THE MATTER OF LEARNING: RECONSIDERING THE
THEORETICAL BASIS OF CONCEPTUAL CHANGE RESEARCH

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This paper sets out the need for a revision to the way that conceptual change is theorised, in order to advance both research and practice in science education. Over the last 50 years, conceptual change research has amassed a huge body of evidence around the ways that young people learn, including the difficulties that they have in many specific areas of science. It has also engaged with how teachers themselves learn, and how pupils respond to the nuances of instruction. However, over those 50 years there have been both theoretical and empirical advances outside of conceptual change research in how we understand the mind and its relation to the world. I will show how these advances have brought into question the way that conceptual change is framed as the development of mental entities, be they coherent theories or fragmented schemas of action.

Through tracing key points in the development of conceptual change theory I will highlight how it has retained a separation of mind and matter which is no longer tenable in light of advances in neuroscience, nor in the face of the philosophical debates around representation, language and mind which straddled the turn of the century. In addition to these threats from outside, debates which have emerged within conceptual change research are far from resolved, leading several authors to comment that there is still no consensus around what conceptual change involves (Clement, 2008; Vosniadou, 2008). Conceptual change researchers are not isolated from broader theoretical discussion, nor are they blind to the theoretical issues in the field. Nevertheless, the field proceeds without resolving these issues and I contend that this is preventing progress.
Throughout the paper, we will return to the example of an object being thrown in the air, and pupils describing its motion. This example has reoccurred through the literature and therefore provides a useful vehicle through which to explore the different characterisations of concepts within conceptual change research. It furthermore allows the paper to draw upon a systematic review of 71 papers on conceptual change in forces and motion, which forms a foundation from which to mount the critique of concepts. The paper begins with a review of key points within the theoretical development of conceptual change research, and how these ultimately led to difficulties in defining concepts. Following this the paper examines the potential challenges from outside the field, before suggesting ways to navigate these challenges.

**Approach**

Use example of a ball being thrown vertically:
- This example reoccurs in the literature.
- Draws on a systematic review of 71 papers
  - conceptual change: forces and motion.
Despite debate since at least the 1970s, there remains no consensus around what concepts are or what conceptual change involves (Clement, 2008; Vosniadou, 2008).

I will take a typical, recent example from Graham et al. (2013), who describes a classroom situation. It involves 11, 17-year olds (or nearly 17 year-olds; 5 boys, 6 girls, diverse backgrounds).

Firstly, the pupils discuss in small groups what a force is, and then make a poster to elicit their existing understanding. These are discussed by the teacher.

Next, the teacher guides discussion around an Aeroplane moving at constant horizontal speed, and then accelerating. The forces are discussed, which leads to a conclusion that unbalanced forces lead to changes in motion, or shape.

The teacher then gives a diagram similar to the above to describe and asks the young people to vote on the resultant force. In their first vote (a further one follow discussion), they give these results. Clearly there are misconceptions despite the obvious display of understanding earlier.
The view that the pupils express in Graham’s study might be linked to Aristotle’s view of motion. Aristotle turned Plato’s contention around universal forms on its head, arguing that the essential forms of entities are to be found only in looking at their particular manifestations. Nevertheless, the essence of each entity is still characterised as a universal quality, and learning as the investigation of these essences.

Of utility to our discussion is Aristotle’s preoccupation with motion as fundamental to all change (especially in *Physics*), and here we come to our first example of falling objects. According to Aristotle, each object has a natural place within the (geocentric) universe: earth and water both fall downwards towards the centre of the earth/universe but earth falls through water, and occupies a natural place closer to the centre of the earth. Air rises (as is evident through bubbles in water), but fire escapes even more readily toward the heavens, so occupies a place above air. Real entities, being made of different ratios of these elements, contain an aggregate of such tendencies. Nevertheless, entities can either move according to their (aggregate) natural tendency, or be moved against them. Aristotle describes four types of cause, (as well as chance). For a stone being tossed we might describe a material cause (that the stone and person are there), a formal cause (the essential tendency of the stone to fall), an efficient cause (that the stone has come from the earth or a mountain) and the final cause (that a stone can be thrown by a person).

Aristotle’s view is pertinent to our discussion in two ways. Firstly, it became the basis for theories of impetus: that a thrown object is implanted with a certain force that
continues its motion once it leaves a thrower’s hand. The impetus is diminished (for example by air resistance) up to the point that the stone begins to fall again, as is its tendency. This view has been found amongst children in several studies, and some conceptual change researchers go as far as ascribing it as an Aristotelean view. This is not of primary concern here though.
The second relationship between Aristotle’s characterisation and discussion of contemporary conceptual change research is the importance of forms and tendencies. Whilst it is a disservice to almost two-and-a-half millennia of human thought to say that Aristotle’s views remain unchallenged, what we can say is that the importance of forms is still implicit in many areas of science. For example Hull (1965) suggests that Aristotle’s view underpins the essentialism we see in taxonomy:

“The three essentialistic tenets of typology are (I) the ontological assertion that Forms exist, (2) the methodological assertion that the task of taxonomy as a science is to discern the essences of species, and (3) the logical assertion concerning definition.” (Hull, 1965, p. 317)

The consideration of forms and natural kinds extends beyond taxonomy however; it informs the classical view of what concepts are.

**Essentialism and the Psychological View of Concepts**

Aristotle’s philosophy did not seek to escape the existence of universal forms, only to situate them in the particular, real entities which exist in the world. From this stems a focus upon the correct definition of a particular entity, which has arguably dominated western philosophy for millennia. Smith & Medin (1981) dubbed this the ‘classical view’ of concepts, and the fact that it is only labelled such in the early 1980’s indicates its dominance over history. This view equates concepts with categories, or what Aristotle called natural kinds:

“First, concepts are mentally represented as definitions. A definition provides
characteristics that are a) necessary and b) jointly sufficient for membership of a category. Second, the classical view argues that every object is either in or not in a category, with no in-between cases.” (Gregory L. Murphy, 2002, p. 15)

So a dog might be specified by the characteristics that it has 4 legs, fur and barks. As Murphy goes on to describe in his book, the study of concepts in psychology has proceeded to debate this, and there are now different views of how concepts should be defined. Very briefly, some psychologists favour a view that when we recall a type of object (e.g. dog), we recall exemplars from our past experience. Others suggest we use a ‘prototype’ concept, which distils the essential characteristics of that object. This explains why some examples of a group are more typical than others: oranges and bananas are more typical fruits than tomatoes. Other psychologists draw attention to the influence of knowledge in building concepts, and how we fit those concepts into system of knowledge.
Murphy (2002) suggests that Inhelder & Piaget held a classical view of concepts. This can be seen in their work:

Inhelder & Piaget (1964, p.281) “We want to know why the organization of behaviour in classification and seriation takes the forms it does. In particular, we want to know why later forms tend to approximate more closely to logico-mathematical structures.”

“There is certainly present to the child a whole world of thought, incapable of formulation and made up of images and motor schemas combined. Out of it issue, at least partially, ideas of force, life, weight, etc., and the relations of objects themselves are penetrated with these indefinable associations. When the child is questioned he translates his thought into words, but these words are necessarily inadequate.” (Piaget, 1929, p. 27)

In Piaget’s view, learning proceeds through stages with children first developing sensorimotor schema about the world, then having pre-operational concepts, then concrete operational concepts and finally being able to manipulate formal operations, with abstract concepts. This pinnacle means that children have acquired the correct logical specifications of a concept (e.g. falling). This is classical in the sense that ‘logic’ is specified as the correct understanding of a concept, and it has an essentialist character.
Bruner, Goodnow & Austin (1956) also focused upon investigating whether children have ‘correct’ logical specifications of concepts, and they arguably started a cottage industry in analysing the correct and incorrect concepts that children held. Bruner’s theoretical frame also includes a taxonomy of learning, centred on different forms of representation. Children move through enactive forms of representation, to iconic and then to abstract symbolic. Like Piaget’s taxonomy, the pinnacle reflects a child’s capacity to manipulate abstract concepts. The two frames for understanding learning both rely on a view of representations of reality as mental concepts which can be correctly (or incorrectly) defined. Aristotle’s essentialism is inherent in this view in that a concept is a representation of reality which reflects the essential characteristics of an object, process or physical law.
Piaget and Inhelder certainly had an influence upon early thinking around concepts in science. However, research in science learning in some ways separated from mainstream psychological investigation of concepts, which focused on categories and objects. This was obviously not sufficient to support how we come to have understanding of processes and laws. In their reviews of the history of conceptual change research in science education, both DiSessa (2006) and Özdemir & Clark (2007) draw attention to how ideas from the philosophy of science filtered into views of conceptual change. This might be seen as taking the ‘systems of knowledge’ view in mainstream psychologies investigation of concepts.

Returning to our example of a ball being tossed in the air, two papers here provide a summary view of the different views of concepts that developed (as discussed by DiSessa (2006).

McCloskey (1983) discusses the naïve theories that pupils have, for example the impetus view in which a ball runs out of impetus as it rises, and then begins to fall (descended from Aristotle’s view). Concepts then are naïve theories which, like scientific theories, should be challenged by the presentation of conflicting evidence. In the very same volume however, DiSessa (1983) developed his account of ‘p-prims’: fragmented understandings often stemming from experience. For example, the point at which a ball thrown vertically is stationary may invoke an understanding of ‘balance’ (DiSessa, 2006, p. 274). This may in turn lead to pupils erroneously considering that there is no resultant force acting on the ball. The well-established fault line between so called ‘coherence’
and ‘fragmented’ views of concepts influences understandings of conceptual change and pedagogy.
However, there is another strong view in the literature, that which takes a sociocultural view of concepts. This derives more from Vygotsky’s view of constructivism than Piaget’s. Graham et al (2013), from whom we took the original example take this view: that concepts are not individual mental representations, but emerge in the interaction between teachers and pupils. They suggest that the reason pupils give the incorrect response is because they spontaneously give a response in relation to (social) circumstances. I would also suggest, reading Graham et al.’s paper, that there is a temporal influence in the responses given: the activity prior to them being asked about rising and falling objects is a discussion of an aeroplane with balanced and unbalanced forces, so in a sense they have been ‘primed’ to see a static object as having no resultant force. The sociocultural view is not new in conceptual change research though, Mercer (2007) concludes a detailed volume on it, in which several researchers consider the social nature of concepts in science education. The issue that remains however is that there are different ways of seeing concepts. Concepts are poorly defined, despite 50 years of research.
I believe that at the heart of our inability to define concepts, lies the essential, dualist character which is given to mind within the field. This, as I have argued, comes from Aristotle by way of Piaget, Bruner and the classical view of concepts. The issue is that concepts are seen as mental representations of the world ‘as it is’. This representational view has been challenged by discourses within the latter part of the 20th century.

In analytical philosophy, Wittgenstein (1953) challenged the claim that a concept could be logically specified by characteristics. Take the example of a dog with 3 legs, no fur and who has lost their bark: it is still a dog. There cannot be necessary and sufficient criteria for an object; the meaning of a concept is actually defined in its usage.

Furthermore, in ‘continental’ post-structuralist discourses, the representational view was troubled by showing that there is not a simple relationship between a signifier (or concept) and what is signified. Drawing on Saussure’s work, Derrida (1976, 1978) showed that meaning is bound to a shifting system of representation.

Pedro J. Sánchez Gómez presented a paper in the ESERA 2017 conference on Monday, looking at how Putnam’s ‘meaning of meaning’ challenges constructivism, and there are undoubtedly many more critiques of constructivism and how concepts are characterised within the philosophical literature.

Theory of mind is another area in which there have been significant developments over the last 50 years, accompanying by technological advances which have changed our understandings of brain and mind. Ryle (1949) challenged the “the dogma of the ghost
in the machine”, arguing against Descartes’ dualist view of mind, and such arguments are only strengthened by neuroscience as it develops at pace. Not only are neuroscientists defining the ways in which grey matter underpins our thoughts and actions, but they are also showing the subtleties of the material influences upon thought and response. For example, in relation to watching an object being thrown in the air, neuroscience suggests that our responses would differ whether we observe the motion from the first of third person perspective (Jackson, Meltzoff, & Decety, 2006), and our acceptance of any description of forces acting would be influenced by our relationships with others and their subtle gestures (van Baaren, et al., 2009). Studies of this kind show a clear link between mind, matter and material context; something which is often overlooked within conceptual change research.

Furthermore, in my doctoral thesis (Hardman, 2015) I investigated the way that complexity theory undermines a separation of mind and matter. Briefly, the question posed by complexity is how mind and matter can interact given the multitude of influences which interact nonlinearly within a complex system: where does mind stop and matter begin?

In recognising the decline of dualism, the question arises as to whether we can sustain an ontological distinction between individual minds, social interaction and material context. I propose that we cannot.

There are philosophical issues with defining ‘concepts’ therefore. I propose that this is already well recognised within science education research. As Toumlin (1972, p.8) complained “The term concept is one that everybody uses and nobody explains – sill less defines” (Toulmin, 1972, p.8). Disessa goes on to say that “The “conceptual” part of the conceptual change label must be treated less literally.” (DiSessa, 2006, p.265). He notes that many different terms are used, each with slightly different meanings in relation to children’s thinking. In the review of literature which underpins this paper, we encountered reference to mental representations, P-prims, naïve theories, beliefs, mental models, cognitive structure, and ontologies. Even within mainstream psychological research into concepts, we find an awareness that any label might be applied: “numerous different representational structures, with different processes operating on them, can be formulated to explain any given research finding.” (Kosslyn, 1978, p.219).

The point is that ‘concepts’ are abstractions, and I suggest that they are in the eye of the beholder.
As well as being ill-defined, science education research recognises that when we are talking about conceptual change, we are not talking about cognition nor thinking. Richard Brock’s paper follows mine at the conference, so I have playfully used his quote here, in which he and Keith Taber refer to an ‘underlying cognitive structure’:

“The change in what a person is thinking (which is what a researcher can hope to directly infer by interpreting data elicited at any one time) from one time to another, may, or may not, reflect a substantive change in the underlying cognitive structure (which is only partially and less directly reflected in research data).” (Brock & Taber, 2016, p.5)

Researchers have also been clear from the outset of conceptual change research that concepts refer to the abstract level, and not to embodied perceptions or sensorimotor actions. Nor is conceptual change just a process of biological maturation. This can all be traced back to Inhelder & Piaget:

Inhelder & Piaget (1964, p.295) “From the very beginning of symbolization, all mental activity, whether pre-operational or operational, is invariably accompanied by a sequence of mental images, i.e. by representation in the form of images. Now mental images have their own laws which are different both from the laws of perceptions and from those of operations.”

As noted earlier, contemporary research also recognises the difficulty in distinguishing individual, cognitive views of conceptual change from social views of conceptual change:
“any new empirical evidence is unlikely to lead to a simple theoretical resolution in favor of an extreme situative or cognitive explanation of conceptual change.” (Mercer, 2007, p.77)

In summary, science education research clearly admits that we have no idea what ‘concepts’ are!
However, we all know what we mean when we talk about concepts, so does it matter that we cannot define them precisely? – Yes it does! I will outline how this lack of definition has implications for practice, as well as research.

The different views of what concepts are, can be associated with different suggestions for how we should promote conceptual change: learning. I will here give substantial simplifications in order to illustrate this point with some example from the literature. If a teacher holds the view that children hold Naïve theories (e.g. McCloskey, 1983), then they may proceed by introducing counterevidence (or ‘cognitive conflict’) in order to show the limitations of that theory and promote change. If however, a teacher characterises concepts as fragmented (e.g. DiSessa, 1983) then they might proceed by trying to uncover and then weave together these fragmented understandings into a coherent framework. Other options exist though, Potvin et al (2015) draw on neuroscience to propose that children actually hold multiple view at the same time, they investigate the advantages of direct instruction around the ‘correct’ scientific concept before trying to challenge ‘incorrect thinking’. As we have mentioned, there is also a sociocultural view of conceptual change; adherents to this view would focus on group work and interaction in the social construction of the correct scientific ideas. The issue therefore is that the view one has of concepts, informs how pedagogy is characterised.

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<th>Concepts as Coherent</th>
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<td>Concepts as fragmented</td>
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There are furthermore arguments mounting against ‘constructivist approaches’ in teaching. It is a leap from constructivist theories of learning to suggestions of practice, so a failure of approaches which might be labelled under the banner of ‘constructivist’ cannot be taken as the death knell for constructivism itself. Nevertheless, constructivism might be held accountable for at least some of the issues with such approaches.

There is a growing (but still minority) argument for a return to more ‘traditional’ forms of teaching which favour direct instruction and the acquisition of knowledge, as specified in curricula. This is being mounted against discovery learning, group work, inquiry and other forms of pupil-led pedagogies. One of the strongest critique of such approaches can be found in a paper called “Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching” by Kirschner, Sweller & Clark (2006). They draw on empirical studies to argue that such approaches do not have a marked impact upon attainment. Whilst I do not accept all of their arguments, they do echo a concern which has emerged from my (subjective and anecdotal) experience in hundreds of classrooms over the last 13 years as an educator and researcher. Many teachers conceive of learning as something which emerges from the activities that they ask pupils to do. However, many do not consider the detail of these activities in terms of how learning will actually occur. For example, a student might be asked to do calculations
around Newton’s 2nd law, and from this it assumed that the student gains an understanding of how objects fall. However, there is a certain ‘looseness’ around how it is assumed that engaging with this particular representation (mathematical equations) enables conceptual understanding. Concepts, to many teachers, are things that are acquired through activities, and this is treated unproblematically. Again, this does not pin the blame directly on how concepts are characterised, but my strong suspicion is that the looseness around concepts is echoed in the looseness around how they are acquired and change in classrooms.
Here I wish to bring together the argument so far. The literature on conceptual change has failed to provide a specific definition of what concepts are. This owes a lot to the essentialist character of concepts, and the dualism which is inherent in seeing concepts as direct representations of natural kinds, or indeed of process or laws within science. This is problematic in the guiding of teaching practice, because how one sees these mental entities guides how you might proceed in changing them. I therefore propose that concepts are abstractions which are unnecessary within educational research. This is a speculative aspect of my thinking at the moment, but I suspect that our reliance on concepts to describe the thinking of others stems from two areas: our language, which has inherited dualist and representational character from history and secondly our use of empathy in how we relate to each other. It is important to have a model of what other people are thinking, and theory of mind develops in young children, as it does in many other animals. It may be important and inevitable that teachers use their assumptions about what other people are thinking during the dynamics of a classroom, and go as far as making judgements about what a young person is able to do at that particular moment. However, when a researcher makes a claim about concepts (which are not the same as thinking or action) they are making a claim about a psychological state which is inaccessible to the researcher, but also inaccessible to the subject(s) of the research. In short, these concepts simply do not exist.
To reinforce my argument I will here specify the issues with postulating with regards to concepts as mental entities. As I have outlined, the ontological commitment to mental entities as distinct from matter, and as representative of essential elements of the world is a position which is greatly in decline within philosophical discourses. Investigations into mental entities is also problematic from a philosophy of science view: if we take Popper’s (1959) contention our hypotheses must be falsifiable, then we see that it is impossible to falsify claims about the nature of mental entities. To illustrate my point with a (somewhat obtuse) example, I could claim that there are fairies in my mind (or perhaps leprechauns since we are in Dublin), and when I answer a question correctly it is because the fairies have woken up. I could even claim that this corresponds to brain activity seen in the prefrontal cortex. This cannot be falsified in any scientific sense. More pragmatically, the focus on concepts and what they are is a distraction within research, occupying time and money with little hope of being resolvable, as intellectually stimulating as the debate is. If one decides that it is necessary to postulate mental processes, those processes should be framed as a ‘hypothetic model’, perhaps in the same way we might talk about ‘learning styles’ with teachers without wanting to commit to those as fixed, verifiable characteristics. To be honest though, even that is problematic, and I am struggling to see in what circumstance postulating concepts is directly useful without it being problematic.
The main point of this paper is to highlight the issues with specifying mental concepts. However, I want to outline (as far as I can in the 15 minutes) that there are alternative ways of framing learning which still uphold many of the insights from conceptual change research. Here I find the philosophy of Gilles Deleuze especially helpful (but there are other starting points for the ‘neo-materialist’ position I am going to outline). Deleuze recognised that there are repeated patterns in the world, e.g. dogs; the application of Newton’s 2nd law.

Each instance is unique, yet we label them with the same ‘concept’ (Deleuze, 1968)

→ Concepts are emergent

Deleuze’s (1968) ‘difference and repetition’ is also helpful seeing that concepts are emergent: they stem from repeated exposure to similar (but ultimately different) instances of phenomena, including the ways that other people label those phenomena.
A concept then is a label, expressed by an individual or group
• Not a link to essential characteristics.
• Not a definable mental state

A teacher/researcher is making a judgement when claiming someone has ‘learned a concept’.
→ A pupil’s ‘behaviour’ is judged as resilient to different contexts

A concept then is a label, expressed by an individual or which is debated, contested or agreed by a group of people. The concept, framed in this way, exists in the ‘difference and repetition’ of the circumstances in which the label is used. This differs from the claim that a concept is related to the essential characteristics some object or logical operation in the world. It also differs from characterising a concept as a definable mental state.

We should recognise that when a teacher is making a judgement about whether someone has successfully ‘acquired a concept’ they are considering whether the pupil has the ‘correct’ responses. Hopefully, they investigate the responses given in a range of circumstances, for example they see that pupils can apply Newton’s laws in the scientifically acceptable way over a range of problems.
Again, there is very little time to develop this properly, but learning might be seen as the adaptation of nested complex systems. Here I am using ‘complex’ in a specific way (rather than just ‘highly complicated’) to denote multiple, nonlinear interactions which mean that a system is potentially sensitive to fine detail, and emergence of new forms of interaction are possible. Davis & Sumara (2006) use nested systems to describe classroom complexity, however I have here adapted it to a neo-materialist view by taking out their reliance upon subjective understanding. There are physical, material bases for each level of analysis we might consider in a classroom, but complexity theory tells us that we cannot reduce things to these material bases (see Hardman, 2015). Adaptation might therefore take place within the brain, in electrical signals and connections; we might see changes in gesture and speech which have a material basis in the body, as well as other physiological changes. Extending beyond the body we can look at the nature and specific of interactions with other people, but also with material artefacts. I have described elsewhere how models can be seen as material artefacts essential to science cleaning (Hardman, 2017). We can also model a boarder level pedagogic practice over time, or even describe how the use of Newton’s laws changes over time. Yet we do not need to leave sight of these having a material basis, even though in it impossible to reduce to this basis. We should also note that all of these systems interact, so any claims of hierarchy or being able to focus on a specific level only should be treated as modelling statements to be contested.

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Learning, when framed in this way becomes something that can be investigated. We have seen a great deal of excellent research which deals (explicitly or implicitly) with these material realities. Neuroscience is becoming increasingly important and we have heard over the last few days about neurological and physiological correlates to learning. At my institution there is a concerted effort by researchers to consider the neuroscience related to ‘conceptual change’ (e.g. Mareschal, 2016). I feel they would benefit from recognising the difficulties of abstracting to mental entities, but their research will nevertheless be instrumental in changing how we view learning. The two papers that follow mine at the conference consider microgenetic methods. As we have already seen, Brock & Taber (2016) postulate a ‘cognitive structure’ beyond momentary thought. My respectful challenge to the next two papers then is whether their arguments still hold if they do away with the reliance upon mental entities – I suspect they do. Colleagues such as Carol Callinan (2014) have looked at gestures as an important part of conceptual change, and I am working currently with John-Paul Riordan to look at what experienced teachers actually do in classrooms, building on this excellent work already in this (Riordan, 2014 and his paper in this conference). There have also been some great papers on facial recognition at the conference which affords a great deal of potential. The last paper in the same session as this one at today’s conference considers actor network theory, and again, without knowing the details of the paper, my suspicion is that the potential of such views of learning have potential even after we escape commitment to mental entities: concepts. There has also been a lot of excellent work
presented at conference around the relationships between models, representations and learning, and the artefactual view of models (amongst others) frames models as material artefacts through which reasoning takes place. This is commensurate with a view of learning as complex and material in basis.

The real potential of changing our view of concepts from that of mental entities, to labels for repeated yet unique, material situations is that learning can be investigated in a more scientific way. We can investigate how neural correlates relate to gestures and speech and models in the classroom to better understand learning science. This will always involve human interpretation and value judgements, but it need not rely on indefinable mental entities.
In summary, there are considerable issues in postulating about concepts as mental entities. 1) They are ill-defined despite 50 years of research. 2) They are characterised as dualist: mental representations of essential aspects of the world. This is considerably eroded in contemporary philosophical discourses. 3) There is ambiguity as to how conceptual research should guide practice, and I believe this is a symptom of unresolvable debates about what concepts are. Put together, these arguments make the case that postulating about concepts as mental entities is highly problematic. Although I have not been able to fully develop it here, I hope to have given a flavour of how seeing learning as the co-adaptation of (nonreducible, material) complex systems allows us to put research into learning on much firmer foundations, through redefining concepts as labels for the repetition we see in different, unique circumstances. This recognises that concepts are labels to be contested in relation to empirical evidence, not through abstraction to an untenable mental world.


References (2)


