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Abstract

In modern,Western societies the purpose of schooling is to ensure that school-goers acquire knowledge of pre-existing practices, events, entities and so on.The knowledge that is learned is then tested to see if the learner has acquired a correct or adequate understanding of it. For this reason, it can be argued that schooling is organised around a representational epistemology: one which holds that knowledge is an accurate representation of something that is separate from knowledge itself. Since the object of knowledge is assumed to exist separately from the knowledge itself, this epistemology can also be considered 'spatial.' In this paper we show how ideas from complexity have challenged the 'spatial epistemology' of representation and we explore possibilities for an alternative 'temporal' understanding of knowledge in its relationship to reality. In addition to complexity, our alternative takes its inspiration from Deweyan 'transactional realism' and deconstruction. We suggest that 'knowledge' and 'reality' should not be understood as separate systems which somehow have to be brought into alignment with each other, but that they are part of the same emerging complex system which is never fully 'present' in any (discrete) moment in time. This not only introduces the notion of time into our understanding of the relationship between knowledge and reality, but also points to the importance of acknowledging the role of the 'unrepresentable' or 'incalculable'. With this understanding knowledge reaches us not as something we receive but as a response, which brings forth new worlds because it necessarily adds something (which was not present anywhere before it appeared) to what came before. This understanding of knowledge suggests that the acquisition of curricular content should not be considered an end in itself. Rather, curricular content should be used to bring forth that which is incalculable from the perspective of the present. The epistemology of emergence therefore calls for a switch in focus for curricular thinking, away from questions about presentation and representation and towards questions about engagement and response.

Introduction

In modern, Western societies schooling is almost invariably organised as an epistemological practice. Educational institutions present knowledge about the world 'outside' and for that very reason they rely upon a representational

epistemology. This is an epistemology which holds that our knowledge 'stands for' or represents a world that is separate from our knowledge itself. Since the object of knowledge is assumed to exist in a separate space from the knowledge itself, this epistemology can also be considered 'spatial.' In this paper we show how 'complexity theory'[1] has challenged the spatial epistemology of representation and we explore possibilities for an alternative understanding of knowledge in its relationship to reality. Our alternative takes its inspiration from complexity, Deweyan 'transactional realism' and deconstruction. With complexity we suggest that 'knowledge' and 'the world' should not be understood as separate systems which somehow have to be brought into alignment with each other, but that they are part of the same evolving complex system. This not only introduces the notion of *time* into our understanding of the relationship between knowledge and reality, but also points to the importance of acknowledging the role of the *unrepresentable* or the 'radically non-relational.'

We should make clear, however, that in pointing out the incompatibility between complexity and representational epistemology, we do not mean to suggest that we can do without representations in schools. All we are suggesting is that we need to review the meaning of our representations in the educational sphere, and hence the representational character of schooling. Our interest is primarily in articulating an epistemology that helps us think about knowledge, representation, education and the world that does not result in, or seek, closure. To put it differently, we are trying to articulate a different ethic or 'way of being' in education, that is less concerned with representing the real than it is with living it out in different ways.

This is an argument more complicated than we will be able to develop in full in this paper. Nevertheless, we have begun to approach this task firstly by providing a very brief account of education as a 're/presentational' practice, in order to make it clear what we are arguing against. Using perspectives from complexity we then show that all representations of complex phenomena ultimately betray their object (see Cilliers, 1998), and in doing this we address the question of what sort of epistemology is required if we would drop the conventional understanding of knowledge as reflecting or representing a pre-given world. We argue that complexity itself suggests an 'emergentist' alternative to representational epistemology. This alternative comes close to Dewey's transactional realism (see Biesta & Burbules, 2003). However it seems to lead to the more radical conclusion that because knowing is transactional, there will always necessarily be something that cannot make its appearance in the domain of representation. That however we order the world, there will always be more ordering yet to come. That there *cannot* be a notion of any final order. To conclude the paper, we suggest that this alternative to representational epistemology—which could be called an 'emergentist' epistemology— could lead to a different way of

understanding educational practice since we find education (becoming educated) is no longer about understanding a finished universe, or even about *participating* in a finished and stable universe. It is the *result*, rather, of participating in the creation of an *unfinished* universe.

Knowledge and Representation

Before discussing our 'emergentist' alternative to representational epistemology, we need to clarify briefly what we mean by representation, since this is an extremely broad concept with an extensive philosophical past. We want to talk about representation in a fairly restricted sense. Firstly, we want to talk about this concept as something external and 'public' (see Hacking, 1983, pp. 132–133). In this regard we are excluding internal mental representations or thoughts. Secondly, we are restricting the concept of representation to include only those forms of representation that claim to be likenesses of the things they represent. This is because external or public representations can include anything that can be examined or regarded, including art-works that aim to distort or challenge conventional understandings of reality. But we also want to stretch the concept a little, to include not only physical objects like drawings, photographs, maps, films, tape-recordings, and scientific or other *models* but also elegant *theories* about electrons, gravitational forces, language and so on. Although one could argue that there is a difference between models and theories, we are purposely conflating these two concepts, since both, in our understanding, are representations which intend to help us understand the world as it *really* is. The purpose of both is to enable our movement towards a knowledge/understanding of what the world is really like, once and for all. It is only when we use *truth* as a criterion to judge between alternative likenesses/representations (rather than, for example, usefulness), and when we understand truth to mean correspondence with reality, that we end up with an epistemology that can be called representational.

In contrast to this representational epistemology—which could also be called a 'spatial epistemology' since it depends on a correspondence between knowledge and reality—we propose that complexity suggests a *temporal* epistemology which implies that the quest for knowledge is not in order that we may develop more accurate understandings of a finished reality, *as it is.* Rather, the quest for knowledge is about finding more and more complex and creative ways of interacting with our reality. Through doing this—through intervening in our own realities—we find out how to create more complex realities with which we can interact in yet more complex and creative ways. The point is that, from a complex systems perspective, there are no final solutions, only ongoing interactions leading to increasingly more complex interactions (and 'solutions'). The key issue, for us, is that this is not how knowledge is commonly understood in Western educational institutions.

Education as a Re/Presentational Practice

Many if not most of our Western, modern educational practices and institutions seem to rely upon a representational epistemology (see Biesta & Osberg, 2007). What is significant here is, first of all, that they rely upon an *epistemology* rather than, say, a political, ethical or relational theory, and thus configure schooling in terms of the transmissions and acquisition of knowledge (there are, of course, some noticeable exceptions, particularly in the more radical forms of progressive education). Secondly, this epistemology is representational in that it is assumed that what is presented in education stands for something else: it stands for something in the world 'out there', and therefore is a representation.

One could argue that from a historical perspective educational practices were initially practices of *presentation* (see Mollenhauer, 1983). For long periods, new generations could learn through direct participation in existing ways of life, by mingling, competing and working with adults in the 'real' world (and in some cultures and settings this is still the way in which new generations learn). Mollenhauer argues, however, that in the sixteenth and seventeenth century the position of children in society changed. What disappeared was the situation in which children were direct participants in life. What emerged instead was a separate sphere or educational world especially for children, where they could be educated for later participation in real life (this first happened for the elites and only by the end of the nineteenth and the beginning of the twentieth century for the masses). Mollenhauer's claim is that it was only when a separate educational world was constructed, that the question of representation became a central educational question. After all, once we take children out of 'real life', but still want to prepare them for 'real life,' we need in some way to represent 'real life' within the confines of the world of the child. Since we obviously cannot get the whole world into the school, we have to select which forms of life to represent in the school. We must select what is valuable from what isn't, and we must then represent this selection in appropriate sequences and formats. It is in precisely this respect that we would say that the central rationale for education is in terms of a representational epistemology: what and how best to represent 'the world'?

There are, however, at least two sets of arguments that, in a sense, challenge the idea of schooling as representation. First, there are arguments from the point of view of learning. The main insight—relatively old, but for some reason education needs to be reminded of it from time to time—is that teaching does not determine learning. What students learn may have a link with what teachers teach, but the two are not necessarily identical. Through their participation in educational practices learners learn much more and

much different things than that which they were supposed to learn. This poses a challenge to curriculum makers. The argument from progressive, participatory and 'situated' learning theories is that the only way in which young people can learn meaningfully is if they can participate in 'real world' practices (see, e.g. Lave & Wenger, 1991). Representational curricula, it is argued, are disconnected from the things they wish to represent and therefore devoid of any real, significant meaning. The solution is therefore to do away with the 're' and make educational institutions into places where the world itself is presented.

However, against this 'presentationalist' or 'participatory' position it has been argued, firstly from a conservative viewpoint, that a 'decent' education is not merely about practical work or apprenticeship, but one in which children get access to all the great works *of a particular cultural tradition*. In this regard, even Dewey argued that schools should present a purified selection of the world (Dewey, 1966). Secondly, from a radical viewpoint, it is argued that participatory or presentational forms of learning end up in socialisation and adaptation and make it difficult to create critical distance and therefore result in one-dimensional ways of learning. In this way 'representational' and 'presentational' pedagogies are somewhat (although not completely) opposed to each other—although both strategies are still the two main approaches to education, and perhaps becoming increasingly intertwined (see Biesta & Osberg, 2007).

But there is another argument that challenges the idea of representation. This argument challenges both presentation *and* representation and therefore opens the possibility of thinking about education in a way that gets away from the intertwined presentation/representation approach. This argument is supported by the work of Jacques Derrida—in particular his critique of 'the metaphysics of presence,' more familiarly known as 'deconstruction'—which can be substantiated by arguments from complexity theory (see Cilliers, 1998). According to this line of thinking, both presentational and representational pedagogies rely upon the idea of a world that is simply present and can simply be represented. Derrida would argue that both presentation and representation are examples of the 'metaphysics of presence'—the idea that there is a world 'out there' that is simply 'present' and to which all our understandings (meanings) are in relation. In contrast to this position, deconstruction resists being drawn into and subsumed by any relationship with presence. While deconstruction certainly offers some interesting perspectives on education (see Biesta & Egéa-Kuehne, 2001, for a general overview; and Ulmer, 1985, and Biesta, 2004, for a discussion about deconstruction and educational [re]presentation), we believe that by challenging both representation and presentation, complexity also offers a way out of the dilemmas in the representational approach to education.

Complexity's Challenge to Representation

Complexity's challenge to representation comes from the idea that models of complex systems appear *not* to be representations in the usual sense of the word. They cannot be understood to 'stand for' or depict reality as it really is. There is no isomorphism between the world and our descriptions of it. We would argue that this is also the case with scientific theories which attempt to reduce the world to a system of rules or laws. This challenge to representation, we believe, does not imply that we should attempt to do without representations, but that we need to rethink the status and the purpose of our representations.

The idea that complex models are not isomorphic with the complex systems they purport to represent has been defended in detail by Cilliers (1998, 2001). In a nutshell, the argument is that since we cannot understand something complex in all its complexity (as humans we have limited means and limited time), models, by definition, have to reduce complexity. It is exactly in this reduction that we generate understanding. A model must necessarily be simpler than the thing modelled. Complex systems, however, are by definition 'incompressible': they cannot be 'reduced' without losing something (Cilliers, 1998, pp. 7–10). This, in fact, is the criterion that can be used to distinguish complex systems from those that are merely 'complicated' (a distinction that, although useful, is not unproblematic: see Cilliers, 2000b). Complex systems cannot be reduced, because of the non-linear nature of their interconnections. The information they contain is not in the individual elements making up the system, but *distributed* in their pattern of interactions. This means that if we leave anything out of the system (which we have to do if we want to make a model) we disrupt the information contained in the system. What is more, the elements left out have non-linear relationships with the other elements, and we cannot therefore predict the magnitude of the effects this will have in a deterministic way.

This point can be expanded to general theories which aim at understanding the universe by reducing its processes to a system of rules or laws. Although our understanding is a result of a reduction (of a distributed set of relationships to a discrete set of rules), this reduction is by definition flawed, and therefore our understanding of complex phenomena is never perfect. We can have different models of the same system, but the understanding generated is always a function of the specific model chosen, and there is no meta-model that does this work for us. The choice of models is not arbitrary—some work better than others—but we cannot claim that they are chosen objectively. Understanding, and the model which generates that understanding, go hand in hand (see also Cilliers, 2000a).

We can therefore argue that models and theories that reduce the world to a system of rules or laws cannot be understood as pure representations of a universe that exists independently, but should rather be understood as valuable but provisional and temporary *tools* by means of which we constantly re-negotiate our understanding of and being in the world. We use the term re-negotiate (rather than the term negotiate) because we hold that the process of negotiating our world does not have an end: rather, it results in the creation of a new and different and sometimes more complex world. In this way our negotiations are always already re-negotiations; they are temporary by nature.

Rules and Boundaries in Complex Systems

To use models to get to the answer that our theories are not representations but re-negotiation tools, we first have to be clear about the fact that both models and theories about complex systems are well framed, receive specific inputs and produce specific outputs, and can therefore be considered as closed systems with well-defined boundaries. In contrast, the natural complex systems that we are interested in modelling—such as language, life, economic systems, ecosystems, education, consciousness, and so on—do *not* have clearly defined boundaries. This difference has an impact on the way in which rules operate in these systems.

What is of significance here is that from the fact that models of complex systems can be reduced to rules, it is sometimes inferred that natural complex systems can be reduced to rules (two examples of this kind of inference can be found in Holland, 1998 and Wolfram, 2002, but there are many other examples in the complexity literature). But in fact the only reason rules work in models is because models have well defined boundaries. For example, in a ‘closed’, non-linear system such as a cellular automaton, where all the initial conditions are very precisely known, and presuming the principle of causality holds, there is only a single trajectory which this system can follow, and the operating rules sharply determine this trajectory. The very same trajectory will be followed every time we have a particular set of initial conditions and rules. The system will produce the same effects time and again, and in this way we can say the output of the system can be accurately represented in terms of the operating rule plus the initial conditions of the system. Our point is that although this may be the case with closed systems (that is, our models and theories), the problem lies in extending such an understanding to natural complex systems, which are open systems, having boundaries that are not clearly defined.

In open systems that interact with their environment and that have interconnections which extend not only internally and between systems, but also across different hierarchical levels, complex behaviour is not so easily reduced to a system of rules. If we assume rules do indeed govern the

behaviour of such systems, this would mean that different rules of operation would criss-cross in ‘individual’ complex systems. So the behaviour of any particular system is contingent on many *different* and overlapping sets of rules (which themselves are emergent products of other interacting complex systems). The problem therefore becomes one of how we can describe or represent or *theorise* a system like this in terms of a single or unified set of rules. The question is how we can represent the behaviour of the system in terms of a set of rules when its output is partially determined by sets of rules to which we have no access (see Cilliers, 2000b, 2001).

This is not to say we *cannot* model or theorise radically contingent systems by looking for their rules of operation. Obviously we can and do, and often successfully, although within limits (e.g. the weather). But we have to acknowledge that to model or theorise any interconnected system we first have to cut it off from the other regularities or systems with which it interacts. We cannot pretend this is not the case. We need boundaries around our regularities before we can model or theorise them, before we can find their rules of operation, because rules make sense only in terms of boundaries. The point is that the setting of the boundary creates the condition of possibility for a rule or a law to exist. When a boundary is not naturally given, as is the case with natural complex systems, the rules that we ‘discover’ also cannot be understood as naturally given. Rules and ‘laws’ are not ‘real’ features of the systems we theorise about. Theories that attempt to reduce complexity to a system of rules or laws, like our models which do precisely this, therefore cannot be understood as pictures of reality.

Representational versus Functional Correspondence

We still, however, have to get from this idea—that models and theories that reduce complexity to a handful of rules are not pure ‘representations of reality’—to the idea that they are instead provisional, helpful tools by means of which we renegotiate our world. We can start with the following question: if our models of complex systems do not reflect reality exactly, why does their behaviour appear to correspond with the behaviour of the system (reality) we are modelling? There are at least two perspectives from which this question can be answered.

First, we could take the traditional perspective that our model represents some real pattern or regularity (albeit a radically interconnected regularity) that actually exists and that all we have done is separate this regularity from ‘reality at large.’ If we look at the situation like this, we see that if we were to try and represent the behaviour of an isolated ‘regularity’ in terms of its rules of operation, we would find that the overlapping sets of rules that made the regularity behave in the way it did within the larger interconnected system are no longer accessible to us. If we want our model to behave in the way the interconnected regularity behaved, we have to find not only a new

set of rules, but also a new set of initial conditions for these rules to operate upon. And because our model has a boundary, such new rules and initial conditions can be found/named. However, the rules and initial conditions that make our isolated model behave like the interconnected regularity cannot be understood to be isomorphic with the rules operating in the interconnected regularity. The rules of our model may produce the same effect as the interconnected regularity, but it is a completely different set of rules and initial conditions that creates this effect. In other words, regularities exist, we can detect them and even find rules that reliably describe their behaviour, but the rules we find are *pragmatic*, they are not real things, they are not pure reflections of reality. There is no isomorphic relationship between the rule in the model and the rule in the real system (if such 'real' rules even exist). While our models may imitate or simulate the behaviour of an observed regularity (at least for a while), and in this way appear to correspond to reality, we must acknowledge that this correspondence is not representational (or isomorphic) but functional or pragmatic. The ability to explain carries little warrant of truth. Our models are *tools*, not pictures of reality. For exactly the same reasons, theories which attempt to represent natural complex systems in terms of a few rules or laws can also not be understood to reflect the 'real' world. Like our models, these theories are pragmatic. They are tools. However, acknowledging that models and theories are tools rather than representations still doesn't get us to the point where we can say that models and theories are tools that *help us re-negotiate our world*. To do this we need to switch perspectives.

A different way of understanding knowledge—and here we draw on Hacking (1983)—is to say that we don't first 'see' the regularity and then try to describe it by means of a set of rules (which don't really exist) in order to understand it (which would be a rather futile operation, to say the least). Rather we *infer* the existence of a regularity from the nature of our interactions with our environment. For example, we can infer the existence of negatively charged electrons because we can do things with them. We can use them to find out something else.[2] However, the purpose of interacting with our environment is not simply to discover what the real world is like, but to find ways of manipulating our environment, so that we can live in it and change it. It is only through experimenting with our environment—interacting with our world—that knowledge emerges. We 'gain knowledge' not from passively observing, but from actively intervening, or, as Francis Bacon aptly put it, by 'twist[ing] the lion's tail' (quoted in Hacking, 1983, p. 246). From this perspective, knowledge is not about 'the world' as such, it is not about truth; rather, it is about what we can *do* in the world, how we can change it. The former understanding leads us to believe that 'the phenomena revealed in the laboratory are part of God's handiwork, waiting to be discovered' (Hacking, 1983, p. 225), and our models/ theories are reflections of this world. The latter, on the other hand, suggests that any phenomena that are 'revealed' are secondary *effects* of our transactions with our environment, and our models/theories are placeholders that allow us to

develop more complex understandings, which in turn enable us to re-negotiate a reality that is becoming increasingly complex as a result of our interventions. We can never 'catch up' with this reality, for each time we make a move in this direction, we create a more complex situation for ourselves. One could say 'acquiring' knowledge does not 'solve' problems for us: it creates problems for us to solve. This represents a significant shift.

We are asked to shift from a spatial or representational understanding of knowledge to a *temporal* understanding of knowledge, where knowledge has to do with the relationship between our actions and their consequences. With the latter understanding there is a split in time rather than in space (that is, the split between mind and world) and so we could call this a *temporal* rather than a spatial epistemology (see Biesta & Burbules, 2003, for details about such a temporal understanding of knowledge and truth). This temporal understanding of knowledge meshes with the idea that our models and theories are not representations of the world as such, but functional or pragmatic *tools* which enable us to interact with the world in more complex ways. In other words, through experimenting with our world, we are led to certain realisations about it which enable us to interact with it differently. This in turn leads to more complex realisations about our world, which may replace those held previously, and so the cycle continues. Through this never ending process of experimenting and rethinking we are able to continuously re-negotiate our own theories, and thus we re-negotiate our position in the world.

Complexity's Challenge to Presentation

We have said that complexity asks us to make a shift from a spatial or re/presentational epistemology to a temporal epistemology. This shift, we believe, brings us to the issue of complexity's challenge to *presentation*. To make this clear we shall review the special way in which complexity understands temporality.

Linear versus Non-Linear Understandings of Temporality

Complexity's understanding of temporality and process contrasts with linear understandings which assume that processes (causal sequences of events) happen over time and so can be understood from *particular* temporal standpoints (with no temporal standpoint being privileged). With this understanding, time is just another variable or parameter that can be applied to the system from without. From a complex systems perspective, however, temporality is not a static variable but an *operator*—functioning from within, an integral part of the structure of the system itself. In other words,

structure and process are inseparable. This is illustrated by the concept of emergence, where we find that first, we cannot talk about one set of structures being ontologically prior to and therefore simply 'giving rise to' another hierarchical level of structures, as is the case with a linear understanding of process. With emergence, if the higher (or emergent) level consists of units of the lower level, then they exist simultaneously (Emmeche *et al*., 1997). Second, we find that emergent features *constrain* the space of possibilities simply by manifesting (ibid.): this is precisely *because* they exist simultaneously with lower level components. In this sense emergent effects must be understood as being imprinted on the lower level components. This sort of 'process' ensures that a complex system has an irreversible trajectory and, more than this, this directionality or historicity is part of the information contained in the very structure of the system itself. It cannot be taken out of the system without destroying the system, which is why structure and process are inseparable in complex systems. The question is, how does this 'emergentist' understanding of time/process affect our understanding of knowledge?

A Complexity Informed Understanding of Knowledge

Before articulating what knowledge could mean from a complex systems perspective, we first need to reiterate that conventional (that is, representational or spatial) understandings of knowledge create a divide between the mind and the world, or between the world and our knowledge of it. Again, we refer to it as a 'spatial' understanding because knowledge is assumed to be 'in the mind' while the object of this knowledge is assumed to be 'out there' in a different place. This understanding of knowledge, however, leaves us with the problem of needing some way of checking that our knowledge or representations of the world correspond to the real world. However, we find we can never be sure that our representations correspond to the real world because every test of our representations simply results in more representations. To attempt to argue for realism at the level of representation is to be locked into a world of representations.

Dewey solves this problem by understanding knowledge and learning in terms of action or, more accurately, transaction (Dewey & Bentley, 1949; Biesta & Burbules, 2003). Although this introduces the dimension of time into our conception of knowledge, it is important to be precise about the temporal character of Dewey's understanding of knowledge. Dewey's point is not simply that learning takes time and that we learn about 'the world' through the effects of our actions. If this were the case we could simply replace the idea of knowledge as a comparison between places (mind and world) with the idea of knowledge as a comparison between events (before and after). The key insight in Dewey's transactional theory of knowing is that the world that comes 'into focus' through our transactions is not a world that is simply 'out there' waiting to be discovered, since this would imply that there is an end to our knowing when the world is perfectly in focus. In fact transaction

never stops and hence ‘the world’ never stops coming into focus. The continuing appearance of reality, in more and more complex guises, one could say, is an *effect* of our interacting in the world, not the starting point.

This situates Dewey’s perspective very much within a complex systems framework. In the vocabulary of complexity we could say that knowledge *emerges* from our transactions with our environment and feeds back into this same environment, such that our environment becomes increasingly meaningful for us. This means we cannot have knowledge *of* our environment, once and for all—it is not something we can see, something to look at. Rather, it is something we have to actively feel our way around and through, unendingly. Why unendingly? Because in acting, we create knowledge, and in creating knowledge, we learn to act in different ways and in acting in different ways we bring about new knowledge which changes our world, which causes us to act differently, and so on, unendingly. There is no final truth of the matter, only increasingly diverse ways of interacting in a world that is becoming increasingly complex.

Although we don’t have the space to develop this idea here, we believe that the way in which complexity understands the notion of knowledge is congruent with Dewey’s transactional realism, and this helps put the observer back in the world as an interested participant rather than a disinterested observer. To put it differently: a ‘complexity based’ understanding of knowledge helps us towards an ‘emergentist’ epistemology in which ‘the world’ and our ‘knowledge’ of it are part of *the same complex system* (rather than being two separate complex systems, which we somehow need to get into alignment). But a similarity with Dewey’s transactional realism is not the end of the story for the epistemology of complexity. There is a further aspect which needs unravelling, and this is complexity’s relationship with the radically *non-relational.*

Knowledge and the Radically Non-relational

Dillon (2000) has suggested that both complexity and poststructuralism understand the world as ‘radically relational’, but that these two positions differ from each other in terms of their understanding of this ‘radical relationality’. In his words:

> For complexity thinkers the anteriority of radical relationality is just that, the anteriority of radical relationality ... . For poststructuralists the anteriority of radical relationality is relationality with the radically non-relational. Here the radically non-relational is the utterly intractable, that which resists being drawn into and subsumed by relation, albeit [that] it transits all relationality as a disruptive movement that continuously prevents the full realisation or final

> closure of relationality, and thus the misfire that continuously precipitates new life and new meaning. There is no relational purchase to be had on the intractable. It resists relation. (Dillon, 2000, p. 5)

However, in contrast to Dillon, we believe that complexity is not oblivious to the 'radically non-relational'. Quite the contrary: 'relationality to the radically non-relational' could be considered *key* to the logic of complex systems.[3] This is evident in Prigogine (1997), who insists that although new order (emergence) results when a complex system explores and finds new ways of working with the initial conditions, and that these initial conditions are provided by the lower hierarchical level—and are 'causal' in this regard—the elements making up the lower level do not provide *everything* necessary for order of a particular kind to emerge at the higher level. In his words:

> The system 'chooses' one of the possible branches available when far from equilibrium. But *nothing in the macroscopic equations justifies the preference for any one solution*. (Prigogine, 1997, p. 68, italics added).

The single actualised version—the 'solution' that is 'chosen' by the system—is always one among a number of plausible alternatives *that happened not to occur.* This means that the 'solution' a system will finally 'settle on' is not a foregone conclusion, but always a matter of chance. To put this another way, the pattern (or organisation) that emerges at the higher level is not only a product of the system's relational past but also of 'something' that is *not present in the system at all.* The combination of the system's relational past with the totally intractable or unrepresentable to produce new emergent order that supervenes on lower levels *ad infinitum* ensures that the system is never in a state where it is fully actualised, is never fully 'present' at any point in time, because an integral part of it is that which is *not* part of it. It therefore remains always in the process of becoming without being (see Osberg & Biesta, 2007, for a more detailed account). This understanding of emergence comes close to key insights, developed by Derrida under the label of 'deconstruction'.

In describing the poststructuralist perspective, Dillon comments,

> for poststructuralist thinkers, not only is there more to life than meets the eye, that 'more' is never something that will ultimately make its appearance in the domain of representation. It is the intractable always already at work within but resistant to representation. Its presence-as-absence spoils the show for representation since it is always already subverting representation's productions. (Dillon, 2000, p. 15)

We believe this is also the case for complexity. Chance is always already at work in complex systems, thereby spoiling the show for representation.

Implications for Schooling

In this paper we have explored issues of representation and presentation, using complexity theory, Deweyan transactional realism and deconstruction. We have shown how complexity theory challenges the idea and possibility of representation, partly through the idea of incompressibility and partly by showing the problem of attempting to represent open systems (reality) by closed systems (representations, models, theories). The upshot of this is not that we should no longer attempt to develop knowledge, models, or theories—but that we shouldn't think of them as 'copies' of the world 'out there'. Rather, we should understand knowledge, models and theories as tools that we use in engaging with 'the world'. This suggests an epistemology in which time has a central role to play—a temporal rather than a spatial epistemology.We have pushed this argument one step further by also problematising the idea and possibility of 'presentation' and 'presence.' The main step here was to see that time is not a static variable unaffected by systems, but rather an operator in the system itself. By using this line of thinking, and combining it with some insight from Dewey and deconstructive ideas, we suggested that complex systems can only be understood if we acknowledge the 'presence' of something that cannot be presented, that can never become 'present'. Here, as we suggested, our explorations came close to key insights developed by Derrida under the label of 'deconstruction'. Along these lines we have tried to show that complexity theory not only problematises conventional—i.e. representational—ways of thinking about knowledge in relation to reality. We have also tried to show that it is possible to develop an alternative 'epistemology' using key ideas from complexity. In this process we found it helpful to refer to the work of Dewey, whose temporal theory of knowledge and whose transactional ontology show a surprising affinity with ideas emerging from complexity theory and deconstruction. Rather, therefore, than thinking of knowledge as the representation of a world that is somewhere present in itself, our considerations suggest an 'emergentist' epistemology in which knowledge reaches us not as something we receive but as a response, which brings forth new worlds because it necessarily adds something (which was not present anywhere before it appeared) to what came before.

The challenge then is to see what this alternative 'emergentist' epistemology— which we may no longer even want to call an epistemology— would imply for the practice of schooling. What would schooling *actually* look like if we dropped the idea that its overall aim is to ensure the acquisition of knowledge of an already existing reality that is fully present? How might such a practice of schooling actually be 'performed'? Such questions, according to Ulmer (1985), open a search for a 'non-magisterial' style of teaching. When

we consider the purpose of schooling in terms of an emergentist understanding of knowledge *and* reality, we must begin to imagine schooling as a practice which makes possible a dynamic, self-renewing and creative engagement with 'content' or 'curriculum' by means of which school-goers are able to respond, and hence bring forth new worlds. With this conception of knowledge, the purpose of the curriculum is no longer to facilitate the *acquisition* of knowledge *about* reality. Acquisition is no longer the name of the game (see Biesta, 2006; Osberg & Biesta, forthcoming). This means questions about what to present in the curriculum and whether these things should be directly presented or should be represented (such that children may acquire knowledge of these things most efficiently or effectively) are no longer relevant as curricular questions. While content is important, the curriculum is less concerned with *what* content is presented and how, and more with the idea that content *is* engaged with and responded to (see Biesta, 2006). Here the content that is engaged is not pre-given, but emerges from the educative situation itself. With this conception of knowledge and the world, the curriculum becomes a tool for the emergence of new worlds rather than a tool for stabilisation and replication (Biesta, 2006; Osberg & Biesta, forthcoming).

An example of an approach which is supported by the emergentist framework that we have suggested in this paper can be found in Davis and Sumara's 'enactivist' or 'complexivist' conception of teaching, which aims to 'expand the space of the possible' (Davis & Sumara, 1997). However, while Davis and Sumara have certainly not ignored epistemology in their pedagogical formulation, their theoretical framework (drawing strongly on recent developments in cognitive science, artificial intelligence and second order cybernetics) has oriented them towards a concern with *private* rather than with *public* knowledge. They focus primarily on questions about teaching and learning without questioning the (problematic) assumption that the knowledge taught and learned in schools stands for something more real than itself. By focussing on 'public knowledge' in this paper, and (i) showing that the way in which public knowledge is thought about in schools aligns schooling with representational epistemology; (ii) offering an alternative 'emergentist' epistemology; and (iii) showing how public knowledge can be understood in terms of this alternative epistemology, we believe we have provided a framework that could serve as a platform from which to launch a series of fruitful discussions between educators and educational researchers who are attempting to articulate an educational ethic that operates some distance away from the representational epistemology of schooling that continues to structure classroom practice in many (Western) societies.

Notes

1. We use the popular term ‘complexity theory’ only for convenience. In fact ideas from complexity are too diverse to constitute a coherent theory.

2. Hacking (1983, pp. 22 –23) gives the example of a super cooled niobium droplet, which, when ‘sprayed’ with electrons (there are standard emitters with which we can spray positrons and electrons) maintains an electric charge which can be kept going around the ball forever. This means the drop can be kept afloat in a magnetic field, and indeed driven back and forth by varying the field, and one can use a magnetometer to tell exactly where the drop is and how fast it is moving. Whatever ‘electrons’ are, they have real effects. It is from these effects that we infer their existence.

3. The difference of opinion here is largely a result of different understandings of the notion of ‘emergence,’ which can be understood in a ‘weak’ or deterministic sense as explicated, e.g. by Holland (1998) or in a ‘strong,’ non-deterministic, or Prigoginian sense (see Chalmers, 2006, Osberg & Biesta, 2007).

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