Concept Maps: Making Learning Meaningful
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EXPLORING THE LIMITS OF CONCEPT MAPPING: WHEN LANGUAGE TAKES OVER

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Abstract. This paper combines a critique of the underlying theories of concept mapping for university level learning and case study data from two students, one in Classics and one in Neuroscience. A shift from the cognitive perspectives of assimilation learning theory towards a more narrative and representational visualisation is described and used to foreground a more dialogic approach. The results and conclusions show how higher education learning research can be developed by focusing on students' changing understandings of their discipline. 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.

1 Introduction

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 et al (2005), for example, provide concept-mapping data for learning in Science; Hay et al (2008) offer data in Medicine; Hay, Wells & Kinchin (2008) in Psychiatry; and Hay & 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 et al, 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 (1963; Ausubel et al, 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 (1986) 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). Exploring the utility of a broader use of concept-mapping for the facilitation of leaning at the university level is part of the purpose of this paper.

Most previous uses of Novak's concept-mapping method depend on using the technique as "windows into the mind" (Shavelsen et al., 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 (1998, p.19).

But these approaches also depend on using mapping only as a 'test' for knowledge, not as means of teaching and learning per se. In this paper, concept maps are used in discipline-based university settings. The consequences of mapping high-level thinking are analysed and the widening use of images and language in the maps is explored.

2 Concept mapping: theory and origins

In the 1970s and 80s 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). 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. 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, 1998; Novak & Mussonda, 1991). 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 (Hay, 2007; Novak, 1998).

2.1 Using concept-mapping in higher education

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 et al (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. However, 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 Leuwen, 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); 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); and 3) finally, by taking the essentially cognitive stance to begin with, traditional concept-mapping theory does not easily accommodate the multiple perspectives encountered in university settings (e.g. primary texts, secondary analysis, teachers' views and students' changing understandings over time).

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, 1998) and where learning depends less on acquiring any given knowledge-content and more on the use and function of narrative (Bruner, 2002; 2006; Hounsell & Anderson, 2009; Mertz, 2007).

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 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 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 further, the question becomes one of what can, and what cannot, be spoken about in concept-maps.

2.2 The conversations of disciplinary inquiry

The issue of correspondence between the logic and affordance of different representational modes is developed by Kress (e.g. 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; Hounsell & Anderson, 2009; Mertz,

2007; Vosniadou, 2007). The interdependence of disciplinary thought and speech is developed in Bruner's writing about the narrative self (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. 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 (e.g. 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), just as the narrative is essential in developing understanding in Classics. So for the purpose of using concept-mapping at the university level, what is important is being able to include this wider range of representational forms, 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. To further explore these issues, concept maps made in university settings in two different disciplines are explored.

3 Methodology

To test and develop a broad approach to the visualisation of understanding, four detailed longitudinal studies were carried out, 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 the intention was 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 the approaches to analysis, the data are too large for the purpose of this paper and the focus is on just two of the individual trajectories, one from a student in Classics and another from Neuroscience.

3.1 Data from maps in classics

Concept mapping was used to collect data to assess students' learning experiences through the duration of a university level course in the humanities. In this way, concept mapping was used as both a research and pedagogical tool. Twenty students in a Classics class were asked to create concept maps of the topic of the course: "The impact of Greek literature and culture on the Roman world." Students were given a brief tutorial on concept mapping at the beginning of the course. The maps were created at three points in the course. The first was made at the beginning of the course, prior to the commencement of teaching. The second map was made at the mid-point of the course, and the third map was made at the end of the course. Participation was voluntary and the maps were not used in their formal assessment of the course. The sequenced maps done by the students are discussed below, with an example of one student's maps presented to highlight the variations in the maps during the course.

3.2 Data from maps in neuroscience

A programme of educational research was undertaken to 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. That work is reported elsewhere (e.g. Wingate et al, 2007), but the study was repeated 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 from one of students. 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.

4 Data

In the data and discussion that follows, the aim is to show how methods that focus on developing and recording learning trajectories in some very different ways to the university learning trajectories previously shown using concept-mapping (e.g. Shavelson et al, 2005; Hay, 2007; Hay et al, 2008). This is because method inevitably interacts with the types of data that it is possible to collect and interpret. Thus, while 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), there must also be caution about what the data means, acknowledging that the interval changes in a person's cognitive map are functions of the method (and its theory) already. Likewise, caution is needed with 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 different perspectives.

4.1 Classics maps: Need for holistic understanding

Traditional concept mapping analysis and assessment methods, both qualitative and quantitative, are only valid for the first map that the student created at the beginning of the course (see Figure 1). The student's initial understanding of the course material (prior to the commencement of teaching) can be assessed under basic concept mapping metrics of hierarchy and propositional linkages. However, the student does not show a deep understanding of the relationships between the concepts, and furthermore the initial map shows a rather particulate view of the topic. This is seen in Figure 1 where the two main topics of discussion (Greek Culture and the Roman World) are not connected together.

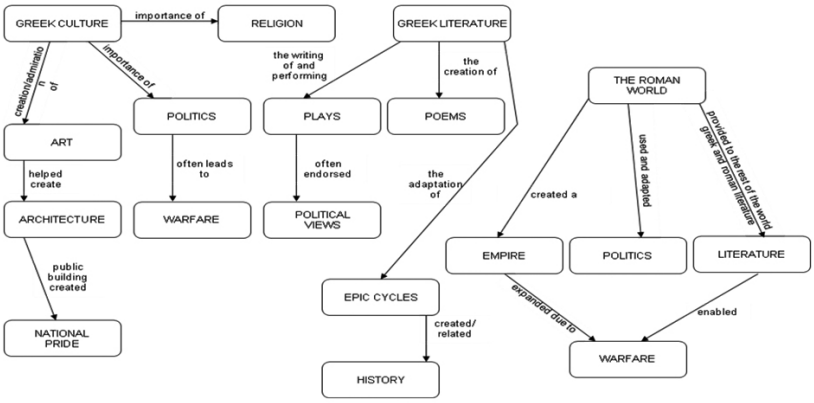

Figure 1. Prior-learning map in Classics

Once students progressed along in the course, their understanding of the concepts moved beyond the initial brief propositional statements that could be organized hierarchically. This is seen in Figure 2, where instead of linking concepts with a word or short phrase, the student often wrote long complete sentences to connect the concepts in the map. Furthermore, in another map, a student combined concept mapping with brief essays to explain the complicated relationship between the concepts. As the maps shown indicate, there was change from the first map to second, which was the case for all of the students. There was a move from a general, descriptive account of the subject matter to the development of personal understanding of the course. However, this understanding can only be seen when the construct of the map is analysed as a whole, rather than as a set of discreet linked concepts. The second case study delves into further issues of the limits of traditional concept mapping at the university level.

4.2 Neuroscience maps: 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 her work the student argued repeatedly that she had no relevant prior knowledge of the subject. When the form-shape of her understanding did eventually appear (see Figure 3), 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, 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, the student had begun to 'picture' and relate towards the subject directly, grasping the sense towards which all her different papers and lectures, between them, were pointing.

As we 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 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 relation with other texts - so that understanding appears of its own volition when different texts are brought together.

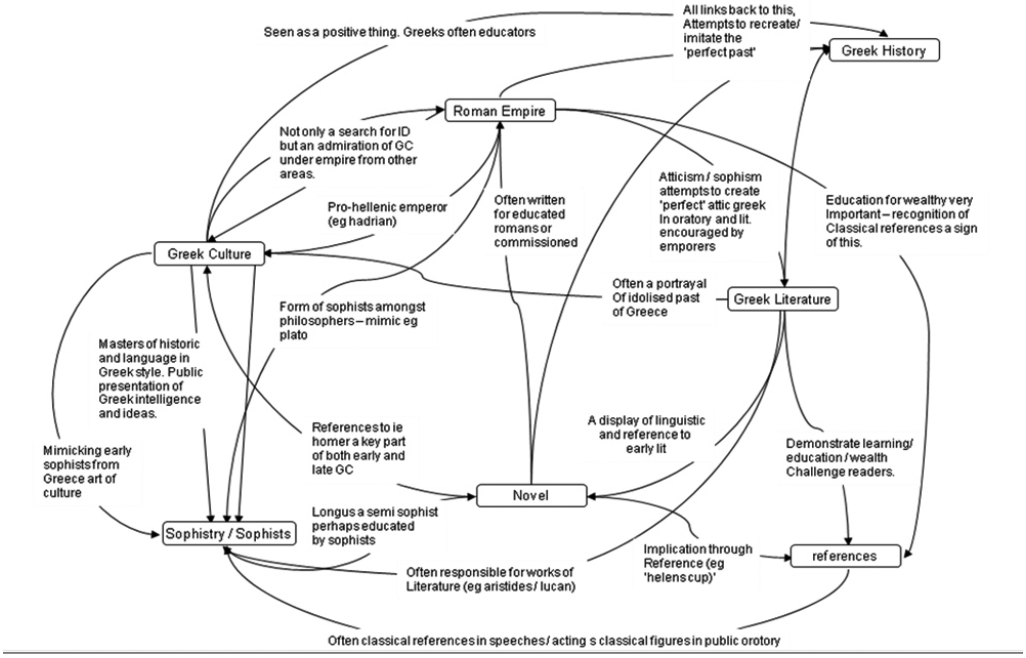

Figure 2. Development of understanding in Classics

5 Discussion

In the case study work, visualisation of understanding in a disciplinary way 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. 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 the neuroscience student 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.

Both of the students' work is more continuous than concept-mapping theory implies. 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 conditionalities 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; 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). 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 university context, our attention shifts towards the understanding 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.

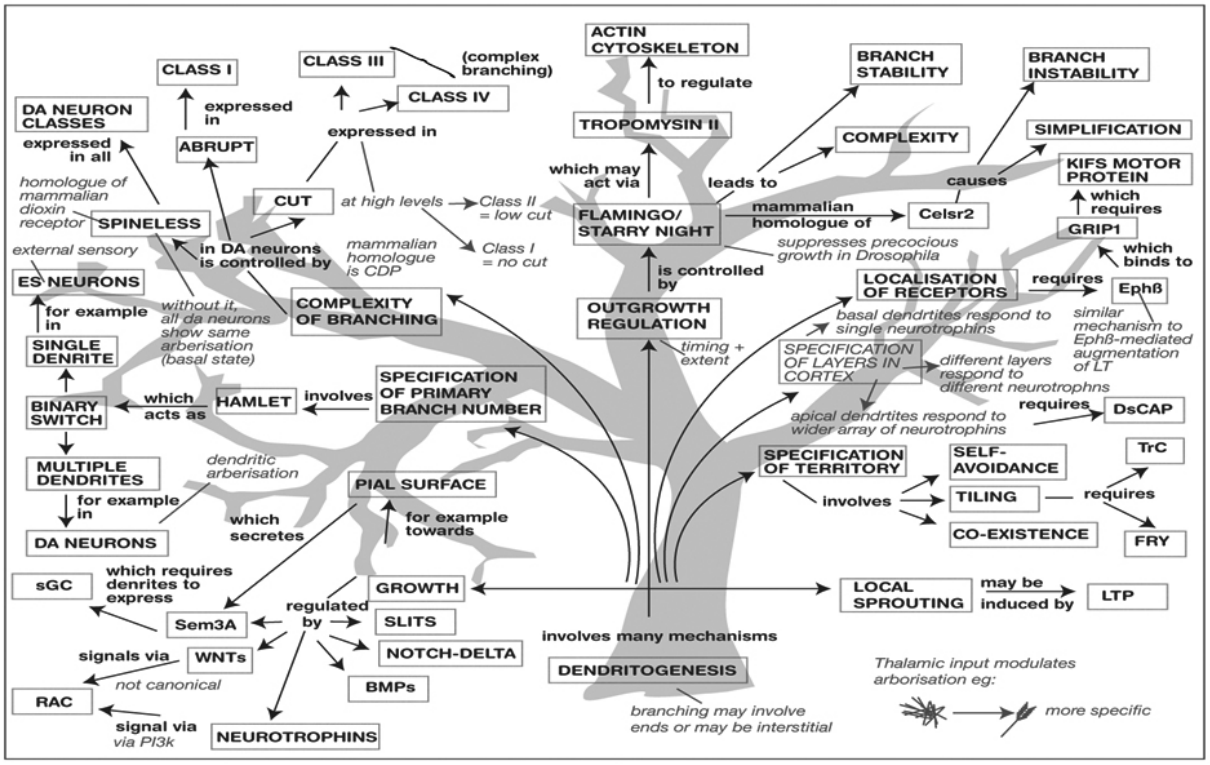

Figure 3. Map from Neuroscience

As a result, the data and the theoretical development presented here, while they are specific to two different university learning contexts, nevertheless they 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; and 3) related to this, the meaningful or rote learning model is problematic because it does not account for the meaning of representation in the course of learning. 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' and therefore fails also to explain understanding as a process.

6 Conclusions

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 complex forms that are used in university learning. The empirical data illustrates the extension of two learners' processes of understanding. Two different types of learning approach have been explored. The learning trajectory of one student (Figures 1 and 2) has been shown to comprise a developing literacy whereby material that is been read and taught to the student is mapped, but the need for language to specify relationships has shown limits of concept mapping. The work of the other (Figure 3) is more imaginative, including acknowledgement of context. The approach is also demonstrably relational and includes a multi-modal understanding of disciplinary knowledge. 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.

In both disciplines, there is reflection upon the topic as a whole which assimilation theory fails to capture. The method of concept mapping allows for the learning process to be made visible and provides snapshots of change; however, these maps show a constant development of narrative of understanding. Therefore, there is much reason to advocate for concept mapping with a different underlying principle than assimilation theory, which is non-hierarchical, not particulate, and not reducible to atomic parts but personally reflective and grounded in narrative. Although rules for creating and assessing concept maps may be valid and useful in some settings, these case studies illustrate that a broad assessment scheme is needed in disciplinary settings. As a research tool, concept mapping at this level of education shows the complexity of students' structuring and understanding of a course. The process of mapping can also be used as a pedagogical tool, but the purpose of mapping and the context of assessment need to be reconceptualised.

What is crucial to this new utility for concept mapping is removing the method from its original assimilationist framework and relocating it in the broader context of dialogic theory (Bakhtin, 1981, 1986; Wegerif, 2007, 2008). Thus the map can be seen as a place where public and private reflection meets and leads to 'ideas made personal.' This is quite a different approach from the traditional stance of concept mapping which assumes each map to be the prior-knowledge structure of another, as well as the vehicle for interpreting new knowledge (Ausubel, 1963). The dialogic approach lays much greater emphasis on the process of linking the public and personal to create a new understanding, which is rather more an issue of self-authorship (Baxter-Magolda, 2004) than assimilation of new knowledge. The attention that Novak and others draw towards the cross-links in an individual's knowledge-structure is important because it signals personal understanding, or creativity in the learning process (e.g. Novak & Gowin, 1984; Novak, 1998; Mintzes et al., 1999). But in order to explain how creative leaps occur and to help to promote them, the instructor needs to engage in the reflective and dialogic learning process.

A movement toward a dialogic perspective acknowledges that the concept map is the text itself, both for the purposes of learning research and for the development of students' personal understanding. In this way, the maps act as tool for feedback and formative assessment in the writing and revision process, rather than as an object for assessment in itself. As Kress (2003, p. 140) states, the movement is away from reading how "text tells the world" to how it "shows the world." This change opens up for the students' self in the learning process) because it invites participation in creation of meaning (Hermansen, 2005). This issue of personal engagement with knowledge is the one that speaks to all disciplinary inquiry as being a creative process, rather than closing it down from the personal perspective.

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