Learning as a Matter of Concern
Reviewing Conventional, Sociocultural and Socio-material Perspectives

Michael Schlauch
Faculty of Education, Free University of Bozen-Bolzano

Abstract: Early progressive and sociocultural theories in education share unexpected similarities with recent research concerned with the socio-materiality of learning settings. Therefore, this scenario retraces the shift from learning as transmission and guided rediscovery towards a performative account of learning as translation. In particular, this paper elaborates the differences between conventional, sociocultural and sociomaterial approaches regarding the unit of analysis, the mediation done by nonhumans and the contemplation of more fluid forms of knowledge. While retracing conceptual links and developing a sociomaterial conception of teaching(-)learning, I argue that the recent line of sociomaterial research carries on what early authors have been aiming at with the idea of practice-based, non-reductive educational science. But, due to its alternative stance on common onto-epistemological assumptions, it opens up new possibilities of collaboration between Science and Technology Studies and educational sciences where the agency of things and the mediation of knowledge emerge as matters of concern.

Keywords: sociomateriality; progressive education; sociocultural theory; learning transfer; scaffolding; zone of proximal development.

Corresponding author: Michael Schlauch, Faculty of Education, Free University of Bozen-Bolzano, Regensburger Allee, v.le Ratisbona 16, 39042, Brixen-Bressanone, Italy. E-mail: Michael.Schlauch@education.unibz.it

1. Introduction

Over recent years, a growing variety of research has been concerned with learning and teaching while following a "post-humanist socio-material tradition of ANT" (actor-network theory) (Sørensen 2007, 16). Among these, we can count studies about the role of objects in classroom interactions (Verran 1999; Sørensen 2009; Röhl 2012; Mulcahy 2012;

TECNOSCIENZA
Italian Journal of Science & Technology Studies
10 (2) pp. 153-172 - ISSN 2038-3460
www.tecnoscienza.net

SOME RIGHTS RESERVED
2019

T/S TECNOSCIENZA
Italian Journal of Science & Technology Studies

Landri and Viteritti 2016), computer assisted instruction and e-learning (Nespor 2011; Thompson 2012), workplace practice in organizations (Orlikowski 2007; Mathisen and Nerland 2012), informal "everyday" learning (Aberton 2012) as well as detailed descriptions about the enactment of prescribed curricula and teacher standards (Edwards 2011; Ceulemans et al. 2012), educational reform (Hamilton 2011) as well as educational assessment procedures (Gorur 2011). All these authors study a world made of "concatenations of mediators" (Latour 2005, 59). Yet, the relatively recent concepts of "relational materiality" and "performativity" (Law 1999) in Science and Technology Studies (STS) also bear some resemblance to the following citations published many years ahead (emphasis added):

> As a result, the immediacy of 'natural' perception is supplanted by a complex *mediated* process; as such, speech becomes an essential part of the child's cognitive development. (Vygotsky 1978, 32)

> [...] we introduce no *knower* to confront what is *known* as if in a different, or superior, realm of being or action; nor any known or knowable as of a different realm to stand over against the knower (Dewey and Bentley 1949, 136)

> Educational influence is *diffused* through *all the surroundings*, and persons, children and teacher, come to take their share, in it. (Montessori 1948, 95)

Although these authors worked separately from each other and in different parts of the world, they all made early contributions for the reconfiguration of learning environments. Their theories reshaped material-discursive practices concerning learning. This is why nowadays there is a recurring interest in progressive education practice and sociocultural perspectives of learning. Looking back at past work, some of their descriptions may sound strangely familiar today. More specifically, considering the importance of "prepared environments" (see Brehony 2000) and the active role of materials in Montessori's pedagogy, it was not necessary for her to read about the "distribution of competences between humans and nonhumans" (Latour 1992, 158) in order to state that the "work of education is divided between the teacher and the environment" (Montessori 1948, 196).

Dewey, Montessori and Vygotsky offer different, but overlapping perspectives on education that explore a non-dualistic alternative to widespread mechanistic views on education at that time (Tolman and Piekkola 1989; Prawat 2000; Bodrova 2003). Indeed, progressive education, sociocultural psychology and recent sociomaterial studies in STS share an interest in the material circumstances and treat learning and teaching as *matters of concern* (Latour 2005) rather than matters of fact. While "starting from observations of real life situations" (see Lee 1984, 107), the intent of most progressive education advocates was to offer a modern,

scientific method of designing education practice. Instead of being a complete solution, Montessori (1948, 388) saw her schools as empirical laboratories for 'experimental pedagogy'. Or, for instance, Freinet searched for a "pedagogical style based on intuition and observations of young children" (Nowak-Fabrykowski 1992, 64). In a similar vein, Vygotsky has based his "experimental-developmental" method in psychology on "experimental interventions and observation" (Vygotsky 1978, 14, 61).

Similarly, today, many authors follow Law (2009a, 141) in treating ANT as a "disparate family of material-semiotic tools, sensibilities, methods of analysis" (see also Nespor 2011; Gorur 2011) instead of suggesting it to be a theory whose "centre has been fixed, pinned down, rendered definite" (Law 1999, 2).

From there, this article fits in with an effort to review how a similar mindset in approaching teaching and learning has produced a variety of influential concepts over many decades, in concordance with larger changes in social sciences, such as the "practice-turn" (Hager 2012; Grasseni and Ronzon 2004) and efforts "to develop non-foundationalist and non-representational ways of researching the social" (Fenwick and Edwards 2013).

Sociomateriality, in this regard, is one of the latest developments concerning practice. As Gherardi (2017) points out, 'sociomateriality' emphasizes the entanglement rather than the separation of the material and the social and is linked to practice-based studies of organization. In its current usage without hyphen, Orlikowski (2007, 1446) established it as a way to "investigate the multiple, emergent, and shifting sociomaterial assemblages that constitute organizations". In short, it underscores the *constitutive entanglement* of the material and the social (Orlikowski 2007). According to Fenwick and Edwards (2013), recent developments in ANT as well as in cultural-historical activity theory (CHAT), which builds on Vygotsky's work, qualify as sociomaterial approaches. The latter are characterized by materiality, inseparability, relationality, performativity and a focus on practices (Gherardi 2017).

But, why should educational researchers adopt such a sociomaterial perspective, and how can STS make use of existing links to educational approaches? Hereafter, in an attempt to bridge the gap between existing pieces of theory about learning, I outline a set of key concepts and conceptual problems and how these can be dealt with from a sociomaterial perspective. In Table 1, we see how key concepts about learning differ with the change of perspective, which I will elaborate in more detail below.

	Conventional paradigm	Sociocultural approach	Sociomaterial approach
Unit of analysis	the mind of the learner	the learner's community of practice and zones (ZPDs) of joint construction	sociomaterial assemblage, actor-network
Participation of objects	object viewed either as tool (intermediary) that extends human decisions, or as a cause that determines human performance	acknowledged mediation of objects in learning, interaction with objects in scaffolds and didactic material	no formal distinction between human and non-human actors, every object (including mundane objects) is allowed to make a difference
Spatial configurations	classroom conception, learning spaces seen as confined regions	learning in prepared environments, can extend beyond classrooms	relations unfold in multiple spatial topologies (*e.g.* regions, network, fluids)
Relation knower-known	knower disconnected from disembodied knowledge	knowledge related to skill, situated in practice	embodied knowledge inseparate from knower
Learning 'transfer'	transmission and abstraction	learning as guided rediscovery in a similar practice	through materiality of learning, teaching(-)learning as translation/propagation
Agency and actors	pre-existing roles and entities, teacher centrality	roles can be reconfigured, teachers as facilitators of the student's own learning	teacher/learner as effect, actors are performed through entangled teaching(-)learning

Table 1 - Theoretical perspectives on aspects of teaching(-)learning (own elaboration).

2. Learning as Transmission, Construction and Participation

According to Rogoff and Toma (1997, 474), most public schools follow a *'transmission model of instruction'* with "basically dyadic" interactions. They are most commonly structured through teacher-centered whole-class teaching. From this perspective, the teacher is the one who applies and displays knowledge, whereas the pupil passively picks up the knowledge. Authors pertaining to classic progressive education, practice-based research as well as sociomaterial studies oppose the reduction of teaching "to narrowly specific prescriptions for what should be transplanted into the heads of kids" (Lave 1996) or where "the dignity of man

is reduced to the level of the dignity of a machine" (Montessori 1948, 17).

Alternative teaching methods in education have been called "constructivist" as they emphasize the child's own construction of knowledge (see also Kamii and Ewing 1996). But, as Rogoff (1994, 212) points out, original authors also distanced themselves from schools that reduced the ideas of progressive education to be a simple reversal of control in the classroom (see also Dewey 1938). Therefore, one must not understand these approaches to be about leaving children to their own devices. One tends to divide education into two extremes that either neglect the input from the learners or from the teachers in a "pendulum swing between control and freedom" (Rogoff 1994, 210).

According to Montessori (1948, 197), the teacher "does nothing more than facilitate and make clear to the child the very active and prolonged work which is reserved for him" or her. This, however, is a constant, continuous effort comparable to that of a "guardian angel of minds concentrated in efforts which are to elevate them" (ibid.). In Dewey (1916/2001, ch. 22) we see that authority does not disappear, but it is distributed as 'social guidance' instead of authoritative dictation.

Thus, focusing on the theory of learning as a whole, constructivist methods imply that new classroom configurations afford not yet another form (or reversal) of transmission. Rather than isolated knowledge construction, we have to picture learners as "active agents in the material world" (Fenwick and Edwards 2013, 50) and focus on their interactions and activities. To illustrate this point, a key concept is Vygotsky's "zone of proximal development" (ZPD) which he defines as follows:

> It is the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers. (Vygotsky 1978, 86)

Thus, Vygotsky (1978) questions the notion of imitation and learning as being "purely mechanical". Rather, the ZPD signifies the child's potential of development as the result of social interaction. Interestingly, we can encounter the ZPD also beyond intentional instruction. We are able to look at certain kinds of play that are "responsible for creating young children's 'zone of proximal development' " (Bodrova 2008, 360). Vygotsky (1978, 102), for example, describes, how, in make-believe play, it is as though the child was "a head taller than himself" and behaves beyond his or her age. To underline the importance of the social and material context of activity, Newman and colleagues (1989) identify the ZPD as a joint "construction zone". In fact, scholars of cultural-historical activity theory have gradually widened their focus from *cultural mediation* (Vygotsky 1978) to *collective activity* (Leontiev 1981/2009) and to *interconnected activity systems* (Engeström 2001).

In a more anthropological account, Tim Ingold (2001) promotes an

understanding of *guided rediscovery* in *taskscapes* where "knowledge consists, in the first place, of skill" and "where every human being is a centre of awareness and agency in a field of practice". Thus, either by learning in the ZPD, or through rediscovery in a "taskscape", the environment "is not merely a source of problems, of adaptive challenges to be resolved; it becomes part of the means for dealing with them." (Ingold 2001, para. 25).

Regarding the social environment, another relevant sociocultural concept is learning as "an aspect of changing participation in changing communities of practice" (Lave 1996, 151). In this approach, the *community of practice* provides information, resources and opportunities for participation that enable learners to access membership in the community, i.e. to change identity and to learn (Lave and Wenger 1991).

Despite the different origins, Star (1995) shows that the "community of practice" and the ZPD are linked to important concepts related to symbolic interactionism. According to her, both the ZPD and the "matrix" in grounded theory (Strauss 1993) "are created through shared practice and co-constructed material conditions, both very local and highly extensive" (Star 1995, 14). In addition, we can define the "social world" as well as the "community of practice" as the main *unit of analysis* for the organization of people's collective learning (ibid.).

Hence, without adopting a strict sociomaterial perspective, we have already reached an understanding of learning with a broader unit of analysis, which allows us to look at the distribution of cognition (Cole and Engeström 1993). In the account of *distributed cognition* by Hutchins (1995), for instance, cognitive processes *emerge* from interactions within *cultural cognitive ecosystems*. Such a cultural cognitive ecosystem "includes a shared world of objects and events as well as adaptive resources internal to each member of the community" (Hutchins 2013, 4).

In sum, we reached a common departure point for a sociomaterial analysis that emerged from different directions. Concerning our widened scope, according to Fenwick (2010, 111), sociomaterial approaches commonly "take the whole system as the unit of analysis, appreciating human/nonhuman action and knowledge as entangled in systemic webs". Another step would be not to "privilege human consciousness or intention, but trace how knowledge, knowers and known (representations, subjects and objects) emerge together with/in activity" (Fenwick 2010, 112). To continue on this path, I next clarify the role of objects, or "nonhumans", in relation to learning.

3. From Tools over Scaffolds to the Participation of Objects

Considering the importance of things and objects in education, con-

ventional research has been rather human-centered or (techno-)deterministic. According to Waltz (2006, 52), over the years serious work "has gone into the development and use of things as educational tools". Less attention, however, has gone into the theory regarding things. They are either framed as "subordinate tools serving human aims or, by contrast, primary movers and therefore overdetermined agents of change" (Waltz 2006, 54). Thus, drawing from ANT, a reconsideration of nonhuman actors can enrich educational research. Namely, it helps discern the contribution of objects in shaping classroom interactions without falling back to binary thinking.

For this reason, I now explore notions of objects beyond the image of mere tools of instruction. For example, in sociocultural learning theory, another widely used metaphor for work with artifacts is "scaffolding" (Wood et al. 1976). With regard to the ZPD, the notion of 'scaffolding' has been introduced to describe the process where a tutor helps somebody who is less expert in the achievement of a problem solving task. In this case, rather than direct usage, the teacher prepares materials for the interaction with the learner in order to make the task more manageable. According to Pea (2004), the employment of *fading* is an essential aspect during work with materials and artifacts crafted specifically for scaffolding. Similar to the dismantling of building scaffolds, the support of the scaffolding or the participation of the tutor gradually fades away as the child achieves autonomy (see also Newman et al. 1989). The term "scaffolding", however, should not be understood as a "one-way" process where the "scaffolder" constructs the scaffold alone and presents it (Daniels 2007, 318). According to the critique of Newman and colleagues (1989), the ZPD is rather created through negotiation between participants.

Therefore, the discussion of "scaffolding" takes us one step nearer to the consideration of the agency of things. In sum, we can understand the construction of the ZPD in relation to a system of multiple contributing human and nonhuman actors where the child moves actively using her own creativity. To illustrate that point, we can rely once more on Montessori, who explains the difference of her *materials of development* and normal tools or "means of teaching" as follows:

> The profound difference [...] is that the objects are not an aid for the mistress who has to explain, that is they do not constitute means of teaching. But they are an aid for the child who chooses them himself, takes possession of them, uses them and employs himself with them according to his own tendencies and needs and just as long as he is interested in them. In this way the objects become means of development." (Montessori 1948, 197)

The teacher takes part in the performance of means of development. She arranges and introduces objects according to the needs and 'initiates' the child "into the ordered and active life of the environment" (Montes-

sori 1948, 95). There is, however, an important difference to conventional scaffolding. "Fading" is not employed by the tutor, but performed by the child who looses interest. We can even go further and imagine scaffolding in the absence of a "scaffolder". One may consider, for example, "forest schools" where natural (non-prepared) environments are known to stimulate the child's creativity (OBrien 2009).

In consequence, often the question of "who teaches" and of "who" provides scaffolding cannot be answered clearly. In other words, looking at human intentionality alone brings us to what Latour (2005, 45) calls the 'under-determination of action'. This is why our focus has to shift from the relations between performances of people towards the inclusion of nonhumans actants as well.

On that premise, it is necessary to highlight the meaning of objects as *mediators*. For instance, while sociocultural accounts stress that human action and learning is shaped by *mediational means*, these are often used as synonym for "cultural tools" (Wertsch and Rupert 1993). But, the image of *cultural tools* that mediate leaves a perplexity to resolve. Namely, how can a tool, which usually is used *by* another acting person or group (thus, passing their action along as an intermediary), simultaneously be a *mediator* that shapes action?

To shed light on this question, a crucial key to avoid confusion is to distinguish between *mediators* and *intermediaries*. According to Latour (2005, 39), an *intermediary* is "what transports meaning or force without transformation: defining its inputs is enough to define its outputs." *Mediators*, on the other hand, "transform, translate, distort, and modify the meaning or the elements they are supposed to carry" (ibid.). Therefore, all mediators perform relations and thus contribute to the outcome of situations, As a result, the question that underpins any analysis is whether we are "talking about causes and their intermediaries or about a concatenation of mediators" (Latour 2005, 62). Hence, when talking about objects as mediators, this is done without reducing the rest to mere intermediaries. As could easily be misunderstood, objects neither replace humans as causes of actions nor they acquire human intentionality. Rather, in a sociomaterial conception, causes and effects are distributed among heterogeneous actors. In short, "agency is not aligned with human intentionality or subjectivity" (Barad 2003, 826). According to the concept of *relational materiality*, the latter, along with divisons and distinctions such as human/non-human are now understood as effects or outcomes (Law 1999). This can be applied to the agency of scaffolds and cultural tools, too.

Looking again at Montessori (1948, 95), she talks about the educational environment as the "whole assemblage[1] of things from which the child is free to choose for using just as he pleases". But, she gives also a vivid description of what now can be interpreted as the agency of educational objects and their "voices":

> The teacher superintends, it is true; but it is the things of various kinds which call to children of various ages. Truly the brilliancy, the colours, the beauty of gaily decorated objects are no other than voices which call the attention of the child to themselves and urge him to do something. Those objects possess an eloquence which no mistress can ever attain to: 'Take me,' they say, 'see that I am not damaged, put me in my place.' And the action carried out at the instigation of the things gives the child that lively satisfaction, that access of energy which prepares him for the more difficult work of intellectual development. (Montessori 1948, 119)

At the same time, however, the teacher has a central role in this assemblage, she "is, in the main, a connecting link between the material (the objects) and the child" (Montessori 1948, 197). To some, this formulation comes as a surprise, as, in common language, we tend to treat objects contrariwise. They are, generally, the connecting link (intermediary) between human actors. Yet, neither the teacher nor the environment transport meanings without transformation, but are participants. Accordingly, given these points, we are now able to conceptualize the agency of humans and nonhumans alike, without neglecting a substantial part of relations that are performed during teaching and learning.

4. Spatial Configurations and Forms of Knowledge

Depending on the type of relations performed through teaching and learning, we can imagine different forms of knowledge. In education, the most common opposition between imaginaries[2] of knowledge is constituted by *representational* knowledge versus *situated*[3] knowledge. These are linked either with a transmission conception of learning or a constructive/discovery model.

As Wineburg (1989) highlights, progressive education authors like Dewey anticipate modern instructional approaches that account for situated cognition in communities of practice. Among the latter I count teaching strategies such as "cognitive apprenticeship" based on "enculturation" (Brown et al. 1989), "reciprocal teaching" (Palinscar and Brown 1984), "knowledge building communities" (Scardamalia and Bereiter 2014), "anchored instruction" (Vanderbilt 1990) as well as other kinds of situated, cooperative learning through teacher-guided discovery. While the two opposite learning paradigms appear to be incompatible to each other, it is possible to either claim all knowledge to be cognitive representations, or, as Lave (1996) sustains, view learning in general as "socially situated", which would then also include all abstract knowledge produced by "decontextualization practices". Nevertheless, classroom teaching, can benefit from a perspective on situated learning that also values mental work on symbolic objects, which is why Bereiter (1997) argues for "the value of thinking of situatedness as varying along a continu-

um".

In other words, how we think about knowledge depends on the configuration of knowledge-making practices we are trying to observe. Verran (1999) provides a telling example of this by confronting the teaching of metric units in the western tradition and in Nigerian (Yoruba) classroom practice. She concludes in highlighting the process of embodiment of knowledge, seen "as a co-constituted embodied participation in collective acting" (Verran 1999, 149). Therefore, we are able to retrace how children pick up public knowledge about quantification through embodied processes in classroom practice.

Given the importance of shared practice and embodied participation, it is useful to look in more detail at the concept of practice from a sociomaterial perspective. In ANT, Law (2009b) defines practices as "assemblages of relations". According to Orlikowski (2007, 1445), practices perform sociomaterial assemblages that bind together a "heterogeneous assembly of distributed agencies". Similarly, Gherardi (2017) shifts from a conventional understanding of practices as "arrays of activities" towards practice "as a mode, relatively stable in time and socially recognized, of ordering heterogeneous items into a coherent set" (Gherardi 2006, 36).

Thus, if we analyze teaching and learning as parts of one sociomaterial teaching(-)learning practice, we need to dis- and reassemble teaching and learning, recognizing the patterns and "forms of presence" (Sørensen 2007) of its heterogeneous, sociomaterial assemblage. In the light of this task, Mol and Law (1994) have established the possibility of multiple spatial topologies to characterize the social world. Namely, they distinguish between *regions*, *networks* and *fluids*[4].

The first spatial configuration "is regional and homogeneous, which distinguishes its objects by talking of territories and setting boundaries between areas" (Mol and Law 1994, 659). According to Sørensen (2009), the classical whole-class teaching set-up produces "regions" that separate children from the knowledge represented by the teacher and the blackboard. On a closer look, materials of instruction such as the blackboard "direct the gazes of the students" and configure students as "recorders of a relatively stable and public knowledge that can be reproduced" (Röhl 2012, 64). Thus, regional spaces perform boundaries and *representational knowledge* (Sørensen 2009, 102).

With the *network* spatiality, on the other hand, one describes relations "as composed of immutable mobiles" that have "invariable links between them" (Mol and Law 1994, 663). These *immutable mobiles* (Latour 2005) are actants that cross boundaries in time and space while being drawn together. As such, networks can produce resonance spaces where elements acting as an "obligatory passage point" draw together material and human participants and form "communal knowledge" (Sørensen 2009, 109). To illustrate this, a fitting example in teaching practice is "collaborative knowledge building" in "knowledge building communities" (Scardamalia and Bereiter 2014) that are focused on producing and improving

knowledge objects that can be seen as such passage points for communal knowledge, without the prior provision of external "facts" or "truth".

Concerning the third spatial topology, i.e. *fluids*, social objects "draw upon and recursively form fluid spaces that are defined by liquid continuity" (Mol and Law 1994, 659). Here, objects aren't well defined and do not always have clear boundaries. Also, "there are mixtures and gradients" and "the world doesn't collapse if some things suddenly fail to appear" (ibid.). Interestingly, stability is achieved by fluid continuity. While networks risk to fall apart because "things that go together depend on one another", in fluid spaces "there is no 'obligatory point of passage' " (Mol and Law 1994, 661). According to Sørensen (2009), "liquid knowledge" is formed through such fluid patterns of relations. The idea of fluidity is recurrent in sociomaterial accounts of informal learning. Aberton (2012) describes the material dimension of everyday learning and its liquid form of local, uncodified and often invisible knowledge that is not controlled, or "colonized" by a pedagogic authority. Similarly, Postma (2012, 152) associates learning in fluid spaces with "invisible pedagogy" (see also Bernstein 1975). Arguably, the latter kind of pedagogy fits in with aspects of alternative, progressive education efforts. There, the teacher also takes the form of an "arrangeur" and the "control of the teacher over the child is implicit rather than explicit" (Postma 2012, 152). For instance, make-believe play among children performs learning in fluid patterns of relations, but can also be facilitated, or "scaffolded" (Bodrova 2008, 366) and subsequently embedded in other learning activities.

5. From Learning Transfer to Translation

How do multiple forms of knowledge relate to each other? In this regard, a socomaterial approach can help us to clarify another conceptual problem about learning, i.e. *learning transfer*. Sørensen (2009, 177) identifies learning transfer as "a crucial problem in theories of learning". From a cognitivist viewpoint, it is not clear how knowledge is transferred into the heads of the students and then decontextualized so that it can be applied at any time and any place. Regarding situated knowledge, too, transfer may occur only when "constrains and affordances" are "invariant over transformations of context" in different situations, as has been sustained by Greeno et al. (1993) (cited in Allal 2001, 412).

But, actor-networks that situate practices are not bound to single contexts. In a sociomaterial conception, Fenwick and Edwards (2011) stress the importance of "observing the proliferation of practices and meanings as different worlds", where *multiplicity*[5] signifies the "enactment of distinct and different, often overlapping, ontologies". Thus, to explain situative/situated learning transfer we may also look at how different social worlds overlap and are connected by "fluid objects" (Law and Single-

ton 2005) or by what we can qualify as *boundary objects*. The latter have "different meanings in different social worlds, but their structure is common enough" to make them recognizable and inhabit more than one world (Star and Griesemer 1989, 393).

As Sørensen points out, the original conception of situated learning takes a regional imaginary for granted. In situated/situative accounts of learning, however, knowledge is not situated in the mind but in a multiplicity of practice (Sørensen 2009). In a similar vein, Mulcahy (2013) argues for a conception of transfer that "far from being transcendent" is seen as performed "differently in different sociomaterial practices and arrangements". Thus, how learning connects to other entities is concerned by what Sørensen (2009, 177) calls 'the materiality of learning':

> The materiality of learning must thus be understood as the achieved ability of a growth in knowledge to connect to other particular entities.

By viewing material relations, however, we see that transfer entails transformation, which is why authors use the concept of *translation* (Callon 1984) as an alternative metaphor for transfer (Mulcahy 2013, 1278). According to Sørensen (2009, 181), for instance, we deal with a multiplicity of overlapping spatial configurations, where sociomaterial processes such as bracketing, recording, or memorizing, don't transfer, but translate and thus change "knowledge from liquid to representational". By the same token, Latour (1995, 56) argues that cognition is studied best by following the "trajectories of modified representations", as he describes cognition as "propagation of representations through various media". Yet, the propagation described by Hutchins (1995) "does not mean transportation without deformation, but a modification, a translation, a shift" (Latour 1995, 57). Therefore, researching teaching and learning with a sociomaterial perspective allows us to trace associations and relations among "the social, textual and material elements of multiply interrelated settings" Mulcahy (2013, 1287).

6. The Performance of Teaching(-)learning

Having discussed the question of "who teaches" from the perspective of transfer and knowledge representation, ANT rather asks the question of "how it is that things get performed (and perform themselves) into relations that are relatively stable and stay in place" (Law 1999, 4). Therefore, we now shift from a representationalist to a performative account of learning.

As we have seen, the above mentioned problem of learning transfer is linked to the imagination of a separate known and knower that have nothing in between them apart from an "abyss between words and world" (Latour 1999, 121). Notably, this has already been criticized by authors like Dewey who rejects "the 'no man's land' of words imagined to

lie between the organism and its environmental objects" (Dewey and Bentley 1949, 136). In fact, Fenwick and Edwards (2013, 50) see Dewey's conception of learning emerging through transactions as the inauguration of "a sociomaterial view of education". Actually, both older (Dewey and Bentley 1949) and newer criticism builds on the discussion of onto-epistemological assumptions in quantum physics and its conflict with traditional representationalism. Introducing a more recent line of thought, Barad (2003) offers a posthumanist performative account that she coins 'agential realism', in which boundaries between matter and meaning, human and non-human, subject and object are performed through *intra-actions*. If we look at the moment of observation as an intra-action, for instance, it is the observation that performs an 'agential cut' that produces causes and effects. As Gherardi (2017, 41) acknowledges, Barad's posthumanist conception allows us to think differently about knowing:

> [...] the knower is not external to or pre-existing the world. Rather, the knower and the 'things' do not pre-exist their interactions but emerge through and as part of their entangled intra-relating.

Thus, we may think of the learner, the teacher as well as of the participating environment as entities that don't pre-exist. Rather, they emerge through their entangled intra-relating in practice. At the same time, teaching and learning can be seen not as two separate processes, but as parts of a "unified teaching-learning continuum" (see also Zürcher 2015, 79). Questions concerning agency, subjectivity and intentionality are thus disconnected from individual bodies. In consequence, one can retrace how "the teacher" emerges out of a sociomaterial assemblage, how the teachers' profile, for instance, is stabilized and "black boxed" as a profession (Ceulemans et al. 2012). On the other hand, however, we are also able to provide a sociomaterial interpretation of Montessori's "educational influence" that is "diffused through all the surroundings" (Montessori 1948, 95). In this light, I argue that teaching(-)learning (or *teachinglearning*[6]) as one sociomaterial practice continuously translates, assembles and guides the making of relations in a changing sociomaterial assemblage. This, in order to qualify as learning, must enhance the learner's ability to either represent these relations as acquired knowledge (in a cognitivist perspective), or to participate in communities of practice (in a situated-knowledge perspective).

At the same time, depending on the type of spatial imaginary one uses, different forms of knowledge, actors and roles result either as more evident or less visible. Consequently, in teaching(-)learning, we understand teaching and learning not as actions of pre-determined human subjects, but rather as the two ends of the same translation/propagation process. Rather than two separate activities, teaching and learning are two perspectives towards one practice. From the viewpoint of teaching, teachinglearning appears as continuous assembling effort. From the viewpoint of learning, teachinglearning results in (partial) internalization

(Latour 1995) as well as in participation, which results as the increased ability to "connect to other entities" (Sørensen 2009, 193).

All things considered, we have now moved across different interpretations of teachinglearning. To summarize the main characteristics of sociomaterial teachinglearning, we shall briefly reconsider Table 1. Departing from a conventional or 'standard paradigm of learning' (Zürcher 2015), I gradually passed to important sociocultural notions that prepare for a full appreciation of sociomateriality. In the first row, we see how the unit of analysis shifted gradually from the individual mind to the joint construction of the ZPD in a community of practice and eventually to the sociomaterial assemblage that accounts for both human and nonhuman actors. Accordingly, objects now participate as mediators, rather than being a mere intermediary or tool of a teacher. As we see in the second column in Table 1, this has already partially been the case with regard to scaffolds and prepared environments. With this, we increased the range of possible spatial configurations that can be taken into account. Learning relations can be performed in regions, network and fluids and are not limited to a specific environment or classroom. This also allows us to resolve incompatible claims about either representational or situated knowledge. As we have learned, it is possible to abandon the notion of knowledge as a separate entity in favor of a performative view where knowledge is embodied, i.e. seen always in connection to who or what is in the process of performing it. Accordingly, learning transfer is made possible not by the transmission and abstraction of knowledge or by invariants among situations, but as a result of translation and the overlapping materiality of social worlds. Lastly, the roles of the teacher and the learner are seen as effects of performed relations rather than being predefined. Thus, we see how it is possible for the agency of the standard teacher to be distributed as educational influence among actors in the prepared environment.

7. Conclusions

As we have seen, a sociomaterial perspective on teaching and learning can be useful in the following ways as a theoretical foundation. First, it allows us to shift from a transmission/construction dichotomy of individual learning to the analysis of participation in material-discursive practices. Second, it helps us to neither neglect nor misplace the participation of mediating materials and scaffolds in sociomaterial assemblages of teaching(-)learning. Third, we can account for multiple forms of knowledge in relation to different spatial configurations, which allows us to acknowledge less teacher-centered and more informal, fluid forms of learning as well. Fourth, instead of hypothesizing learning transfer without transformation and mediation, we are now able to situate learning in a wider range of sociomaterial knowledge-making practices. This, for instance, applies to situations where the contribution of objects is less visi-

ble as well as to practices that are held together by technological devices over long distances.

Yet, as the recent growth of attention may suggest, the agency of things has not started to be a matter of concern since STS scholars began to scrutinize the introduction of digital devices as well as apparatuses of standardization in modern classrooms. Rather, as I have suggested in this article, it started ever since progressive educators talked specifically about prepared environments and included its related assembling efforts into their conception of teaching. This, along with other parallels to past theory, gives rise to a new set of common issues that may broaden the path for future collaborations among researchers in the education sciences and STS.

Acknowledgments

References

Aberton, H. (2012) *Material Enactments Of Identities And Learning In Everyday Community Practices: Implications For Pedagogy*, in "Pedagogy, Culture & Society", 20 (1), pp. 113–136.

Allal, L. (2001) *Situated cognition and learning: From conceptual frameworks to classroom investigations*, in "Schweizerische Zeitschrift für Bildungswissenschaften", 23, pp. 407–422.

Barad, K. (2003) *Posthumanist Performativity: Toward an Understanding of How Matter Comes to Matter*, in "Signs", 28 (3), pp. 801–831.

Bereiter, C. (1997) *Situated Cognition and How to Overcome It*, in D. Kirshner and J.A. Whitson (eds.) *Situated Cognition: Social, Semiotic, And Psychological Perspectives*, Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers, pp. 281–300.

Bernstein, B. (1975) *Class, Codes And Control. Vol. 3. Towards A Theory Of Educational Transmission*, London: Routledge & Kegan Paul.

Bodrova, E. (2003) *Vygotsky and Montessori: One Dream, Two Visions*, in "Montessori Life", 15 (1), pp. 30–33.

Bodrova, E. (2008) *Make-believe play versus academic skills: a Vygotskian approach to today's dilemma of early childhood education*, in "European Early Childhood Education Research Journal", 16 (3), pp. 357–369.

Brehony, K.J. (2000) *Montessori, Individual Work And Individuality In The Elementary School Classroom*, in "History of Education", 29 (2), pp. 115–128.

Brown, J.S., Collins, A. and Duguid, P. (1989*) Situated Cognition and the Culture of Learning*, in "Educational Researcher", 18 (1), pp. 32–42.

Callon, M. (1984) *Some Elements of a Sociology of Translation: Domestication of the Scallops and the Fishermen of St Brieuc Bay*, in "The Sociological Review", 32 (1), pp. 196–233.

Ceulemans, C., Simons, M. and Struyf, E. (2012) *Professional Standards For Teachers: How Do They 'Work'? An Experiment In Tracing Standardisation In-The-Making In Teacher Education*, in "Pedagogy, Culture & Society", 20 (1), pp. 29–47.

Cole, M. and Engeström, Y. (1993) *A cultural-historical approach to distributed cognitio*n, in G. Salomon (ed.) *Distributed Cognitions: Psychological And Educational Considerations,* New York: Cambridge University Press, pp. 1–46.

Daniels, H. (2007) *Pedagogy,* in H. Daniels, M. Cole and J.V. Wertsch (eds.) *The Cambridge Companion to Vygotsky*, New York: Cambridge University Press, pp. 307–331.

Dewey, J. (1916/2001) *Democracy and Education, Electronic Classics Series*, Hazleton: Pennsylvania State University.

Dewey, J. (1938) *Experience and education*, New York: Macmillan.

Dewey, J. and Bentley, A.F. (1949) *Knowing and the Known*, Boston: Beacon Press.

Edwards, R. (2011) *Translating the Prescribed into the Enacted Curriculum in College and School*, in "Educational Philosophy and Theory", 43 (Suppl. 1), pp. 38–54.

Engeström, Y. (2001) *Expansive Learning at Work: Toward an activity theoretical reconceptualization*, in "Journal of Education and Work", 14 (1), pp. 133–156.

Fenwick, T. (2010) *Re-thinking the "thing"*, in "Journal of Workplace Learning", 22 (1/2), pp. 104–116.

Fenwick, T. and Edwards, R. (2011) *Considering Materiality in Educational Policy: Messy Objects and Multiple Reals*, in "Educational Theory", 61 (6), pp. 709–726.

Fenwick, T. and Edwards, R. (2013) *Performative Ontologies: Sociomaterial Approaches To Researching Adult Education And Lifelong Learning,* in "European Journal for Research on the Education and Learning of Adults", 4 (1), pp. 49–63.

Gherardi, S. (2006) *Organizational Knowledge: The Texture of Workplace Learning*, Oxford: Blackwell.

Gherardi, S. (2017) *Sociomateriality in Posthuman Practice Theory*, in A. Hui, E. Shove and T. Schatzki (eds.) *The Nexus of Practices: Connections, Constellations, and Practitioners*, London, Routledge, pp. 38–51.

Gorur, R. (2011) *ANT on the PISA Trail: Following the statistical pursuit of certainty*, in "Educational Philosophy and Theory", 43 (Suppl. 1), pp. 76–93.

Grasseni, C. and Ronzon, F. (2004) *Pratiche e cognizione*, Roma, Meltemi editore.

Greeno, J., Smith, D.R. and Moore, J. (1993) *Transfer of situated learning*, in D.K. Detterman and R.J. Sternberg (eds.) *Transfer on trial: Intelligence, cognition, and instruction*, Norwood, NJ: Ablex, pp. 99–167.

Hager, P. (2012) *Theories of Practice and Their Connections with Learning: A Continuum of More and Less Inclusive Accounts*, in P. Hager, A. Lee and A. Reich (eds.) *Professional and Practice-based Learning*, Dordrecht: Springer, pp. 17–32.

Hamilton, M. (2011) *Unruly Practices: What a Sociology Of Translations Can Offer To Educational Policy Analysis*, in "Educational Philosophy and Theory", 43 (Suppl. 1), pp. 55–75.

Hutchins, E. (1995) *Cognition in the Wild*, Cambridge, MA: MIT Press.

Hutchins, E. (2013) *The Cultural Ecosystem Of Human Cognition*, in "Philosophical Psychology", 27 (1), pp. 34–49.

Ingold, T. (2001) *From the transmission of representations to the education of attention*, in H. Whitehouse (ed.) *The Debated Mind: Evolutionary psychology versus ethnography*, Oxford: Berg, pp. 113–153, (retrieved from http://lchc.ucsd.edu/mca/Paper/ingold/ingold1.htm October 20, 2019).

Kamii, C. and Ewing, J.K. (1996) *Basing Teaching on Piagets Constructivism*, in "Childhood Education", 72 (5), pp. 260–264.

Landri, P. and Viteritti, A. (2016) *Introduzione. Le masse mancanti in educazione*, in "Scuola democratica, Learning for Democracy", 7 (1), pp. 7–22.

Latour, B. (1992) *Where Are the Missing Masses? The Sociology of a Few Mundane Artifacts*, in J.L. Wiebe Bijker (ed.) *Shaping Technology/Building Society: Studies in Sociotechnical Change*, Campridge, MA: MIT Press, pp. 225–258.

Latour, B. (1995) C*ogito ergo sumus! Or, Psychology Swept Inside Out By The Fresh Air Of The Upper Deck.* in "Mind, Culture, and Activity", 3, pp. 54–63.

Latour, B. (1999) *For Bloor ... and beyond: a reply to David Bloor's 'Anti-Latour'*, in "Studies in History and Philosophy of Science", 30 (1), pp. 113–129.

Latour, B. (2005) *Reassembling the Social: An Introduction to Actor-Network-Theory: An Introduction to Actor-Network-Theory*, Clarendon Lectures in Management Studies, OUP Oxford.

Lave, J. (1996) *Teaching, as Learning, in Practice*, in "Mind, Culture, and Activity", 3 (3), pp. 149–164.

Lave, J. and Wenger, E. (1991) *Legitimate Peripheral Participation in Communities of Practice, in Situated Learning,* Cambridge University Press, pp. 89–118.

Law, J. (1999) *After Ant: Complexity, Naming and Topology*, in "The Sociological Review", 47 (Suppl. 1), pp. 1–14.

Law, J. (2009a) *Actor Network Theory and Material Semiotics*, in B. Turner (ed.) *The New Blackwell Companion to Social Theory*, Malden, MA: Backwell, pp. 141–158.

Law, J. (2009b) *Collateral Realities,* http://www.heterogeneities.net-/publications/Law2009CollateralRealities.pdf, (retrieved October 20, 2019).

Law, J. and Mol, A. (2001) *Situating Technoscience: An Inquiry into Spatialities*, in "Environment and Planning D: Society and Space", 19 (5), pp. 609–621.

Law, J. and Singleton, V. (2005) *Object Lessons*, in "Organization", 12 (3), pp. 331–355.

Lee, W.B. (1984) *Célestin Freinet, the Unknown Reformer*, in "The Educational Forum", 48 (1), pp. 96–113.

Leontiev, A.N. (1981/2009) *The Development of Mind - Selected Works of A.N. Leontyev* with a preface by Mike Cole, Pacifica, CA: Marxist Internet Archive.

Mathisen, A. and Nerland, M. (2012) *The Pedagogy Of Complex Work Support Systems: Infrastructuring Practices And The Production Of Critical Awareness In Risk Auditing*, in "Pedagogy, Culture & Society", 20 (1), pp. 71–91.

Mol, A. and Law, J. (1994) *Regions, Networks and Fluids: Anaemia and Social Topology*, in "Social Studies of Science", 24 (4), pp. 641–671.

Mol, A.M. (2002) *The Body Multiple: Ontology in Medical Practice*, Durham, North Carolina: Duke University Press.

Montessori, M. (1948) *The Discovery of the Child*, Madras: Kalakshetra Publications.

Mulcahy, D. (2012) *Affective Assemblages: Body Matters In The Pedagogic Practices Of Contemporary School Classrooms*, in "Pedagogy, Culture & Society", 20 (1), pp. 9–27.

Mulcahy, D. (2013) *Turning Around the Question of 'Transfer' in Education: Tracing the sociomaterial*, in "Educational Philosophy and Theory", 45 (12), pp. 1276–1289.

Nespor, J. (2011) *Devices and Educational Change*, in "Educational Philosophy and Theory", 43 (Suppl. 1), pp. 15–37.

Newman, D., Griffin, P. and Cole, M. (1989) *The Construction Zone: Working for Cognitive Change in Schoo*l, New York: Cambridge University Press.

Nowak-Fabrykowski, K. (1992) *Freinet's Concept of Teachers and Theory of Teaching*, in "McGill Journal of Education / Revue des sciences de l'éducation de McGill", 27 (1).

OBrien, L. (2009) *Learning Outdoors: The Forest School Approach*, in "Education 3-13", 37 (1), pp. 45–60.

Orlikowski, W.J. (2007) *Sociomaterial Practices: Exploring Technology at Work*, in "Organization Studies", 28 (9), pp. 1435–1448.

Palinscar, A.S. and Brown, A.L. (1984) *Reciprocal Teaching of Comprehension-Fostering and Comprehension-Monitoring Activities*, in "Cognition and Instruction", 1 (2), pp. 117–175.

Pea, R.D. (2004) *The Social and Technological Dimensions of Scaffolding and Related Theoretical Concepts for Learning, Education, and Human Activity*, in "The Journal of the Learning Sciences", 13 (3), pp. 423–451.

Postma, D. (2012) *Education as Sociomaterial Critique*, in "Pedagogy, Culture & Society", 20 (1), pp. 137–156.

Prawat, R.S. (2000) *Dewey Meets the "Mozart of Psychology" in Moscow: The Untold Story*, in "American Educational Research Journal", 37 (3), pp. 663–696.

Rogoff, B. (1994) *Developing Understanding Of The Idea Of Communities Of Learners*, in "Mind, Culture, and Activity", 1 (4), pp. 209–229.

Rogoff, B. and Toma, C. (1997) *Shared Thinking: Community And Institutional Variations*, in "Discourse Processes", 23 (3), pp. 471–497.

Röhl, T. (2012) *Disassembling the Classroom – An Ethnographic Approach To The Materiality Of Education*, in "Ethnography and Education", 7 (1), pp. 109–126.

Scardamalia, M. and Bereiter, C. (2014) *Knowledge Building and Knowledge Creation*, in R.K. Sawyer (ed.) *The Cambridge Handbook of the Learning Sciences*, Cambridge University Press, pp. 397–417.

Sørensen, E. (2007) *STS Goes To School: Spatial Imaginaries Of Technology, Knowledge And Presence*, in "Outlines. Critical Practice Studies", 9 (2), pp. 15–27.

Sørensen, E. (2009) *The Materiality of Learning: Technology and Knowledge in Educational Practice, Learning in Doing: Social, Cognitive and Computational Perspectives*, New York: Cambridge University Press.

Star, S.L. (1995) *Listening for connections*, in "Mind, Culture, and Activity", 2 (1), pp. 12–17.

Star, S.L. and Griesemer, J.R. (1989) *Institutional Ecology, Translations and Boundary Objects: Amateurs and Professionals in Berkeleys Museum of Vertebrate Zoology, 1907-39*, in "Social Studies of Science", 19 (3), pp. 387–420.

Strauss, A. (1993) *Continual permutations of action*, Hawthorne, NY: Aldine de Gruyter.

Thompson, T.L. (2012) *(Re/dis)assembling Learning Practices Online With Fluid Objects And Spaces*, in "Studies in Continuing Education", 34 (3), pp. 251–266.

Tolman, C. and Piekkola, B. (1989) *John Dewey and Dialectical Materialism: Anticipations Of Activity Theory In The Critique Of The Reflex Arc Concept*, in "Activity Theory", 1, pp. 43–46.

Vanderbilt, T. (1990) *Anchored Instruction and Its Relationship to Situated Cognition*, in "Educational Researcher", 19 (6), pp. 2–10.

Verran, H. (1998) *Re-imagining Land Ownership in Australia*, in "Postcolonial Studies", 1 (2), pp. 237–254.

Verran, H. (1999) *Staying True to the Laughter in Nigerian Classrooms*, in "The Sociological Review", 47 (1), pp. 136–155.

Vygotsky, L. (1978) *Mind in Society: The Development Of Higher Psychological Processes*, Cambridge, Massachusetts: Harvard University Press, (translated and edited by M.Cole et. al., original manuscripts ca. 1930-1934).

Waltz, S.B. (2006) *Nonhumans Unbound: Actor-Network-Theory and the Reconsideration of "Things" in Educational Foundations*, in "The Journal of Educational Foundations", 20 (3-4), pp. 51–68.

Wertsch, J.V. and Rupert, L.J. (1993) *The Authority of Cultural Tools in a Sociocultural Approach to Mediated Agency*, in "Cognition and Instruction", 11 (3-4), pp. 227–239.

Wineburg, S.S. (1989) *Commentary: Remembrance of Theories Past*, in "Educational Researcher", 18 (4), pp. 7–10.

Wood, D., Bruner, J.S. and Ross, G. (1976) *The Role of Tutoring in Problem Solving*, in "Journal of Child Psychology and Psychiatry", 17 (2), pp. 89–100.

Zürcher, R. (2015) *A Sociomaterial Model Of The Teaching-Learning Continuum*, in "European Journal for Research on the Education and Learning of Adults", 6 (1), pp. 73–90.

Yang, J. (2018) *Biopower*, in Callan H. (ed.), *The International Encyclopedia of Anthropology*, Hoboken, NJ, John Wiley & Sons, Ltd, pp. 1-9.

Zehr, H. (2002) *The Little Book Of Restorative Justice*, New York, Skyhorse Publishing, Inc.

---

[1] See Law (2009a) for a sociomaterial understanding of assemblage as "agencement".

[2] The epistemic meaning of 'imaginary' has been discussed by Verran (1998).

[3] Authors such as Allal (2001) propose the term situative learning as an alternative to render visible the participation of more remote objects along "chains of actors" (Latour 2005, 173) distributed in time and space.

[4] This list is not exhaustive, later Law and Mol (2001) also write about the "fire" spatiality.

[5] As originally described by Mol (2002).

[6] As in the word sociomateriality, we may choose to remove the hyphen to distinguish this new interpretation from classic 'teaching' and 'learning'.