities are stabilized and destabilized. The point is not to reify or to focus on '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.

Humans and what they take to be their learning and social processes do not float, distinct, in 'contexts' of practice that are a background of material stuff and spaces. The things that assemble these contexts, the actions and bodies 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— as 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 practice and the processes of learning.

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, or at least some versions of it, talks about co-specification where two entities become attracted and, through their association, begin to imitate one another and to link together. A series of dynamic, non-linear interactions produce 'emergence' (Davis and Sumara 2006). This is the phenomenon in (complex adaptive) systems

whereby events and actors are mutually dependent, mutually constitutive and actually emerge together in dynamic structures. Actor-network theory traditionally has talked in terms of 'translation' (Latour 2005), the process by which entities, human and non-human, come together and connect. They change ('translate') one another to form links that bring forth networks of coordinated action and things.

But, ask some, how can matter and material things have 'agency'? Objects clearly don't make choices, don't form meanings, except in the hands of humans. And aren't humans the ones creating all these accounts of objects in the final analysis? Isn't this emphasis on materiality simply attributing human qualities to non-human phenomena, in a long-standing tradition of anthropomorphizing our worlds? The response to these important queries lies in pointing again to the ontology of *assemblage*, of webs of relations, and emphasizing again that the point here is not to isolate and reify the *thing*, as though material 'things' are separate from human beings and we are now attributing intentions and agency to things. In fact, the concept of 'agency' has traditionally been limited by its human-centric definitions associated with intention, initiative and exercises of power. Callon (2005), an ANT commentator, defines agency as 'capacity to act and to give meaning to action'—which enables us to understand agency as collective, relational and distributed. Bennett (2010) draws from sociomaterial theories (ANT and complexity in particular) to show how all phenomena and events can be conceived as 'vital materiality'. Agency is understood as a distributed *effect* produced in material webs of human and non-human assemblages. Agency is possible only through networks/assemblages whereby human desire and interests, for instance, become linked with things like policies deregulating electricity, transmission wires, understaffed power plants, buildings with increased demand for electricity, energy trading corporations and a brush fire—to cite Bennett's example of the massive 2003 New York City blackout. The important issues are not *where* agency is located or what *kind* of agency is human or non-human, but rather the profound *uncertainty* about the nature of action, and controversies about how agency is distributed.

These are some of the themes that appear in accounts of the three sociomaterial perspectives selected for discussion here: complexity theory, cultural-historical activity theory and actor-network theory. It bears repeating that each perspective not only represents a vast diversity of interpretations but that each is also rooted in very different assumptions about the nature of knowing, being, agency and practice. Each also has been used to interrogate what some call 'learning' in 'practice', showing ways to understand diverse kinds of practice, the nature of participation and how practices become reconfigured.

Learning as Emergence of Collective Cognition and Environment: Complexity Theory

What we refer to as 'complexity theory' comprises a highly heterogeneous set of perspectives with origins in evolutionary biology, mathematical fractals, general systems theory, cybernetics and other sources. Educationists who theorize learning

with complexity theory do so in diverse ways, reflecting different traditions of complexity. Perhaps one key contribution of some of these studies is to show how practices become reconfigured, through non-linear dynamics of emergence that are unpredictable and always open to radical possibility.

One central understanding in complexity, at least in many educational and organizational uptakes of complexity theory, is *emergence*. This is the idea that in (complex adaptive) systems, phenomena, events and actors are mutually dependent, mutually constitutive and actually *emerge together* in dynamic structures. That is, the nature of the system as well as its elements and their practices—both human and non-human—emerges through the continuous rich and recursive improvizational interactions among these elements. In Prigogine's terms (1997), in any complex system comprising a practice, the non-linear dynamics at play mean that a series of choices is available at each moment, *to each and every interacting element of the system*, human and non-human. Not only are choices being made by these entities in ways that are not accessible to human consciousness, but also the forces affecting these choices are often not visible, or even present, in the system at any given moment. Among the possibilities emerging at any given time in the system, it is impossible to predict which will *most influence* what will happen next. This is partly because the principles influencing the system's choices for action and knowledge are *not already given* in the system's present patterns or its parts and practices—they emerge too, in the dynamic processes of emergence. Once a choice is made, it is irreversible—because that choice immediately spawns a new set of choice-making activities among entities affected by that choice. Prigogine stressed the importance of both interaction and the presence of large numbers to evoke the phenomena of emergence. Within these masses of interaction, the smaller parts of the system become energized and sensitive to even minor fluctuations. When energy is applied to a system, such as external pressures or amplifications of disturbances within a system, it moves to a state far from equilibrium, when it shifts to new patterns in a series of jumps, not incremental steps. Novel patterns are thus continually emerging in surprising ways that often refute laws of causality. The result is an essential undecidability for practice, for knowledge and for education (Osberg et al. 2008).

In any practice, 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. These interactions are recursive, continuing to elaborate what is present and what is possible in the system. In terms of learning, complexity theorist Brent Davis et al. (2000: 74) describe emergence as 'a new understanding of cognition':

Rather than being cast as a locatable process or phenomenon, cognition has been reinterpreted as a joint participation, a choreography. An agent's knowing, in this sense, are those patterns of acting that afford it a coherence—that is, that make it discernible as a unity, a wholeness, an identity. The question, 'Where does cognition happen?' is thus equivalent to, 'Who or what is perceived to be acting?' In this way, a rain forest is cognitive—and humanity is necessarily participating in its cogitations/evolutions. That is, our habits of thought are entwined and implicated in unfolding global conditions.

All complex adaptive systems—forests, weather patterns, stock markets, school districts or groups of students—learn, where learning is defined as transformation that expands the system's potential range of action. Research on HIV-AIDs systems, for example, demonstrates that the immune system remembers, forgets, recognizes, hypothesizes, errors, adapts and thus learns (Davis and Sumara 2006). A traffic system of roads and intersections, car manufacturers and parkades, traffic lights that malfunction now and then and unexpected roadslides that block passage continually adapts and reconfigures itself. Human beings are nested within these larger systems that are continuously learning, and as participants in these systems, humans bear their characteristics in the ways that the single fern leaf resembles the whole fern plant. Learning also could be the sudden jumps in the system's phase states, its transformations, as it experiences disturbances and internal fluctuations that can become amplified. Cognition occurs in the new possibilities that are always opening for unpredictable shared action. Learning is defined as expanded possibilities for action, or becoming 'capable of more sophisticated, more flexible, more creative action' (Davis and Sumara 2006).

These complexity concepts of the materiality of learning are increasingly being applied to professional practice. Haggis (2009), for instance, has shown how professionals might be taught complexity concepts to help them understand the material simultaneities in which they must work, and opening a more flexible, emergent forms of response. McMurtry (2007) introduced a complexity-based approach to interprofessional practice in health care. Practitioners learned to attune to the diversity and interconnections of various elements, including embedded knowledge, in the material practices of different professional domains. Practitioners also learned to apply complexity's nested systems concepts to understand their participation. They developed awareness of how their own actions produced unanticipated consequences in the different nested systems in which their actions were nested: patients and families, system policies, databases and patient charts, interprofessional talk, hospital instruments, pharmaceuticals, community resources and so forth. The most effective collaborations and the greatest emergence occurred, not when large overlaps occurred in different professionals' knowledge, but rather when:

> specialization is allowed and encouraged, and differing professional specializations are brought together into coherent—if not always internally homogenous—collective plants, treatments or 'thoughts' through a different kind of commonality: *trust*. (McMurtry 2007: 91)

Learning to trust in practice is conventionally discussed as an intersubjective phenomenon. The complexity approach as adopted by these educational authors, attuned to the interconnections and disturbances among *non-human materials* as well as to human intersubjective elements, suggests a very different perspective of trust in practice. However, the question remains of how power flows within a system to enact particular entities, positions and rewards, which has been debated at length among critical educational writers (see Fenwick et al. 2011). Power may appear to flow through the system according to how, in everyday interactions, people take up positions and understand others' positions in relation to themselves. We might well ask: What knowledge and activities, among the various relations and processes

occurring within the practices of a complex system, are afforded the greatest visibility and influence over the movements and directions of the system? Whose interests are most advantaged or disadvantaged by the practices that emerge? What subjectivities and what possibilities for alternative subjectivities are made available? And for those influenced by more activist concerns, how can better practices—more generative, open, fair and life sustaining—be induced in a complex system, or at least be available as possibilities? The constructs of complexity, originally emerging from biology, mathematics and cybernetics, do not pretend to address such questions. As Davis and Sumara (2008: 169–170) wryly observe:

> Unequal distributions of wealth and power, argue complexivists, are not only inevitabilities; these are phenomena that are given to self-amplification. Consider, for example the way people aggregate into cities. As insulting as it might sound, the emergent patterns of organization do not depend at all on the fact that humans are doing the clustering. The same patterns show up in colonies of bacteria. In fact, they arise when smoke particles deposit on a ceiling. The rich *will* get richer, the advantaged *will* gain more advantage—not because of intention, but because of the laws of nonlinear dynamics. Such statements are met with knowing nods by complexivists and with indignation by critical theorists.

Overall, however, complexity theory, with its concepts of emergence, non-linear dynamics, nested systems and interaction among large numbers of diverse phenomena, seems useful for analyzing the sociomaterial processes through which a practice or nest of practices emerges and changes. Further, as the educational theorists mentioned here have shown, complexity theory may be useful in assisting participants in a practice to understand its dynamics and elements—both the manifest and the invisible, and to learn to participate with greater attunement, resilience and creativity. Whilst complexity does not attempt to address questions of inequities, hierarchies, exclusions or oppression in social practices, we have many other analytic tools provided by critical social theories to examine political processes. Instead, complexity offers insights into the actual non-linear processes of emergences and nestings that produce, stabilize and help disrupt social and natural entities, patterns and activities, including those that create inequity and oppression.

Learning as Expansion of Objects and Ideas: Cultural-Historical Activity

Cultural-historical activity theory (CHAT) analyzes these ongoing dynamic interactions in ways that show how practices arise and how they can become reconfigured. Engeström (2001), one of CHAT's leading proponents, has formulated an 'expansive' view of learning that shows the system dynamics constituting practices but that, unlike complexity, foregrounds human social processes. Here again, there is significant debate, even different 'schools' of CHAT evident now in its many studies of practice-based learning. Some for example treat Engeström's formulations of CHAT very critically (see Fenwick et al. 2011 for discussion). However, his ideas have become so influential in workplace research that they are worth noting. 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). Many 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. Thus, CHAT offers insights not only into how practices become reconfigured but about the different kinds of practices holding a system together and how they emerged historically.

From an Engeström-influenced 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.

CHAT has been used to show how the boundaries and contradictions inherent in any system of practices are lashed together by material as well as discursive, emotional, political and technological dynamics. One example is a study conducted by Edwards et al. (2009) exploring how multi-professional units (social workers, teachers, psychiatrists, etc.) developed new practices to serve vulnerable youth. The multiple boundaries between their professional disciplines, the agencies and stakeholders involved in their work, and the contradictions of values, regulations and structures of practice inherent in their multi-professional unit, offered important spaces for learning. Practitioners were assisted to first recognize these boundaries and contradictions, to analyze how their own actions, language, texts and objects of practice were implicated in sustaining them, and to find the discursive and material levers for expanding these boundaries and contradictions (Edwards et al. 2009). Edwards and

Kinti (2009) also used CHAT to show how effective practice involves 'relational agency', recognizing the motives and resources that others draw upon in enacting and understanding the 'object of activity' or primary task, and working with them to expand this. That is, practitioners can learn to recognize the categories and values at play in the sociomaterial practices of different other specialists, and the language used by these others to mediate their practices. They can learn to engage with these categories and values of others in processes of negotiating action on a single object.

In another example, 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 analyzed 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, or struggling in computer labs. The material dynamics of these systems—their artefacts and the histories and cultures embedding these artefacts 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. These examples are, of course, highly selective and cannot do justice to the vast body of practice-based learning research that has accumulated under the CHAT banner. Some studies focus more on analyzing systems of activity, particularly multiple intersecting systems, revealing how practices conflict and are negotiated. Some versions focus more on understanding the deep contradictions of workplace practices, seeking to show how these embed fundamental oppressions created through the contradictions of a capitalist economy. Other studies are interventionist, working with CHAT approaches to help organizational members analyze and reconfigure problematic practices. Critiques have been levelled at CHAT's sometimes overly formulaic analyses determined by models of triangles, its neglect of emotion and subjectivity in systems and of its failure (in some permutations) to address important contradictions of capitalism. Overall however, CHAT studies have revealed how useful its constructs can be in illuminating how learning is rooted in activity, how boundaries and boundary objects function, how history configures culture and power and how artefacts mediate workplace practices and learning.

Learning as 'Translation' and Mobilization: Actor-Network Theory

Actor-network theory (ANT), claiming its continuing proponents, is not a theory but a sensibility—indeed, many diffused sensibilities that have evolved in ways that eschew its original tenets. Indeed, some writers distance themselves completely from the 'ANT' label even whilst working with ANT language and approaches,

preferring to call their work 'after-ANT' (Law and Hassard 1999) or STS—Science and Technology Studies. 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. In this way, ANT is useful to illuminate different forms of participation in practice—in fact, it shows the limits of notions of 'participation'. ANT approaches can trace the ways that human and non-human energies negotiate their connections and their mutual influences to assemble into some form of practice (or not), that can become extended, or powerful, or contingent, or partial, or prescriptive and so forth. Selected concepts of this field that seem to be most frequently applied to questions of learning, knowledge generation and practice include central notions of the following: *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 whilst 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 and Edwards 2010).

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—for example, books, mobile phones, measuring instruments, projection screens, boxes and 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 non-humans— 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 practice-based learning among cement workers, 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 interconnected networks.

Like the other perspectives, ANT has enjoyed its fair share of critique (see Fenwick and Edwards 2010 for a summary). Much of this has opened new questions and directions for ANT—around which 'actors' are being studied and which are being excluded, about the problems of humans representing human/non-human heterogeneity, about the limits of a 'network metaphor' and about questions of human meaning and subjectivity. A few have critiqued ANT for not addressing issues of power and politics particularly in workplace practice and knowing-in-practice. This position indicates a fundamental misunderstanding of ANT's basic premises and approaches, at least those explained at length and demonstrated empirically by its leading commentators: Bruno Latour, John Law, Michael Callon, Anne-Marie Mol, Vicki Singleton, Kevin Hetherington and many more. For analyzing politics and policy in educational research, Jan Nespor (2002: 376) argues that ANT raises important questions about 'how and in what forms people, representations and arte-facts move, how they are combined, where they get accumulated and what happens when they are hooked up with other networks already in motion'. ANT analyses not only trace the shifting locus of power, how different actors are dominant at different times within different networks but also expose the nuances and ambivalences within this performance of power. ANT's methods begin by following the ways human and non-human capacities become gathered, and stabilized, into patterns that exert power. Its approaches examine closely all the political negotiations and their effects that occur in these gatherings and orderings. In doing so, ANT shows how the entities that we commonly work with and often take for granted as categories in workplace practices, many of them deeply entrenched and continually recreating inequities, are in fact assemblages of myriad things that govern practices. These assemblages are usually precarious and require a great deal of ongoing work to sustain their linkages. ANT points to how such assemblages can be *unmade* as well as made, and how counter-networks or alternative forms and spaces can take shape and develop strength. As Latour (2005: 261) argued, ANT's political power is 'to highlight the stabilizing mechanisms so that the premature transformation of matters of concern into matters of fact is counteracted'.

Discussion: Sociomaterial Perspectives of Learning

All three perspectives—complexity theory, cultural-historical activity theory and actor-network theory, whilst deriving from wholly different premises and each

representing a contested world of interpretations—bear some commonalities. First, all three take the *whole system* as the unit of analysis, appreciating human/non-human 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 interaction (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 in its various interpretations appears to offer a rich analysis of the *biological* (as well as social, personal, cultural) flows inherent in practices. Its constructs can examine the materialization processes through which particular patterns, ideas and events are produced, the elaborate intertwining of human/non-human elements and the non-linear simultaneous dynamics and conditions which produce *emergence*. The 'system' in complexity theory is typically viewed as 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 treated as something to be 'managed' towards producing greater homogeneity, as some approaches to workplace learning might advocate, but to be interconnected. In elaborating this point, Davis and Sumara (2006) explain 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.

By contrast, in many versions of 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 human-centred orientation than either

complexity or ANT. Non-human 'artefacts', for example, are portrayed as bounded, distinct from humans. Whilst embedding their own cultural histories, artefacts 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 analyzing precisely these political dynamics that are so important to practices whilst 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 sociocultural 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, practice 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 assemblages, 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.

In terms of understanding practice and practice-based learning, a key contribution of all three perspectives is to decentre the human being in conceptions of learn-

ing, activity and agency. All three trace how disparate elements—human and non-human—emerge in webs of activity and become linked into assemblages that collectively exert power. The question of *kinds* of practice, and of distinctions between 'practice' and 'practicing', is tied up with different processes of materialization and material assembly. The question of *participation* in practice is broadened far beyond a focus on personal and social engagements to trace how things themselves participate to produce and sustain practices, often in ways either overlooked by humans or assumed to be controlled by humans. But when we begin to appreciate how a confederate agency of things participates in ways such that human action and intention are interlinked but not central, we can see multiple networks of influence upon any given encounter. Encouraging human participation, then, becomes far more a matter of attunement to things seen and unseen, a sensibility to what may be far-reaching consequences of the tiniest human intervention, a sense of building relations and understanding delicate responsibilities, than a brute assertion of human intention and control. Finally, the question of how a practice becomes *reconfigured* or transformed is addressed by each perspective at the nexus of sociomaterial connections. With their diverse emphases on emergence, translation and expansion, these theories each conceptualize change as a series of complex negotiations at micro-levels setting in motion complex dynamics that reconfigure systems. Importantly too, each of these theories shows the interplay between stabilization and dynamism. That is, they show both how practices become fixed and durable in time and space but also the way in which disordering elements and disequilibrium emerge to enable radical new possibilities. These sorts of analyses are particularly helpful not only in understanding just how practices can change but also in distinguishing among kinds of practices that play different roles in stabilizing or disordering a system, in making connections or amplifying disturbances and in attuning to ambivalences and uncertainties—the openings for unknown possibilities.

Endnotes

1. Of course, these perspectives are only a few of the myriad treatments of materiality that have emerged in social sciences. Important theories such as critical realism, sociologies of technology, new cultural geographies, post-representationist theories, post-humanist theories, some queer theories, feminist theories particularly those treating sexuality and the body, some Feminist-Marxist theories and so forth are all developing fruitful insights for conceptualizing life and practice as sociomaterial. However, the three perspectives chosen for discussion here, at least at the time of writing, appear to have become particularly influential in studies of work, organization and learning working with concepts of practice.
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. Whilst such debates cannot be addressed satisfactorily in this brief overview, interested readers might consult resources such as Sawchuk et al. (2005), *EPAT* (2008) (special issue on complexity and education), Osberg and Biesta (2010), Law and Hassard (1999), Fenwick and Edwards (2010) and Fenwick et al. (2011).

References

Barad, K. (2003). Posthumanist performativity: Toward an understanding of how matter comes to matter. *Signs: Journal of Women in Culture and Society, 28*(3), 801–831.

Bennett, J. (2010). *Vibrant matter: A political ecology of things*. Durham: Duke University Press.

Callon, M. (2005). Why virtualism paves the way to political impotence: A reply to Daniel Miller's critique of The Laws of the Markets. *Economic Sociology: The European Electronic Newsletter, 6*(2), 3–20.

Davis, B., & Sumara, D. J. (2006). *Complexity and education: Inquiries into learning, teaching and research*. Mahwah: Erlbaum.

Davis, B., & Sumara, D. J. (2008). The death and life of great educational ideas: Why we might want to avoid a critical complexity theory. *Journal of the Canadian Association for Curriculum Studies, 6*(1), 163–176.

Davis, B., Sumara, D. J., & Kuce-Kapler, R. (2000). *Engaging minds: Learning and teaching in a complex world*. Mahwah: Lawrence Erlbaum.

Edwards, A., & Kinti, I. (2009). Working relationally at organisational boundaries: Negotiating expertise and identity. In H. Daniels, A. Edwards, Y. Engeström, & S. Ludvigsen (Eds.), *Activity theory in practice: Promoting learning across boundaries and agencies*. London: Routledge.

Edwards, A., Daniels, H., Gallagher, T., Leadbetter, J., & Warmington, P. (2009). *Improving inter-professional collaborations: Multi-agency working for children's wellbeing*. London: Routledge.

Engeström, Y. (1999). Innovative learning in work teams. In Y. Engeström, R. Miettinen, & R.-L. Punamaki (Eds.), *Perspectives on activity theory* (pp. 377–406). Cambridge: Cambridge University Press.

Engeström, Y. (2001). Expansive learning at work: Toward an activity theoretical reconceptualization. *Journal of Education and Work, 14*(1), 133–146.

EPAT. (2008). Special issue: Complexity theory and the philosophy of education. *Educational Philosophy and Theory, 40*(1), 1–245.

Fenwick, T., & Edwards, E. (2010). *Actor-network theory in education*. London: Routledge.

Fenwick, T., Edwards, R., & Sawchuk, P. (2011). *Emerging approaches in educational research: Tracing the sociomaterial*. London: Routledge.

Gherardi, S., & Nicolini, D. (2000). To transfer is to transform: The circulation of safety knowledge. *Organization, 7*(2), 329–348.

Haggis, T. (2009). Beyond 'mutual constitution': Looking at learning and context from the perspective of complexity theory. In R. Edwards, G. Biesta, & M. Thorpe (Eds.), *Rethinking contexts for learning and teaching: Communities, activities and networks*. London: Routledge.

Latour, B. (1999). On recalling ANT. In J. Law & J. Hassard (Eds.), *Actor network theory and after* (pp. 15–25). Oxford: Blackwell/The Sociological Review.

Latour, B. (2005). *Re-assembling the social – An introduction to Actor Network Theory*. London: Oxford University Press.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Law, J., & Hassard, J. (1999). *Actor network theory and after*. Oxford: Blackwell.

McMurtry, A. (2007). *Complexity science and the education of interdisciplinary health teams*. Unpublished doctoral thesis, University of Alberta, Edmonton, AB.

Miettinen, R. (1999). The riddle of things: Activity theory and actor-network theory as approaches to studying innovations. *Mind, Culture, and Activity, 6*, 170–195.

Miettinen, R., Lehenkari, J., & Tuunainen, J. (2008). Learning and network collaboration in product development: How things work for human use. *Management Learning, 39*(2), 203–219.

Nespor, J. (2002). Networks and contexts of reform. *Journal of Educational Change, 3*(3–4), 365–382.

Osberg, D. C., & Biesta, G. J. J. (Eds.). (2010). *Complexity theory and the politics of education*. Rotterdam: Sense.

Osberg, D., Biesta, G. J. J., & Cilliers, P. (2008). From representation to emergence: Complexity's challenge to the epistemology of schooling. *Educational Philosophy and Theory, 40*(1), 213–227.

Prigogine, I. (1997). *The end of certainty: Time, chaos, and the new laws of nature*. New York: Free Press.

Sawchuk, P. (2003). *Adult learning, technology, and working class life*. Cambridge: Cambridge University Press.

Sawchuk, P., Duarte, N., & Elhammoumi, M. (Eds.). (2005). *Critical perspectives on activity: Explorations across education, work and everyday life*. Cambridge: Cambridge University Press.

Schatzki, T. R. (2001). Practice theory. In T. R. Schatzki, K. Knorr-Cetina, & E. von Savigny (Eds.), *The practice turn in contemporary theory* (pp. 1–14). London/New York: Routledge.

Wenger, E. (1998). *Communities of practice: Learning, meaning, and identity*. Cambridge: Cambridge University Press.

This chapter is based on a 2010 article 'Rethinking the thing: Sociomaterial approaches to understanding and researching learning in work', *Journal of Workplace Learning*, 22(1), 104–116, which has been extensively updated and revised.