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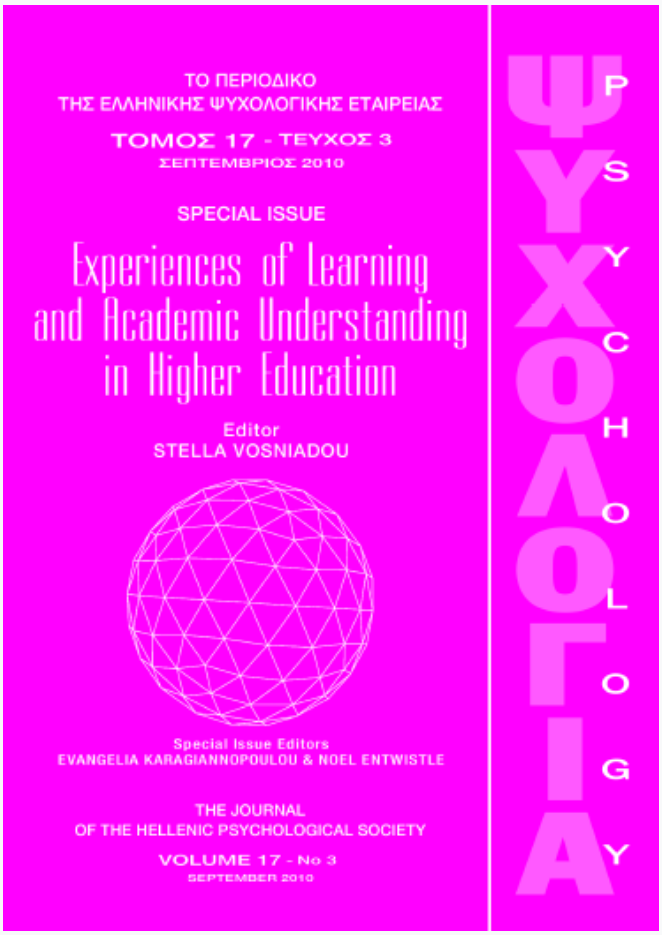

Η λειτουργία της φαντασίας στη μάθηση: θεωρία και δεδομένα μελέτης περίπτωσης τριτοετών φοιτητών στις Νευροεπιστήμες

David B. Hay

doi: 10.12681/psy_hps.23767

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Βιβλιογραφική αναφορά:

B. Hay, D. (2020). Η λειτουργία της φαντασίας στη μάθηση: θεωρία και δεδομένα μελέτης περίπτωσης τριτοετών φοιτητών στις Νευροεπιστήμες. *Ψυχολογία: το περιοδικό της Ελληνικής Ψυχολογικής Εταιρείας*, *17*(3), 259–288. https://doi.org/10.12681/psy_hps.23767

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The imaginative function in student learning: Theory and case study data from third year neuroscience

DAVID B. HAY[1]

ABSTRACT

This paper combines critique of learning theory and case study data from two third-year Neuroscience students. The results and conclusions show how higher education learning research can be developed by focusing on students' changing locution of their study-subjects. A shift from the cognitive perspectives of assimilation learning theory, towards visualising dialogue is described and used to foreground the ways that the cognitive and dialogic "positions" construe learning differently. The analysis shows that theories and methods addressing language use provide richer learning data and a more explanatory account of understanding in an academic context.

The data provide empirical evidence for the function of imagination in learning. They also illustrate two different ways in which the re-patterning of text leads to insight. The data of the first case study is ostensibly formal, comprising creativity in a continuous semiotic extension as the student shifts from one mode of representation (writing) to another (drawing). Here, however, the locution of the subject rarely goes "beyond-the-given" of the pre-existing discourse. The work of the second student is more conspicuously inter-textual, involving the active postponement of commitments to form, as multiple texts and text-types are read in their relations. This depends on reading and re-writing each separate lecture or paper from a growing apprehension of the perspectives of yet another (lecture or paper). Thus the student's academic subject is eventually re-patterned originally in an inter-animation of all these texts together: an imaginative process that includes awareness of the context of text (i.e. the relativized positions of particular authors), as well as affective relationship towards the subject and its speakers.

The discussion focuses on academic reading/writing as a simultaneous process of dialogue and design and a view of the imaginative function is developed that is relevant to science education, as much as to literary criticism. The implications for university teaching are considered and some suggestions are made for future research.

Key words: Interviews, Dialogic, Dialogical concept-mapping, Creativity, Pedagogy, Higher education.

1. Address: King's Learning Institute, King's College London, 57, Waterloo Road, London, SE1 8WA, UK. Tel: 0044 (0) 20-7848-3265; fax: 0044 (0) 20-7847-3253; e-mail: david.2.hay@kcl.ac.uk

1. Introduction

In the literature of higher education there is growing acknowledgment of the need for carefully documented individual learning trajectories (e.g. Hay, Wells, & Kinchin, 2008; Vosniadou, 2007). "*It is the person who learns*" says Jarvis (2006, p. 32), but with a few notable exceptions (e.g. Perry, 1970; Flower, 1994), detailed longitudinal studies of university students are rare. Moreover, while there is some data on issues of changing epistemology or writing, these are seldom accompanied by simultaneous analysis of the knowledge objects (Entwistle & Marton, 1994; Entwistle & Entwistle, 2003) or the representational forms by which students pattern and visualize their study subjects (Hay, 2008).

Recently, however, a number of papers have reported the use of Novak's concept-mapping method (Novak, 1998) to document knowledge-change in the disciplines of university learning. Shavelsen, Ruiz-Primo and Wiley (2005), for example, provide concept-mapping data for learning in Science; Hay *et al.* (2008) offer data in Medicine; Hay, Wells and Kinchin (2008) in Psychiatry; and Hay and Kinchin (2008) in Education and Business Studies. These reports are important because they help to throw light on the interplay between student prior knowledge and the sense that is made of teaching (review by Hay, Kinchin, & Lygo-Baker, 2008). But as Hay (2008) explains, the concept-mapping data of higher education needs to be treated with caution for several important reasons. First, Novak's concept-mapping method depends on certain rules of map construction that shape *a-priori* what can and cannot be said using concept-mapping. Second, and related to this first concern, the epistemological commitments of students' concept-maps are often left unstated when concept-mapping is the only mode of expression (Kress, 2003). Third, the theoretical position of concept-mapping is grounded in Ausubel's theory of assimilation learning (Ausubel, 1963; Ausubel, Novak, & Hanesian, 1978). This makes concept-mapping suited to just those university disciplines with a corresponding theory of knowledge, whilst also predisposing the interpretation of concept-mapping data towards particular educational theories (like Vygotsky's model of learning in the zone of proximal development), because it presupposes that learning is essentially cognitive rather than being also a function of the social imagination (Hay, 2008). Widening the utility of concept-mapping for a broader use in both research and facilitation of leaning is part of the purpose of this paper.

2. Previous research

Most previous uses of Novak's concept-mapping method depend on using the technique as "*windows into the mind*" (Shavelsen, Ruiz-Primo & Wiley, 2005, p. 413). This is because concept-mapping is essentially a method of cognitive psychology and it was first developed to test for conceptions (and misconceptions) from a cognitive standpoint (Novak & Gowin, 1984). Thus, for example, Hay *et al.* (2008) describe concept-mapping as a part of meaningful teaching design: first, as a means of ensuring that the methods and approaches of teaching are grounded in student prior knowledge and, second, as a way of documenting whether or not misconceptions are corrected through teaching. Both of these applications are consequences of Novak's prerequisites for meaningful learning:

> "*1) Relevant prior knowledge: That is, the learner must know some information that relates to the new information to be learned in some nontrivial way;*
> *2) Meaningful material: That is, the knowledge to be learned must be relevant to other knowledge and must contain significant concepts and propositions;*
> *3. The learner must choose to learn meaningfully. That is, the learner must consciously and deliberately choose to relate new knowledge to knowledge the learner already knows in some nontrivial way."*
>
> (Novak, 1998, p.19).

But these approaches also depend on using mapping only as a "test" for knowledge, not as

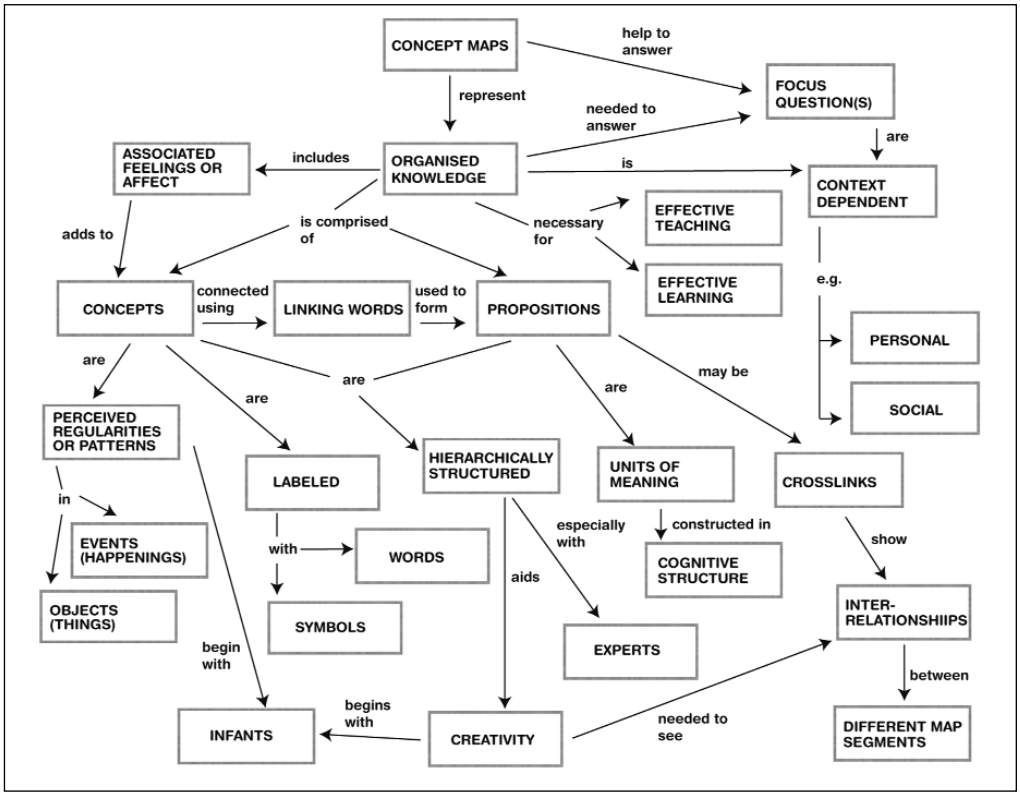

Figure 1

This concept-map, redrawn from Cañas, & Novak (2008), explains Novak's definition of meaningful learning. It also illustrates the rules of concept-mapping: (1) concept labels are written in boxes; (2) these are arranged hierarchically (so that bigger more inclusive labels subsume details); and (3) concepts are linked by directional arrows; that (4) must have explanatory words or statements to show the relationships between one and another (forming discrete propositions).

means of teaching and learning *per se.* In this context, the agency of teaching is *measured* in terms of a mediated action on cognition. It is the position developed by this paper, however, that concept-mapping can be a learning process in its own right. But, as we shall see, this depends on seeing the concept-mapping method from the different perspective of dialogic theory (after Bakhtin, 1981), whereupon *calling* the method "concept-mapping" becomes untenable. Widening its function towards dialogue, and narrative more generally, acts also to supersede both the notion of the "concept" and the cartographic metaphor of "mapping" and, since dialogism is ultimately an issue of language, reframing concept-mapping in a dialogic context also depends on careful examination of the rules of concept-mapping as a writing practice. Thus the relationship between a "subject of inquiry" and the "language" used by its interlocutor (speaker) is a crucial theme of this paper.

The work is organised into two parts. The first is theoretical and deals with issues of dialectics and dialogic theory, as well as the more general problem of a language of concept-mapping. The

second part of the work comprises two longitudinal case studies. Both of these document the trajectories of individual students learning in Neuroscience but demonstrate some very different approaches to learning.

3. Theoretical analysis

As a whole, the theoretical analysis of this work focuses on two inter-related themes: (1) the relationship between understandings patterned in mind and the conversations with "others" in which meanings are constituted; and (2) the corresponding association between understanding and language that interoperate in academic discourse. The analysis begins with an introduction to the concept-mapping method which is then widened to include dialogic theory and debates about narrative, imagination and cognitive process.

Novak's original concept-mapping method

In the 1970's and 80's Novak and his colleagues developed a new method for the analysis of school students' spoken accounts of the science subjects they were learning (see Novak & Gowin, 1984; Novak & Mussonda, 1991; Novak & Symington, 1982). The approach was called concept-mapping and is summarised in Figure 1.

Briefly, the original concept-mapping method allowed researchers to convert the interview transcripts of student subjects into simple graphic structures comprising concept labels and propositions (Figure 1). These maps could then be compared in the longitudinal direction of the subjects' learning, allowing comparison of changing cognitive organisation, content and the occurrence of misconceptions (Novak & Mussonda, 1991; Novak, 1998). Since the approach was grounded in a theory of assimilation that took the integrative reconciliation of new knowledge (or the lack of it) to be a measure of change (after Ausubel, 1963, 2000), so it allowed empirical analysis of the quality of learning (Novak, 1998; Hay, 2007). Figure 2 illustrates this approach.

The underpinning theory that affords this measurement of learning was explicitly cognitive (Cañas & Novak, 2008; Ausubel, Novak, & Hanesian, 1978) and each act of the pupil's speech was taken to be a "measure" of an understanding in mind in much the same way that protocol-analysis is taken as a proxy for cognitive content and structure (Ericsson & Simon, 1993). Thus the method was never intended for facilitating concept *formation* (Novak, 1998, p. 43), nor for enabling the making of meaning through social (or academic) discourse: instead, it was a method for assessing change that occurred as a consequence of teaching. Kinchin (2003), for example, explains how concept-mapping is an initial "prompting ground" for dialogue between teachers and students, but the teaching, not the mapping itself, is seen as the potential mediator of learning. Likewise, Cañas, & Novak (2008), describe how concept-mapping can be used to make teaching meaningful because of anchoring feedback in awareness of conceptions (and misconceptions) of individual learners: but it is feedback that provides the corrective impetus. However, this position overlooks another possibility: that concept-mapping can be understood as a means of dialogic interaction to begin with. To develop this contention requires a complex argument, however, because on the one hand, concept-mapping is already used as a primary locution (rather than a means of merely coding previous speech acts), and on the other, the original positioning of concept-mapping *theory* does not easily accommodate learning in the dialogic sense.

Using concept-mapping in higher education

As already described, Novak's concept-mapping method has been used to document the trajectories of university student learning, but has previously focused on using maps from the traditional perspectives of cognitive psychology. Kinchin, Hay and Adams (2000) explain this theoretical positioning more fully. These authors draw on the work of Halford (1993) to show that concept-mapping is a means to make explicit an internal representation or a mental model that reflects the structure of a concept in mind. These

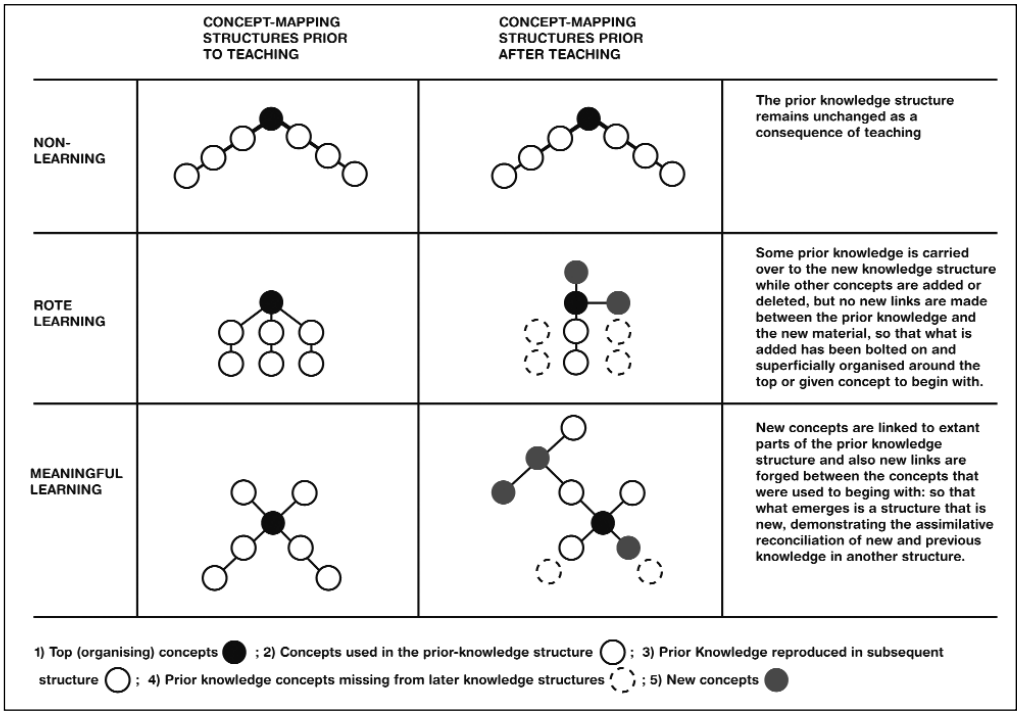

Figure 2

A graphic representation of the use of concept-mapping to measure different types of cognitive change (from: Hay, Kinchin & Lygo-Baker, 2008). Concept labels are shown as circles and linking statements as simple lines. The 'before' and 'after' representations are caricatures of genuine concept-mapping data showing different qualities of learning according to the degree of integration of new learning material and the pre-existing knowledge structure (see Hay, 2007).

mental representations can include a mixture of propositional symbolic strings (corresponding to natural language), models (which are structural analogies of the world), and images (which are the perceptual correlates of models from a particular point of view). But concept-maps are, none-the-less, seen exclusively as portrayals of a cognitive structure, not a means of dialogue. Moreover, concept-maps, while they generally entail a spatial arrangement of words, do not include visual images constructed by the map author. Of course, many modern concept-mapping technologies *do* make use of images and graphics or symbols; but these are almost invariably used to illustrate a map *after* construction, rather than acknowledging that the act of constituting the image-form is at least as significant as making a map using concept labels (Kress & van Leeuwen, 2001). Thus the problems of concept-mapping for higher education are that: 1) the method does not fully acknowledge that interactions between mind and language (or whatever form of expression can be seen to constitute the communicative act) are mediated through various symbolic structures, only some of which might be accommodated by the concept-mapping method (Hay, 2008); and 2) that without denying that knowledge is somehow patterned in mind, nevertheless, concepts are rather more

malleable, vicariously distributed, conditional and tentative in the very *process* of "language" *use* (Vosniadou, 2007). Finally, by taking the essentially cognitive stance to begin with, traditional concept-mapping theory does not easily accommodate the dialogic view that the self (and the personal understandings that the self embodies) are all a consequence of relationship to "the other" or to "otherness" in general (Holquist, 2005).

These concerns would remain relatively inconsequential if concept-mapping were still being used exclusively to code the more natural speech acts of interview subjects. But since the original publication of Novak & Mussonda (1991), most concept-mapping studies report the method as a mode of self-expression. This transposition has never been accompanied by any substantial renegotiation of concept-mapping theory, but the shift is likely to be particularly problematic as one also moves from schools to higher learning settings, where discourse becomes increasingly specialised (Lea & Street, 1999) and where learning depends less on acquiring any given knowledge-content and more on the use and function of narrative (Bruner, 1997, 2002, 2006; Hounsell & Anderson, 2009; Mertz, 2007). This issue of language *use* is central to dialogic theory and a more detailed treatment of dialogism is warranted before returning to analysis of the "language of concept-mapping".

4. Dialogism and the visualisation of dialogue

Drawing on Bakhtin's dialogic theory (Bakhtin, 1981, 1986), Wegerif (2008) explains that dialogism implies much more for education than merely focussing on the importance of dialogue as a tool for changing what a pupil knows in mind. For Wegerif (2007), dialogue is also the *purpose* of learning and inquiry ("*an end in itself* ", Wegerif, 2007, p. 28). This is because dialogic theory sees understanding as an act of inter-illumination of difference. Thus Wegerif (*ibid.*) explains that any conversation includes not just the words addressed horizontally to the immediate "other", but also a simultaneous and vertical conversation, which is the "model" of what can be understood. It is this vertical dimension that Bakhtin refers to as the conversation with a *"super-addressee"* and it is this that makes dialogue, an educational end in itself. According to Wegerif, induction into dialogue implies the gradual taking of the perspective of the super-addressee, whence comes *understanding* that is always increasingly inclusive, whole and encompassing, rising above the two (or more) immediate voices in conversation to include them both (or all). This is an essentially imaginative function:

> *"...taking the perspective of the super-addressee is already a transcendence of context. This transcendence provides a space in which new more general insights emerge, are marked or labelled and can then be shared. The first step is seeing things from another's point of view but the more that person is an unknown quality, the more different and strange they are, the more one is led to see things from the point of view of not just this or that specific other but otherness in general and that means to see things afresh in new and often unexpected ways."*
>
> (Wegerif, 2007, p. 238)

From a dialogic position, learners do not come to understand things in isolation, but meanings are shaped through the inter-animation of the different voices (or texts) of other(s), as students learn to see things from other perspectives. Here, it is an increasing inclusion of *difference* that leads towards more encompassing understandings; each new perspective remaining in irreducible tension with the other or, at least, so the two (or more) views can never be simply reconciled in a common vision (Wegerif, *pers. com.*). This is markedly different from the dialectic stance that sees one knowledge structure overcoming another or perhaps a singular construction being achieved in a synthesis (Wegerif, 2008). Thus for higher education, the concept of a super-addressee has considerable significance: the vertical dimension for academic discourse

suggests a way in which students and tenured academics alike are not juxtaposed as "expert" and "novice", but simultaneously orientated towards the relevant questions of disciplinary inquiry from whatever perspectives they begin. This is also to say that the developing subjectivity of the learner/researcher is inseparable from the subject they are speaking (Kristeva, 1998).

From the perspectives of dialogism, student conversations *include* the voice of "another" whenever learners re-pattern their subject discourse in dialogue, so that listening to lecturers, watching demonstrations, or reading books and papers, are all, potentially, the simultaneous re-writing of text to make meaning (Lee, 2004; Delp, 2004). This orientation towards insight (rather than the simple grasp of the "facts" of text) is an orientation towards the vertical conversations of the subject and it implies simultaneity with the student's essential voice as well as the pre-existing disciplinary one. Thus the dialogic view has more potentiality than mere "socialisation" into discourse (Lave & Wenger, 1991); it offers an explanatory mechanism (of insight or imagination) arising inter-textually (Kristeva, 1986a) that makes understanding genuinely original (or re-creative) through semiotic extension (Kristeva, 1986b) and anticipation that the subject can always be spoken better by its interlocutor (Kress, 2000, 2003).

This is also to say that the representational "form" of the subject includes much more than its given knowledge-content. In narrative students can begin to apprehend what types of questions are relevant, even what types of guesses or deductions are appropriate to a given discipline (Bruner, 1960) or a practice setting (Bruner, 2002). Moreover, this can happen while the learner/researcher/practitioner is still essentially speaking for themselves (Northedge & McArthur, 2009; McArthur, 2009), preserving what Taylor (1991) calls an "*authentic identity*" that is inseparable from their developing academic or professional voice. But all of this is achieved through dialogue; it does not just depend on teaching as an act of instruction or correction, even though dialogism also preserves the crucial role of the authorised academic position, because this is the one most likely to be relevant *and* different enough to invoke relation to the academic "other". As a consequence, dialogue with those already more established in their academic positions gives a purpose to higher education teaching that is more than "transmission" of knowledge (Northedge & McArthur, 2009) or the loan of more advanced knowledge in a zone of proximal development (Vygotsky, 1978) and dialogism offers a solution to the apparent paradox that gaining access to the language of a discipline and being able to understand its subject are concomitant (Northedge, 2003).

To adopt the dialogic standpoint, however, would be an entirely new position for concept-mapping theory (as indeed it would for many educational debates), since, as Kress (2003) explains, such a change is also to forgo the assimilation learning theory of concept-mapping. But perhaps, surprisingly, concept-mapping *practice* can accommodate this shift rather easily, all be it that in doing so we have to eschew the label "concept" (and "mapping") in its title. All it takes is acknowledgement that, while concept-maps may indeed comprise the surfaced products of an internalised knowledge structure, they can also be seen to include the voices of others in conversation. Rather than being just a means of anchoring corrective horizontal dialogue, concept-mapping can be taken from the dialogic perspective to include the *voices of others* and to be a *mode* of communication from the beginning. Thus for example, while the maps that students make at the start of a course of study are usually taken as measures of their prior knowledge, it is a also sensible to suggest that they are already conversational responses to *context*; a student map-maker anticipating what they think the course will be about as well as how their teachers might expect them to speak the subject.

This more conversational view of concept-mapping may be already suggested in several concept-mapping studies. Kinchin (2000a, b) shows that students offer different explanations towards different addressees (a parent *versus* a teacher, for example), suggesting that indeed the dialogic issue of context enters in already, as part of the mapping act. Nevertheless, the ease with

which concept-mapping practice can include plural, even contradictory, explanations is not evidence that distinguishing between dialectics and dialogism is trivial; it suggests that reframing concept-mapping theory is necessary to make sense of some of the data that the method can offer already. But now the question of a language of mapping becomes even more pressing since, if we want to take concept-mapping dialogically, the question becomes one of what can, and what cannot, be spoken about in concept-maps.

5. The conversations of disciplinary inquiry

The issue of correspondence between the logic and affordance of different representational modes is developed by Kress (e.g. Kress, 2003), and it coincides with another strand of the higher education literature that includes the notion of "disciplinary ways of thinking and practising" (e.g. Hounsell & McCune, 2002; Vosniadou, 2007; Mertz, 2007; Hounsell & Anderson, 2009). This work also echoes a wider appreciation of the relationships between the sign and the signified that are the province of semiotics and, in many ways, a corner-stone of modern sociolinguistics.

Acknowledgement of the interdependence of disciplinary thought and speech is also attributable to the impacts of dialogism. Holquist (in Bakhtin, 1981) explains that "*the secondary genres of language are what constitute* [for Bakhtin] *not only literary, but all other text types (legal, scientific, journalistic) as well* [so that] *in actual fact, what distinguishes one human undertaking from another, one science from another, is the roster of genres each has appropriated as its own*." (*ibid.,* p. xvi). This is a theme developed in Bruner's writing about the narrative self (e.g. Bruner, 1997, 2006) and it explains why the learning of any discipline is much more than learning its "facts" and information (or its "concepts").

For Bruner (*ibid.*) the issue of understanding constituted in language goes beyond knowledge and its organisation: all of utterance is important to shaping the ways that disciplinary subjects are both thought of and used, and thus also to how academics and professionals use language in their service to others. Bruner (1997) explains that the lawyer's ability to help a client shape and reshape their personal narratives is what defines law as a disciplinary practice, superimposing the dialogic function over and above disciplinary "knowledge". While Bruner tends to focus of the vocational professions, similar issues of literacy pertain to the academic disciplines and their propensity for inquiry. In Bioscience, for example, research data often needs to be depicted graphically before it can be understood and many of the key hypotheses of biology are actually constituted in visual images (Fischer's Lock and Key Hypothesis (Fischer, 1894), Barker's structural model of the neurone (Barker, 1899) and the double helix structure of DNA (Watson & Crick, 1953) being just a few of many examples). Learning to read and write in images is therefore central to becoming a biologist (Hounsell & Anderson, 2009) and what constitutes description or analysis in biology is also defined by the image as a representational form of the subject (Chanock, 2000). So for the purpose of using concept-mapping in university bioscience, what is important is being able to include this wider range of representational form, not just because this allows more to be said, but also because, otherwise, concept-mapping *cannot* be a means of *learning* from the whole of narrative. These themes are explored in the following case studies.

6. The case studies

To test and develop a more dialogic approach to the visualisation of understanding I have carried out four detailed longitudinal studies, each with a small cohort of learners in History, Classics, Bioscience and Medicine. These disciplines were chosen to represent a broad spectrum of higher education, but the focus of the work was not to extract generality, nor to be able to compare work in different disciplines; rather I intended to document the trajectories of representational form and voice that the students would use as individual speakers of their subjects of inquiry. Although the broader scope of the

work underpins some of my approaches to analysis, the data are too large for the purpose of this paper and I focus on just two of the individual trajectories, both from students in Neuroscience.

Background and context for the cases

At the start of the academic year 2006-7, I agreed to undertake a programme of educational research that would test the impacts of teaching in a third-year module for "Developmental Neurobiology", in what for most students is their final undergraduate year. The work was done using concept-mapping before, during, and after, the taught programme and a subsequent analysis of the students' knowledge structures was carried out using the more traditional approaches to concept-map analysis (as summarised by Figure 2, for example). The results of this work are reported elsewhere (e.g. Wingate et al., 2007), but in 2007-8, we repeated the study with a new student cohort, this time asking for volunteers who would be willing to share in a much more detailed programme of research. This entailed the development and practice of more varied representational forms than concept-mapping traditionally allows. Four students agreed to take part and the data presented here was obtained from just two of them. These two students also took part in regular conversational interviews during the taught module, in the second semester of laboratory project work afterwards, during the exams revision period, and once their final results had been published. They also agreed that some of their work could be shared with their tutors and the report of their work includes responses to their tutors' feedback.

In presenting the case-study data, I refer to all the student's representations as their "maps". I do so for the sake of brevity and also because this is how the students and I described these representations, but I remind the reader that while they are not "concept" maps, neither are they really cartographic models. Some of the "maps" are difficult to read, particularly for those unfamiliar with the conventions and concerns of modern Neuroscience. This is unavoidable given the issues of representation that this paper is intended to explore. However, the account draws on excerpts from the students' interviews and I hope that this, when also accompanied by a commentary of my own, will help to show the significance of the students' work, and of the developing reading or imaginative process that is described in those extracts.

Case study one

The overall trajectory of Student X was marked by a gradual transduction of representational form (Kress, 2003): a shift from the mode of writing (using lexical labels for concepts) to the use of the pictorial image. In the student's own words: "*I never really looked at the images before: I mean I would look at the legend of a text-book figure or a picture in a paper, or I would listen to the things that were said about an image in a lecture – but I never learned to read the picture itself - I would just avoid it*". But by the end of the study he said:*"...now I understand what the image means, how it lets you say things that are not said in words, but also how you have to imagine the relations between one image and another. This is where you see the process of "Developmental Neuroscience" - in the relationships between images. Now the images I have made are my own – they are my own understanding*". Thus all the maps of Student X chart a gradual progression towards a "reading of the image" that is complex and subtle, going beyond a simple series of anatomical representations and towards understanding the *process* that includes the student's developing literacy. This is built up piece-by-piece, starting with the developing use of structural and developmental models offered in his early lectures and becoming gradually more complex as well as more real (biological), as each successive pattern is superimposed on the one that precedes it. This over-writing never completely transforms the image of an earlier representation however and, importantly, the starting-point was not his own prior knowledge, but a structure "*borrowed*" from his lectures.

In all of the student's commentary on learning, he draws most significant attention to one particular moment of feedback on his work, that

he calls his "*epiphany*". It is the moment he discovers that the lecturers who read his maps can see through his currently superficial grasp of the subject and related to this, point towards an undeveloped potential for the reading of biological images - not as the depiction of isolated tissue-structures, but as illustrative representations for the stages in a sequence of development "behind" them. As we shall see, it is towards this deeper grasp of images as having significance in more complex temporal relations that Student X is orientated in his "reading" after this feedback.

The absence of relevant prior-knowledge

The role of prior knowledge is central to concept-mapping and attendant assimilation learning theory. But in all the interviews surrounding the work of Student X, he (like student Y also), argued repeatedly that he had no relevant prior knowledge of the subject. This makes his early maps "*borrowed*" (his word) from the explanations offered in the first few lectures. His first map (not shown) was a representation of this borrowed structure and Figure 3 shows his second map, made after just four lectures, revising his lecture notes and reading two recommended papers. In fact this map was identical in *structure* to the first one but comprised additional explanatory detail. In the subsequent student-group meeting, Student X made a third map from memory, this is not shown separately because it was almost identical to his second representation, but the inset portions of Figure 3 shows the mistakes occurring in this memory test because of reversing the roles of certain structures.

In the subsequent interviews with Student X, he had this to say:

> "*The thing is that I really new just about nothing of this topic beforehand. It was all entirely new to me. My degree is in Medicine and I have taken this third year option in Neuroscience because I thought it would be interesting. But because I am studying Medicine, most of this was completely unfamiliar - I really had no prior knowledge of the subject at all*."

And later in one of our subsequent conversations:

> "*I didn't have any understanding of the subject to begin with so I had to go to lectures and get a grasp of each new topic before I did anything else. So each lecture was 'given'* [original emphasis] *to me - if you know what I mean. It did not matter if sometimes I did not pay a proper attention to the details, what was important was just going there; at least if I went, I got a picture of the story as a whole and when I came to a paper later, then I could see it organized along the lines of what I had been 'given' already. I would say I 'borrowed' the structures from the lectures and otherwise it would have been impossible to make any sense of the topic.*"

The impact of feed-back

The first three maps of the student's work were given to two of his tutors for their comment. At first glance they were impressed by his grasp of the subject, stating that the second map (Figure 3) was: "*... about as full a picture as possible from the material already covered in the module*". On closer inspection however, particular attention was drawn to the two mistakes that occurred when the map was reproduced from memory (insets Figure 3):

> *"I mean from one point of view these are just small errors; points of detail that the student has reversed when recalling them: but also these are mistakes that you just couldn't make if you were living the subject. Making these mistakes is like mistaking day for night!"*

And this was followed by another more detailed commentary on the way that the student was using and reading images in his map:

> *"It all seems very static to me, there's no cell movement here. It is as if the student is reading each structure as fixed when the interesting question is about how things move; how they relate in space and*

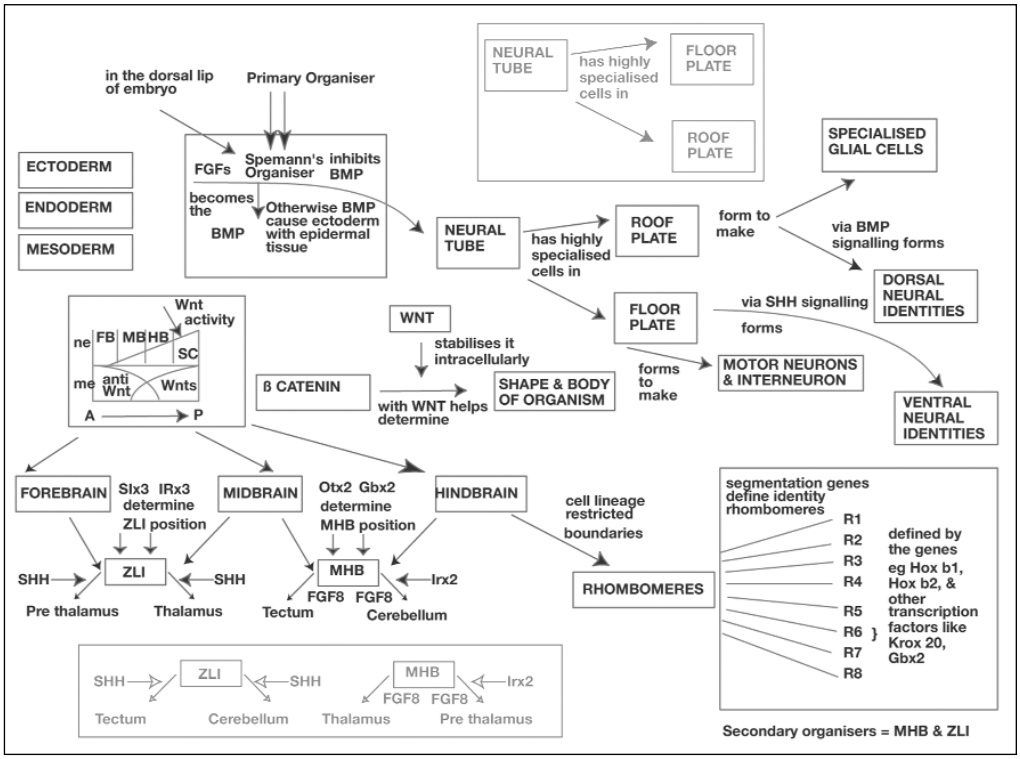

Figure 3

Student X made three concept-maps in the first ten days of the study. This is the second, made during six hours of private work while reviewing his notes from the first four lectures and reading two recommended review articles. The panels inset (lighter text top centre and bottom left) show the only two differences that occurred between the second map and the third that was made from memory at our subsequent meeting.

also, of course, how they change in time. What are these molecules doing in relation to morphogenesis [gestures towards the map] *– how is it happening – what changes what? And where do the cells move as they differentiate? The student needs a stronger visual representation of the whole, and one that is also dynamic. Maybe these diagrams, which I recognize from my own teaching are just not enough. The students need to see the images that include <u>movement</u> and this student is seeing each image separately – not its flow. I would like to tell them to think about reading comics. In a comic book the story develops in between each single image – it is how each picture is different from the ones that come before and after it that gives the plot: but this student is looking at each image in isolation. What might help them is some three dimensional images too. Ask them to try to picture the structures they know on a tube of cardboard, like a toilet roll. Then they might also begin to see the objects <u>and</u> processes in relation."*

The following quotes are examples of what

the student had to say when I passed on the tutors' feedback:

> *"What interests me is that they* [the tutors] *could see that I was just recalling information; not understanding it. With me, lots of things are just facts and I try to remember the facts rather than troubling to understand the subject first. But I always wanted to know this - I mean to know if they could see this or not. I can see what they mean by making mistakes that are day for night. I don't really know the material so I can easily get it wrong when I try to remember it. They can see that and it's worrying!"*
>
> *"...And what they say about visual models, that's important too. So far, my maps have just been the things I have copied from the lectures. I haven't made them myself. I don't really know how to make or read pictures. When I find pictures in a paper, usually I just skip over them. I mean I will read what is said about the picture in the text but I will tend to ignore the image itself because I find it difficult to see what it means– then I also find it difficult turning words and concepts into images – even trying to see biological things as they really are – as process – as movement – I can see what my tutors are trying to say to me – why it is important. I'll start struggling with that because I think I know what they are asking for and it is what I have always tried to avoid in the past."*

A lot of hard work

It is difficult to do justice to the amount of sincere hard work that went into this student's subsequent rounds of mapping and study. Over the next two months, he made another 14 concept-maps (each of which took between one and six hours to make) and he explained repeatedly that his effort was directed towards trying to "*picture*" the subject: "*to imagine it in three dimensions and as a process*":

> *"I am beginning to realise the significance of images – and now I understand that many biological images are idealised. They are composite images made up of lots of different views, and sometimes different stages of a process are superimposed. Now I understand this it is becoming much easier to read them – and I see what my tutors mean about reading images or structures together. It is exactly as they say, the biological process that is important has to be found between the images in their series – and you have to <u>imagine</u> that. Now the pictures I am drawing are my own. I sort of make them up by reading images and text in papers and by drawing on my lectures - it helps me to bring everything together in an image that is mine. So I would say that most of these* [his most recent maps] *are really my own understanding. And because I have made them myself I can also remember them."*

It is important to explain the process by which each map was developed at this stage of the work. Despite his reference to the imagination needed to picture what occurs between images in series, nevertheless, each map was actually made in a very deliberate and protracted process. Student X read papers in turn, and reviewed his lecture notes sequentially, making detailed summaries from each of these. Then these notes from notes were brought together in yet more condensed written text and drawings and only this was used to make each map: "*as a summary of summaries*". What was also important, however, was the degree of care that was now extended towards each pictographic form. In the course of the work Student X re-drew and explained several of his maps from memory, just as he did at the start of the trajectory. But now, each image was drawn slowly as he spoke aloud the meaning of each axis in a graph or the curve of a data plot. Similarly drawings of biological tissues were made with attention, as if the width of a line mattered or the relative position of constituent parts of the image *counted* as part of the form. This was different from his drawing process to begin with, where images were sketched rapidly and without comment. At the same time, Student X would speak of his maps as heuristics:

> "*You see my maps are the summaries of everything I have tried to understand and once*

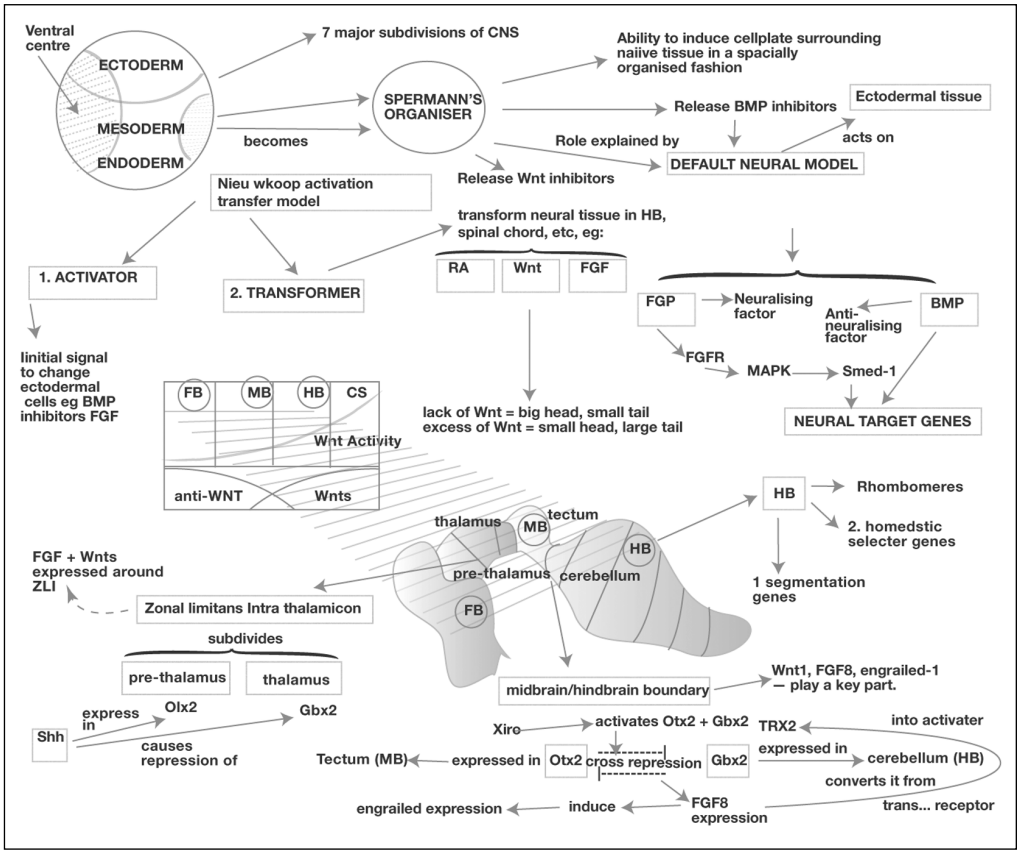

Figure 4

This map was made by Student X at the mid-point of the taught programme. It shows the progressive development of a structure laid down already (e.g. Figure 3) towards increasing complexity and convergence on the image of real biological tissues (like the image below centre: of the fore-brain, mid-brain and hind-brain structure).

I have built them I can see them in my mind – I know I can picture what I've worked out and drawn in a map and I can use it to answer an exam question – but it's not everything I know, it's the key points and because of it I can access all the other things that are underneath it, the things in my notes that may be too detailed to get into a map."

Figure 4 shows one of the maps produced during this phase of study.

A developmental sequence

By the end of the module the maps that Student X produced were a rich and complex mix of words and pictures, developing the pattern of Figure 4, for example, until it was a network of integrated graphic structures and annotations for all he had studied. Nevertheless, the very basic structure, established right at the start of his work, was still recognisable – as if what was laid down to begin with was continuously overlain, but never substantially transformed. If you compare Figures

3 and 4, for example, you will see the structure of one in the other. The difference, Student X would say, was in how he understood it:

> *"When I look back, actually it's quite interesting to see that some of the ways I have arranged things are pretty much the same as they were at the beginning – I mean this leads to that and this goes there etc. I think that this is because I actually started by memorising the ways that the lectures and papers explained things – and those were right weren't they - at least they ought to be! But it's quite shocking the reorganization of understanding that's gone on. Some of it looks the same, but actually I'd say it's all different ... the difference is that I understand it!"*
>
> *"That feedback I got, about making mistakes - where I muddled-up the roof-plate and the floor-plate - and where it showed I made mistakes that were like day for night - that I couldn't see the biological structures that were important: that was a kind of epiphany for me. It made me realise that I had to go back to the beginning - that I had to understand things first, and that I had to see them not in words, but for what they really were – and then I realised I could make the maps that would help me remember what I had understood. I had to understand it first: then map it. So it took a lot of time and effort – reading and writing - but now I know that you have to do that work, I know what it means."*

No revision necessary

Although the examination for this module took place five months after the teaching, Student X did not feel it necessary to revise this subject at all: *"I felt that all my revision was done already, or at least it wasn't really necessary. I mean I knew I understood the subject well, because of all the work I had already done and also I knew I could picture it - remember it - to answer almost any question.*" Thus our final discussions focused on ways that the mapping process and his learning to read the image had helped him:

> *"Making-maps - that's a way of bringing things together. It is the concrete thing in my mind that I will refer to, but you have to be careful, it can also be dangerous. I become so comfortable with these ideas when I put them in a map - then I can make a huge error somewhere and because I've accepted it to be the exact replica of understanding it, I can keep making that kind of mistake until it's too late..."*
>
> *"...But at the same time, all of this, I would never have done it without this project, without the mapping and the tutor's comments. Imagine that! I mean what I would have done is just put all the lecture notes in a file and forgotten about them until revision time. None of this would have happened, none of my work, none of my understanding, just those things I tried to memorize and those mistakes I started with!"*
>
> *"And I have to say that what I did here was quite different from doing coursework. When you have essays to write, then you just put all your understanding on hold. You concentrate on the marks you have to get and whether you understand it or not isn't important. So the coursework was just the interruption of my understanding and only after the assignments were done could I go back to trying to get an understanding of the subject."*

Case study two

Case study two showed a quite different approach to the learning process. Student X (above) made successive studies of the forms already given in teaching: Student Y, however, postponed her representational commitments in an extended series of inter-textual readings, patterning her grasp of the subject imaginatively and developing *form* only in the final stages of revision. When the form-shape of her understanding did eventually appear, it also coincided with the given images of the subject, but this coincidence was not direct; it was not a product of learning to draw and read the image of biological tissues, (as it

was, more or less, in case study one), it was a lexical arrangement (not pictographic) in which the patterning of structure could be shown to be derived from a growing apprehension, emotional as well as cognitive of the subject of inquiry. This is to say that, without ever trying to learn the forms given in her teaching, Student Y had begun to "picture" and relate towards the subject directly, grasping the sense towards which all her different papers and lectures were pointing between them. If the student's understanding did not converge on the forms of the discipline, then we would be concerned about *what* it was she had learned, but the coincidence here is a function of imagination.

As we shall see: (1) her work was constituted originally, in a series of lexical shapes that were always unique; (2) its coincident pattern was *implied* by the form-shape drawn with words rather than ever being drawn directly; and (3) while the *underlying* form was often the biological one (suggesting recognizable anatomical structures or a temporal development processes), this was not always the case; sometimes it is more metaphorical imagery that patterned the student's words - giving rise to structure she described as: "*an analogue of the subject*"; or: "*the shapes that I feel and remember because this is what I imagine it must be like inside the structures I am describing*". Most importantly, however, all of the patterning of understanding documented in the second case arose in the process of repeated inter-textual reading. Essentially, the student grasps what it means to read in an academic fashion; understanding that the significance of a written text (or image) is not to be found in a simple and personal interpretation of its substance, but in its inter-animation (or inter-illumination) with other texts - so that understanding appears of its own imaginative volition when different texts are brought together in contact.

Mapping while reading or listening

Right from the start, Student Y used mapping as a reading process:

> "*I always make maps when I'm reading. Usually the lectures or papers that I have to study are very complicated, so I have to pull out key words and try and fit them together myself. I use mapping to re-arrange the information in the work and to sketch it on the page. When I have finished, I make another map to reorganise the first: to check what I have understood and to correct anything that I didn't read correctly. But when I am finished I will throw the maps away, I don't want them after I'm done. I do the same in lectures as I do with a paper: I listen, I make a map and then I revise it when I get home; but when that's done I throw it away and start again the next day."*

Thus, in the course of the module, Student Y made nearly 50 maps, each of them a "reading" of a lecture or written article. Figure 5 is an example, made while Student X was studying a review paper. The reading-map is described in three stages:

> *"I do each reading in three phases: the first to get the gist of the paper* [Figure 5; uppermost]*; the second to extract new information* [middle]*; and the third to make sure that what I am reading fits with what I understand already, as well as what I think I need to know* [bottom]. *In the first and second phases, what I try to do is to unravel the structure that the author made and I search and scan for things that help me to see the arguments and data they have drawn together. When I do this I have in my mind all the things I have read before and the things that I know my lecturers think are important. I will also focus on the information that is new to me because I know I need to get more information than was given in the lectures. In the third phase, I will play about with the relationships in my map and tie in what I have just read with knowledge that I am already confident about - I will also leave things out on purpose. That's because I don't want to remember things if they're not important or if I can't be sure of certain details."*

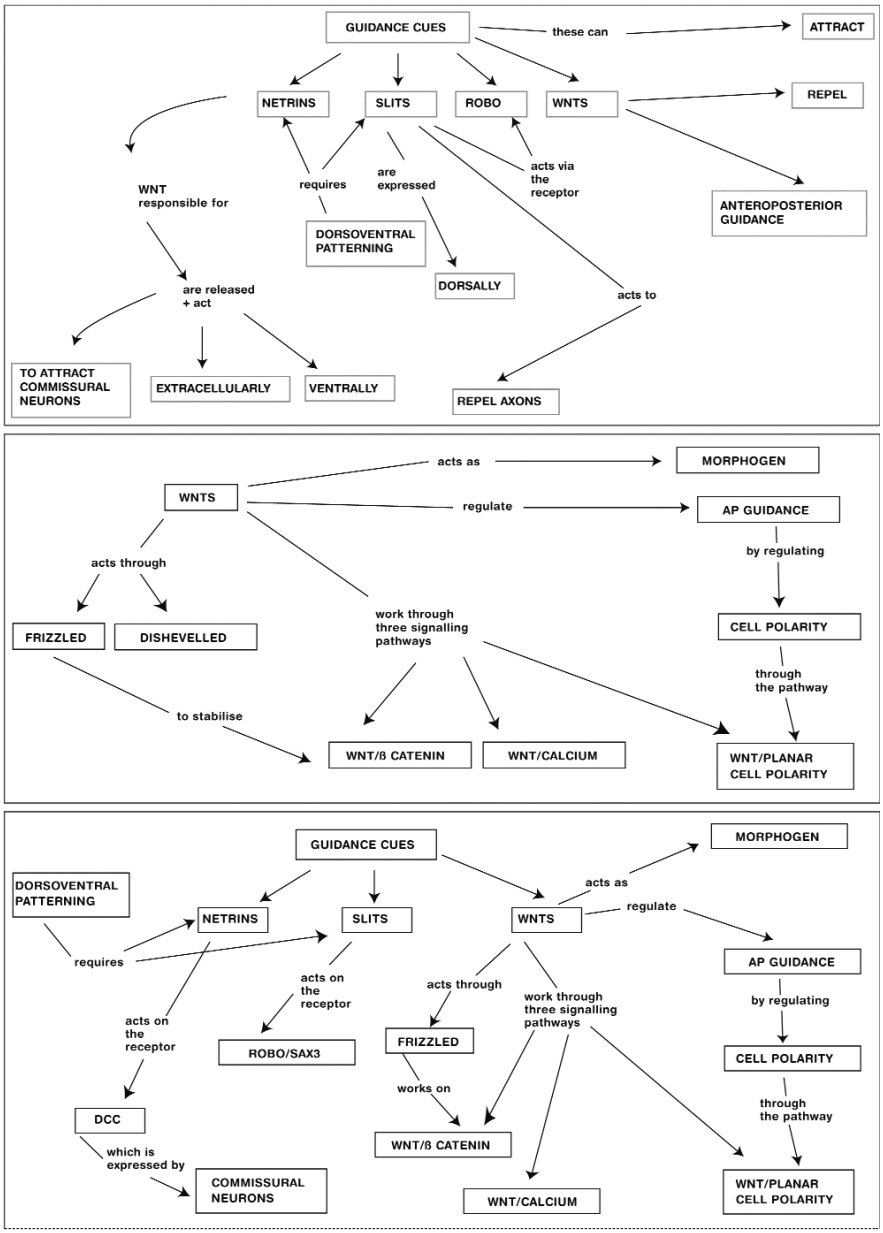

Figure 5

This series of maps document the three successive stages of reading described by Student Y: "*reading for gist*" – top; "*reading to extract new information*" – middle; and "*reading in the light of context*" – bottom. It shows how Student Y reads inter-textually, attempting to reconstrue the subject of each paper in what is also a developing apprehension of her lecturers'.

Inter-textuality

Each reading is essentially inter-textual, however, because multiple texts are held in mind simultaneously and the particular positions or viewpoints of one (or more) are used to re-pattern the original:

> *"The point is that reading any paper (or even a lecture), you have to recognise the views of the author. I mean review articles are supposed to be neutral, but they are not. The author has a position too, and he or she slants their writing towards how they want their own work to be seen, or else they might be positioning themselves for a future grant. Each time you read a different article, you get a completely different picture of the topic. Obviously I recognize the same terms when they occur - so I know I'm reading about the right thing* [laughs] *and it's like signposts that you're on the right track - but I never remember the same things from different sources of information – not as if they were directly related anyhow. It's always like reading something completely new, even though you know you're in the right place. So what you have to do is to try to imagine this new paper from another perspective; one you have already read. Often I try to see what this might look like from the perspectives of a particular lecture. Then in the end I come to realize how everything is really related and I'm able to connect everything together - but this cannot happen until much later and when it comes, it is not as if I were looking for it - it just happens!"*

Thus Student Y also said: *"each reading colours the ones that come later"* and each reading-map is not so much a representation of what she knows already (in the cognitive sense), nor of how she interprets a text herself, rather*: "it is how I interact with what I read and how I relate each explanation to another one.*" The emotional content is this process is important:

> *"... so if you asked me to repeat a map tomorrow, I wouldn't be able to. I would not be able to recall the relationships between the ideas. But if I went and researched the topic again, and read about those relationships again in another context, then I would understand what I was reading more immediately because I would recognise the things I had read before. It's like making friends - reading and re-reading and going to different sources of information. Patterns become familiar and they start to help you; helping you make sense of new things that you haven't met before. And I don't just mean information, I mean getting to see why this question is important while another one is not, or that this theory is more likely than another. Then you get a feeling for the author of each paper and for your lecturers too: a sense of where they are coming from and why such and such is important for them. It takes a lot of work to get to an understanding that includes this, but eventually it does. And related to this, I have to be able to see the ideas in my visual space. I don't mean I will necessary see things as objects, but they have to be coloured somehow, coloured and arranged spatially, according to how I know them, how I can picture them and which ones are closer to me or further away – that is what I mean by making friends with ideas and this also means getting to know the people that explain ideas or data."*

The active postponement of commitments to form

This imaginative re-patterning takes time: it requires an active postponement of commitments to form, so that many different perspectives can become included.

> "*It takes time for a pattern to emerge – and you have to find it gradually – for yourself. You also have to watch out that things don't get fixed too early. That is why I throw my maps away. It's a symbolic gesture that represents the way I want to learn. The problem is not just that you*

might get stuck with something wrong – it is that if it forms too early, then it is also too small ... it is not the big picture, or it is not the understanding that includes seeing the material from many different sides. But I also have to say that I don't really know what I will do in the exam! All my learning is my reading and each reading is quite different; so what will I learn to remember?"

Reading during laboratory work

Thus far, all of the student's maps and comments were made in the course of the taught module (in semester one of the student's final year), but in the second semester she continued to read and map while she was doing her project work. Her following words explain how her practical experience continued to develop her approach to reading:

"*In teaching they* [the lecturers] *give us all sorts of papers to read. But it is difficult to understand what they want us to read for. These papers are clearly the ones that they think are most useful, but it is only when you begin to perceive the questions that they are asking themselves that you begin to see what is important about a particular article or a piece of research. Now I am working in a lab I am beginning to know the sorts of questions that my supervisor asks. Now I read papers almost every day, because when you go into the lab in the morning, you have to be able to have a reasonably informed conversation with your supervisor and with the other people that work there. It used to take me days to read an article; but now I can read a couple of papers in an evening because I am also beginning to see the question that makes sense of them. I have been talking about this with my tutor* [one of the researcher/teachers responsible for the previous module]. *The problem is that when things are taught you try to understand them as facts, but facts are not meaningful on their own. It is the conversation about them that makes them meaningful - so trying to understand 'facts' is like trying to understand a conversation when all you get to hear is the very last word."*

Revision

In the few weeks before exams, Student Y made another 20 reading-maps for the purposes of her revision. Figure 6 is an example.

"I have not kept my maps and I have never made what you call notes - so in my revision I had to start again – reading again like I always did. Of course I could be a little more selective with the papers I chose, but basically I did what I have always done. I read papers and made maps as I went. Then I would draw the map again, but this time trying to include all sorts of other information, using what I could remember from other lecturers and reading and trying to picture how the topic might look from my lecturers' perspectives. So these 20 maps [e.g. Figure 6 above and 7 below] *are these 'pictures' and they also include another layer of working, because I went back to them later, making other notes over what I had written already – highlighting things and adding details of what I thought I might need to remember."*

"When I look back at what I have done in these maps, however, it is really quite surprising. This is a map of 'growth cones' [not shown] *and you can see it is made from criss-crossing words so that it is web-shaped. Actually, that's how I imagine the structure of the growth cones to be. And I didn't do that on purpose. But when I looked at that map after I had made it I could see that I didn't need to read anything more about the topic. I mean I knew I could remember all this because all I had to do was to picture what it would look like to be inside a growth cone and all of that detail would come back to me. I just did that without realizing it. Then if you look at most of my other maps, they have a*

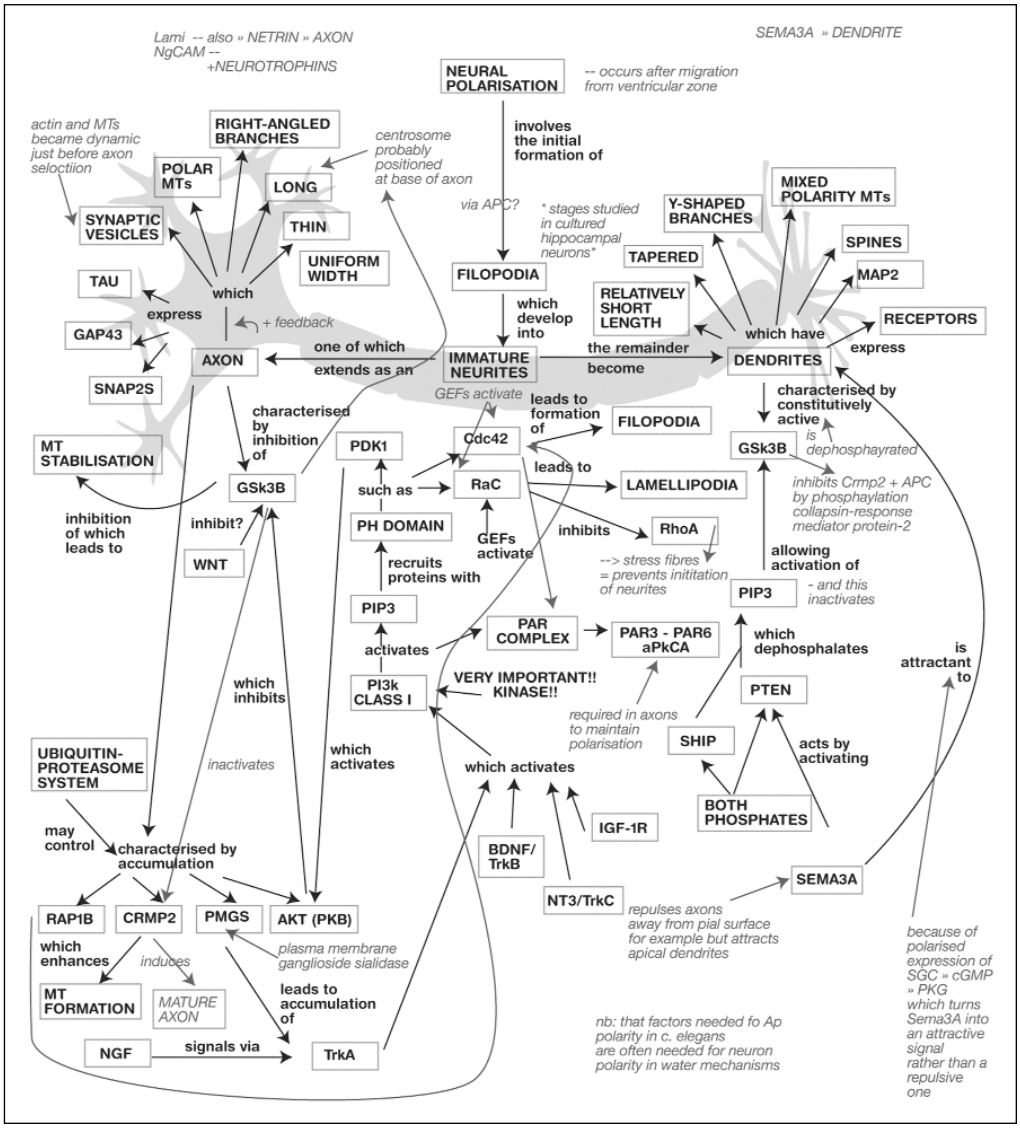

Figure 6

This map is a just one of 20 made by Student Y in the course of revision. All the maps were entirely lexical in composition and the words (in light and dark print) show two different stages of development: (1) the darker text is the primary reading, developed while reviewing some previously read papers; (2) the lighter print shows the notes that were added later when the map itself was reviewed. The structural images (of the axon [left] and the dendrite [right]) have been superimposed later in response to what the student had to say about the maps: "... [Student laughs] of course, you can see what I have done, I have patterned my map according to the structure of the things I am talking of - see here the structure of the axon - and [here] the dendrite".

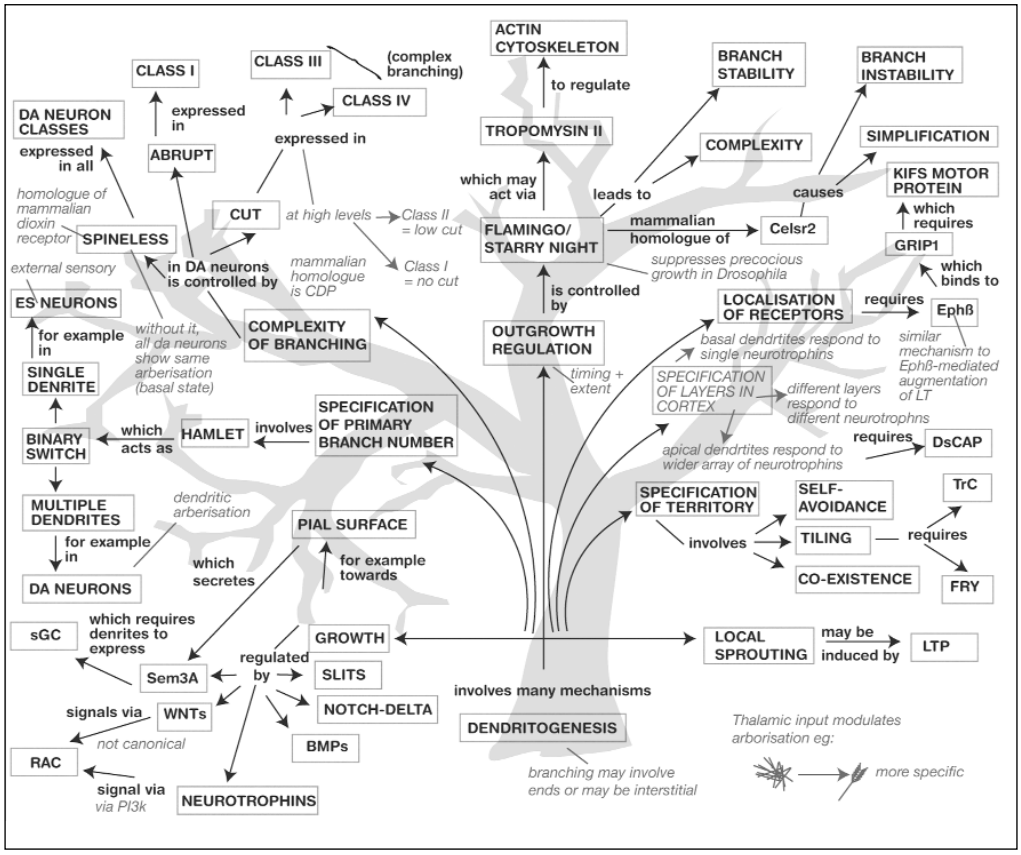

Figure 7

This map is another example of the revision work of Student Y. The tree-like structure has been added afterwards to illustrate the pattern that the student used to envisage the process of 'dendrogenesis'. The student acknowledged that the form has an emotional component that lends additional propensity to the memory function. Like Figure 6, the darker written text shows the map at the first stage of construction and the notes and sketches in lighter print are the second layer of development superimposed later.

similar underling pattern - where the words I have used are sort of mapped on top of what I imagine the topic to be. So this one [not shown] *is a map of the biological process: all the words are the names of molecules or cells, but the way I have arranged them gives the process... this one* [gestures to the map shown in Figure 6]: *looks like the things it describes* [the axon and the dendrite]."

"*Like I said I didn't really know that this is what I was doing, but when I saw it, I also realized that I really knew all of these subjects already, and that if I had to help myself remember, then all I had to do was picture these underlying structures. But*

sometimes I couldn't find the pattern - the biological pattern - and then I had to use something else. This map [Figure 7] *is a model of the process of dendrogenesis: I could see that already I remembered it well, because again it had a physical structure - it was a tree! So once I had drawn this map, I didn't need to look at it very many times before I could remember it all – it was as if it had started making sense to me already because I could picture it tree-shaped, and this shape is always close to me. All the terms in the map, they are just words or concepts, but in the image I can see the process I want to describe."*

A concluding commentary on the case study data

Despite the differences in learning approach between the two students, both of the cases provide evidence of the imaginative function in developing understanding of one science subject. The work of Student Y is conspicuously inter-textual, which is also to say that it develops in a frame of inter-personal relationships mediated through reading (Bruner, 2002). But so too, the developing understanding of Student X is also social, occurring in continuous narration of the subject-form and including therefore developing relationships towards other people: most pointedly, relationships towards the student's tutors.

The most important difference in the cases, however, is the different positions that the students adopt towards their discipline, and related to this, their different appreception of what an academic understanding *is*. Student X relied on the feedback of his tutors to direct him towards the deeper formal function of his subject; a subject in which images signify more in their relations to one another, than each of them does on its own. Even when the beginnings of this are grasped, however, the work of Student X remains ostensibly formal. While the maps he eventually produces are original, illustrating a process that is not actually offered by any of the images or the written texts that he draws upon, still his composite picture is the synthetic one, comprising a learning to read the images "given", in ways that are already intended by his discipline. Thus the position of this student is the one of learning *how* to read (in a disciplinary context), or in other words, of learning the narrative function that is pre-determined by the subject-discourse. This demands imagination since narrative is already the product of a social dialogue (Bruner, 2002, 2006) and importantly his understanding is constituted in what Kress (2003) describes as transduction: repeated shifts between the different representational modes of written text and drawing so that insight accrues in the process. Thus Student X describes the difference between mimicking given forms and eventually *understanding* them. But this is not yet the imaginative propensity of student Y - that is also *critical*. Student X we might say is located as a developing student of the subject, while Student Y is already situated *within* her discipline - as a function of self-authorship simultaneously (Baxter-Magolda, 2004, 2009). This is because Student Y already realises that the position Student X assumes must also be extended to *all* the researcher/speakers of the discourse, including her lecturers and the authors of the papers that she reads, as well as herself. For Student Y, it matters less what *her* interpretation is, but rather how her own position appears as a result of seeing the subject from (yet) another's perspective. She reads a review paper from the positions of her lecturers, for example, so that the subject towards which both the paper and the lecture are pointing arises in an inter-animation between them both. This is a sophisticated academic stance; it is acknowledgement that after all, a merely "personal" interpretation is unwarranted (or at least it is not sufficiently critical), but that the "*subject in process",* including the subject of inquiry and its speaker (Kristeva, 1998), develops simultaneously because of seeing each text critically (in the literary sense) in relation to other texts.

While the work of Students X and Y is different, however, there is also an important difference between them both and the original stance of concept-mapping theory. This is part of what Kress (2003) describes in his work on "*Literacy in the*

New Media Age" - it is a *literary* shift that changes the metaphor of learning from "*telling the world*" (where reading is a process of interpretation) towards the one of "*showing it*" (ibid., 2003, p. 140), acknowledging that reading to get meaning from a text (in the narrowest sense) is quite different from drawing on what is there to be read (Barthes, 1974). This reading potential is what Student X is developing towards, because he has grasped the principle that each single image needs to be read in relation to others (even if it is not what he knows about text-types in general and his learning narrative is yet to include the issues of context that relativise text): but it is the position assumed by Student Y already.

It is also Student Y's approach towards reading that drives her active postponement of commitment to form. This is higher risk as a learning strategy since Student X can always draw on the latest representation that he has developed, whereas Student Y "*just reads*". But it is just this reading that gives Student Y the possibility of patterning the subject more imaginatively, more whole, more complete, more encompassing of different perspectives, and thus also more original, when it comes to light. Student Y has begun to sense and apprehend the subject itself and this includes a rich emotional relation towards the patterns that she forms, as well as therefore including the *context* of her learning in her understanding. People and the laboratory practice situation are prominent in Student Y's account and they are clearly part of the subject she conceives. Perhaps most telling, by the end of the work, Student Y had begun to say "*we*", "*us*" and "*I*" in relation to the subject of neuroscience, while to begin with she only ever said "*they*" or "*it*":

> "*I see Science in its historical context. When you see it like that, then it is as a whole conversation and you are part of that. The work we are doing in my laboratory is part of this bigger dialogue. So what I can see now is the scientific process behind the facts - how this or that comes to be taken as 'right', rather than just being told 'it's a fact'. You need to see how one experiment has led to particular findings that lead in turn to other experiments - and so you get this whole process, and communication going on between different people and you need to understand that this includes people. Eventually, at the end of, I don't know however long it takes, we get an answer, but even that leads to another question. That whole process - that is science - when you want to understand science you need to understand that all the scientists are part of the conversations of science as well."*

7. Discussion

In the discussion that follows, I return to the questions of "method" introduced at the beginning of the paper. I aim to show how methods that focus on developing and recording a continuous dialogic interaction document learning in some very different ways to the university learning trajectories previously shown using concept-mapping (e.g. Shavelson, Ruiz-Primo, & Wiley, 2005; Hay, 2007; Hay, Wells, & Kinchin, 2008). This is because *method* inevitably interacts with the types of data that it is possible to collect and interpret. Thus, while I argue that concept-mapping still has an important role to play in higher education learning-research and in university teaching (by helping lecturers to document the direction of their students' learning outcomes), we must also be cautious about what this data means, acknowledging that the interval changes in a person's cognitive map are functions of the method (and its theory) already. Likewise, we might be rightly cautious of the case study data here, particularly since it is derived from work with just two students, but it is nevertheless an important addition to the field precisely because it visualises learning from a different perspective.

8. Methods

In the case study work, visualisation of imaginative function has been possible because

of shifting the methodology from the theoretical frame of concept-mapping towards analysis of communicative form. The issue is that methods like concept-mapping require that learning is seen solely from a cognitive perspective, showing even a continuous learning trajectory as an interval process - because the ways that concept-mapping theory construes learning are also interval (i.e. depending on super-ordinate changes in a cognitive structure). But at the same time, concept-mapping offers no causal explanation of *understanding*: it only suggests that cognitive reorganisation can have different qualities (Hay, 2007) or that each map can be more or less correct when compared to the authorised structure of knowledge worked out already (Hay, 2008). Picture for example, how we might interpret the data if we had used concept-mapping theory to locate them, and also if we had to do so without recourse to the students' spoken narratives. Then, the work of Student Y in particular would be very difficult to explain, since what has actually been visualised here is a learning *process* rather than successive stages of development towards a pre-determined knowledge structure. We might also conclude that each of the maps of Student X were the product of re-combining prior knowledge with new learning material - when in actual fact Student X describes each map as the structures that he borrows and comes to understand by reading them.

We have also seen that both of the students' work is more continuous than concept-mapping theory implies. It occurs in a semiotic extension and depends on a constant process of dialogue. This all happens in the development of dialogue itself, so that each writing or drawing act must be considered simultaneous to an act of "reading" also; and in the case of Student Y in particular, a reading that brings many different texts into contact. It is not the grasp of new "concepts" that makes one map different from another but, in the discourse, the "concept" (idea) and the narrative function are inseparable, and *understanding* arises as insight. Even, we might add, all the forms of the subject already include more than their *knowledge* structure: they encompass the conditionality of the subject and the positions of their respective speaker/authors. All the hedges and bets of inquiry (into a subject that is still not fully known to science) are represented too, so that understanding what is still to be discovered is also potential in each representation. *All* of this accrues as *understanding* inter-textually (to greater or lesser extent in the cases); none of the *meanings* of form can be given directly, excepting that the form already comprises clues for reading in its semiotic function (Kress, 2003). Signification is carried as the reading potential of the forms to begin with and then also in their propensity for inter-animation when different texts are brought together. This is why even the initial "mimics" with which Student X begins his work cannot be likened to learning by rote (Novak, 1998). Using language in discourse is *always* meaningful (Kress, 2003), because *use* implies participation in meaning-making (Wegerif, 2007). If learning is viewed from the cognitive perspective of concept-mapping then the continuum from rote to meaningful learning quality may be relevant, but in a dialogic context, our attention shifts towards the dialogue itself; the quality of the reading/writing that is design (Kress, 2000; Lillis, 2003) and the advice that lecturers can give to help their students "read" in increasingly sophisticated ways. The feedback that Student X receives from his tutors is not so important for the mistakes it points out, but for giving direction towards a developing academic literacy – a way of *reading* the subject more deeply.

As a result, the data and the theoretical development presented here, while they are specific to a single university learning context (and a particular third-year subject as it was espoused by just two students), nevertheless challenge the relevance of some of the central assumptions of concept-mapping and associated assimilation learning theory: (1) the learner's prior knowledge has *not* been shown to always be the precondition of developing understanding; rather learning for understanding is explained in terms of reading (including a view of writing or drawing as "reading" also); (2) the relevance of integrative assimilation among new and old knowledge structures is also questioned by data that points to a process of insight emerging in transductions of the

representational mode, or more conspicuously, in the inter-animation of texts; and (3) related to this, the meaningful or rote learning model is problematic because it does not acknowledge that representation is always meaningful in a dialogic context. None of this is criticism of concept-mapping however, a method that remains relevant for use from a cognitive perspective, but it does suggest that assimilation theory ignores the richness of "learning" in dialogue and therefore fails also to explain *understanding* as a process. As I now explain, these issues have important implications for teaching.

9. Implications for Teaching

The concept-mapping literature offers very sound advice for university teaching. It suggests for example, that university lecturers should assess their student's prior knowledge and adjust their teaching accordingly. Moreover it offers a method of doing this assessment that is compatible with modern higher education (see Hay, Kinchin, & Lygo-Baker, 2008). But as we have seen, concept-mapping also makes assumptions about what learning is: emphasising the importance of cognitive structure, the supply of meaning to ideas worked out already and directing teaching towards the "fit" of lecturer's explanations with a separate understandings of their students. If we acknowledge that learning for understanding is essentially imaginative, however, then this also directs the debate of teaching quality towards other issues: towards ways of reading, for example, and also the social preconditions of imaginative potential (Alexander, 2004, Rowland, 2005; Wegerif, 2007). Haggis (2009) points out that the higher education community has rather tended to speak about student learning as "*theirs*" [the students']; the positions of dialogism, however, includes the lecturer/teacher/researcher *and* student as simultaneous participants in the educational process and suggests that university teaching need not be seen as just explaining and testing for expert knowledge, but also as creating space (or we might say relationship) for dialogue (Savin-Baden, 2008). The emphasis falls on scaffolding reading and inquiry in their social context as well as scaffolding "knowledge" (Northedge & McCarthur, 2009).

This issue of *context* is particularly important. Sometimes the teaching of higher education is criticised because different lecturers espouse their subject-knowledge without much discussion of the common ground between them (see Kinchin, de-Leij, & Hay, 2005 for example). But this is not to say that university teachers need to agree their subject as a single target (Entwistle & Smith, 2002). As we have seen, it is a growing apperception of the *different* perspectives of many others that leads Student Y to grasp the subject herself. It is in the differences between these texts that her insights arise - because the different speakers of research constitute and project their subject-content differently, according to their own subject locution. But crucially the learning disposition of Student Y is already one of seeking meaning inter-textually rather than just trying to understand the facts and information that each conveys in isolation. This is an approach to learning of the deepest kind (*sensu*: Marton & Säljö, 1976; Säljö 1979 and many others reviewed by Entwistle, 2007, 2009). The work reported here is therefore to develop one of the most enduring and relevant themes of higher education research by suggesting that directing students towards the inter-textual process is a means of shifting surface level study towards deeper inquiry and more genuine academic practice. But this shift must be supported by developing teaching strategy. Lecturers might be encouraged to read and give feedback on their students' notes, for example. After all, the maps of Students X and Y are really notes of the subject and each one of them shows the student's reading potential. Thus, even if we suggest that university lecturers do not need to talk about their subject-content any more than they do already, they might be encouraged to discuss *learning* with their students more often and also to model the ways that they read themselves (Weller, 2010).

Drawing attention to the pedagogy of reading is probably essential and in many subjects, like the neuroscience described here, a grammar of the image is equally relevant to

that of written text. But reading and learning from images is still under researched (Kress & van Leeuwen, 2006) and, as Chandler (2002) points out, our education system has consistently privileged the literacy of the spoken/written language at the expense of other semiotic modes (like drawing). This is increasingly problematic as university teaching (and wider society) shifts towards newer forms of communication, using Power-Point presentations and a variety of e-learning technologies in ways that ask different things of our shared communication (e.g. Kinchin, Chadha, & Kokotailo, 2008; Kinchin & Cabot, 2007; Kress, 2003; Kress & van Leeuwen, 2006). Likewise, we need also to acknowledge that academic literacy is multi-modal (Kress, 2003; Kress & van Leeuwen, 2001). Moving from one mode of representation to another (transduction from writing to drawing for example) is important, since this allows knowledge to be re-configured and re-shaped, and it is in these processes that creativity happens (Kress, 2003, p. 36). But again, much more research is needed here and this should be combined with the development of teaching strategies that knowingly employ different modes of communication to create more "learning-space" (Savin-Baden, 2008). In all of this, however, it is crucially important to understand what is really at stake. A focus on literacy is not just vital because reading is a necessary academic skill. More fundamentally, a shift from the theories of knowledge acquisition (in assimilation learning theory) towards seeing learning as a semiotic function offers a better potential for explaining and developing student apperception. This is also to acknowledge that multi-modal literacy is a process of "*interested design*" (Kress, 2000): a means of developing creativity because an individual's existing semiotic resource is never fully adequate for representing the subject, but becomes more nearly so as it is extended (Kress, 2003, p. 46). Finally, it is important to acknowledge that this takes time; that patterning a subject imaginatively is protracted and continuous assessment may be detrimental to the process by interrupting it.

10. Conclusion

The central theme of this paper has been the study of a subject that is patterned in dialogue: a subject pattern that is thereby constituent also of the learner's subjectivity and amenable for study since it can be visualised in the primary locution of the subject of inquiry. Sternglass (1997) describes many of the difficulties inherent in collecting individual learning data like this; but it is worth the effort since the subject in process is also the subject of higher education (Hay, 2008). One could also argue that researching this locution is what university lecturers have always done as part of their teaching function – researching and developing dialogue with students in tutorials; in assessment; and in teaching more generally. But rarely is it also reported with the rigour and critical scrutiny necessary for developing of teaching praxis. As regards formal learning research however, Fyrenius, Wirell and Silén (2007) point out that much of the literature of higher education has a second order perspective; focussing, for example, on students' approaches to learning or the ways that they shape their knowledge-objects (Entwistle & Marton, 1994; Entwistle & Entwistle, 2003), without supplying simultaneous evidence of individual locution for these subjects or objects. It is the combination of both reportage *and* documented "form" that is most needed, particularly when this data collection can be extended through time to show change. The "*inner logic of a subject and its pedagogy*" (Entwistle, 2009) exists in the discourse of practice (Bruner, 2002; Mertz, 2007) and while exploring how individuals gain entreaty to discourse is crucial in itself, it is also vital for drawing attention to the imaginative function in academic understanding.

This paper has shown how the methods of concept mapping, originally developed for the longitudinal documentation of cognitive change can be re-framed theoretically, and in practice, to record the successive and multi-modal forms that are used in dialogue. The empirical data has comprised the student's representational maps, conversational interviews and responses to tutor-

feedback, and it illustrates the extension of two learner's semiotic resources. The analysis has focussed on the ways reading-writing proceeds through imaginative re-patterning and is constituent of *both* an academic understanding for the subject as well as the developing subjectivity of the subject-speaker. Two different types of learning approach have been explored. The learning trajectory of one student (Student X) has been shown to comprise a developing literacy whereby imagination functions in the space of transduction from written text to drawing, but here the re-patterning that occurs is formal: directed towards the supply of meaning for the previously ordered representational elements of teaching. The work of the other (Student Y) is more essentially imaginative and inter-textual; extending the re-patterning of representation towards all text-types, including acknowledgement of context (or the relativized positions of other author/researcher/teachers) and postponing commitment to form so a reorganisation is more fully achieved. The approach of Student Y is also demonstrably relational (as affective as it is cognitive) but it is important to emphasise that she finds the inter-personal warmth of her subject in reading. Rowland (2005) highlights the importance of relationship towards a discipline; despite the constraints of modern higher education teaching, these data show that this relationship is there to be found by undergraduates so long as it is read.

The distinction between dialogic explanations of learning and notions of learning by assimilation (or knowledge acquisition) has been a central theme of this paper. From the dialogic perspective, the outcomes of learning can never be predicted (Alexander, 2004; Wegerif, 2007) but Vygotsky's notion of learning in a zone of proximal development (Vygotsky, 1978) is always pre-determined by monopoly of foresight (Bruner, 1986, p. 75). This is because understanding itself is construed differently by dialogic and dialectic theory (see Wegerif, 2008). In Vygotsky's account, understanding is the supply of meaning to what is worked out already (i.e. what is known from a more advanced position of knowledge) and language is the tool for bringing this about (Vygotsky, 1978, 1986). Dialogism, on the other hand, suggests that quite apart from language as tool (or rather including it), dialogue is also the *ends* whereby understanding arises individually (creatively). Bakhtin's dialogic theory is particularly important to education because it explains the process of imagination: as a function of inter-textuality (Kristeva 1986a, 1986b). This is not a licence to "understand" just anyhow, but rather a cogent explanation of the subject in process, even when the pattern of form must coincide with knowledge already agreed at the cultural level. The theory is therefore a relevant explanation of imaginative function in science and it has the potential to revitalise science learning and teaching. Dialogism also directs attention towards a general university pedagogy that is the theory of literary criticism already.

Acknowledgments

I am grateful to Richard Wingate and Darren Williams for facilitating this research. Rik Gadsby produced the art-work and Noel Entwistle, Ray Land and Rupert Wegerif made comments on earlier drafts of this paper. This work was funded by a grant from the Higher Education Academy UK (GRANTSGEN-EV111), and is the extension of research previously funded by the Society Educational Studies. The two students who took part achieved excellent examination results. One of them (Student X) is now in the fourth year of Medicine, the other (Student Y) was awarded a PhD student scholarship as a consequence of her final examination results and is currently engaged in research.

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Η λειτουργία της φαντασίας στη μάθηση: θεωρία και δεδομένα μελέτης περίπτωσης τριτοετών φοιτητών στις Νευροεπιστήμες

DAVID B. HAY[1]

Περίληψη

Η εργασία συνδυάζει κριτική θεωρίας μάθησης και δεδομένα μελέτης περίπτωσης που αφορούν δύο τριτοετείς φοιτητές Νευροεπιστημών. Τα αποτελέσματα και τα συμπεράσματα δείχνουν πώς η έρευνα για τη μάθηση στην ανώτατη εκπαίδευση είναι δυνατόν να αναπτυχθεί εστιάζοντας στην αλλαγή της έκφρασης των θεματικών αντικειμένων, εκ μέρους των φοιτητών. Περιγράφεται μια μετακίνηση από τις γνωστικές πλευρές της θεωρίας της αφομοίωσης στη μάθηση προς την οπτικοποίηση του διαλόγου, και αυτή χρησιμοποιείται προκειμένου να έρθουν στο προσκήνιο οι διαφορετικοί τρόποι με τους οποίους οι γνωστικές και οι διαλογικές «θέσεις» ερμηνεύουν τη μάθηση. Η ανάλυση δείχνει ότι οι θεωρίες και οι μέθοδοι που καταδεικνύουν τη χρήση της γλώσσας προσφέρουν πιο πλούσια δεδομένα όσον αφορά τη μάθηση και μια πιο ερμηνευτική περιγραφή της κατανόησης σε ένα ακαδημαϊκό πλαίσιο.

Τα δεδομένα προσφέρουν εμπειρικές ενδείξεις για τη λειτουργία της φαντασίας στη μάθηση. Επίσης, απεικονίζουν δύο διαφορετικούς τρόπους με τους οποίους η επανα-διαμόρφωση του κειμένου οδηγεί σε βαθιά γνώση. Τα δεδομένα της πρώτης μελέτης περίπτωσης είναι φαινομενικά τυπικά και περιλαμβάνουν δημιουργικότητα σε μια συνεχή σημειωτική επέκταση, καθώς ο φοιτητής μετακινείται από τη μια μορφή αναπαράστασης (γραφή) στην άλλη (σχεδίαση). Εδώ, ωστόσο, η έκφραση που υιοθετεί το υποκείμενο σπάνια «πηγαίνει πέραν του δεδομένου», όπως παρουσιάζεται στον ήδη υφιστάμενο διάλογο. Η δουλειά του δευτέρου φοιτητή είναι εμφανώς πιο διακειμενική και εμπλέκει την ενεργό αναβολή δεσμεύσεων στη μορφή, καθώς τα πολλαπλά κείμενα και τα είδη των κειμένων διαβάζονται στο πλαίσιο των μεταξύ τους συσχετίσεων. Αυτό εξαρτάται από την ανάγνωση και το ξαναγράψιμο καθεμιάς διάλεξης ή επιστημονικού άρθρου υπό μία αναπτυσσόμενη αντίληψη των οπτικών των άλλων (διαλέξεων ή επιστημονικών άρθρων). Έτσι, το θεωρητικό/ακαδημαϊκό αντικείμενο που πραγματεύεται ο φοιτητής τελικά αναμορφοποιείται με τρόπο πρωτότυπο στο πλαίσιο της αλληλοδιαπλοκής όλων αυτών των κειμένων συνολικά: μια διαδικασία της φαντασίας που περιλαμβάνει την επίγνωση του πλαισίου του κειμένου (π.χ. τις συσχετιζόμενες θέσεις συγκεκριμένων συγγραφέων) καθώς και τη συναισθηματική σχέση προς το αντικείμενο και τους ομιλητές του.

Η συζήτηση εστιάζει στην ακαδημαϊκή ανάγνωση/γραφή ως μια ταυτόχρονη διαδικασία διαλόγου και σχεδίασης και αναπτύσσεται μια οπτική της λειτουργίας της φαντασίας, η οποία σχετίζεται τόσο με τις σπουδές στις θετικές επιστήμες όσο και με την κριτική της λογοτεχνίας. Εξετάζονται εφαρμογές στην πανεπιστημιακή διδασκαλία και γίνονται κάποιες προτάσεις για μελλοντική έρευνα.

Λέξεις-κλειδιά: Συνεντεύξεις, Διαλογικός-διαλογικότητα, Διαλογική χαρτογράφηση εννοιών, Δημιουργικότητα, Παιδαγωγική, Ανώτατη εκπαίδευση.

1. Διεύθυνση: King's Learning Institute, King's College London, 57, Waterloo Road, London, SE1 8WA, UK. Tel: 0044 (0) 20-7848-3265; fax: 0044 (0) 20-7847-3253; e-mail: david.2.hay@kcl.ac.uk