Visualising Powerful Knowledge to Develop the Expert Student

A Knowledge Structures Perspective on Teaching and Learning at University

Ian M. Kinchin

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For Anne

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COVER PHOTOGRAPH

This geodesic dome was given to the University of Surrey during the 1982 International Space Structures Conference. It now stands in the campus of the university. Photo by author.

CHAPTER 1

THE FRAMEWORK

Linking Key Ideas

INTRODUCTION

Academics who teach at university are there because they are subject experts. Not only do they know many things about a given discipline, but their knowledge is also well-organised in a way that allows them to be active members of an academic community that develops the field of knowledge as well as teaches it. As summarised by Goldsmith et al. (1991: 88) '*To be knowledgeable in some area is to understand the interrelationships among the important concepts in that domain*.'

However, whilst new university academics have a degree of expert subject knowledge, they are often novices when it comes to teaching, or to displaying a level of pedagogical content knowledge (e.g. Shulman, 1987). Their lack of teaching expertise is exemplified through their views about their learning compared with their students' learning, with significant inconsistencies between academics' views of their own learning and what they expect of their students. Kinchin et al. (2009) found that many of those new to university teaching were acting as disciplinary experts in terms of research in which they expected their own understanding to grow slowly, building on prior knowledge, but simultaneously acted as novice teachers, expecting students to acquire understanding as soon as the information had been transmitted. West (1966: 767) touched on this when pointing to the tensions that teachers feel when faced with the conflicting demands created by the desire to help students pass exams and the desire to help students develop expertise:

> Most teachers understand the importance of developing the students' capacity for critical thinking and self-education, but most of us are too busy telling them what we know to get around to showing them how we learn. Possibly they would gain more from watching us learn than from watching us teach.

Indeed, Lea (2005) has suggested that many teaching activities are designed to keep undergraduates as perpetual novices. This may be seen by some academics as a less threatening way of keeping control of teaching, as it maintains a clear power differential between the student and teacher. Unfortunately it also means that the student never becomes an autonomous learner – something that, ironically, the same teachers find a source of annoyance. To ensure the smooth running of this model, the inevitable conclusion is a tacit collusion between teachers and students, in order to simply pass the course, in a culture that becomes one of anti-reflection and even anti-learning (Harland et al., 2006).

It is clear that some academics take to teaching must more easily than others. Some colleagues will be seen as 'good teachers', even if they have received no formal training. They are just seen as 'naturals'. However, even these naturals can find it difficult to articulate what it is they do, and this is a handicap when it comes to supporting and mentoring more junior colleagues who do not find classroom practice easy to master. As explained by Mcleod et al. (2003: 638):

> The good ones (i.e. proficient teachers) usually possess knowledge of content-specific pedagogy – a special form of knowledge which develops through the apprenticeship model of observation and experience. Their experience usually relates to behaviours, strategies and instructional techniques – the 'how' of teaching – but few understand the basic principles, theories and concepts of the teaching process – the 'why' of pedagogic behaviours.

Within this book, I hope to make ideas of pedagogy explicit, so that rather than pedagogy being considered the 'underware' of the teaching process (relative to the software and hardware used in teaching, Adams, 2004), it is brought to the fore as a starting point for scholarly discussions about teaching, and visualised through the application of concept mapping.

UNDERPINNING PHILOSOPHY

To help set the trajectory for this and the subsequent chapters, here I consider three statements drawn from different corners of the educational research literature. The first is from an under-cited paper by Novak and Symington (1982: 8) who state: '*moving from a linear structure to a hierarchical structure and back again is in some ways the fundamental educational problem'*. The idea represented with this statement has the potential to expand the potential of concept mapping (explored in detail in Chapter 2) from a simple study aid to a heuristic device that can demonstrate the links between elements of pedagogic theory and teaching practice (Kinchin, 2013). Within studies of student and teacher knowledge structures, the widespread occurrence of linear and hierarchical concept maps has stimulated analysis of the consequences for practice. Particular structures can be seen to populate different sections of a knowledge transformation cycle that underpins teaching episodes (Kinchin & Hay, 2007; Kinchin & Miller, 2012). The complex (often hierarchical) understanding of the expert is converted to a linear teaching sequence of lectures and tutorials. From this the student is expected to construct his/her own integrated understanding of the topic. The students' hierarchical understanding is then often assessed using a linear format (such as an essay or a multiple choice paper). In such scenarios the hierarchical structures held by student and teacher remain private whilst only the linear translation is shared for scrutiny (Figure 1). We, therefore, need to help teachers and students to access each other's abstract concepts of the subject and use these as a tool in learning.

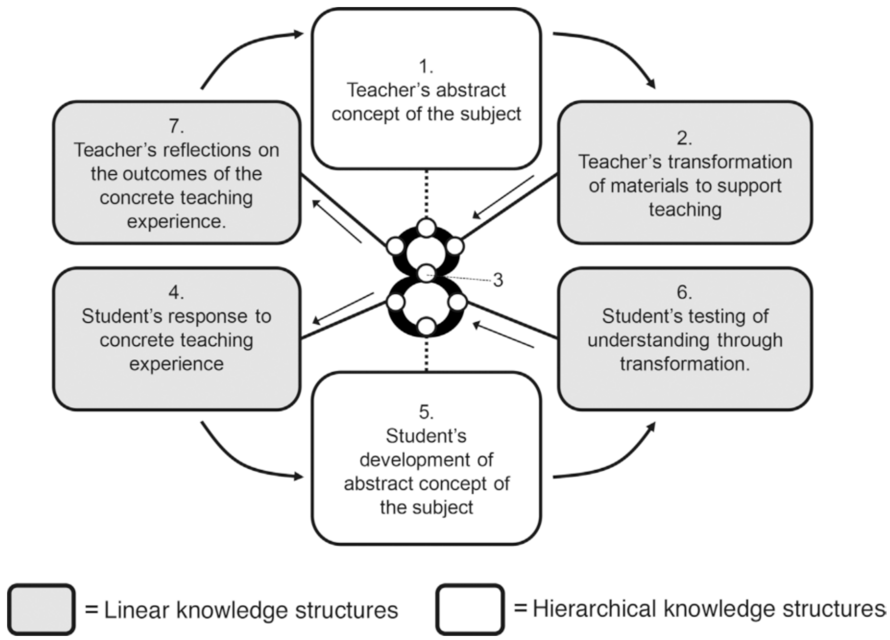

Figure 1. A double cycle in which the teacher's abstract concept of the subject and the student's abstract concept of the subject are only able to interact during teaching events (point 3) through the sharing of linear transformations of the content (From Kinchin & Miller, 2012)

The second statement, from Norman (2005: 418), refers to the significance of the transformation of knowledge structures in the development of professional expertise, whatever the discipline, '*expertise lies in the availability of multiple representations of knowledge*'. For the disciplinary expert, the translation of information from one form to another is second nature. In the clinical sciences, the professional can compare a patient's case notes with a radiograph; an environmental scientist should be able to switch between a table of data and the graphical interpretation of that data; while a stage manager will be able to relate the recorded stage directions that summarises actors' positions in a scene to the actors' movements on the theatre stage. Such multiple representations are taken for granted within many professional contexts, but may be overlooked in the classroom environment. With this in mind, many of the ideas presented in this book require the dual presentation of information in complementary graphical and textual formats, and the reader is encouraged to use both in order to develop their own personal understanding for use in their own context. The transformation of text into a diagram requires a level of understanding for the process to work. The paragraph of text in Figure 2 is summarised as a concept map with the intention that students would use the map to help navigate their way through the text and gain a greater appreciation of the links between the concepts.

The double helix structure of DNA was discovered by Watson and Crick in 1953. Each molecule consists of two strands of nucleotides that are wound round histone proteins. A nucleotide is made of phospohoric acid, a pentose sugar (deoxyribose) and an organic base. The bases are of two types, purines (Adenine and Guanine) and pyrimidines (Cytosine and Thymine). The bases form complimentary pairs (A-T & C-G) by hydrogen bonding. This maintains the molecule's double helix structure.

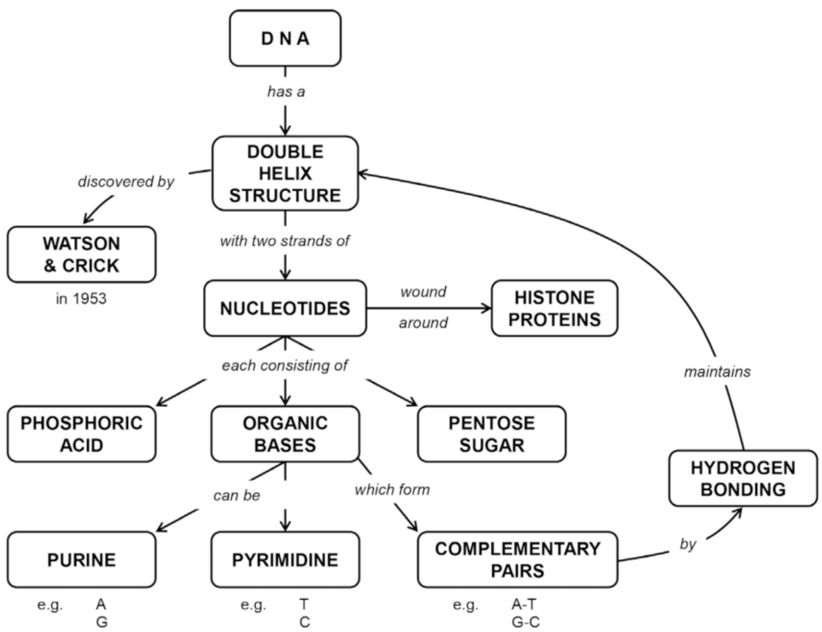

Figure 2. Comparing text about the structure of DNA with a concept map of the same content

The third statement is from Keiny's work on educational change (2002: 208) in which she offers a definition of learning that stresses key concepts of engagement, development and community: '*to learn is to participate in and contribute to the* *evolution of the communal practice*'. If learning is defined as being participatory and evolutionary within a community of practice then traditional modes of teaching-as-telling immediately become redundant. To contribute to the evolution of communal practice (including the evolution of university teaching practice) then the voices of the learners have to be heard in order to make use of prior knowledge.

A FRAMEWORK

Within this book, it is not possible to cover every potentially interesting or useful idea that may contribute to an enhanced student learning experience at university. In order to frame the scope of the discussion, and to ensure that what is discussed is connected and coherent, I offer a framework (Figure 3) against which the major ideas presented here may be evaluated and synthesised. I acknowledge it is only one route to a possible answer, and I anticipate that readers will each bring with them additional and alternative prior knowledge that will allow them to modify and personalise this route. This book offers an interrogation of the framework for the readers by analysing the concepts and the links between them. In keeping with the spirit of the book, for the reader to construct their own powerful knowledge from the information presented, they need to manipulate the knowledge structures presented (as stated within Figure 3), relate them to the structural grammar of their own discipline and apply it to their own practice. Then they will be starting to act as expert students of professional practice.

The framework in Figure 3 represents one perspective on the links between concepts at a given time and for a particular purpose. By taking a different concept as the organising principle at the top of the map (e.g. knowledge structures instead of expert student), a different set of linkages and an alternative arrangement of concepts would emerge. In contrast, if the reader choses to memorise the information summarised within this map, s/he is effectively transforming it into a linear chain in which the cognitive load (work undertaken to construct the map e.g. Sweller, 1988) has already been done by someone else.

The framework illustrates links between concepts that are explored in the following chapters. Visualisation of knowledge using concept maps is explored explicitly in Chapter 2 and underpins much of the work described in this book. Patterns of learning (networks and chains) are explored in Chapter 3 and how this relates to disciplinary structures within the curriculum is examined in Chapter 4. The key concepts of the expert student and the nature of powerful knowledge are examined in Chapter 5, whilst Chapter 6 focuses on links with contemporary educational theories (threshold concepts, semantic gravity and punctuated learning). Chapter 7 considers student feedback as part of the discourse on curriculum design and then in Chapter 8, I consider how the framework can be addressed within academic development of university teachers so that academics may support the education of expert students through the purposeful manipulation of knowledge structures.

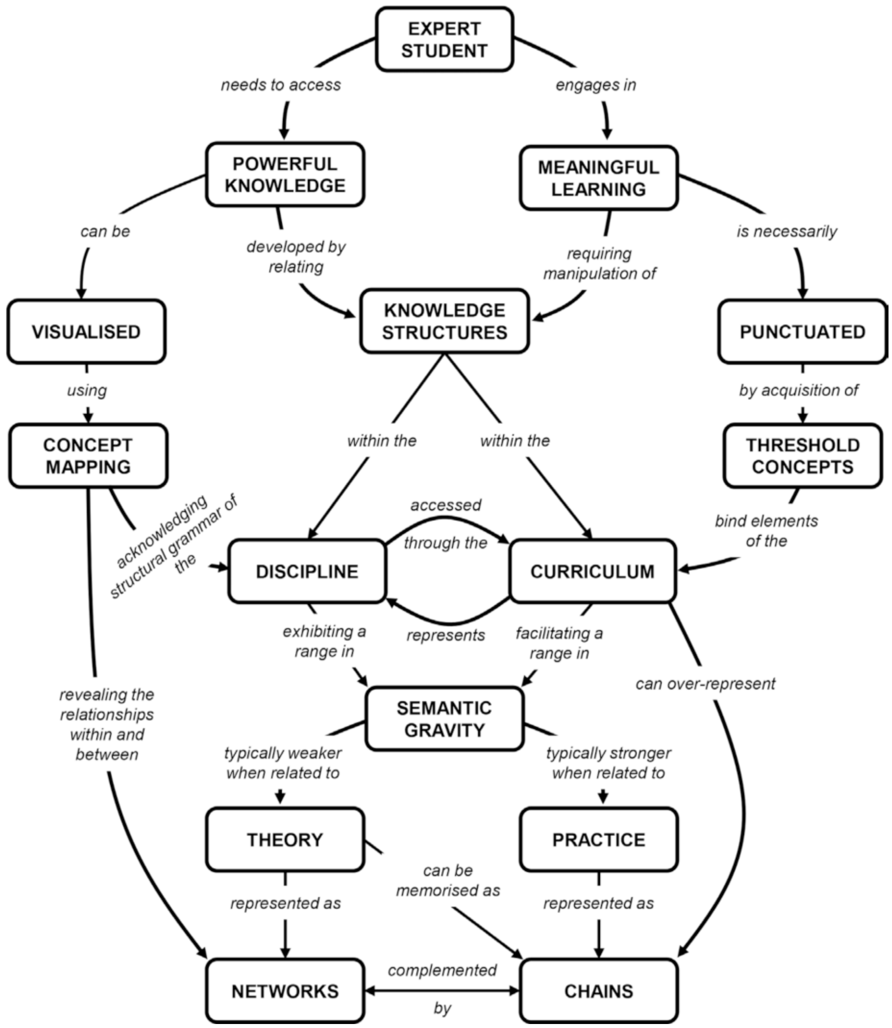

Figure 3. Possible framework for the connection of major ideas presented in this book

MOVING FROM TRANSMISSION TEACHING & ROTE LEARNING

When talking to academics who are teaching in universities, it is clear that they believe their world is not perfect. Many academics hark back to an unspecified 'golden age', when students were apparently cleverer, economics was not the driving force on campus, and professors had more time and freedom to follow their own academic pursuits. Simultaneously, other colleagues question what they see as the outmoded practices that still dominate university teaching and the stubborn adherence to medieval approaches to teaching (Bodner et al., 1997), such as lecturing, in a world that is dominated by digital media. Despite the range of contradictory views and complaints, there does seem to be agreement that academics are not happy with the *status quo* in education.

Typically however, the desire to complain is more than offset by an unwillingness to change. This became apparent when I wrote an article with colleagues a few years ago with the deliberately provocative title '*universities as centres of non-learning*' (Kinchin et al., 2008). This idea will be explored in detail later in the book, but it is summarised within Figure 3 by the link at the bottom of the map that states '*theory can be memorised as chains*'. This is the essence of the non-learning argument and has been described in various ways in the literature. One of the most evocative images referring to '*bulimic learning*' (Zorek et al., 2010). This is where students gorge on information only to regurgitate it later in undigested form in examinations, and thus purging themselves of any responsibility to actually digest and use the information profitably. I quite expected a backlash at the non-learning accusation from colleagues who might take offence at the thought that collectively we were not doing a good job. The actual response – silence. So do academics accept that non-learning is the norm and it is the only way of balancing teaching commitments with research activities? Or are they too weary to continue the fight for excellence? The arguments against 'tell-memorise-test-forget' models of teaching are not new. David and Brierley (1985: 19) commented that:

> What should be asked of the student is not that s/he learn, by heart, and in all their detail, all the facts current during his/her time as a student: that will be of little service in his/her later professional life when many of them will have changed. Of far greater importance will be a knowledge of the structure within which those facts are organized and the relationship of the facts among themselves.

One of the problems in moving from 'traditional' teaching models towards 'effective' models is perhaps the lack of accessible tools with which to support the change from the non-learning of inert knowledge to the meaningful learning of powerful knowledge. Any such tool has to be universal in application (so avoiding the 'it doesn't work like that in Physics' comments); immediately useful; contribute to teaching efficiency (i.e. not create extra work); adaptable and non-threatening. In short, it has to be embedded within the discipline so as not to be seen to be dragging academics away from their core interests. Indeed, if it can enhance activities in their core research interests, all the better. This is the 'project specification' with which I have been grappling for the past decade in academic development.

A few years ago I was mentoring a new academic on a teaching certificate course. Before I went to observe his lecture we discussed what he was going to teach. He told me that his brief was to 'cover cell biology in 45 minutes'. I looked at him quizzically and asked the rhetorical question 'is that possible?'. Unsurprisingly his response was 'no, it's impossible'. What was more surprising was that he then went on to say ‘but I have to try anyway’. From this, it seems that when pushed into a corner, very clever people engage in some very unproductive teaching practices. The inevitable outcome of such a ‘transmission teaching model’ was that the teacher ended up talking very quickly whilst projecting far too many PowerPoint slides so that the students did not really understand anything that had been said and were so bored by the process that they had little inclination to undertake the necessary further reading in order to have any appreciation of cell biology. This was a very poor use of the 45 minutes. The students didn’t gain any new understanding and, even worse, were put off from undertaking any further private study. This represents an extreme, but not unique, example. This type of teaching is still quite common. The belief remains among segments of the teaching community that the content has to ‘be covered’ – meaning that it has to be spoken to an assembly of student in a classroom. This appears to be the antithesis of problem-based learning. Rather than referring to it as ‘transmission teaching’, it is often referred to as ‘traditional teaching’, as if to confer some unjustified legitimacy to unproductive practices.

It is clear that many of the ‘givens’ within university teaching are not ‘given’ at all. The lack of dialogue within university departments about the fundamentals of teaching and learning is a cause for concern. When I talk to academics about the purpose of the lecture, I never get a unified response from the audience. Some colleagues claim that lectures are used to inspire their students, whilst others state that they are simply there to impart information to the students. It is clear that we have to work harder to develop a shared view of teaching at university. This is not about homogenizing teaching practices and making everything the same, but about having a shared and explicit set of underpinning values that inform teaching. As O’Brien (2008: 303) has put it:

> The pedagogical act of teaching remains variably interpreted and enacted within higher education despite decades of praxis. For teaching to become practice directed at both the facilitation of transformative learning, as well as the induction of students into disciplinary ways of thinking and viewing, more is required of the average academic.

THE CURRENT CONTEXT

The debate about ‘active learning’ seems to have been going on for a very long time, with an overwhelming view that ‘active’ is better than ‘passive’, and yet some colleagues still find some novelty in the discussion. Within this context, Wolff et al. (2015) have looked at techniques to foster engagement and encourage self-directed learning in the classroom. Within their paper, they offer some useful practical advice such as:

Incorporate pauses. So many sessions are stuffed full of content with no time to pause and reflect to see if students have really understood the content. Inserting a pause to allow learners to clarify points is a very simple thing to do and (importantly) has no resource implications.

Tell a story. Many colleagues have found that the story approach provides the hook that makes students listen, and provides a structure to help recall. The oral tradition has existed throughout history, but is not often reflected in our PowerPoint-filled teaching environment. These stories are particularly powerful when linked to real people and recognizable contexts to which students can relate.

Learn by doing. I am not sure if anyone would argue against this. Doing something is always more interesting than doing nothing.

Get a commitment. The use of audience response systems is a more sophisticated way of getting students to raise their hands, and can offer instant feedback about what students think about a problem, and whether or not there is a common misconception that needs to be addressed.

Draw a map. Converting text to diagram (or *vice versa*) has many benefits, and the creation of links needed within a map requires higher levels of thinking and processing. Building on the work of Mayer (2009) and Van Meter and Garner (2005), a model has been suggested by Quillin and Thomas (2015) to summarise the complex interactions between the processes of learning and drawing (Figure 4). It is important to realise here that the act of drawing may contribute to the development of mental models, and so diagrams produced by students may not always be a representation of what has been learned, but rather what is currently being learned.

The practical tips that are offered by Wolff et al. (2015) are all sensible ideas that can help to enhance the classroom environment. However, none of these is a guarantee of success and to be effective they need to be embedded within an appropriate curriculum that relates to the knowledge structure of the discipline. This structure can be made explicit using concept maps – a tool that can support the visualisation of knowledge, as explored in Chapter 2. As knowledge is continually developing, a concept map should often to be considered as a work in progress. We will see in the subsequent chapters of this book, that each of these steps (select, organize and integrate) presents the learner with particular problems to be overcome. The externalisation of ideas as a concept map allows the developing understanding to be manipulated by the learner without placing impossible demands on short-term memory, and also allows the developing understanding to be shared for peer review and evaluation.

Drawing a map of an idea is, therefore, much more than a ‘filler activity’ to keep students busy in the classroom. It can have a major impact on the quality of understanding.

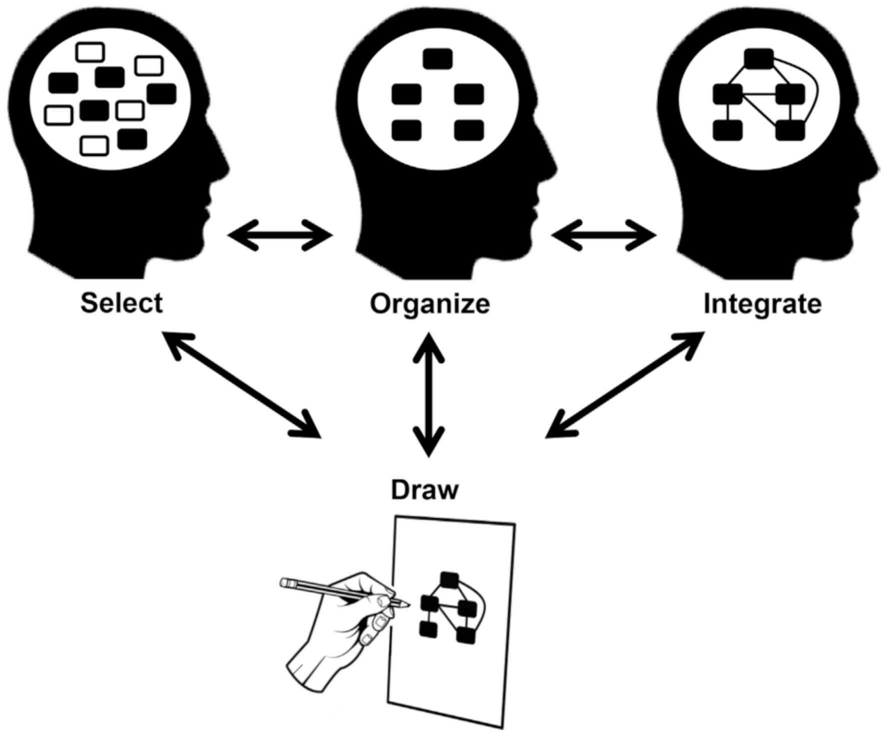

Figure 4. Visual framework for the generative theory of drawing construction (Redrawn from Quillin & Thomas, 2015)

TEACHING AS THE POOR COUSIN

I have heard comments from colleagues at universities who attempt to justify their lack of interest in teaching by explaining that they are 'serious researchers', with the assumption that research always trumps teaching. This has been termed the 'politics of reluctance' by Mills and Huber (2005). The unspoken criticism of teaching colleagues is that that they focus on teaching because they can't 'hack it as researchers'. In truth, many of the best teachers I have observed over the years have also been excellent researchers. Whilst some of those who may be struggling with the teaching are also struggling with their research, evidently the best academics excel at both activities. One such figure is Carl Wieman – a Nobel Laureate who spends considerable energy on the development of university teaching (see Mervis, 2013). Wieman asks why institutions disregard decades of research that show the superiority of student-centred, active learning over the traditional 50 minute lecture? Science is built on observation and evidence. And yet when scientists teach they can appear to ignore both. Years of observation and pages of research evidence point to particular ways of teaching as being more effective than others. Remarkably, making students sit in silence, on uncomfortable rows of seats in a cold room, and listen passively to a monologue describing research performed by others and depicted as a blizzard of bullet points, appears not to be the optimum. So why do we still observe this happening in the university of the 21st Century? How do we break the cycle of bored students and uninspired teachers? We have to think about what got the academics into teaching in the first place. Most are passionate about their own discipline, learning, researching and finding out things for themselves. So why is there a difference between teaching and research? Michael (2001: 155) comments:

> There is a remarkable difference in attitude between university staff as teachers and as researchers. As researchers we critically read the newest literature, we think of new approaches and theories, look for empirical verification and submit our work to the critique of others through rigorous peer review. The scientific attitude lies at the heart of scholarship and is accepted by everyone in the field. The situation seems quite different in education. As teachers we seem to have a different attitude. We do the things we do because that is the way it has been done for many years, even centuries. We hardly read the literature on education, or more appropriately, are not even aware that such literature exists. It is difficult to change things in education, because as teachers we are highly convinced that what we do is appropriate and any challenge to one's convictions is an actual challenge to one's personal integrity. We go into the classroom assuming that all we need bring there is our content expertise, our long years of having taught the discipline, and our dedication to doing the best job we can do. But that is not enough: we need to teach the way we do research.

A SCHOLARLY APPETITE FOR CHANGE

When university teachers are persuaded to make a change, it is usually an incremental change of a single factor in the classroom. After all, that is the way to be scientific – to change a single factor and measure the effect. But teaching cannot be changed in this way. For example, you cannot change the teaching methods and leave the assessment the same. Teaching and assessments need to be aligned. It reminds me of the joke about changing the traffic patterns in the UK to fall in line with the rest of Europe. The plan: make all the buses and lorries drive on the right side of the road this year. If it is a success, then we'll make the cars and bicycles drive on the right as well in the following year. The stupidity of this suggestion is obvious, but the pattern in educational change persists. Surely a passion for the subject should also translate into a passion for teaching the subject? As Roxå and Mårtensson (2011: 26) have commented, '*when you are interested in a subject, you simply have to teach it*.' And yet so many university teachers appear to be uninterested in talking about (even less researching) the quality of their teaching. Carl Wieman comments that '*There's an entire industry devoted to measuring how important my research is,* *with impact factors of papers and so on. Yet we don't even collect data on how I am teaching.*' (Mervis, 2013: 293). This is a strange omission in institutions that claim to be research-led.

So is there any appetite for change? Well, if we are talking about Government-imposed change on the basis of politically-motivated metrics that appear to be anything but research-informed, then probably no. But academics are by their nature enquiring and questioning, and if they can be persuaded that change can be scholarly in approach and beneficial in outcome, then I feel the response is more positive. There are clear indicators in the disciplinary literature that active pockets of innovation and research are trying to make a difference. Within the pages of many journals there are papers that are encouraging colleagues to teach more effectively (e.g. Dolan & Collins, 2015), and supporting colleagues to engage in a scholarly pursuit of teaching by offering 'how-to guides' (Rowland & Myatt, 2014) or 'high-yield bibliographies' (Kay & Kibble, 2016). These will help colleagues overcome some of the practical and linguistic barriers to engagement with discourses of teaching. The ideas presented in this book provide the basis for a toolkit that will enable academics to construct a flexible, discipline-sensitive and personal route into the scholarship of teaching whilst maintaining a focus on their home discipline.

IN CONCLUSION

When Parker Palmer talked about the 'courage to teach' (Palmer, 2010), he was correct in emphasising the difficulties faced by academics who are determined to do the best job they can and not just follow the crowd. But I appreciate that it can be difficult to raise your head above the parapet and try something different, summarised beautifully by Machiavelli (1515: 24):

> And it ought to be remembered that there is nothing more difficult to take in hand, more perilous to conduct, or more uncertain in its success, than to take the lead in the introduction of a new order of things. Because the innovator has for enemies all those who have done well under the old conditions, and lukewarm defenders in those who may do well under the new.

I hope that we have since found new ways to communicate and develop professional networks so that innovators should not have to work alone, but link with colleagues who are similarly engaged in the enhancement of teaching.

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CHAPTER 2

VISUALISING KNOWLEDGE

Applying Concept Mapping

INTRODUCTION

Very often in my classes over the years students have come to me to announce that they are 'stuck' and 'don't understand'. A conversation then takes place in which I would ask things like, 'where are you stuck?' or 'what don't you understand?'. This then presents the student with an even greater problem – to explain what they do not understand. Unless they are able to pinpoint the problem (such as 'I don't understand the word, catalyst', or 'I missed the lecture on the origins of democracy') it can be difficult for them to explain what they do not know, when they do not know it. As a teacher you then spend time trying to diagnose the source of the student's problem. The obstacle then for the teacher is to try to 'see' what the difficulty is, particularly from the student's perspective, which lacks the teacher's disciplinary overview.

Then I discovered concept mapping (Novak & Gowin, 1984). This is a tool that helps me not only to see how the student is putting ideas together (or not), but can also help the students to diagnose their own difficulties. So now instead of students saying something vague like 'I just don't get it!', they can come with more focussed questions such as 'what is the connection between heat and evaporation?'. This is something concrete and defined where I can help the student without spending so much time finding out where the problem is. So at the very least, it guides students to ask better, more focussed questions.

Concept mapping was developed by Prof. Joe Novak at Cornell University in the 1970s, drawing on Ausubel's Assimilation Theory of learning (see Ausubel (2000) for the most recent summary of this work). In a 12-year longitudinal study of conceptual change in high school students (Novak & Musonda, 1991), concept maps were used to represent students' cognitive knowledge structures by organizing concepts into propositional networks. They used this to summarise data from taped interviews in a way that allowed the researchers to observe in detail the quality of conceptual change over several years. The concept mapping tool has continued to develop (Novak & Cañas, 2006; 2007) and the application of concept mapping has subsequently been explored in a large number of studies across a range of disciplines and educational levels (e.g. Nesbit & Adesope, 2006).

So if this is now all so simple, why isn't everyone accessing student knowledge structures as a matter of course within their teaching? The difficulty many teachers have with adopting concept mapping seems to stem from years of rote-mode learning practice in their school setting (Novak & Cañas, 2007). If rote learning is the model that is followed within a classroom, then the students' prior knowledge and their developing knowledge structure are irrelevant (Figure 5). Teachers who are firmly rooted in the epistemological world view that there is a single correct answer to be acquired, memorised and reproduced will have difficulty in seeing the possible benefit of accessing students' knowledge structures through concept mapping. Some of these teachers will try concept mapping as a tool, but will often provide students with complete maps to memorize or with fill-in-the-gap mapping blanks to be completed by rote. Neither of these classroom scenarios will provide much in the way of enhancement to the quality of learning. A mechanistic approach to concept mapping will not generate the anticipated learning gains or support development of the expert student. One of the key factors that may indicate 'success' of concept mapping interventions is the enhancement of metacognitive skills (Salmon & Kelly, 2015).

The constructivist epistemology has been summarised by Novak (1993) as being based on the belief that from birth to senescence or death, individuals continually construct and reconstruct the meaning of events and objects they observe. This was developed into the human constructivist view as an attempt to integrate the psychology of human learning and the epistemology of knowledge production, which can be outlined in three key assertions: human beings are meaning-makers, the goal of education is the construction of shared meaning, and shared meanings may be facilitated by the active intervention of well-prepared teachers. Where teachers may not have had experiences within their own education that foster such a view of learning, they will need support to appreciate teaching models that stem from an epistemological standpoint that does not fit their own personal construction of learning (Cannella & Reiff, 1994). This may generate a lack of epistemological resonance between the curriculum and the concept mapping tool, and is a major barrier to the effective adoption of concept mapping as a classroom tool (Kinchin, 2001).

Figure 5 shows how epistemology is central to the application of Ausubel's Assimilation Theory of Learning (Ausubel, 2000) and the use of knowledge structures to reveal meaningful learning. In brief, on order to align the epistemology of the classroom to the human constructivist epistemology underpinning the evolution of concept mapping, it is helpful if teachers can start to envisage students as producers of knowledge (and eventually as transformers of knowledge) rather than passive consumers of information (Gamache, 2002). This constitutes part of the development of the well-prepared teacher that runs in parallel to the expert subject knowledge that teachers require.

CONSTRUCTING MAPS

There is a considerable and diverse literature on the nature of concepts, but in order to maintain consistency with the literature of concept mapping, and to provide a simple and practical way forward, I will simply follow the definition provided by Novak and Cañas (2007: 33) that a concept is '*a perceived regularity (or pattern)*

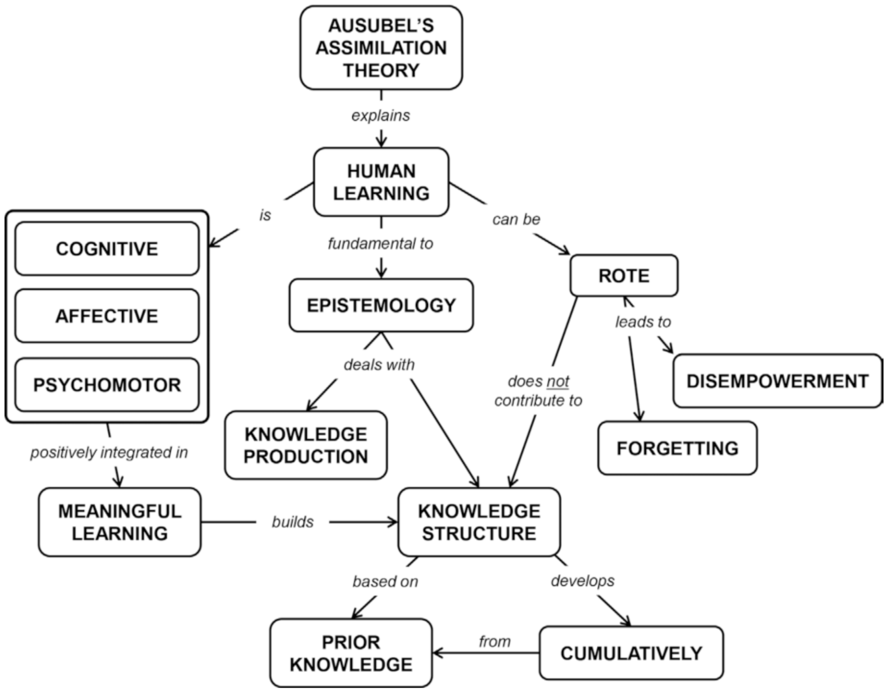

Figure 5. Relating epistemology to the development of knowledge structures (Developed from Novak, 2010)

in events or objects, or records of events or objects, designated by a label'. This provides sufficient flexibility and scope for colleagues to be able to apply this idea to their own disciplinary areas without difficulty.

In order to construct a concept map, the mapper first needs to consider the focus question that the map will address – the top concept (or root concept) to guide the construction of the rest of the map. Cañas, Novak and Reiska (2012) comment that teachers rarely spend sufficient time preparing the focus questions that are presented to students. So a map of 'British politics' will produce a particular type of map, whereas a map of 'the causes of change in British politics' will produce something a little different – and possibly more interesting.

Once the focus question is clarified, the mapper needs to consider which concepts should be included in the map. This requires a brief brain-storming session in order to create what many colleagues term 'a parking lot of concepts', from which the mapper can then select the most important for inclusion. There is usually no need to spend vast amounts of time on this process. Important concepts are usually those that spring to mind most quickly. Once concept labels are being arranged on the page, any gaps or omissions in the list of concepts will become apparent to the mapper. If not the gaps will be apparent to the teacher who will be evaluating the map, who may recognise this as a gap in the mapper's knowledge.

Once the mapper has the list of concepts to choose from they must then be arranged on the page,[1] each one written within a box,[2] in order start to create the structure of the map. Here the mapper has to choose which of the concepts are most important (these should go near the top of the map), and show the way in which items may be clustered to show the degree of relatedness. Arrows will then be drawn between the concepts to show the links that are intended. At this point, many novice mappers will think that they are almost complete. However, experience has shown that the most challenging part of map construction still remains – to formulate the linking phrases that populate the linking arrows to create propositions (concept → explanatory link → concept). These are the words that really convey the quality of meaning represented by the map. A map that lacks linking phrases conveys little or no meaning. The 'proto-map' in Figure 6 lacks any linking phrases and so the meaning of the map is ambiguous and the understanding held by the mapper is unclear. Some mappers will try to explain that 'the meaning is self-evident and does not need to be included'. This is often a claim made by senior students or even teachers who feel under pressure to reveal their thoughts and may be anxious that their ideas will be different to those held by the rest of the group. However, it is the potential variation in interpretation among the group that may foster meaningful dialogue and uncover previously hidden perceptions.

The more basic the idea, the more anxiety and reluctance to commit may be evident. For example, among a group of university lecturers, the link within the proposition STUDENTS→LECTURES will reveal considerable variation in view. Some colleagues will suggest that the arrow stands for 'must attend' whilst others might suggest, 'rarely attend'. Some colleagues will suggest 'learn in', whilst others will suggest 'are bored in'. The anxiety among mappers arises as their suggested link starts to reveal who they are and what type of lecturer they are. This level of anxiety is not so acute when students are concerned as they will consider that they are there to learn rather than to demonstrate their expertise.

The proto-map in Figure 6 is ambiguous in its current form and fails to demonstrate understanding of the topic.

The chain of propositions in Figure 6 that forms:

FOOD → BACTERIA → ACID

may elicit a variety of responses from students that reveals differing levels of understanding and misconceptions. For example, the responses below have both been offered by students of dentistry:

FOOD → provides nutrition for → BACTERIA → to create → ACID

FOOD → contains → BACTERIA → that release → ACID

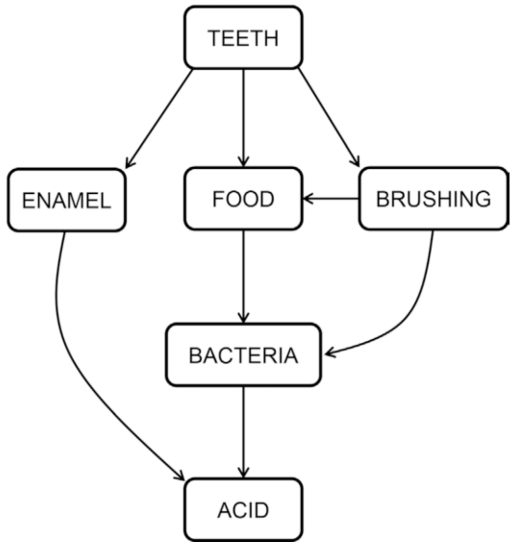

Figure 6. A ‘proto-map’ in which there are no labels linking the concepts

We can see here that the source of the bacteria and the source of the acid are not agreed upon by these students. The variety of understanding across the class would be hidden from the teacher’s view if s/he simply said to the group ‘we all know about the importance of acid on teeth and the role played by oral bacteria, don’t we?’. To which a typical round of communal nodding would suggest a single, unified understanding where none may exist. The linking phrases are, therefore, crucial to convey meaning.

CONSTRUCTING LINKS

We have seen that a lack of links fails to communicate understanding. The links and the labels placed upon them are the key factor that increases the expressive power of concept maps in comparison with other diagrammatic tools that may be employed in the classroom (Crandall, Klein, & Hoffman, 2006). The choice of linking words and phrases is therefore vital to convey the quality of understanding. Whilst a link may be correct, it may not be the ‘best’ or most instructive link. The mapper needs to think, how do the links help to move the map beyond the descriptive and towards the explanatory?

Dynamic relationships have been defined by Safayeni, Derbentseva and Cañas (2005) as those which establish implication, functional interdependence and covariation among the concepts. They are recognised within a concept map as those which imply movement, action or change. Miller and Cañas (2008) have developed this to consider dynamic propositions as either causative or non-causative. In the case of causative propositions, a relationship of cause and effect is evident. Examples of static, non-causative dynamic and causative dynamic relationships could be:

Static propositions:	The sky is blue. Practical theology includes homiletics.
Non-causative dynamic propositions:	Cars cost money. Children eat sweets.
Causative dynamic propositions (CDPs):	Economic stability attracts investment. Heat melts ice.
Quantified & qualified CDPs:	Aerated soil has a more diverse flora. Highly integrated maps suggest better understanding.

The two map fragments in Figures 7 and 8 are of about equal size and complexity, with neither offering a complete picture of the concept of animal cells. But even within these small fragments, differences in quality can be observed. The map at the top (Figure 7) lists structures found within cells and the map has very limited explanatory power. The map author is simply recalling what a cell contains. From what is presented we are unable to tell if the map author understands what the cell organelles do or indeed if there is any understanding of how these structures relate to each other. The limited understanding represented within this map is emphasised by the lack of variety used in the linking words.

In contrast, the map fragment in Figure 8 is much more dynamic. This stems in part from the author's choice of considering processes rather than structures, offering greater scope for developing linking phrases that offer greater explanatory power in the way the concepts are related, introducing ideas such as division, cleavage and movement.

As a consequence of these differences, the subsequent questions that these maps invite are also different. The teacher wishing to interrogate the understanding of the author of Figure 7 would probably have to start with questions that test factual recall: 'what is a mitochondrion?', 'what is cytoplasm?'. The map in Figure 8 invites more challenging questions: 'how do the chromosomes move?', 'what is the significance of the diploid number?'. Students need to be directed to think about the ways in which the concepts are linked and to try to go beyond the simple descriptive links to those that offer dynamism and explanation. The map is, therefore, not the end-product of learning (Wexler, 2001), but a step in the dialogue. The map needs to invite further steps to be taken and further dialogue in order to interrogate meaning.

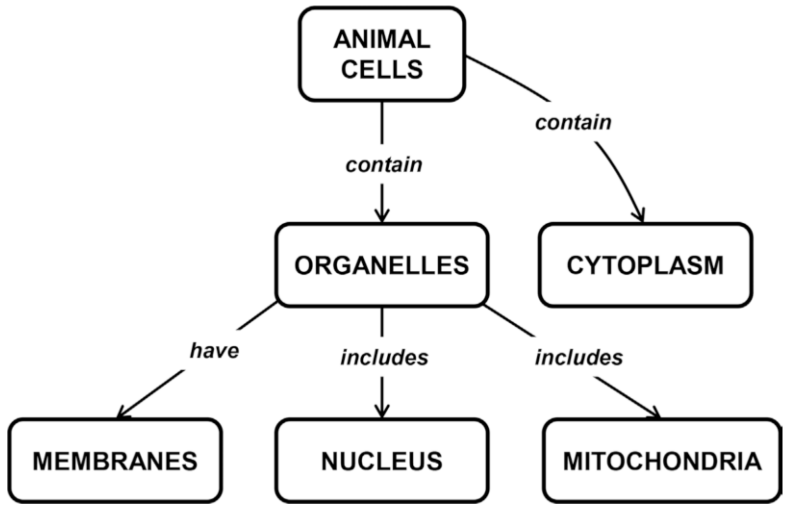

Figure 7. Student map of "Animal Cells" demonstrating passive links

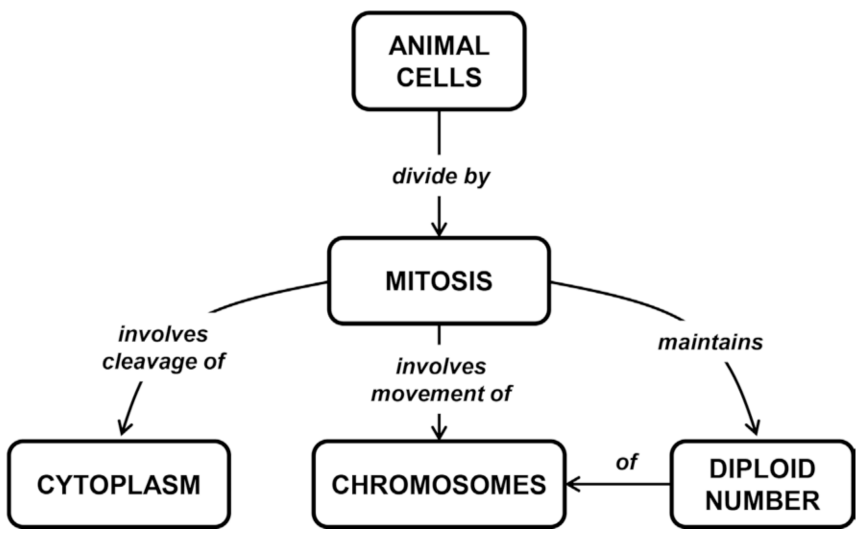

Figure 8. Student map of "Animal Cells" demonstrating active links

EXPLANATORY POWER

One of the most important questions to ask while generating a concept map concerns its explanatory power. This arises from the mixture of concept labels selected, linking phrases used and the overall morphology of the map, and is best explored through the analysis of an example. In Figure 9, the map of 'practical theology' does not seem to answer a question, except perhaps, 'what are the elements of practical theology?'. But even to this question, the map provides no explanation. The radial structure gives no hint of the ways in which the subordinate concepts might be linked, and the repetition of a single linking word (includes), indicates that this map is little more than a pictorial list of related concepts. Whilst it could be argued that there is merit in producing this map as an interim stage in the development of the student's understanding so that additional links and concepts could be added later, there is also the problem that some students (and teachers) may regard this a the finished item. The map's lack of explanatory power may then be seen as a weakness of concept mapping *per se*. This map structure is typical of those that are produced as the result of a brainstorming session (e.g. Moreira, 2012).

The map in Figure 10 is starting to develop some explanatory power to enrich ideas that are held under the umbrella term, 'practical theology'. The links are showing a degree of variation and use terms that offer insight to the quality of linkage. The two halves of the map are also integrated with a cross-link between 'theory' and 'practices'. The enhanced quality of this map over the map in Figure 9 is often generated as a result of dialogue with peers and/or personal reflection on the concepts. The development therefore takes effort and time.

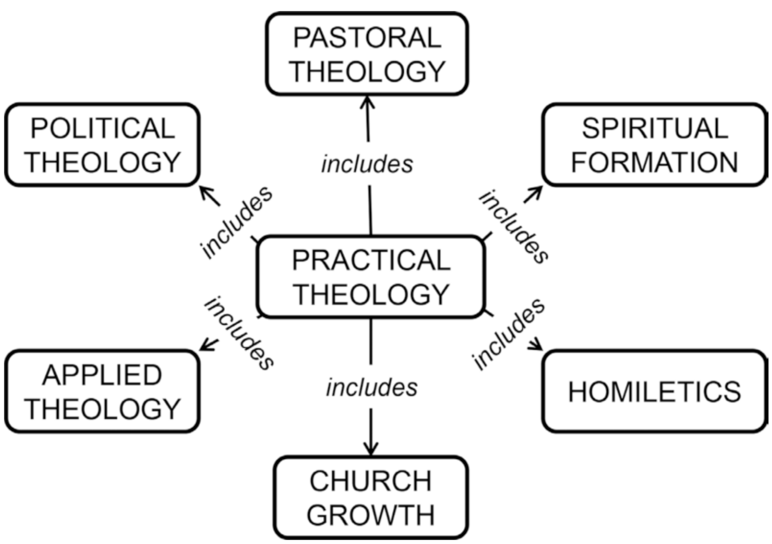

Figure 9. A student concept map of 'practical theology' demonstrating low explanatory power

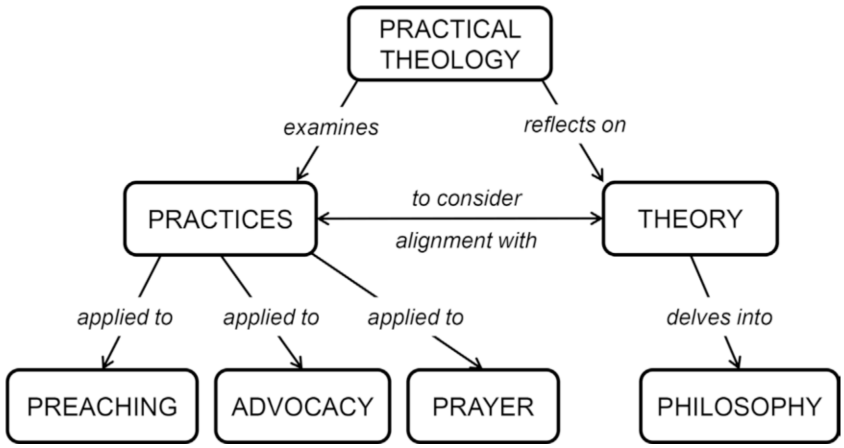

Figure 10. A student concept map of 'practical theology' demonstrating the emergence of enhanced explanatory power

INCREASING COMPLEXITY OR CLARITY

Figure 11 offers depictions of exemplar maps that may be typical of the 'good' and 'poor' maps that may be produced by students across the spectrum of examination results. Those poor maps that are associated with students with low exam marks tend to have few concepts and rudimentary links. In comparison, students who have excellent exam results can also draw poor maps as rated by various scoring protocols, but these maps tend to have concepts that represent the key ideas within a topic and are linked with phrases that reveal more about the level of student understanding and are dynamic and explanatory.

These observations suggest that concept mapping should be considered as more of a learning tool than an assessment tool – particularly where assessment requires a simple number or grade. What is clear from this is that bigger does not always mean better when evaluating concept maps. An economical presentation of data may indicate a greater level of expertise and may provide enough of a trigger for a student to recall the detail of the information. Clearly we need to adopt a more nuanced appreciation of the quality of student understanding. Students with little understanding can produce a map, but it may not be elegant or sophisticated. Cañas et al. (2015) consider maps according to levels of concept quality (Figure 12).

Concept maps that exhibit either poor quality of content or poor structure are designated as Level 1 maps (Figure 12). Those that do not fall below 'good' in either dimension would be designated as 'good maps', whilst those that exhibit excellent content and structure may be considered to be 'excellent maps'. According

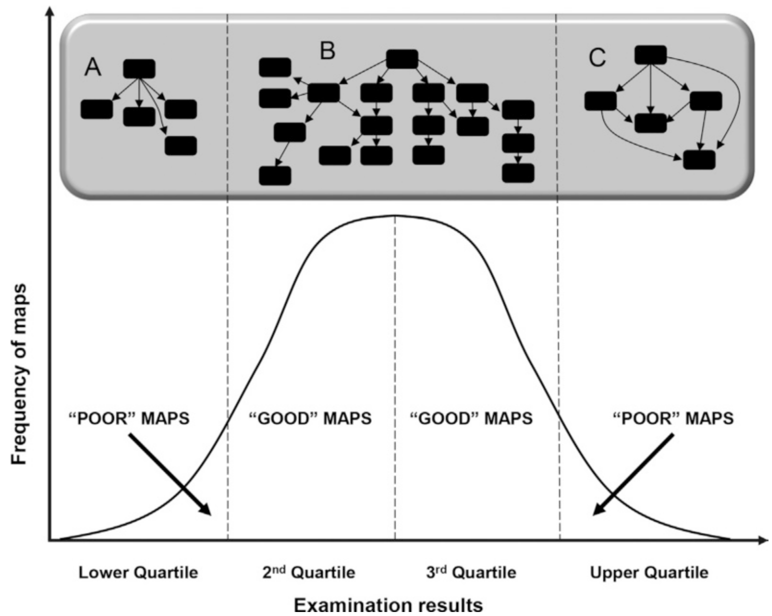

Figure 11. Distribution of maps across final exam results with exemplar map morphologies inset (From Kinchin, 2014; redrawn and modified from Johnstone & Otis, 2006)

to Cañas et al. (2015), for maps to be considered excellent they should also exhibit additional qualities:

Excellent maps are concise: just like an essay that rambles on and on about things that are beyond the scope of the title, a map that just includes everything that might be vaguely associated with the focus question is not helpful. Finding enough information is not always the criterion by which excellence is judged – deciding which information to exclude is just as important. Clariana and Taricani (2010) have commented that students who may include a lot of correct information in their maps may not always include the most important terms or place them in the most appropriate position in the map. So in order for excellent maps to be concise, the mapper has to evaluate the information to decide on it inclusion or exclusion. It is essential to make clear the teacher expectations of the outcomes of a mapping exercise to students. If students think that the goal is to include every possible piece of related information in their map, they will be overwhelmed by the volume of potential content and be deterred from further exploring the potential of concept mapping to support their learning (Bentley, Kennedy, & Semsar, 2011).

Excellent maps exhibit clarity: The purpose of a map is to convey an idea. If the ideas are so cluttered and congested that they become lost in the crowd, the message is lost. The map needs to present the author's message clearly in order to

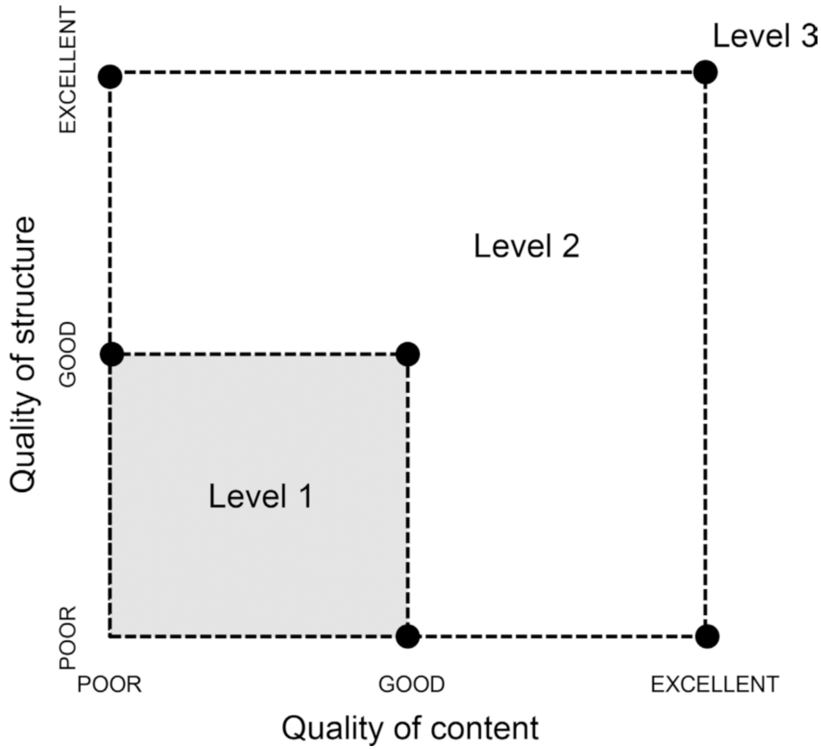

Figure 12. Levels of concept map quality (After Cañas, Novak, & Reiska, 2015)

communicate it well to the reader. This means that concepts should be clustered appropriately to avoid the linking arrows from crossing over each other.

Excellent maps are explanatory: If the map is purely descriptive then it does not provide any explanatory power. Maps that are pictorial representations of lists can fail to demonstrate any deep understanding. Whilst 'elegance' may appear to be a rather spurious and indefinable aim for a mapping exercise, it is evident when observing large numbers of maps that elegance of design often accompanies clarity of expression.

Excellent maps are balanced: Maps that exhibit branches that are of wildly unequal sizes are probably reflecting the bias or selective knowledge of the author. Unless there is good reason to produce an unbalanced map, selection of the higher order concepts should successfully produce a balanced map. The suggestion is that an unbalanced map either shows incomplete knowledge of a subject, or results from the selection of inappropriate higher concepts and should be reconsidered.

Excellent maps are appropriate for the intended audience: If the map is intended for a general audience, then use of highly specialised technical terminology is probably not helpful in terms of clarity or explanatory power. Alternatively, a very specialist audience would be put off by a map that uses colloquialisms.

Thus we can see that the exemplar map morphologies, A, B & C (included in Figure 11) can be mapped against the three levels considered by Cañas, Novak and Reiska (2015). The 'poor' maps in the lower quartile (A) tend to have a very simple structure and the number of concepts is small so unless they have been carefully chosen and linked with particularly good explanatory labels these are likely to be poor maps. The maps in the 2nd and 3rd quartiles (B) are those that have typically been labelled as 'good' maps. But these are rarely excellent maps as they often fall down in not being concise, clear or explanatory. Very often these are 'exploratory' rather than explanatory. In the literature, these maps typically gain high scores that reward the quantity of knowledge through the acquisition of information (demonstrating a good memory) rather than the quality of understanding that may demonstrate the ability to manipulate and transform information. Those maps in the upper quartile (C) have often been 'measured' as being 'poor' maps as they do not score highly in many of the quantitative rubrics. However, depending on the content and the nature of the links, these may be excellent maps if they conform to the dimensions discussed above.

Approaches that give the mapper maximum freedom in terms of content and structure are most likely to offer the greatest learning potential (Cañas, Novak, & Reiska, 2012). However, they will also produce the greatest diversity of maps within a class and will create work for the teacher/researcher if they need to be analysed and evaluated. Attempts to standardize maps by restricting the choice of concept labels to be used, or by providing a skeletal framework for the map construction will reduce the degree of diversity. This will make analysis easier, but may reduce the richness of the data and may reduce the maps' potential for supporting learning. There is therefore a tension between using concept maps as a research tool (where the focus is on analysis) and as a teaching tool (where the focus is on reflection). One of the problems encountered in mapping interventions is that mappers will not always conform to the 'accepted structural grammar' of Novakian concept maps (Novak, 2010) and will devise their own tacit rules of construction so that (for example) the major concept or focus question may not appear at the top of the page; concept labels may appear twice in a map or hierarchy may be ignored or ambiguous.

MAP TOPOGRAPHY

Comparison of map morphology is made difficult when difference is a result of variation in the instructions given to mappers. This is not just a question of aesthetics, the morphology of a student's map can be as important an indicator of their understanding as the content they have included or omitted. Methods to help in the analysis of map structure are therefore an important aspect of the value of maps in determining student understanding.

The difficulty in comparing maps that exhibit such diversity has been addressed by Buhmann and Kingsbury (2015) who have devised a method that considers map topography. They first re-draw the maps as 'content-free' skeletons by removing the concept labels and the linking phrases. The structure is then geometrically rearranged in a process they refer to as 'topological normalisation'. Within the process, the key concept (indicated as a square box) is placed clearly at the top of the map and the other concepts (indicated as round boxes) are arranged on levels that correspond to their distance from the key concept (see Figure 13). The transformation of maps in this way reveals the problems that some of the qualitative protocols have in identifying hierarchy and cross linkages. Within Figure 13 (i), it can be seen that the link between concepts 1–4 and between 1–3 appear to be cross linkages. This is clearly not the case in the normalised map in Figure 13 (ii), in which only the link between concepts 4–9 is seen as a cross link.

This topological normalisation procedure transforms the content-free concept map into a form which preserves the concept vertices and their links. By following a consistent and simple protocol, the ability to compare diverse presentation styles is enhanced. Buhmann and Kingsbury (2015) place the key concept at the top of the page, and concepts which are once, twice etc. removed from it are placed on subsequent hierarchical levels and linked as in their original form. Starting from the top, branches emerging from each concept vertex are ordered from left to right according to the following simple rules:

1. Place the deepest (longest) branch first.
2. For branches of equal length, place the branch with the largest total number of concepts first.
3. For branches with an equal number of concepts, place the branch with the largest number of longest sub-branches first.
4. For branches with an equal numbers of such sub-branches, place the branch whose uppermost concept has the largest number of sub-branches first.
5. For branches with equal numbers of sub-branches of the uppermost concept, place the branch with the largest number of cross-links first.

Where maps are not normalised in the manner suggested, and main concepts are allowed to be drawn centrally rather than above subordinate concepts (e.g. Mendonça & Silveira, 2016), it is not clear if the idiosyncrasies observed are representative of differences in understanding of the concepts, or just idiosyncrasies in the application of a visual grammar. In such instances it is difficult to visualise trends in developing understanding. Buhmann and Kingsbury (2015) claim that normalisation lays the foundation for the analysis of map morphologies which is not based on the mappers' idiosyncrasies. Through this process they have identified a number of common map types (Figure 14):

i. *Broad*: multiple branches from the key concept with little cross linking.
ii. *Deep*: multiple chains emanating from the key concept.

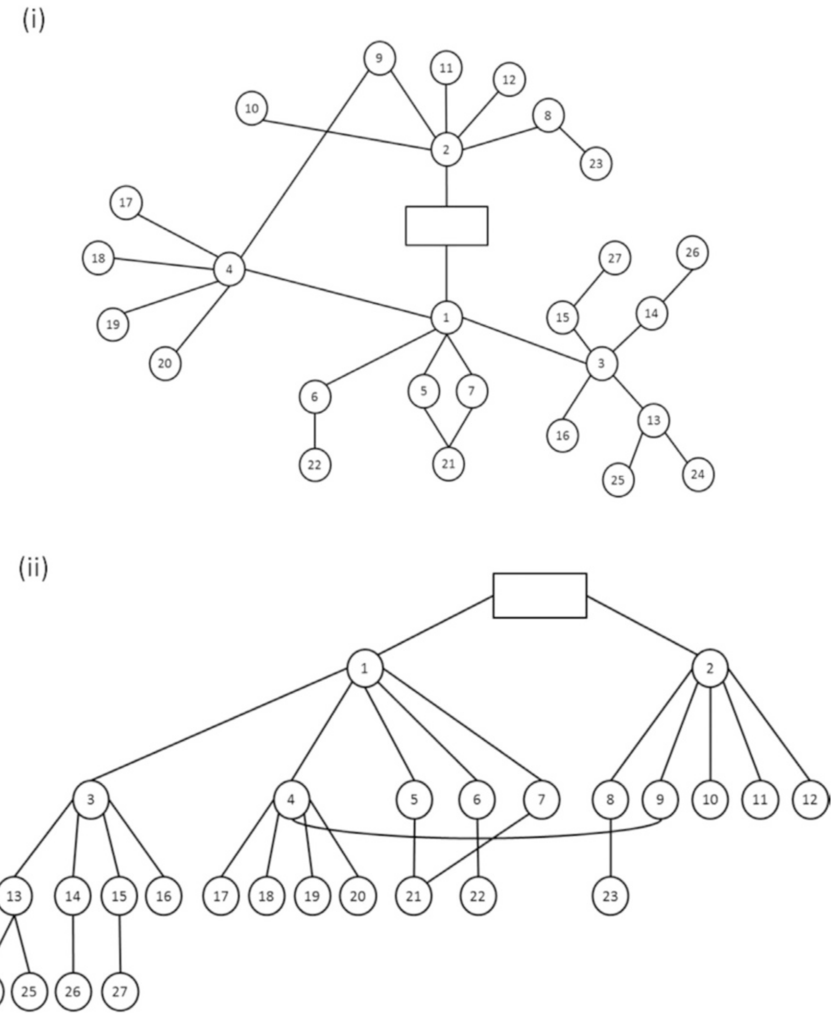

Figure 13. Geometrical rearrangement of content-free maps. (i) Content-free concept map with the concepts numbered to illustrate their repositioning in (ii) the topologically normalised version (From Buhmann & Kingsbury, 2015)

iii. *Imbalanced*: some chains are much more developed than others.
iv. *Disconnected*: segments have no link to the key concept.
v. *Interconnected*: forming an often messy network
vi. *Normal*: balanced structure that is well-connected; not dominated by multiple branches or multiple chains and features only significant cross links that do not obscure the overall structure.

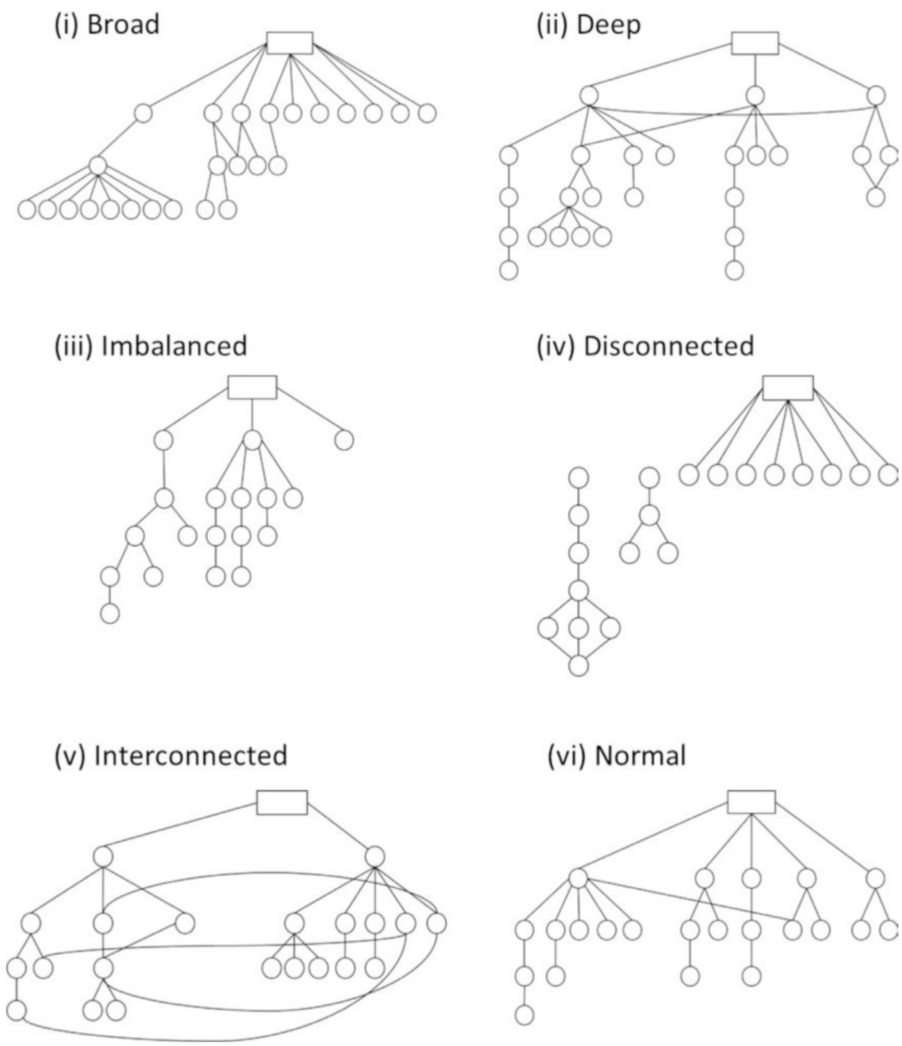

Figure 14. Example student concept maps illustrating common morphological classes in topologically normalised concept maps (From Buhmann & Kingsbury, 2015)

It is probably among these 'normal' maps that Cañas, Novak and Reiska (2015) would be looking for those that feature characteristics of excellence.

CONSISTENCY IN MAPPING

It is not just the learners/mappers who will apply arbitrary rules to their maps. In many of the research reports that are available in the literature, one finds comments where authors have tried to explain their research approach, but which are unjustifiable in educational terms. For example, Schmid and Telaro (1990: 80) explain how in the classes they were studying the '*instructor introduced content in the normal fashion [mainly lecturing] and, at the appropriate point, set aside time for each student to create a map of the specified content*.' The evident conflict between the traditional transmissive teaching model exemplified by lectures, and the constructivist basis of concept mapping is not recognised within this report. This is typical of many interventions that have attempted to stimulate classroom change through the implementation of concept mapping without due consideration of the environment where the intervention is being introduced. Similarly, Lehman, Carter and Kahle (1985: 669) describe how researchers have attempted to isolate or bracket out key factors in the classroom, such as the role of the teacher which they considered not to be '*significant influences*' in their study. More rigorous observations have shown teachers to be one of the strongest influences in the classroom (e.g. Reiss, 2000). Researchers are now recognising the intricacies of the classroom such that they cannot be seen as laboratories where all the variables can be controlled, but are more like ecological fieldwork in which the complexity can only be modelled, not controlled.

In order to avoid some of the weaknesses within the literature, the following recommendations are offered by Kinchin (2014) to guide the consistent development of future concept mapping interventions:

- Concept mapping should be used in compatible curriculum settings that reflect the constructivist underpinnings of the tool. It is important that the concept mapping tool is epistemologically aligned with the context in which it is set. If the teaching and the assessment regimes within a curriculum are intent on transmitting fixed information from teacher to student, then the potential utility of concept mapping is lessened. There must be room in the curriculum for students to visualise personal understanding if the tool is to be helpful. Concept mapping should be used where assessment regimes are focussed on meaningful learning and not memorization and recall.
- Concept mapping should be used as a learning tool, 'directing' the search for information, not 'ending' it (Wexler, 2001). If the expert concept map represents the answer to be memorised by students then the curriculum intent is non-learning (Kinchin, Lygo-Baker, & Hay, 2008) rather than meaningful learning (Novak, 2010). Possible pathways to meaningful learning must be recognised if concept mapping is to play an active part in the students' development.
- Teachers/researchers should have clear instructional objectives for the use of concept mapping that need to be conveyed to students. It is not helpful to students to simply deposit concept mapping as an activity within the teaching scheme unless there is a clear aim in doing so. Teachers need to be clear regarding what the benefits of a concept mapping activity might be, and should share this with their students.

- The degree of freedom afforded students in a concept mapping intervention should be justified and explicit. Students may be presented with a blank sheet of paper or with a list of concepts to link. Either approach has validity, depending what it is that the teacher is hoping to achieve (Cañas, Novak, & Reiska, 2012).
- The structural grammar used within a concept mapping intervention should be representative of the discipline. It is only sensible to insist that students construct hierarchical concept maps if the structure of the discipline being mapped is indeed hierarchical. It is, therefore, important to determine the structure of the discipline before asking students to map it (Kinchin, 2011; Donald, 2002). It should also be noted that a single map may not be adequate in representing the structure of applied sciences, and that sequential mapping over time may be required to observe changes in understanding (Kharatmal & Nagarjuna, 2013; Kinchin, 2013; Wu & Wang, 2012).
- Concept mapping should be combined with other learning strategies such as retrieval practices, collaborative learning, dialogue, and feedback. Concept mapping is most effective as a learning tool when combined with complementary activities to enhance the learning environment (e.g. Francisco et al., 1998). Students' interactions with concept mapping will be personal and idiosyncratic, with some students requiring more scaffolding and supplementary learning tools than others in order to gain the most from concept mapping activities.

IN CONCLUSION

The aim of producing excellent concept maps is not an exercise in academic vanity. Indeed, the production of a beautiful final map is usually not be the point of the mapping exercise as it is really the cognitive engagement with the concepts, i.e. a significant educational experience (as described by Hinchliffe, 2011) rather than an artefact of assessment that is more important. This is why many colleagues refer to 'concept mapping' as a process rather than 'concept maps' as outcomes. However, after expending considerable effort of their maps, many students and teachers are keen to keep them, and (in fairness) they may offer a future focus for further reflection. Excellent maps, as determined by the various dimensions explored above, will provide greater utility in supporting development of the teaching environment in which the expert student can develop. The use of poor maps that lack explanatory power is not helpful in developing the expert student and so it is important to clarify the characteristics that define excellent maps before colleagues investigate their use in inappropriate ways and then complain that concept maps are not helpful. There is some conceptual slippage in the published literature in which the term 'concept map' has been used too loosely and without the adequate theoretical context provided by the work of Ausubel (2000) or Novak (2010).

We will still find papers in which the authors do not adequately distinguish between concept maps and mind maps (e.g. Pudelko et al., 2012), tools which have different properties and different uses (Eppler, 2006; Davis, 2011). Research papers that use poor concept maps as exemplars suggest teaching that can at best support rote learning rather than meaningful learning because they lack key information such as linking phrases (e.g. Trelease, 2014), or they attempt to be too comprehensive and lose clarity because they are not sufficiently concise (e.g. Berglund, 2015). It is important to be precise and consistent with the use of terms if we are to develop a shared understanding of the significance of any tool in the visualisation of knowledge structures for the development of expert students. Finally, mappers need to appreciate that selecting content to be mapped and placing the nodes on the page is just the first stage in producing an excellent concept map. Counting concepts is not a good indicator of understanding. It should be the relations and interactions between ideas that serve as the unit of analysis when assessing student understanding (Semetsky, 2008).

NOTES

1. The term 'page' is used to refer to the area in which a concept map is constructed. However, it is acknowledged that for colleagues who are constructing their concept maps using software such as cmap tools, the term 'screen' may be more appropriate.
2. The term 'box' is used to describe the areas within a concept map that form the nodes on the map. For those colleagues who are using sticky Post-it notes to construct their maps, each box will be equivalent to a single Post-it note.

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CHAPTER 3

PATTERNS OF LEARNING

Spokes, Chains, Nets and Disciplines

INTRODUCTION

Curriculum design that focuses heavily on learning outcomes (see for example, Hussey & Smith, 2008) does not necessarily provide sufficient focus on the learning trajectories used by students to achieve the outcomes. Therefore, some students may arrive at a given outcome via a direct route whilst others may have taken a more circuitous journey to arrive at the same place. If we are unaware of the learning journeys that students have taken to arrive at the end point, we are not in a position to help those who fail to achieve the desired outcomes (or those who achieve unintended learning outcomes) as we do not know where or how their learning journeys deviated from the anticipated route. It is clear that student experiences of learning and understanding can vary in qualitatively different ways at various stages of a programme, and indeed students' intention to understand may also vary during a course, influenced by the ways in which the subject is represented (Weurlander et al., 2014). Quality is therefore something that we need to consider in detail when plotting learners' trajectories towards expertise.

LEARNING QUALITY

Not all learning is the same. Many of the things that students may have learnt at school years ago will have been forgotten by the time they are undergraduates. Other things are never forgotten. So what makes some things more memorable than others? Part of the answer lies in novelty and impact of the experience. Other aspects of learning are concerned with how often it is repeated. We must also consider how things were learnt in the first place. The most commonly used short-hand description of how learning quality is achieved is through the descriptions of 'deep' and 'surface' approaches, by Marton and Säljö (1976). A surface approach to learning has been condemned by Schmeck (1988: 321) as it leads to:

> a learning outcome that is essentially a literal reproduction of the words of textbook authors or instructors. Furthermore, the surface approach does not include perception of the holistic structure of information, but instead atomizes it into disconnected bits and pieces that are memorized through repetition.

> Thus, individuals taking a surface approach are likely to have a quantitative conception of the process. If the outcome is organized at all, it is merely a stringing together of memorized bits and pieces of information.

Whilst the consideration of these two approaches to learning as a simple oppositional binary may be over simplistic (Beattie, Collins, & McInnes, 1997; Howie & Bagnall, 2013, 2015), it none-the-less provides a useful starting point for the examination of learning quality and for the teaching activities to which they relate. They can also be linked to student attitudes and teacher motivations – summarized in Table 1.

Table 1. Characteristics of deep and surface learning approaches

Deep learning	*Surface learning*
Linking new information with prior knowledge.	Acquiring new information as isolated items.
Active engagement with content.	Passive absorption of content.
Linking course content to practical context.	Seeing course content only as preparation for the examination.
Having intrinsic curiosity about the subject.	Requiring extrinsic motivators such as acquisition of diploma.
Positive attitude to learning.	Negative or cynical attitude to learning.
Emphasis on understanding.	Emphasis on coverage of content.
Gives rise to networked knowledge Structures.	Gives rise to linear knowledge structures.

OPPOSITIONAL BINARIES

The simplicity of the 'deep-surface' idea often resonates with new academics' perceptions of teaching. However, Tormey (2014: 8) has warned that '*a framework that is simple enough to be a powerful metaphor may be too simple to adequately account for learning in different contexts*', and that its blind acceptance by new entrants to the profession has '*imposed blinkers that make useful alternative conceptualisations invisible*'. Even within the apparent simplicity of the deep-surface idea, it is helpful to visualise what this means in terms of possible variability in the students' developing knowledge structures. Shambaugh (1995: 8) describes the classroom use of a range of visual tools to provide a mechanism to aid the construction of understanding and states:

> This approach adopts the belief that true knowledge and understanding can be developed in the learner and by the learner through the transformation of fragmented, compartmentalised bits of knowledge into knowledge of personalised meanings.

Another oppositional binary that is commonly presented to novice university teachers refers to the extremes on the learning styles continuum. The most widely recognised and accepted dimension of learning style is described as holist (=wholist) → serialist (=analyst) (reviewed by Adey et al., 1999). Holists like to get an overview of what is to be learned and to reach a conclusion based on the 'big picture' whilst serialists tend to look at the details, bit by bit. Huai (1997) suggests that for 'holists', who have a 'global approach', visualisation of patterns of understanding using concept mapping can help the learner to focus on critical details, whereas, 'serialists' can be stimulated to take a wider perspective. Like the deep-surface binary, the holist-serialist dichotomy covers a diversity of perspectives, details of which can be analysed using concept mapping. Concept maps provide an indicator of a student's learning approach for a given context. Rayner and Riding (1997: 21) have speculated that:

> The idea that 'style awareness' may help reach the 'hard to teach', and perhaps contribute to reducing failure generally by enhancing the learning process, is an elusive but tantalising prospect which clearly merits further attention.

Styles can be linked to tendencies to develop particular knowledge structures that are identifiable at the extremes where serialists tend towards chains and holists tend towards the formation of networks (Kinchin, 2011). Students who gain most from concept mapping may be those identified by Silverman (1989) as 'visual-spatial learners', who excel when provided with visual representations. Such students reject rote memorisation and have a need to see how the parts relate to the whole before they can make sense of isolated ideas.

Like all teaching tools, concept mapping is not a panacea; it will not suit all learners or all learning situations. However, concept mapping may encourage teachers to question their teaching and to reflect upon their students' learning. This in itself may provide long term benefits to their classroom environment by encouraging in them development of the characteristics of learner empowerment as discussed by Cannella and Reiff (1994); these are inquisitiveness, enthusiasm, reflection and autonomy. The knowledge structures approach shows that whilst oppositional binaries might be a useful shorthand to describe the range of learning patterns that may be observed within the student population, in reality the patterns of learning exhibited by individuals are much more complex, and often messy, and may include elements of deep and surface learning within the same subject (Hay, 2007). Typical assessments of learning often only reveal the measurable outcomes of study, but do not tell the whole story, rarely offering insight to the pathways students have taken to reach an assessed 'end-point'.

LEARNING AND CHANGE

One of the most frequently cited papers within the literature on conceptual change is the influential work by Posner et al. (1982); providing a model of conceptual change. In this there is an implication that students' naïve conceptions need to be exchanged for the accepted conceptions. For this to occur, Posner et al. (1982) identified four prerequisite conditions: there must be dissatisfaction with currently held conceptions and that any new conception must be intelligible, initially plausible and fruitful. In a later revision of this model, Strike and Posner (1992) accept that the interaction of prior conceptions and new conceptions was not sufficiently acknowledged and that their initial theory had placed too much emphasis on the rational and neglected affective and social issues. Their initial model has been strengthened by the inclusion of Toulmin's (1972) idea of a conceptual ecology (Strike & Posner, 1992). A conceptual ecology includes the learner's epistemological commitments, metaphors, analogies, beliefs, competing conceptions and knowledge from outside the field – all of which influence conceptual change. Possible application of this notion to the work presented here is described below.

Within higher education it is widely perceived that prior knowledge is a key factor that influences learning, as summarized by Clifton and Slowiaczek (1981: 142): '*Our ability to understand and remember new information critically depends upon what we already know and how our knowledge is organised*'. Within a student's conceptual ecology, s/he is able to hold conflicting conceptions simultaneously (ie. a misconception and an acceptable conception). These may well have points of overlap, or '*… common elements that are simultaneously embedded in and serve as activation links between and among related communities of concepts*' (Jones et al., 2000: 141). The student can then choose between them depending upon the context by using an 'if…then…' type of reasoning that links the two. This has been described as '*opportunistic differentiation among contexts of interpretation*' by Caravita and Halldén (1994: 89). Within a given topic area, there may be two (or more) competing frameworks, many of which are described in the literature (e.g. Driver et al., 1994). An 'alternative framework' may represent the dominant viewpoint among students in a class, particularly if they share formative out-of-school experiences or cultural traditions that help to reinforce it. Examples of alternative frameworks are given in Table 2.

Concept mapping can reveal the structure of the conceptual framework in which a particular conception is embedded, with some structures appearing to be more receptive to change than others. Such change that is recorded may, however, be an artefact resulting from a restricted focus of the observations made. Students may be simply 'switching' from one framework to another in response to contextual cues, but the individual frameworks may remain unchanged (Figure 15) Correct answers given might, therefore, not be an indicator of conceptual development, but rather of appropriate contextual switching. This switching may be reversed if original cues are restored, giving the illusion of 'conceptual decay' in which understanding is observed to revert to previously held conceptions. Both 'change' and 'switching' can be considered as meaningful learning, depending upon the context. As Lemke (1990: 187) has asserted, '*Making meaning is the process of connecting things to contexts.*'

Whilst contextual switching does not indicate any change in knowledge structures, the ability to recognise the appropriateness of different frameworks in different contexts may be seen as a development in practice. For example, the language used within a group of paediatric clinicians may be more technically accurate than that used with a child, but may be contextually inappropriate to use with a young patient. Naïve views have practical utility in certain social contexts so that it is difficult (and perhaps even unhelpful) for them to be eradicated. Their use of everyday language and expressions can ease communication in situations where precise or technical jargon is not helpful or appropriate.

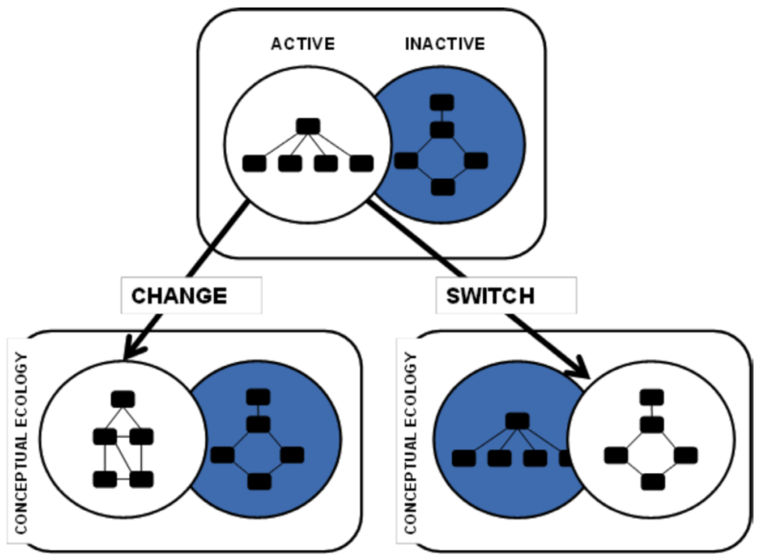

Figure 15. Maintenance of two conflicting conceptual frameworks is shown. Where the active framework develops in structure this would be conceptual change. Where the movement is from one framework to another (the inactive becoming active) without any parallel development, this would be contextual switching. (Redrawn from Kinchin, 2000)

Table 2. Naïve and accepted world views

Naïve	*Accepted*
A geocentric world view.	A heliocentric world view.
Plants require feeding.	Plants make food by photosynthesis.
Christmas presents are made by Santa's elves in a workshop at the North Pole.	Christmas presents are made in an electronics factory in China.

SPOKES, CHAINS & NETS

After examining a large number of concept maps produced by students and teachers, I have shown that their structures can be broadly described as either *spokes* (where all subordinate concepts link directly to the key idea, but not to each other); *chains* (where the concepts are arranged in a linear sequence); and *nets* (where multiple links exist between concepts at all levels in the map) (Kinchin, Hay, & Adams, 2000). Examples of these are shown in Figure 16 that give an indication of the variation in perspectives that can be offered of the same content when mapped in different ways. The spoke structure indicates only some of the concepts that are linked to the central idea, and uses repetitive linking words that add little to understanding the nature of the link. The chain structure provides a succinct summary that can be memorised for later recall, but only offers a limited perspective and shows little progression from the spoke. The network structure indicates how the important concepts are linked and uses linking words and phrases that enhance the explanatory power of the map.

The relationship between the morphological types of concept map are summarised in Figure 17. The map may be read vertically or horizontally. The vertical dimension explains the characteristics and roles of each of the knowledge structures. The spoke indicates a learning-ready novice, i.e. someone who can acquire new information for later integration without the need for radical restructuring of existing understanding (Hay & Kinchin, 2006). Unfortunately, many students embark upon their undergraduate studies with firmly established chains of understanding that are incomplete or inappropriate for their new context. Chains are resistant to development, and so students who develop chain-like knowledge structures are faced with the dilemma of either trying to abandon their prior knowledge, or rote-learning the new material as an adjunct to their existing knowledge. Therefore a promotion of initial spoke structures may be a good starting point for many bridging courses or induction programmes.

The chain of appropriate understanding is indicative of our strategically successful learners (students and lecturers). These chains are exemplified by the student who learns comprehensive lists of facts for each topic, and by those students who are well rehearsed in practical activities in such a manner that they know ‘how’ but do not understand ‘why’. Such goal-orientation enables these learners to select the essential information from that which is available, whilst selectively ignoring the rest. This may be seen by some as an efficient way of studying, whilst others could interpret this as a blinkered view of higher education.

There is certainly a tension created within the university environment by attitudes towards this kind of strategic approach that may reflect disciplinary differences. For example, in the clinical teaching environment, the development of chains of practice is seen as one of the key aims (e.g. de Cossart & Fish, 2005), with the underlying network of understanding left deliberately obscure to the observer (Katz, 1988).

The demonstration of highly developed and integrated nets of understanding may be seen as the hallmark of an academic’s expert understanding (Bradley,

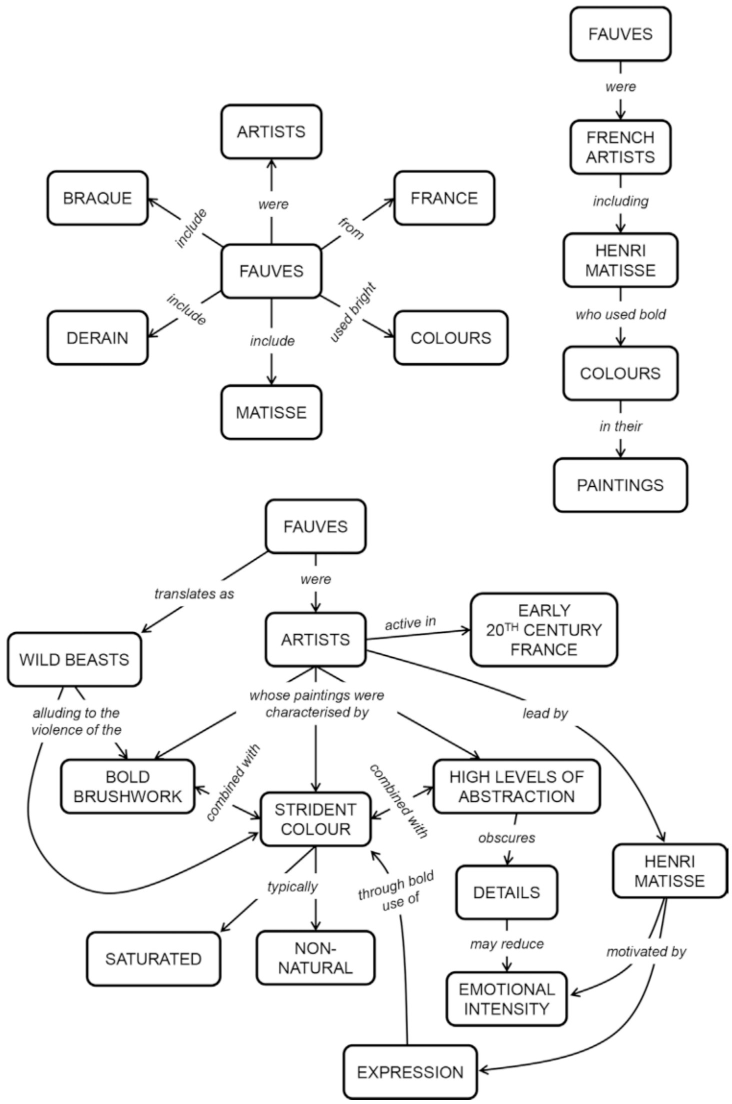

Figure 16. Different levels of understanding of the same content exemplified by a spoke, chain and network structure

Paul, & Seeman, 2006), for whom the demonstration of expertise is achieved by the accommodation of competing chains of understanding and the selection of appropriate chains to suit particular contexts (e.g. Schmidt, Norman, & Boshuizen, 1990). A particular chain of practice from an array held by the expert may be appropriate for

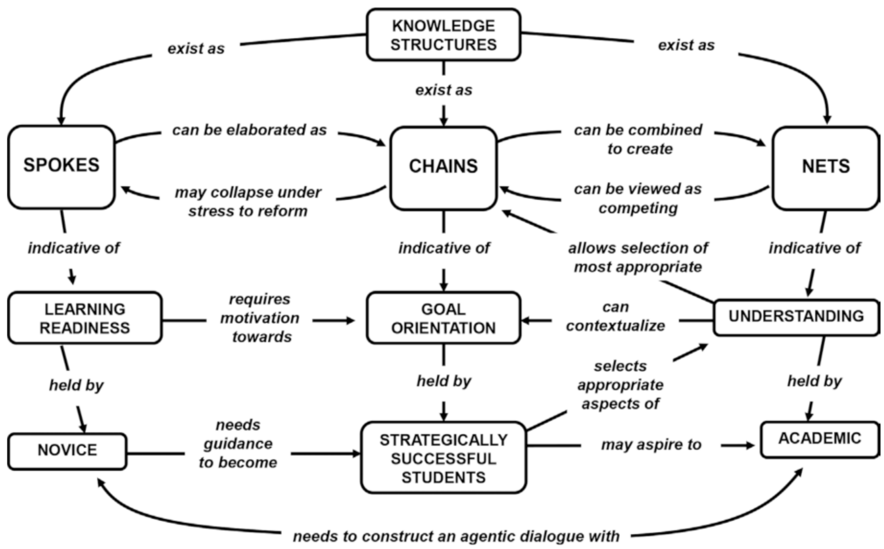

Figure 17. A concept map to summarise the significance of concept map morphologies (spokes, chains and nets) and their relationships to one another

use within a particular teaching context. The selection will depend upon the purpose of the session and the level of prior knowledge held by the audience.

A horizontal reading of Figure 17 suggests a progression in the development of knowledge structures from spokes to nets (via chains). Such a directional development has been observed (Kinchin, Hay, & Adams, 2000), though the mechanisms of change are complex and have been introduced elsewhere (Hay, 2007). The implication that the development of net structures among students may be the goal of higher education is one that may be contested, particularly where the utility of chains of practice are rated above networks of understanding.

The three knowledge structures (spoke, chain and net) are supported by the three phases of knowledge development described by Pedrosa de Jesus et al. (2006) as:

a. an acquisition phase;
b. a specialisation phase, and
c. an integration phase.

However, a simple linear progression from one phase to the next cannot be assumed. The phases may be employed simultaneously across different regions of a particular knowledge structure (Hay, 2007), and so cannot be usefully considered in isolation from each other.

The summary in Figure 17 not only helps to describe teaching within the disciplines, but may also be applied to lecturers' developing constructions of the scholarship of teaching as it relates to their teaching context. Trigwell and Shale (2004) cite Ryle (1949), who proposed that the most meaningful measure of personal understanding of a concept is what that person is able to do with it. The on the scholarship of teaching suggest this is very little at present. Tackling the scholarship of teaching and learning (SoTL) using discipline-specific language acknowledges Guskey's (2002) view of professional development, in which changes to practice are encouraged to provide a context in which changes in belief may be subsequently encouraged. Therefore, the scholarship of teaching may be evaluated by the ability of a colleague to reflect upon the interactions depicted in Figure 17, and to act to implement its development within a changing context. This is with the aim of increasing pedagogic resonance by creating overlap between the knowledge frameworks of the lecturers within the disciplines with those held by educational developers (Kelly & Green, 1998). Eventually this may lead to a shared conception of SoTL.

Horn (1998: 81) considers that such topologies 'communicate meaning' because they are based on the Gestalt principles of human perception – something that has also been explored by Wallace et al. (1998) in the context of concept mapping. Horn considers that the words used in a concept map cannot be evaluated separately from the incorporated images and shapes. He describes 'making meaning' from the integration of these elements as 'semantic fusion'. Wallace et al. (1998) have shown that application of Gestalt principles to concept mapping can help recall and retention of information.

DEVELOPING MORPHOLOGIES

Expert knowledge structures are typically viewed as being elaborate, holistic and highly integrated (Hoffman & Lintern, 2006). However, such structures do not develop quickly and must pass through various structural changes, before they would be recognised as expert. Reviewing the development of understanding, by having students produce concept maps periodically can illustrate the paths that different students will take, and can reveal much about a student's motivation and ability. Crucially, the maps produced by students also show that learners do not always focus on the ideas as intended by their teacher.

Development of the structure of student understanding from a rudimentary starting point can be viewed along a number of trajectories (Figure 18):

1. Elaboration of the initial spoke structure by adding more concepts that are linked directly to the central concept. The concepts remain isolated from each other with no cross-linkages being formed. The student is acquiring information, but not integrating it in a way that can promote understanding.
2. Adding chains of information to arms of the initial spoke structure. This is often indicative of rote learning where chains are mimicking the sequencing of information delivered in lectures. Such sequences may reflect procedural chains

that are of value when undertaking routine clinical procedures, but chains are characterised by their lack of flexibility and the students' inability to modify a chain in the face of new understanding.

3. Adding linkages to the existing structure may indicate a deeper learning strategy where a student is trying to understand the material and find different ways of relating the elements within the map. In such cases, it is not always necessary to add lots of new concepts to enhance understanding, but it is more important to develop the links between concepts. The tendency of many undergraduate courses of bombarding students with lots of new content may be less productive than developing understanding of material that has already been delivered.

An important aspect of the development of expertise is to maintain a balance between the development of chains (Figure 18, part 2) and the elaboration of links (Figure 18, part 3). The ability to oscillate purposefully between these structures is an indicator of expertise, and is suggestive of the sorts of conceptual exercises that could be employed to promote flexible thinking. Recognition of this provides teachers with a rationale for avoiding undue linearity in their teaching that can stifle creative thinking.

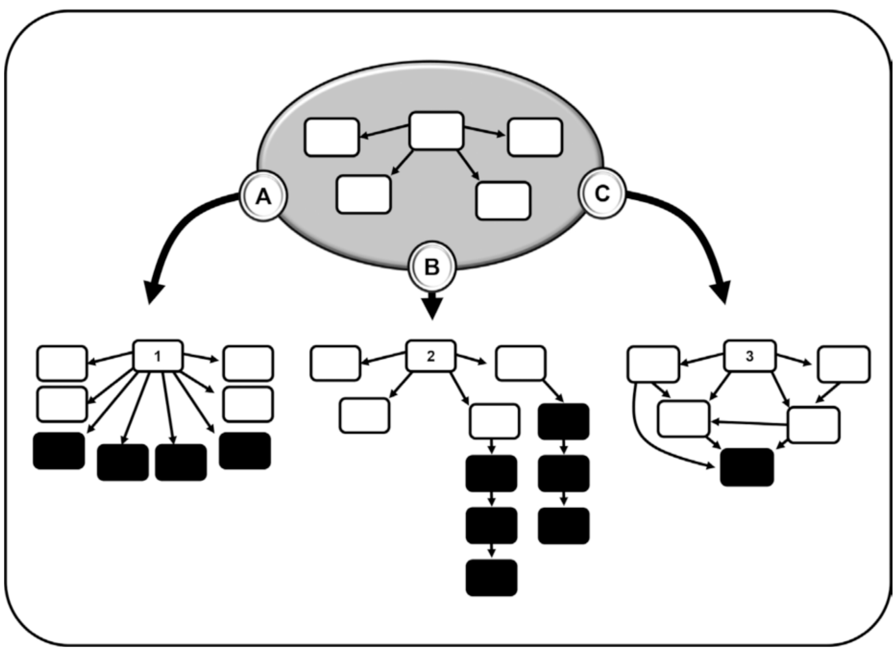

Figure 18. Learning from an initial structure of prior knowledge can proceed through (A) acquisition, (B) specialisation or (C) integration to contribute to the formation of (1) spokes, (2) chains or (3)nets

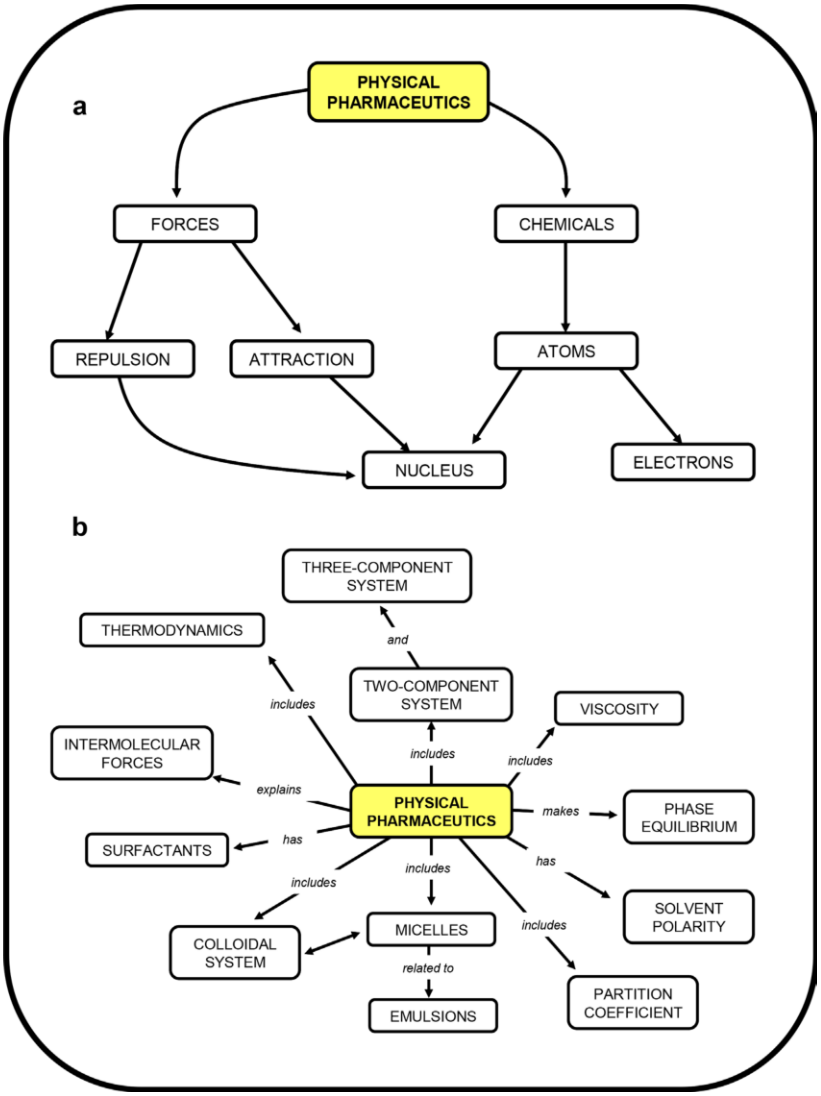

Figure 19. Maps to compare a student's change in understanding of physical pharmaceutics from (a) the beginning to (b) the end of a course (From Jones et al., 2008)

In addition to spokes, chains and nets, there is an important additional morphological type of concept map that needs to be mentioned here. Cyclic maps have been identified as a way of emphasising the dynamism that can be inherent in student (and expert) thinking (Safayeni et al., 2005; Derbentseva et al., 2007).

Cycles of concepts can be indicative of an evolving perspective in which the understanding represented by a concept label can change with every turn of the cycle. Such maps are powerful when the links between the concepts emphasise the dynamism inherent in the overall structure. However, some care is needed in the interpretation of cyclic diagrams as there is a tendency for confusion when a procedural cycle (e.g. the Carbon Cycle or the Nitrogen Cycle) is seen as a conceptual map. A concept map of the Carbon Cycle would not have to be cyclic to represent understanding of the concepts involved.

PERSONAL LEARNING JOURNEYS

When following the learning of individual students, we can often see an initial knowledge structure (Figure 19). This usually includes misconceptions and/or links between ideas that are not adequately verbalised to indicate understanding (i.e. the absence of linking phrases in the arrows). The student in Figure 19 progresses from the initial structure (above) to develop a spoke arrangement of concepts (below). Whilst the links between these newly acquired concepts are labelled, there are few cross links to suggest meaningful learning. This type of spoke arrangement is commonly found among students who are anxious to acquire facts from teachers who are equally anxious to dispense them. The number of facts transferred offers both student and teacher vindication that work has been done and assessment of successful transfer can be undertaken in order to verify this.

If they are to be recognised as ‘expert students’, students must choose to learn meaningfully by the purposeful integration of new knowledge with existing understanding. Some students can grasp the meaning of new teaching quickly because their prior knowledge supports new understanding. Others will find new learning more difficult as a consequence of their prior knowledge. Some students’ understanding will remain unchanged despite the teaching they receive and this may be viewed as non-learning. Students who first learn by rote will learn meaningfully later if they can integrate their new learning with their prior knowledge. Otherwise they will tend to forget what they have been taught and revert to non-learning. Figure 20 summarises the choices and consequences for learning quality that students need to navigate during their studies. The first ‘choice’ is whether or not to evaluate new material taught in class with their prior knowledge. By choosing not to evaluate the new material, the student is already making their journey more difficult as they are either heading towards a non-learning outcome or later (after a period of rote learning) decide to go back and evaluate the new knowledge. The teacher, therefore has the responsibility here to guide the students and to help them to make links with prior knowledge. This may require teachers to have a knowledge of their students’ previous years of study, and/or to link the new material to familiar contexts (such as current events or popular culture). This is not ‘dumbing down’ as some academics claim, but facilitating access. For a student who makes the initial choice to link new and prior knowledge, we then need to consider how the prior knowledge has

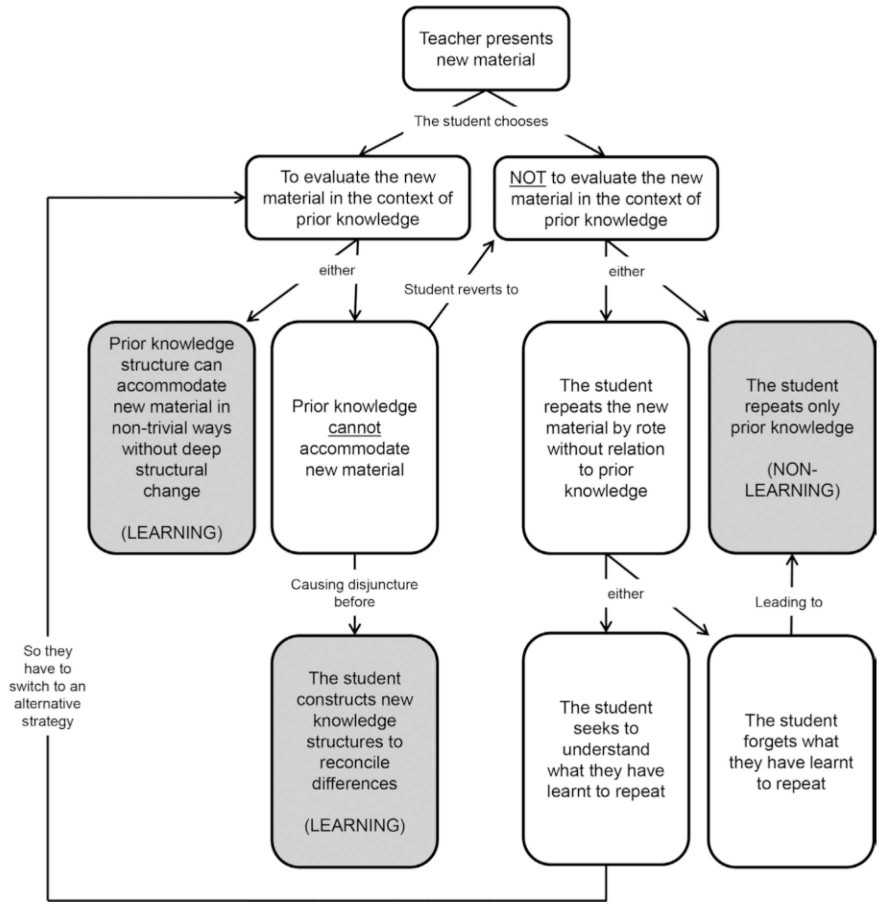

Figure 20. A general model of learning quality (Redrawn from Hay, Kinchin, & Lygo-Baker, 2008)

been organised relative to the structural organisation of the new knowledge. Where the two are compatible, then learning may occur. Where the two are incompatible, the student may experience a moment of 'disjuncture' before the difference can be reconciled and learning is achieved. Such an example is described in Figure 21.

To recognise the learning trajectories undertaken by our students, it is useful to have a number of case studies against which we can compare our students' progress. Teachers with years of experience probably retain a memory bank of past students who may act as personal exemplars of various learning patterns. However, for the novice teacher, it is helpful to consider some indicative case studies of student learning patterns in preparation for their own teaching practice. Whilst analysis of a single student case study does not produce data that is necessarily generalizable across a cohort of students, the richness of the data produced can be a valuable tool for the generation of reflection upon student learning and in identifying previously unnoticed phenomena of potential importance.

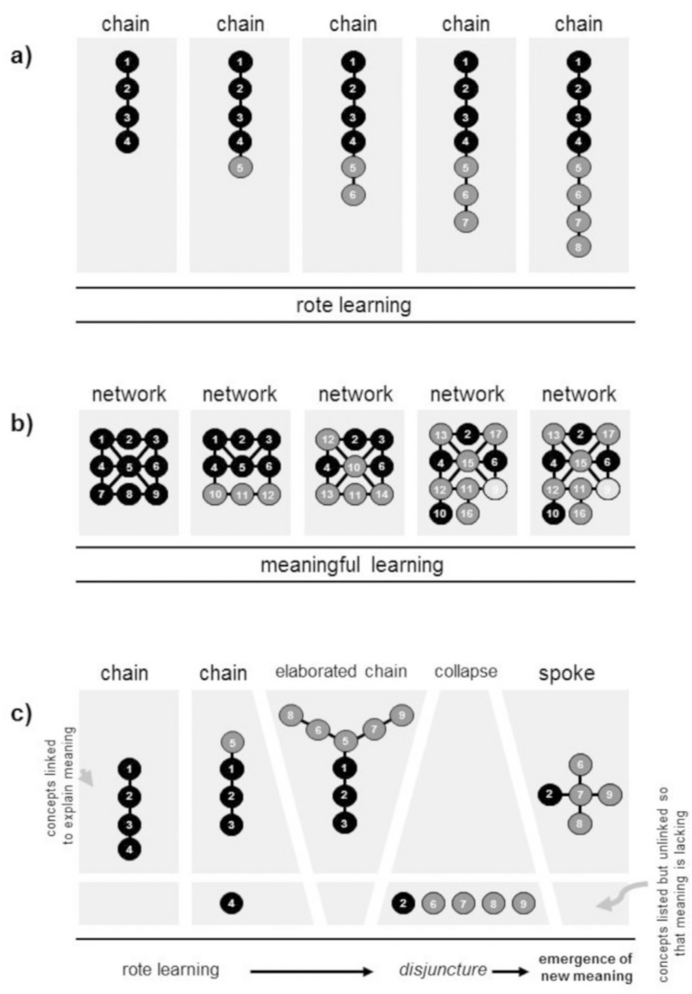

Figure 21. Patterns of learning exhibited by three students (After Hay, Kinchin, & Lygo-Baker, 2008)

Figure 21 shows data gathered from three students. Student a) exhibits learning by rote in which concepts are simply added to the student's pre-existing linear knowledge structure. Many students are able to acquire large volumes of information in this way in preparation for the final examination, but then tend to forget the details very quickly afterwards. Student b) is an example where a student starts with an elaborate knowledge structure and makes radical changes to the linkages between the concepts through meaningful learning. Student c) starts by rote learning material, elaborating upon her initial linear knowledge structure. However, this student found that what was being taught was irreconcilable with what she had understood at the beginning. The result was a period of 'disjuncture' during which she was less able to explain the topic than she had been before. Effectively, she was unable to structure her understanding. After a difficult period, during which she initially failed her examination, she was able to restructure her understanding of the topic to produce a more robust structure that was able to accommodate additional concepts.

IN CONCLUSION

Patterns of learning are idiosyncratic and personal. Some students will learn new material quickly whilst others will need more time. Some will aim strategically for the 'end point' whilst others will take diversions into interesting distractions. Some students will be highly motivated whilst others will need some encouragement to engage with the subject. However, despite all the possible variations within the teaching-learning environment, there are a number of things that teachers can consider to help students achieve success in their studies – however that is defined. A nuanced appreciation of the quality of student learning, beyond the deep-surface distinction can help in the framing of the content within the curriculum, and help the student to navigate the content. The ways students navigate this will be personal and idiosyncratic and so we need to understand individual cases (e.g. Figures 19 & 21) before we can start to make any generalizations based on cohort average changes.

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CHAPTER 4

PRESENTING THE CURRICULUM

Hiding the Discipline from View

INTRODUCTION

Recognition of the importance of the structure of the curriculum can be traced back over 100 years to the writings of Dewey (1910: 204). In consideration of the ways that curricula are constructed by experts, he stated:

> just because the order is logical, it represents the survey of subject matter made by one who already understands it, not the path of progress followed by a mind that is learning. The former may describe a uniform straight-way course, the latter must be a series of zig-zag movements back and forth.

Dewey's '*straight-way course*' is often what is depicted within formal curriculum documentation to describe a programme to undergraduates. Course documentation is often to be found offering lists of modules and lectures that show the chronology of the teaching rather than the links between the ideas. This has to be re-interpreted by the students and placed within a wider framework of the discipline. Unfortunately, this is a framework that (as students) they are not yet familiar with. As a result, their 'zig-zag' movements through the content may support their learning if they happen to correspond to the underlying structure of the discipline, or may represent an unproductive expenditure of energy if they do not.

To create a smooth curriculum that forms a clear sequence, teachers remove many of the variables in the teaching of complex networks of information to try to make the materials more accessible for their students. This is with the intention of guiding students to focus on key ideas and not to get distracted by interesting tangents, or to go down 'blind alleys'. However, in doing this, the students end up learning simplifications that are not representative of disciplinary systems. Campanella and Lygo-Baker (2014) found that lecturers in veterinary science acknowledged that the linear flow of their teaching did not reflect the reality of the complex information they were trying to deliver. While in his analysis of a business school curriculum, Brady (2014) found that the principle of progression between modules appeared to be lost so that academics struggled to define an organizing principle that linked the three years of the programme. Students learn what has been described as a pedagogised version of the information in which the carrier becomes more important than the message (Singh, 2002). To resolve the tension between simplicity and accessibility on one hand, and complexity and inaccessibility on the other, materials tend to presented to students as a uni-dimensional knowledge structure which promotes rote learning, but which is not supportive of meaningful learning or powerful knowledge (Wheelahan, 2007). Once these simplified knowledge structures have been memorised by students, they tend to be retained quite conservatively over time without revision or development (Hay, Wells, & Kinchin, 2008).

REVEALING THE DISCIPLINE

The structure of an academic discipline may be hidden from the view of the novice, and so it is the role of the curriculum to make the overall structure of the discipline explicit to the student (Luckett, 2009). Fontaine (2002) writes a fascinating glimpse of this when she gives an account of her learning of karate, in which the author reflects on what she has learned about university teaching from revisiting the experience of being a novice. She asserts the value for even seasoned teachers to maintain a beginner's mind that is free of the habits of the expert, ready to accept, to doubt, and to be open to new possibilities. From this new position, the author's awareness of what she does in the classroom shifts, as her respect for students grows and her understanding of their feelings deepens.

Concept mapping may help to keep the disciplinary structure visible during curriculum development. Sherborne (2008) has explored the potential of concept maps as a curriculum development tool and provides four reasons for advocating their wider use in designing, communicating and implementing curricula:

1. Concept maps support 'big picture thinking' so that major ideas do not get lost in a mass of detailed knowledge.
2. Concept maps are embedded in constructivist learning theory, and their implementation will help student-centred approaches survive the transformation into classroom practice. By employing a tool that has its origins deeply embedded in educational theory it is thought more likely that theory will be enacted in the classroom. This helps teaching move from being regarded as an a-theoretical, practical exercise, to a theory-driven, scholarly endeavour.
3. Concept maps support collaborative planning through shared visualisation, and provide a reference point for discussion.
4. Concept maps reduce the 'cognitive load' placed on teachers so that organisation of the most important factors within the curriculum do not have to be held in the mind.

Whilst Simon (2010: 303) found that concept mapping proved useful in addressing a number of key questions in the *revision* of a curriculum: the identification of topics to omit and include, the identification of omissions and to ensure cohesion and limit complexity.

Donald (2002) has shown that disciplines vary in structure. In general, the sciences tend to be structured in highly cohesive and hierarchical arrangements whilst the arts and humanities can be viewed as more loosely arranged blocks of information. However, curriculum documents and course handbooks persist in presenting course syllabi as undifferentiated lists of content.

Within a discipline different concepts can have different values. This has been taken further by Meyer and Land (2003) who describe certain ideas within each discipline as acting as threshold concepts. These are not just important ideas within a subject, but they provide the key to understanding a discipline in anything that might approach an expert way of thinking. In particular, acquisition of threshold concepts takes a student from a novice state of understanding to a sophisticated state of knowing by transforming a learner's perspective of a discipline in irreversible ways (see Chapter 6).

Nilson (2007) provides a detailed discussion of alternatives that can break away from the limitations of linear presentation and better illustrate the links between curriculum areas to reveal the 'big picture' of the subject, as well as the details held within it. The student has to relate the linear (temporal) sequence of teaching to a more networked (conceptual) map of the ideas to be introduced. To engage with this profitably, the student cannot expect to just absorb information passively, but is required to actively seek links between the temporal and conceptual representations of their course. Such a dualistic notion of the curriculum fits with the observations made on the ways in which successful students study, considering the interplay between the details and the wholes (e.g. Wilhelmsson et al., 2010). The extent to which each student moves between these perspectives is seen as an indicator of depth of understanding and of developing expertise (Anderson & Schönborn, 2008). While Ausubel (2000) talks about prior knowledge in terms of 'what students already know' as a starting point for instruction, it is clear from what has already been said that we have to look beyond the quantity of information that is held by students and consider 'how' that knowledge is organised as this will also influence the trajectory of future learning.

ARRANGING KNOWLEDGE STRUCTURES IN A CURRICULUM

There is an increasing recognition of the significance for student learning of the interactions between complementary knowledge structures in the development of expertise (Kinchin & Cabot, 2010). Access to these structures needs to be provided by the curriculum if it is to support the student in developing as a professional (Kinchin, 2012). Appropriate acquisition of knowledge structures also requires the application of qualitatively different learning approaches. Maton (2009: 44) has considered how:

> curriculum structures play a role in creating conditions for students to experience cumulative learning, where their understandings integrate and subsume previous knowledge, or segmented learning, where new ideas or skills are accumulated alongside rather than build on past knowledge.

This is reiterated by Winch (2013: 128) who considers:

> A key feature of good curriculum design is the ability to manage the different types of knowledge in a sequence that matches not just the needs of the subject, but also that of the student, so that the different kinds of disciplinary knowledge are introduced in such a way that the development of expertise is not compromised.

For this to be effective, it is not just the students who need to be aware of the types of knowledge and their relationship. Teachers also need to be working with '*a clear conceptual map related to the appropriate ways of learning the relevant subject matter*' (Winch, 2013: 138). Whilst we have authors writing from various perspectives and theoretical/practical standpoints on the crucial importance of structure to support the process of learning, it is generally impossible for a student to divine the structure of a discipline from the materials that are usually presented. Such materials focus on the mechanics of the curriculum (Instructional Discourse) to the neglect of not only the underpinning values, but also of the discipline itself.

These observations throw up a number of practical issues which need to be considered at this point, relating to materials that teachers use to support and guide their students' learning. For example, many textbooks have been written by subject experts who have never considered the structure of the content presented, and whose view of pedagogy has only been coloured by their own student experiences – often dominated by traditional lecture-based transmission of facts. Books are therefore commonly intended to transmit content in as clear a way as possible. I have no doubt that there is a place for the traditional textbook in the modern university, but teachers need to consider their resources and textbooks through a knowledge structures lens if they are to support development of the expert student.

For example, in their comparison of school level and undergraduate level biology texts, Kelly-Laubscher and Luckett (2016) have shown a mismatch between the presentation of related content at the different levels. They found that the school text was locked into its context and did not adequately prepare learners for the same topic at undergraduate level. At the higher level, students were expected to develop the ability to identify the connections between empirical data and scientific theory. In order to overcome weaknesses in the school text, which is aptly described as an "SG flatline" (i.e. very little oscillation between theory and context – see Chapter 7, Figure 38), school students would need additional support from school or home. This does raise questions about the validity of the spiral curriculum concept as it is enacted in educational institutions (Figure 22). Revisiting content may not promote learning as anticipated if the repeat visits are not adequately structured (Kinchin & Cabot, 2012). Where knowledge is structured as linear chains of practice, it will not be receptive to re-structuring. In order for the benefits of the spiral curriculum to be realised, knowledge has to be structured purposefully in a way that will be receptive to qualitative enhancement when revisited and avoid cycles of non-learning. We can see from the student data in Figure 21 that if assessment periods are aligned with periods of liminality or disjuncture (student c) then students may be minded to stay with the tried and tested rote learning strategies (student a) to avoid the possibility of being tested while their knowledge structure is in transition. The pedagogic challenge for the programme designer is to optimise periods where students are radically restructuring their knowledge and acquiring threshold concepts so that the course does not become conceptually fragmented and teaching and assessment are kept in phase (Land et al., 2014).

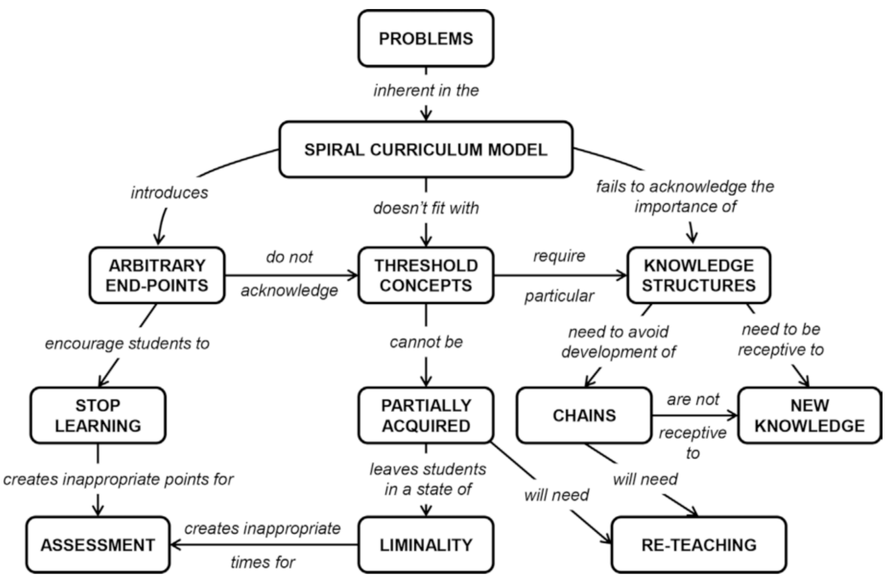


Figure 22. Problems associated with application of the spiral curriculum model

TEXTBOOK STRUCTURES

Active learning should not be confined to the classroom. Contact time is only a small proportion of most students' *learning time* and so we need to think about what students will be doing *between* teaching sessions. Students should be encouraged to prepare actively for their lectures, undertake some preparatory reading and so be able to ask questions that they have already thought about – rather than going to a lecture 'cold'. Students need time to process information and become familiar with language before they can then formulate a question. But what should they be reading? The obvious answer is the course textbook. But does that convey the essence of the discipline, or just a list of the key facts? Hyland (2004: 106) comments that '*textbooks construct a fiction of the discipline for novices and outsiders*'. So is this creating a problem for later on? Even when a textbook is considered excellent, it can create problems. Paxton (2007) argues that in economics, the discourses and practices of first year university economics textbooks provide a model of literacy practices which contradict many of the literacy practices of the discipline. This is exacerbated by the way in which textbooks tend to be '*single-voiced'* and '*give the impression of consensus in the discipline*' that will encourage '*rote learning and plagiarism*'. This sounds like a major issue for our students as they progress from the elementary courses to more advanced courses, if they have the facts, but not appropriately embedded within a disciplinary discourse or knowledge structure that accurately represents the subject being studied. Paxton (2007: 112) argues that one of the keys to providing better access to these academic discourses is to make the practice of discipline explicit:

> If the literary practices of the discipline are not made explicit, this leads to gaps between teacher expectations and student interpretations of certain tasks and activities. For instance, the need for referencing and the penalties of plagiarism may repeatedly be stressed in lectures and departmental handbooks, and yet students will continue to plagiarise because accessing a new and foreign discourse is a slow and very complex process and because students need a careful induction into the literacy practices of the discipline.

Jensen (1998a; 1998b; 1998c) has considered the way in which chemistry is portrayed in the standard textbook and has concluded that the current state of the subject should reflect its historical evolution, rather than blocking out prior discourses, as this would help to logically organize the current concepts and models of chemistry, while simultaneously revealing many of their underlying assumptions and interrelationships. Without such a structured framework Jensen (1998b: 817) found that textbooks randomly mix levels of discourse, making them '*operationally useless to a student*'. If students cannot navigate their discipline in order to make meaning, then they are likely to resort to rote memorization of chains of facts.

I have heard students comment on similar issues when being given a diet of review papers to guide their study. One comment was '*it's like someone has already done the thinking for us, so all we can do is memorize it. Where's the challenge*?' The student was asking to be directed to the conflicting primary sources so she could weigh up the pros and cons of a particular argument for herself. It is noticeable that most students do not make this comment. Perhaps because they are not that insightful, and really do believe that everyone in their disciplinary area thinks the same thing? Or is it because they have worked out what is going on, but will just play the strategic examination game and avoid rocking the boat? Either way, it should be of concern if students are not working in authentic disciplinary ways. This is not to say that we should not use textbooks. Textbooks have a role. But teachers need to understand the nuances of that role and need to guide students to reflect on what it is that textbooks do, and what they do not.

THE PERSISTENCE OF CHAINS

The persistence of chains can be explained by the cumulative selection pressures created by a number of factors that are to be found as common place in the university setting (Figure 23). There are those factors which may be described as 'individual factors', which influence university teachers at the personal level. These include:

- A lack of experience in the teaching arena.
- A level of anxiety when it comes to teaching.
- Teachers having a fragmented view of the curriculum.

There are also a number of factors which may be seen as 'institutional factors', where policies or standard work practices act against the individual from finding their own voice in the classroom. These include:

- The pressure of work experienced by academics who are trying to balance their teaching commitments with their research obligations.
- The examination regime which may have evolved alongside a non-learning curriculum to the extent that it has become 'non-assessment'.
- The dominant culture of an establishment or of a department in which the more experienced academics have learnt to 'play the game' to their own advantage and see new ideas as only providing potential to rock the boat and upset the established *status quo*.

So whilst the chain structure running down the centre of the concept map in Figures 17 and 23 is seen as being indicative of the goal (exam) orientation held by the strategically successful student, it may also be viewed as the knowledge structure of choice for the exam-orientated and strategically successful academic. Such motivations are laid bare by academics who talk about their need to 'cover the content' so that the students may pass the examination. This alludes to a tacit complicity between students and teachers in which neither group may be explicitly aware of the transactions in which they are engaged (Kinchin, Lygo-Baker, & Hay, 2008). Lord (1999) has picked up on this to argue that it is not the role of the professor to 'cover the content' (i.e. provide the diet of chains that can be successfully regurgitated in the examination), but rather to 'uncover the content', which would involve helping the student to see how chains of content may be related to each other in the wider context, and to the underpinning network of understanding.

Along with colleagues in academic development, I have undertaken large numbers of structured observations of university teaching that suggest classrooms are dominated by practices which promote chain thinking. This is summarised in the sketch graph (Figure 23 – lower half) superimposed upon the model within Figure 23 (upper half), to indicate the relative proportion of teaching episodes that would be likely to evoke spoke, chain or net knowledge structures. This shows how the factors mentioned above exert stabilising selection pressures (indicated by the arrows) upon teaching in higher education to maintain a focus on the reproduction of chains of understanding. The result overall is a cycle of teaching-learning in which chains of understanding are exchanged between teachers and students. Accurate reproduction of these chains is rewarded to such an extent that change (the defining characteristic of learning for Jarvis, 1992) is effectively discouraged. In this way, teachers and students are complicit in a cycle of non-learning that allows the maintenance of an 'economy of practice' resulting from an audit culture (Stronach et al., 2002) that maintains the *status quo*. Gardner and Boix-Mansilla (1999) have identified how students and teachers agree to honour the correct answer compromise, when both partners agree to accept certain formulations as evidence of mastery. This helps to maintain the system, with both parties employing the tacit rules of an examination game (Miller & Parlett, 1974).

The persistence of chains appears unproblematic in the short term. Chains can be transferred from teacher to student and back again within the assessment regime so that an appearance of meaningful learning can be maintained. However, this situation becomes problematic when the understanding that these chains is supposed to represent is found to be absent in subsequent courses. This can be observed across campuses where students pass from one year to the next and are not able to demonstrate the assumed level of prior knowledge that is required in higher level classes.

The frustration of teachers is then evident as they have to 're-teach' the basics before the students can progress to the core of the module. These are, however, often the same teachers who supplied the students with those chains of non-learning in the first place, and then complain that there is insufficient time available to cover the curriculum.

LINEAR AMPLIFICATION WITH POWERPOINT

The inherent linearity of thought embedded within many teachers' perception of their teaching role can be difficult to make visible for scrutiny. However, the widespread use of PowerPoint in classrooms offers a window into teachers' thinking as well as a commentary on their practice. Analysis of the PowerPoint slides that are used tend to show the 'straight-way course' described by Dewey, employing bullet points or lists rather than any other form of representation (Figure 24). The value of PowerPoint as a teaching tool has been questioned by many authors with one of the most critical commentaries being offered by Tufte (2006), who highlights a number of key issues:

1. *Over-reliance on bullet points.* Tufte makes the statement that 'bullet points can make us stupid', because they omit the narrative between the points and so conceal the reasoning behind them that confers meaning. Atkinson (2005) takes up this criticism and states that 'bullet points kill communication'. This occurs in a number of ways. First, the format often results in a very lack-lustre performance

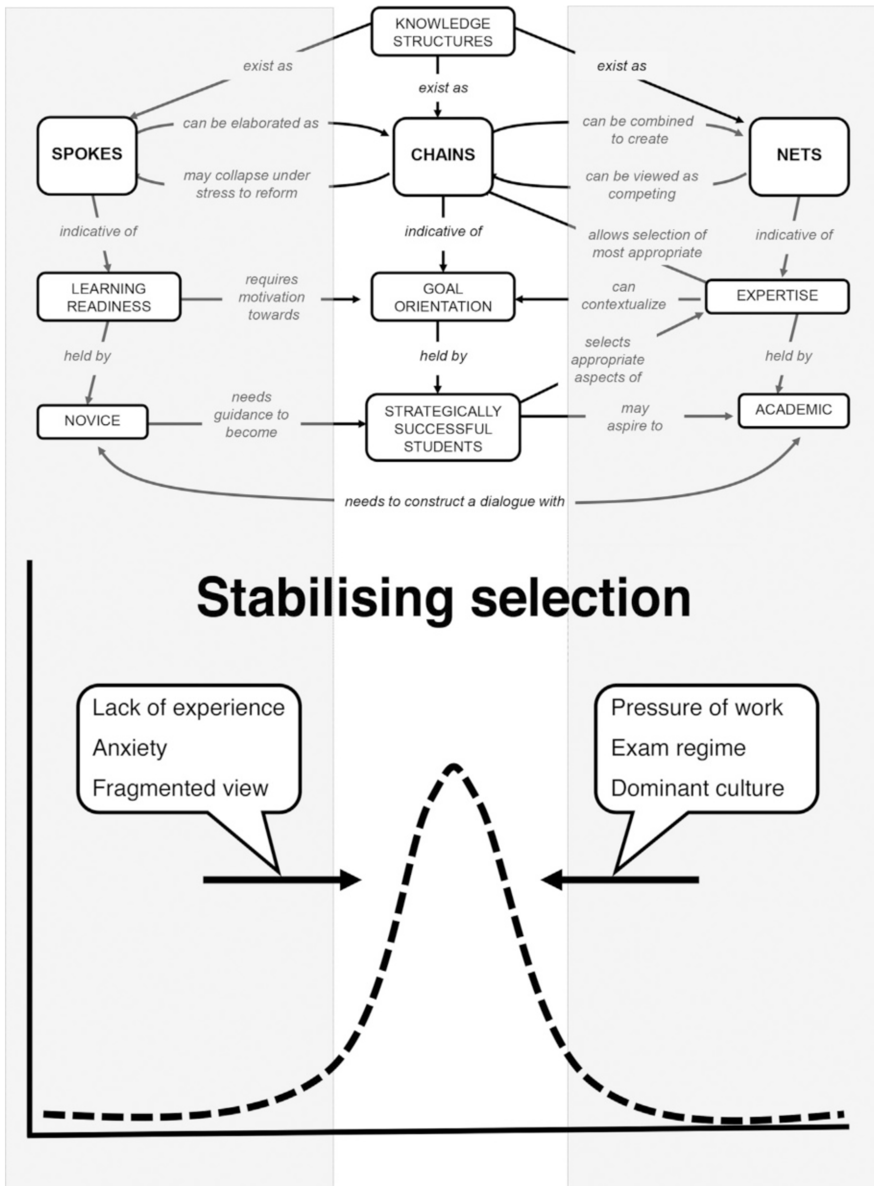
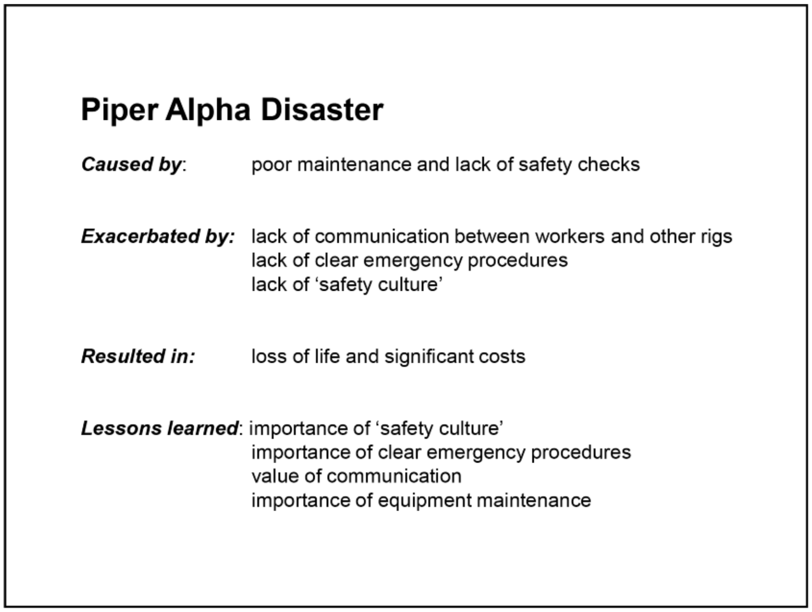


Figure 23. The relationships between spokes, chains and nets and the selection pressure to maintain the dominance of chains in the curriculum (After Kinchin, Lygo-Baker, & Hay, 2008)

by the teacher who often resorts to reading out the bullet points aloud to the irritation of the audience who have probably read them by the time the teacher starts. While the teacher is reading the bullet points s/he is also looking at the screen rather than the audience so it gives the appearance that the teacher is talking to the PowerPoint rather than the students. The presentation of information in this way also gives the impression that these points are agreed facts that cannot be contested and so there is little point in engaging in any discussion about them or asking any questions. A continuous diet of slides with bullet points also gives the presentation a uniform appearance – a 'flat landscape' lacking landmarks and without any notable 'highs' to win the students' attention.

2. *Reliance on templates.* The use of pre-designed templates makes the construction of presentations relatively unproblematic and gives them a professional appearance. However, it also results in teachers using particular templates without thinking how they may help or hinder the teaching of a particular topic. Corporate templates also give the slides the appearance that they are not owned by the teacher but are a third-party production in which the teacher has given little personal investment. As such they help to construct a barrier between the teacher and the student.
3. *Low resolution.* PowerPoint slides deliver relatively small amounts of information in comparison with other media such as paper handouts. The complementary use of handouts and other materials is then compromised when the handout is simply a reproduction of the slides.
4. *Sequentiality of slides.* The adoption of PowerPoint seems to compel the teacher into a well-organised (rigid) path, along which the most important points will be emphasised. This raises the danger that anything that is not emphasised will be assumed to be unimportant. It also makes student input to the flow of information very difficult to accommodate if it does not fit with the pre-defined sequence. The use of PowerPoint therefore implies a set-piece lecture that does not seek dialogue or questions from the audience.

In focusing on the PowerPoint presentations that colleagues produce to support their lectures, it must be acknowledged that these are teaching artefacts that have limited power on their own, and only fulfil their potential in conjunction with the activities of teachers and students (i.e. the verbal commentary of the lecture and the dialogue that this might generate). However, it is also common practice for teachers to place their PowerPoint presentations on the web for students to use on their own. When students are using these materials in an environment that is not directly supported by the lecturers' verbal input, it is important that the presentation scaffolds their learning and does not inadvertently lead them astray in their thinking. Optimising the structure of a PowerPoint presentation to support the development of expertise would, therefore, seem to be a sensible aim (Kinchin, Chadha, & Kokotailo, 2008).



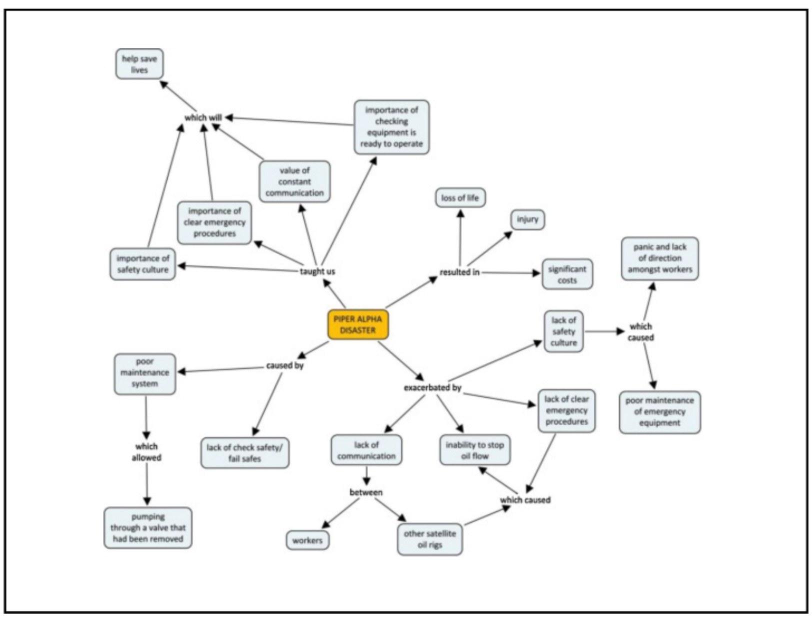


Figure 24. PowerPoint slides depicting the same content as a list of points (above) to support rote learning or as a concept map (below) to support dialogue and meaningful learning (Based on Shallcross, 2013)

The slides are also often supported by supplementary materials or hand-outs to help students to navigate the content. However, the role of hand-outs is rarely examined in the literature. Tufte (2006) states that 'PowerPoint slides are a lazy and ridiculous way' to format hand-outs and describes how printed material in PowerPoint slide format typically offers 2–10% of the typographical richness of non-fiction bestsellers. Doumont (2005: 66) also concludes that '*presentation slides do not double up effectively as presentation hand-out*'. Teachers typically spend hours designing and refining their PowerPoint slides, but when it comes to producing a hand-out to complement the presentation, a printout of the slides (usually six per page) is often produced, suggesting little thought about how it will be used by students, and is simply a repeat of the presentation. Rather than supporting and directing further learning from the presentation, the hand-out merely acts as a record of what it was that was seen. I would argue that the hand-out should do more than this. It should provide challenge for the students and have its own role in promoting student learning. Typically, the six-slides-to-a-sheet printout does not do this. Shwom and Keller (2003: 14) comment that '*the sequential nature of PowerPoint does not easily map onto the hierarchical complexity required by in-depth analyses*'. However, they suggest that providing an ongoing view of the big picture can be done by using verbal and graphical cues to indicate how a single slide fits into a hierarchical structure. Supplementary hand-out material may provide another tool to emphasise the nature of the big picture. Kinchin (2006) has described how PowerPoint slides can be arranged on a hand-out in the form of a concept map that reveals a multiplicity of possible routes through the content, inviting the students to construct their own personal understanding. This can be a better way of demonstrating the various links between the slides than the typical six-slides-to-a-page format that tends to reinforce a linear structure and combines the affordances for learning offered by PowerPoint and concept mapping (Table 3).

Table 3. Comparing the affordances for learning offered by PowerPoint and by concept mapping (From Kinchin, 2006)

PowerPoint	*Concept mapping*
Promotes a single perspective.	Promotes multiple perspectives.
Promotes a linear knowledge structure.	Promotes an integrated knowledge structure.
Reflects an objectivist epistemology.	Reflects a constructivist epistemology.
Has a focus on content.	Has a focus on learning.
Is assessment-led.	Is understanding-led.
Promotes student passivity.	Promotes dialogue.
Promotes rote learning.	Promotes meaningful learning.

STUDENT ENGAGEMENT IN A NON-LEARNING ENVIRONMENT

Student engagement is one of those expressions in education that is rarely questioned or explored. It is a 'given' that high levels of student engagement are a good thing, from which other good things (including student satisfaction) will follow. Policy makers promote student engagement as one of the keys to addressing problems such as low achievement and student dropout (e.g. Fredricks, 2011). However, without some consideration of its quality, the promotion of student engagement produces a 'scatter gun' approach to development of activities to enhance the student experience. Engagement can be usefully characterized as a multidimensional construct that includes engagement that is:

- *Behavioural*: indicated by attendance and participation
- *Emotional*: indicated by a sense of belonging
- *Cognitive*: indicated by purposeful effort in classroom tasks
- *Agentic*: indicated by student contribution to the flow of instruction.

The apparently robust link between behavioural engagement and achievement may be due primarily to the types of assessment used within evaluative research designs, dominated by low-level tests based in simple recall. Behavioural engagement may not be as good a predictor of achievement on tasks that require higher order processing because students can be '*behaviourally engaged*' (i.e. busy) without the strong cognitive engagement that the task requires (Sinatra, Heddy, & Lombardi, 2015). In other words, the class can look engaged within a non-learning environment (Kinchin, Lygo-Baker, & Hay, 2008). This resonates with the '*look busy, the boss is coming*' philosophy, but has little to do with the promotion of meaningful learning or the development of the expert student. The engagement of students has to be agentic (Figure 25), that is the students have to control, or at least, disrupt the flow of learning through their engagement with the material (Reeve, 2013).

The 'game changer' is agentic engagement (Reeve & Tseng, 2011; Reeve, 2013), that represents "*the range of actions that students take in order to advance from not knowing, understanding or achieving to knowing, understanding and achieving*" (Reeve, 2013: 580). Reeve goes on to describe agentic engagement (see Figure 25) as providing not only a "*pathway to academic progress, but it is also a student-initiated pathway to a more motivationally supportive learning environment*" (*ibid*. 581). Students do this by expressing their preferences, asking questions and letting teachers know what they like, need and want in way that can contribute to the development of the learning environment.

A balance has, therefore to be achieved within the engagement profile so that students are supported in the maintenance of behavioural, emotional and cognitive engagement in their studies. Agentic engagement indicates a level of investment in their studies and dialogue with their teachers. This has been developed into a view of the '*agentic learner*' by Richards, Sweet and Billett (2013) who suggest that students need to become learners with '*agentic personal epistemologies*' that allow

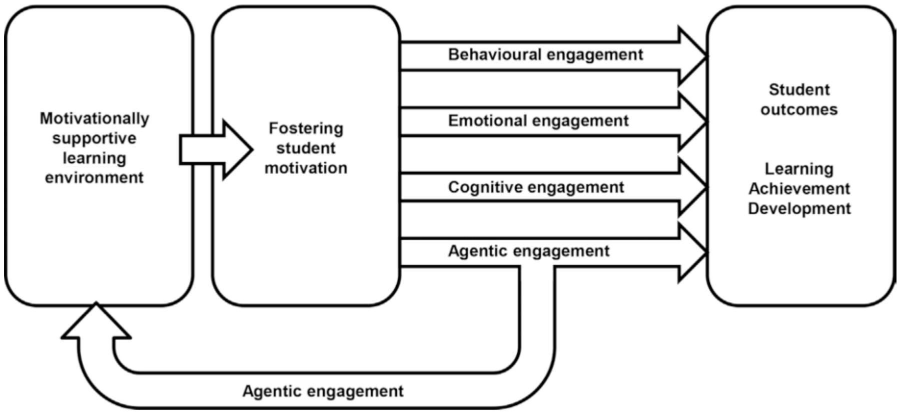


Figure 25. Four interrelated aspects of student engagement that explain students' positive outcomes (four horizontal lines) plus agentic engagement's unique contribution to constructive changes in the learning environment (curved line at the base of the figure) (Redrawn from Reeve, 2013)

them to negotiate, engage and learn from the materials presented to them. These personal epistemologies comprise individuals' beliefs about what knowledge is and how this will shape their actions as learners (Billett, 2002).

MAPPING COMPLEMENTARY DISCOURSES IN TEACHING

Historically, concept mapping has been concerned with mapping content – i.e. the instructional discourse of teaching. This mirrors the 'content-first' model of curriculum design that can still be observed in higher education. However, as the importance of the underpinning regulative discourse (*sensu* Bernstein, 2000) becomes more evident in both curriculum design and teacher-development, the role of concept mapping is likely to change (Kinchin, 2014), and help to visualise the challenges to the dominant educational discourses. The relationships between instructional and regulative discourses is visualised in Figure 26.

When getting teachers to map their models of teaching, they tend to start with a focus on the instructional discourse – the familiar mechanics of teaching, timetabling, assessment and so on. Once these ideas are on the page, the introduction of ideas that might be absent can start to direct teachers to think of the values and beliefs that underpin their actions and to reveal connections between the two (Figure 27).

When attempting to map teachers' models of teaching using concept mapping, Kinchin and Miller (2012) found one teacher in their research cohort who was unable to produce his map in isolation. His teaching practice was tightly bound to the interactions with his students. Therefore, he was unable to complete his map of his model of teaching without reference to his students. He described how he

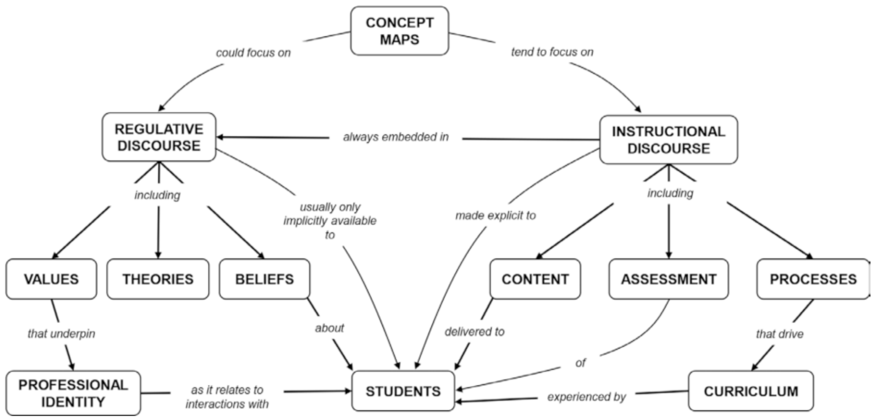


Figure 26. Relating regulative and instructional discourses

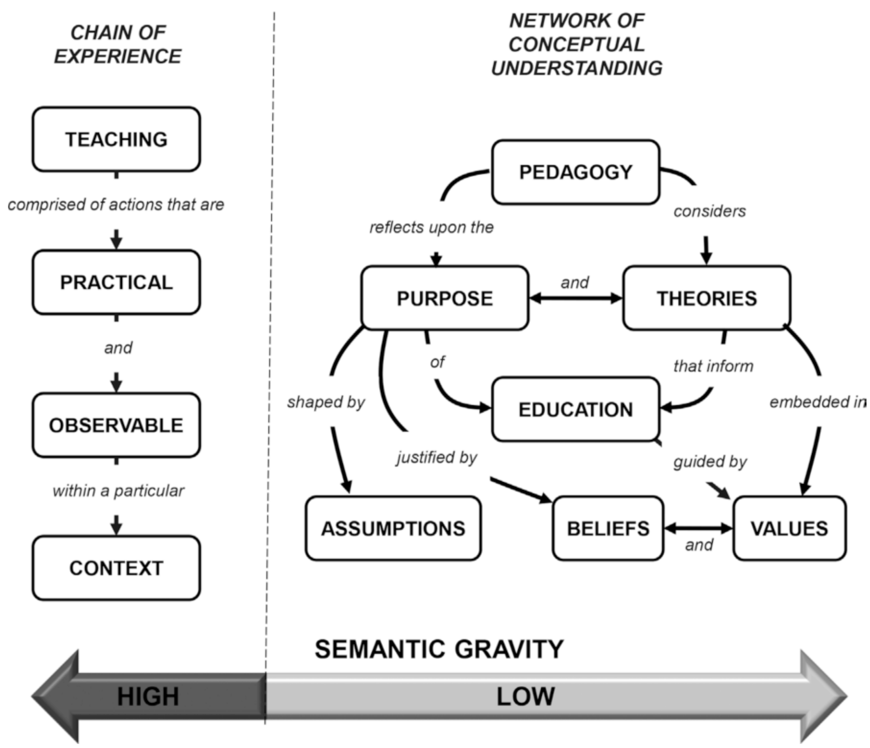


Figure 27. A procedural chain of practice (teaching) juxtaposed with an underpinning network of understanding (pedagogy) to emphasise the difference in semantic gravity between the two (Modified from Yiend, Weller, & Kinchin, 2014)

asked his students to be involved in the construction of his map. Not only did this help him to better articulate his model of teaching, but it also ignited a dialogue that allowed students to better appreciate some of the decisions he made about his classroom strategies. Cook-Sather (2014) sees this development of a student-faculty partnership in academic development as the acquisition of a threshold concept in pedagogical practice on the part of this teacher. The process of mapping these ideas helped this teacher to articulate the ideas that he held about teaching and increased his understanding of the relationships between the terms. By learning to work with knowledge representations of teaching in this way the teacher was better able to *'perceive, express, manipulate, transform, explain and share information'* – skills that support development of expertise (Mislevy, 2010: 264).

When peers within a discipline are observing each other's teaching, there is a tendency for the discussion to focus on the linear discourse of teaching, concentrating on the practical and the observable (Yiend et al., 2014). The educational expert may then have a role in bringing the complementary hierarchical discourse of pedagogy into view by raising issues concerning the assumptions, beliefs and values that underpin classroom practice. In this way, the chain of teaching practice is in articulation with the underlying network of pedagogic understanding and provides a portal into what Bernstein (2000: 30) has termed the '*yet-to-be thought*', allowing teaching to move beyond the reproduction of traditional practices.

IN CONCLUSION

Many curriculum structures within universities have long historical origins and are bound up with issues such as internal politics and research funding as much as they are to do with any underpinning pedagogical claims. However, that is not to say that they cannot evolve and outgrow some of the more dated and restrictive practices that have helped to shape them. For example, that universities still tend to timetable lectures for about an hour even though we 'know' that students will typically only concentrate for about twenty minutes of that hour is a practical outcome of the logistical impracticality of moving in and out of classes every twenty minutes. However, the advent of the flipped classroom supported by digital technology is making the twenty minute lecture a more practical alternative (O'Flaherty & Phillips, 2015). But we still need to be clear how the curriculum is structured, whatever the mode of delivery. It still needs to complement the discipline. As stated by Muller (2009: 216), '*disciplinary form does impose constraints on appropriate curricular form*'.

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CHAPTER 5

THE EXPERT STUDENT

The Need to Manipulate Knowledge

INTRODUCTION

The concept of the 'expert student' has been considered for some time (e.g. Sternberg, 1998, 2003). Here I am considering the expert student in the context of knowledge creation and the ways in which learning approaches can utilize disciplinary knowledge structures in order to develop authentic understanding and practice. As such, the expert student has been defined as '*one who recognises the existence and complementary purposes of different knowledge structures, and seeks to integrate them in the application of practice*' (Kinchin, 2011: 187).

Concept mapping studies of expert practice have suggested a dual processing model of expertise in which the expert has to deal simultaneously with the linear structures inherent in practice/experience and the hierarchical structures typical of conceptual understanding (Kinchin & Cabot, 2010). While the expert practitioner can undertake these knowledge transformations in an automated and opaque manner, the expert teacher has to offer more transparency and reveal these transformations to his/her students. This has been summarised by Tsui (2009) as the complementary capabilities of 'theorizing practical knowledge' and 'practicalizing theoretical knowledge' – skills that needs to be modelled for students.

CONSIDERING EXPERTISE

The model in Figure 28 was derived from the qualitative examination of several thousand concept maps produced by students and their teachers over a 10 year period (Kinchin, 2000; Kinchin, DeLeij, & Hay, 2005; Kinchin & Hay, 2007; Kinchin, Cabot, & Hay, 2008). These maps were elicited from students and teachers from a wide range of arts and science disciplines. The studies have indicated a great diversity in patterns of learning such that a teacher could not hope to track the learning pathways of all the students in a cohort. But the maps have indicated the importance of knowledge transformations and knowledge structures that are particularly helpful in relating theory and practice (Kinchin, Baysan, & Cabot, 2008).

The vertical dimension of Figure 28 (reading down each side of the figure from top to bottom) explains the characteristics and roles of each of the knowledge structures – chains and nets. Many students embark upon their undergraduate studies with firmly established chains of understanding that have developed during their secondary schooling.

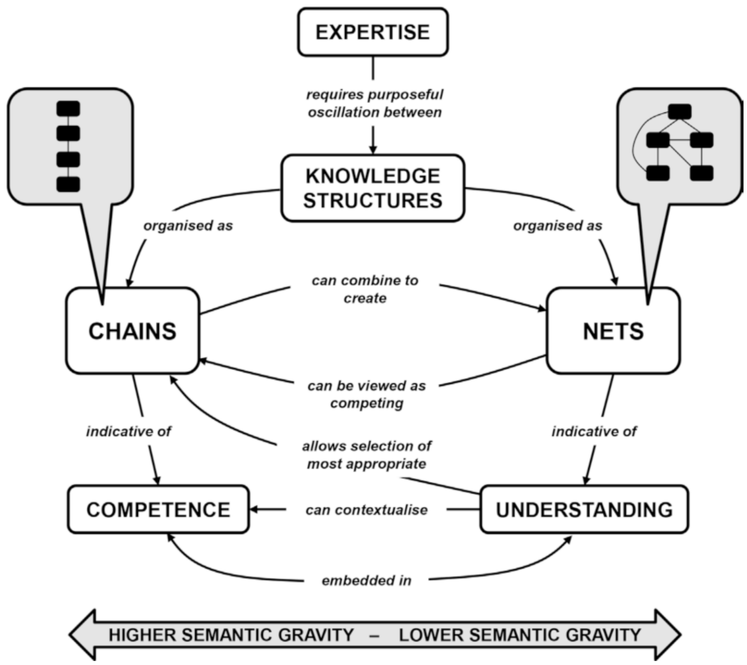

Figure 28. A dual-processing knowledge structures perspective on the nature of expertise (After Kinchin & Cabot, 2010)

The chains result from students' repeated exposure to linear teaching sequences in which materials are presented to facilitate rote learning. These chains are often incomplete or inappropriate for their new context – typically representing a single route through a sequence of ideas. They are resistant to development (Hay & Kinchin, 2006) and so students are faced with the dilemma of either trying to abandon their existing beliefs or rote-learning the new material as an adjunct to their existing prior knowledge (Hay, Wells, & Kinchin, 2008). The chain of appropriate understanding is indicative of strategically successful learners (students and lecturers) as they represent the most economical way of storing key points of information – indicated by the dominance of such structures within student study guides. Such goal-orientation enables these learners to select the essential information from that which is available whilst selectively ignoring the rest. This may be seen by some as an efficient way of studying (avoiding blind alleys and tangents to thinking) whilst others could interpret this as a blinkered view of higher education that does not encourage alternative points of view. There is certainly a tension created within the university environment by attitudes towards this kind of strategic learning that may reflect disciplinary differences. For example, in the clinical environment the development of chains of clinical reasoning is seen as one of the key aims, so that students can be seen to perform sequences of procedures with a high degree of competence (Talbot, 2004).

The demonstration of highly developed and integrated networks of understanding may be seen as the hallmark of the expert (Bradley et al., 2006), for whom the demonstration of expertise is achieved by the accommodation of competing chains of understanding and the selection of appropriate chains to suit particular contexts. The chains are described as 'competing' as a particular chain may be seen to be more appropriate in a given context that an alternative (or competing) chain. However, the competitive value of a chain may change as the context develops so that an alternative chain may be selected at a later date. Net structures need to be explicitly connected to chains of practice if they are to have any practical application. In some disciplines, this may be seen as linking 'professional' and 'academic' learning, with professional learning concentrating on the development of linearly arranged practical procedures and practices and the academic learning focussing on the integration of understanding. This linking of theory and practice is often a source of difficulty in many vocational university courses, such as dentistry or engineering. The dual processing of the two formats (nets and chains) supports the contention that '*expertise lies in the availability of multiple representations of knowledge*' (Norman, 2005: 418). This also resonates with the work by Vance, Zell, and Groves (2008: 232) who consider the issue from a learning styles perspective and concluded that '*successful individual innovative capability actually would tend to reflect both nonlinear and linear dimensions in a composite thinking style*'.

A horizontal reading across the model suggests a progression in the development of knowledge structures from chains to nets, i.e., that students may initially memorise sequences of information that are later integrated into a more holistic understanding of the subject. Such a directional development has been observed (Kinchin, Hay, & Adams, 2000) though the mechanisms of change are complex. The implication that the development of net structures among students may be the goal of higher education is one that may be contested, particularly where chains of practice seemingly have more immediate practical application than networks of understanding. In the clinical context, the chains and networks need to develop in parallel. As an individual develops expertise, the networks of understanding will develop sophistication whilst the choice of embedded chains of practice will also grow. The smoothness of transition between the two will increase with increasing expertise. Unlike other models of expertise (e.g. Yielder, 2004; Dall'Alba & Sandberg, 2006), the model proposed by Kinchin and Cabot (2010) addresses a number of the issues that currently inhibit the development of university teaching beyond the self-limiting cycles of non-learning that have been discussed by Kinchin, Lygo-Baker and Hay (2008):

1. It addresses the theory-practice gap that features in so much of the literature, especially in the applied and clinical sciences. The explicit focus on the links between the chains of practice and networks of understanding (practice and theory) that allow the model to function effectively overcomes this problem.
2. It facilitates epistemological access where the epistemology of a discipline is seen to be in conflict with the epistemology of educational development. Taylor (1993) describes in accessible terms how she came to grips with her own epistemological conflict. Such a personal challenge is seldom acknowledged in public, and the sanitized nature of academic writing never suggests that such personal issues are widespread among the academic community. Taylor's personal account may provide an exemplar against which colleagues could compare their own situations.
3. It places the responsibility for learning on the shoulders of students. The teacher has to be able to demonstrate the manipulation of knowledge that is appropriate for the discipline (e.g. from chains to nets and back again) in an explicit manner that is visible to students and then provide the appropriate learning environment where students can try this for themselves.
4. It places teacher development within the disciplines and so the traditional 'battlegrounds' between academics and academic developers (e.g. student vs. teacher-centredness) become obsolete, with focus now on a common interest – the development of expertise-centredness. This shift allows the discussion of pedagogy to become part of the general discourse of higher education rather than the preserve of specialists in teaching and learning (e.g. Green & Lee, 1995).

EDUCATION FOR EXPERTISE DEVELOPMENT

From their analysis of the literature, Elvira et al. (2016) have developed ten interrelated instructional principles to promote expertise development. In the context of the knowledge structures approach, these are:

1. *Support students in their epistemological understanding*. The epistemological underpinnings of the knowledge structures approach is emphasised in Chapter 2 (see Figure 5). The complexity and uncertainty in knowledge should not be kept away from students in order for them to have the opportunity to develop their skills in processing information, reason more effectively and develop better problem solving skills. Dolan and Collins (2015) talk about the value of open-ended, messy or 'wicked' problems which demand more than simple factual answers – outcomes that may even have the power to shock and surprize (Young & Muller, 2013).
2. *Provide students with opportunities to differentiate between and among concepts.* Elvira et al. (2016) consider the importance of providing students with repeated encounters with ideas in a range of contexts. This fits with the comments made by Maton (2014a: 106) who considers the widespread problems created by

the segmentalism of learning that results in meaning being so tied to context that it is only meaningful in the context in which it was learned. This he refers to as a 'spectre that is haunting education'. Kaipainen et al. (2008: 477) conclude that a single perspective should be regarded as a transient and partial view of a complex environment, and that a 'more profound comprehension emerges in the course of an iterative process of exploring the data from alternative perspectives'. The need for a cognitive system that 'binds together subsequent perceptions', may be fulfilled by the application of threshold concepts, whose function is to integrate concepts (Meyer & Land, 2006).

3. *Enable students to experience complexity and ambiguity*. The problems that are presented to students need to be authentic and not over-sanitized versions of reality. Otherwise we end up with problems like the ones I have encountered when students in a dissection class have informed me that '*their rat is wrong*', because its interior organs do not look like the drawings in the textbook. The complexity and ambiguity inherent in university level knowledge can be emphasised through the application of concept mapping. However, for the tool to have a positive contribution, it is vital to achieve alignment between the instructional goals and assessment regime with the concept mapping exercise (Bentley et al., 2011).
4. *Enable students to understand how particular concepts are connected*. This is the essence of concept mapping and the knowledge structures approach. The connections between concepts are possibly more important (and certainly more demanding to write down) than the concepts themselves. As stated by Goldsmith et al. (1991: 88), '*To be knowledgeable in some area is to understand the interrelationships among important concepts in that domain*'.
5. *Target for relevance*. The so-called 'theory-practice' gap is considered in some disciplines to be the most important challenge to the concept of research-based practice (e.g. Scully, 2011).
6. *Share inexpressible knowledge*. Elvira et al. (2016: 9) state that '*converting procedural knowledge into conceptual knowledge means finding a way to express the inexpressible*'. The issue of the inexpressible has been explored by Kinchin, Cabot and Hay (2008) who considered tacit knowledge to be found in the spaces between complementary knowledge structures. That experienced teachers cannot always articulate rational explanations for their practice resonates with Polanyi's view of tacit knowledge as a description of 'knowing more than we can tell' (Polanyi, 1967: 4). But the 'black box' of tacit knowledge and intuition does little to support the student or the teacher in the development of academic expertise. If colleagues are unable to verbalize their actions, it may simply be that they lack the appropriate tools to uncover what it is that they are doing, and/or the vocabulary to articulate it. Hoffman and Lintern (2006: 216) argue that there is no indication that tacit knowledge '*lies beyond the reach of science in some unscientific netherworld of intuitions and unobservables*', and that tools such as concept mapping can support colleagues

in identifying and describing their practice with unprecedented clarity. That knowledge may be tacit is not in doubt. Where I depart from many accepted views is that not all such knowledge need remain tacit and undescribed. Transparency, mediated by concept mapping, may help students and teachers appreciate the other's perspective and avoid the problem described by Perkins (2006: 40):

> Learners' tacit presumptions can miss the target by miles, and teachers' more seasoned tacit presumptions can operate like conceptual submarines that learners never manage to detect or track.

7. *Pay explicit attention to prior knowledge*. Central to the implementation of an expertise-based approach to teaching is the conceptualisation of learning as change: a process of development from prior knowledge to new understanding. Ausubel (2000), whose theory of learning lay the groundwork for the development of concept mapping, has commented that what students know already is the most important thing to identify before teaching starts as this represents the cognitive raw material that students have at their disposal to support further learning. However, teachers in higher education comment that in practical terms, it can be very difficult to access students' prior knowledge for the purpose of conducting a meaningful dialogue. Concept mapping provides the practical tool to make prior knowledge visible (Hay, Kinchin, & Lygo-Baker, 2008). Once in this form, students can share their understanding with their teacher, their peers or even reflect upon it themselves in a manner that was not previously practicable. My experience undergraduate students has been that they will engage with each other enthusiastically to discuss the merits of different concept map structures in ways that I have not observed with other classroom strategies. Students embarking upon an undergraduate course will always have some prior knowledge of the field. This prior knowledge may be well-constructed and appropriate to the context (in which case it will help the students' future learning), or it may be fragmentary and full of errors and misconceptions and lack the semantic range expected at undergraduate level (Kelly-Laubscher & Luckett, 2016), in which case it will create an impediment to future learning. Making prior knowledge visible so that it is available for scrutiny will help the student to articulate the difficulties s/he may be having and provides a common language for students to share understandings with each other and with their teachers. It makes misconceptions easier to diagnose and helps to focus the teacher's attention to where it will be most beneficial.
8. *Support students in strengthening their problem-solving strategies*. The development of concept maps that summarise knowledge tend to emphasise the process of constructing understanding. This is of great value to students who are engaged in problem-based learning where the recognising the process of coming to an answer is often as important as achieving the answer. Problem

solving is seen as a way forward to develop meaningful learning, particularly in ill-structured domains where there is rarely a single answer to be extracted from the problem. In such cases, the mapping of the process may well be of benefit to the learner (e.g. Wu et al., 2013).

9. *Evoke reflection.* The application of concept mapping to reveal knowledge structures offers a tool to support reflection. It allows the visualisation of novice and expert thought processes so that students are able to see the distance they have to travel to acquire a level of expertise in the subject. By laying bare the thought process as a concept map, the student can offer his/her thought processes for critique which makes it difficult for the student to offer an outcome that simply mimics expertise.
10. *Facilitate metacognition.* Elvira et al. (2016) consider students not only need to develop metacognitive knowledge, but also need to be given tools to plan, monitor and evaluate their own work. The visual prompts provided by concept maps are likely to be more dynamic and integrated that the use of checklists in this regard. Salmon and Kelly (2012) have explored the application of concept mapping as a metacognitive tool for teachers to help them think critically about their teaching and suggest that teachers' metacognitive ability can be differentiated by the quality of the concept maps they produce.

SETTING EXPECTATIONS

The expectations that students bring with them to the classroom can be a major determining factor in how teaching will be received, and how innovation can succeed or fail. Díaz et al. (2008) describe how poor student performance often results from a mismatch between what teachers expect of their students and what those students imagine their task to be. If teachers expect students to act like sponges, passively absorbing information, then that is probably what they will do. But if students do not know what is expected of them, how will they behave as learners? Díaz et al. (2008) go on to explain, in the context of history, how most professors learned how to be disciplinary experts by 'osmosis', without explicit instruction on how to perform many of the operations necessary to produce disciplinary knowledge.

Without explicit reflection on what they do automatically, teachers fail to model for their students some of the most basic and essential steps in their work without realising that these activities are not natural for many of their students. In consequence, these activities remain invisible for the students, leaving students with the facts of the subject, but no idea how they were created. Identical scenarios are played out in other disciplines where the actions of experts can be so quick that students are unable to identify the steps that have been taken. Without an explicit role model in how to learn, students often revert to memorisation and rote learning. But this is not a way to develop expertise.

MOVING BETWEEN KNOWLEDGE STRUCTURES

Practice knowledge and theory knowledge may be separated and exhibit distinct knowledge structures. This is often exaggerated in university curricula where the ‘practice’ is often taught by ‘practitioner-teachers’ in the practice setting (clinics, surgeries, laboratories, courts, factories etc.), whilst the conceptual knowledge is often taught by ‘teacher-researchers’ at a different time and in a different place (through lectures, seminars, tutorials etc.). Typically the practice knowledge is quite linear in structure to emphasise efficiency and clarity of procedures, whereas the theory knowledge tends to be more of a networked structure in which multiple links and avenues can be designed to create uncertainty and creative thought. If the students are unaware of the differences between the two knowledge structures (in terms of design and purpose) they will find it difficult to relate the two – contributing to the ‘theory-practice gap’. The teaching of language has not developed a prominent profile within the concept mapping literature, but comments made in the literature can be interpreted from a knowledge structures perspective. For example, McCormick (1994: 49) acknowledges the process view of reading as textual competence (taking information from the page), but then elaborates a wider socio-cultural view of text appreciation in which students ‘*must be given access to discourses that can allow them to explore the ways in which their own reading acts are embedded in complex social and historical relations*’, to demonstrate cultural competence.

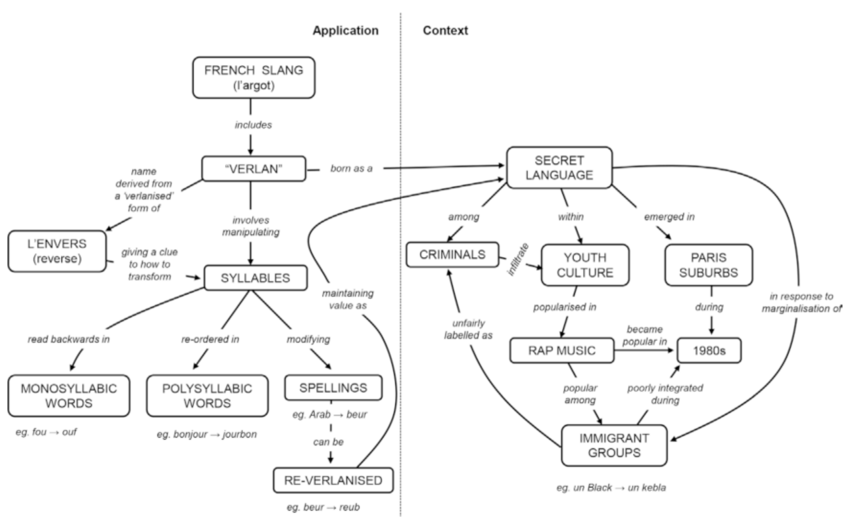

Figure 29. A student’s knowledge structure of the application and social context of French slang (verlan) (After Kinchin, 2013)

Figure 29 is a student’s knowledge structure of French slang (verlan) made to summarise a class on the subject. Here the application is seen as a protocol to be followed in order to 'verlanise' language, whilst the social context within which this practice has evolved is quite networked. Importantly, the two knowledge structures are linked. It is therefore possible for someone to learn to use the slang by simply adopting the procedures to verlanise words (changing the orders of syllables or altering the spelling to create 'new' words). The chain of practice here relates to textual competence (Nord, 1991), whilst the network of understanding relates to a wider appreciation of culture (Witte, 1996). However, for someone to use verlanised French without having any regard for its origins within the youth culture of Paris may give the appearance of being in-authentic or generating a parody that may be insulting to the social groups who developed it. Therefore adoption of the procedures without an appreciation of the underlying theory would simply be to mimic expertise in this domain.

Figure 29 is a 'student map', produced by someone who is still learning about verlan, but who was not yet an expert in its application. As such we can see that whilst the theory (network on the right) and practice (chain on the left) are quite well developed, the map still has room for refinement in order to make the chain of practice more efficient and maybe to generate a more robust link between the two structures. In contrast, the maps in Figure 30 were constructed by a disciplinary expert.

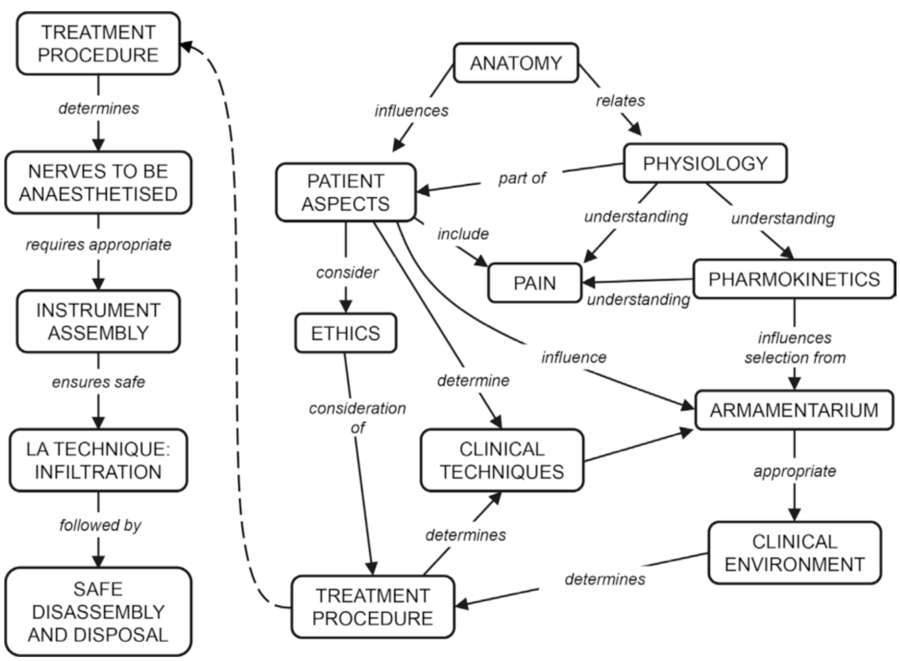

Figure 30. An expert's knowledge structure of the application of local anaesthesia (LA) in dentistry (After Clarke, 2011)

Within this expert's knowledge structure the well-developed chain of practice and network of understanding are quite separate, linked by a single robust link that moves the 'treatment procedure' from theory into practice. The chain of practice is simple, with no deviations. Development of such an efficient chain is required in order to develop agreed clinical protocols that can be understood by a clinical team who may be holding different levels of theoretical understanding (e.g. between nurses and doctors or dentists). Competence frameworks (e.g. Talbot, 2004) therefore have a place in certain domains of education where the student is only concerned with developing the efficient chain of practice. However, such chains are only efficient within a largely predictable environment that presents the same problem over and over again. In such cases, routinized expertise may be seen as the goal. But where the environment is less predictable or changing in a certain direction, the routinized chain may not be fit for purpose. In such cases, the expert understanding of the theory is needed in order to provide the knowledge that allows the chain of practice to evolve. Individuals who are excluded from the underpinning theory will be denied access to the powerful knowledge of expertise (Wheelahan, 2007). This is when the expert is able to select or adapt to the most appropriate chain for an unusual instance by reference to the related theory. Whilst this is easy to appreciate in a clinical environment, it is also true of the map of verlan (Figure 29), where for the language to remain 'secret', it has to adapt as it is decoded by outsiders to the community. Expertise, therefore, requires the purposeful oscillation between the chain of practice and the network of understanding (Figure 28). The fluidity of this linkage makes the expert knowledge powerful.

DEVELOPING POWERFUL KNOWLEDGE

Recognition of the variety of knowledge in terms of structure and function allows students to develop understanding that has utility beyond the immediate goal of passing the exam. This more nuanced appreciation of knowledge goes beyond the simple deep-surface dichotomy that is described within many teacher development programmes (e.g. Kandlbinder & Peseta, 2009). It not only relates to 'acquisition-of-the-known', but also granting possible access to the 'yet-to-be-known' (*sensu* Bernstein, 2000), and 'new ways of thinking' (*sensu* Young, 2008), that '*frees those who have access to it and enables them to envisage alternative and new possibilities*' (Young & Muller, 2013: 245).

Traditional transmissive teaching approaches tend to emphasise the contents of the 'nodes' of information that are a feature of the visual representations used in this book. So, for example in Figure 30 the nodes (pain, physiology, clinical techniques etc.) represent the topics to be learned, and probably also the titles of the modules in which the content is packaged. Teaching to support the development of powerful knowledge also needs to emphasise the nature of the links between the nodes. This is where students can generate an appreciation of the explanatory power of their knowledge, as discussed in Chapter 2. Therefore to support the development of powerful knowledge and develop student expertise we need to:

> provide students with access to the relational connections within a field of study and between fields, and students need access to the disciplinary style of reasoning to move beyond a focus on isolated examples of content. Unless students have access to these relational systems of meaning they will not be able to drive the production of knowledge, or to determine the criteria they need to evaluate knowledge. (Wheelahan, 2010: 84)

Students will need guidance in the evaluation of knowledge as they will not have access to the whole disciplinary picture. This guidance is unlikely to emerge as a happy accident and so requires intentionality on the part of the teaching team who need to appreciate the ways in which different forms of knowledge are brought to the curriculum by their colleagues. For example, in the clinical scenario in Figure 30, the clinicians who teach the chain of practice may be separate from the scientists teaching the physiology. Mastery of one aspect of the subject is not enough. Students need to grasp the 'conceptual spine' that runs through a discipline. Teachers need to ensure that this is not 'scrambled' as a consequence of disciplinary fragmentation or modularisation of the programme (Muller, 2009). Clear conceptual links across a programme of study are not just desirable they are a necessary condition for students to construct powerful knowledge:

> 'powerful knowledge' comprises not one kind of knowledge but rather mastery of how different knowledges are brought together and changed through semantic waving and weaving. (Maton, 2014b: 181)

In view of the comments made by Maton, it seems obvious (but may still benefit from stating explicitly) that dependence upon a single theoretical perspective on educational research (e.g. sociological or psychological) or on a single disciplinary context (e.g. arts or sciences) or a single methodological perspective (e.g. quantitative or qualitative) is unlikely to generate a complete picture of learning in higher education. Maton's 'waving' and 'weaving' needs to encompass an acknowledgement of epistemological pluralism within the university (e.g. Miller et al., 2008) to help generate a more integrated understanding and avoid the creation of competing bodies of powerful disciplinary knowledge – which would then (paradoxically) not be powerful at all, except in maintaining territorial fiefdoms. I therefore, have to acknowledge here that the knowledge structures approach that is the focus of this book has to be seen as one perspective on the development of university teaching that will be complemented by different perspectives from other research traditions.

If students were 'empowered' by content, then it would follow that the more content we throw at students, the more empowered they would become. However, we know from experience that this is not the case. Students often feel swamped by content and as this feeling grows, the likelihood of them retreating into the 'safe haven' of rote learning also increases. This then seems to drive teachers to support this approach and we end up with the familiar cycles of non-learning (Kinchin, Lygo-Baker, & Hay, 2008). In such a scenario, the power that might have been found within the acquired knowledge disappears along with any appreciation of its structure or function beyond passing the examination. This is unlikely to generate excitement about either learning or teaching. When students are interested or excited with the curriculum, they are more likely to develop other positive emotions towards their learning that help to maintain active engagement (Rowe et al., 2013).

IN CONCLUSION

The knowledge structures approach may give the impression that the emergence of the 'expert student' can be achieved through a rather mechanistic adherence to structural protocols that could be mimicked to offer an appearance of expertise as a subversive ploy by a strategic student. The recognition of the expert student as more than adherence to protocols is helped by the view offered by Reid et al. (2011: 122) who address this by considering the expert student to have made a commitment to studies that goes '*beyond studying aspects of their discipline simply because they are part of the curriculum*' and '*are aware of the role and importance of their expanding knowledge*'. This may include efforts to integrate characteristics of their future profession within their current studies. This then goes beyond the purely cognitive to accept the importance of the affective domain in learning.

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CHAPTER 6

EMBEDDING WIDER THEORY

Threshold Concepts, Semantic Gravity & Punctuated Learning

INTRODUCTION

The development of concept mapping (unlike many other classroom tools and study aids) is underpinned by a robust theoretical framework, based on the learning psychology of Ausubel's assimilation theory of learning (Novak & Cañas, 2006). After its emergence in the 1970s, concept mapping has been applied to learning in a wide variety of disciplines, and from primary, secondary and higher education to business and military strategy (e.g. Novak, 2010; Rasmussen et al., 2009). During a period of consolidation, stimulated by the release of 'cmaptools' that allowed concept maps to be drawn digitally and shared online followed by a series of international concept mapping conferences, the application of concept maps in teaching has moved from the fringes of education to part of the mainstream (Figure 31).

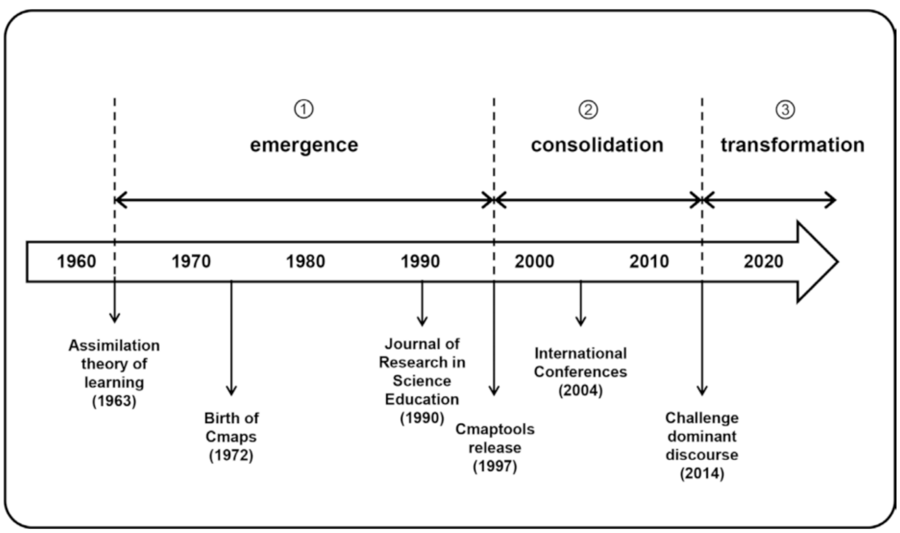

Figure 31. Historical development of concept mapping from the 60s to today (From Kinchin, 2015; redrawn and modified from Cordeiro et al., 2012)

During the ‘emergence’ and ‘consolidation’ phases of the evolution of concept mapping, the tool has been used largely to map content rather than to investigate the discourses that underpin the teaching of that content, or in the development of pedagogic theory. As such, concept mapping research has tried to fit in with the dominant discourses in order to gain recognition as providing a credible contribution to the study of student learning. However, it has been suggested more recently that academics should challenge the dominant discourses in education through the application of concept mapping by integrating the tool with contemporary educational theories from both the psychology and the sociology of education. This third phase (transformation) is likely to see concept mapping studies that upset the *status quo* and ask awkward questions about issues that seem to be taken for granted within university curricula (Kinchin, 2015).

VISUALISING THEORY & DEVELOPING THEORY

One of the problems encountered by new entrants into the teaching profession in higher education is the fragmented nature of educational research (coming from various research traditions such as the sociology or psychology of education) and the resulting ‘*fractured discourses*’ that have developed alongside the research (Ashwin et al., 2015). This tends to deter academics in other disciplines from delving into the educational research literature, and so prevents their teaching from benefiting from the latest pedagogic research – despite the ubiquitous claim that universities are engaged in research-led teaching.

Attempts to visualise existing theories through their impact on knowledge structures provides an alternative (or more correctly, a complementary method) to investigating through text alone. The development of concept maps to summarise texts has all the advantages for scholars of teaching and learning that it has for students of biology, geography or history. One of the problems encountered by scholars, which is identical to the problem encountered by students, is that to visualise or to map a problem takes considerable mental effort. It is much simpler to list attributes of a phenomenon than to produce an integrated map of those same attributes. So whilst scholars may use common terms in their discussions, until we ‘see’ how they link those terms, we cannot be sure that they are all meaning the same thing. Buckley and Waring (2013) concluded that the amalgamation of text and drawings can act as a powerful tool for the dissemination of complex ideas to critical audiences, but that the use of diagrams still seems to be an area of under-explored potential for the development of theory.

Mapping existing terrain also allows otherwise unknown features to come to the surface. In this way, concept mapping may not only be a way of visualising existing theory to enable verification and dialogue, but it may also help new theoretical perspectives to emerge. This is often as a result of identifying links between ideas that had not been previously made, or by viewing known links from a different perspective.

Finally, the application of knowledge mapping does not rely so much on canonical language. It has therefore helped to find useful overlap between different research traditions across the fractured discourses of education. For example, the links between the psychology of David Ausubel and the sociology of Basil Bernstein (who used very different terminology to explain their theories) are only made clear as a result of recognising overlap in graphic depictions of their work.

THE NATURE OF THRESHOLD CONCEPTS

Threshold concepts are seen as more than just important or difficult ideas within a subject. They provide the gateway between being a novice and (potentially) becoming an expert within a discipline. This view is summarised by Meyer and Land (2003: 1):

> A threshold concept can be considered as akin to a portal, opening up a new and previously inaccessible way of thinking about something. It represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress. As a consequence of comprehending a threshold concept there may thus be a transformed internal view of subject matter, subject landscape, or even world view.

The identification of threshold concepts within disciplines has proved to be a difficult task in many cases. This is possibly because the overall structure of many disciplines has not previously been made explicit and because there is so much fragmentation and specialisation within disciplines, that few academics have sufficient overview to identify threshold concepts in the curriculum. Meyer and Land (2003) have identified the key characteristics of threshold concepts that disciplinary experts may use to identify threshold concepts in their own subject areas. Threshold concepts are:

a. *Transformative*, in that once understood, they result in a change in perception of the subject that may involve a shift in values or attitudes as well as in understanding. A threshold concept may also involve a performative element as an increase in confidence can lead to an enhanced appreciation of what has to be done. For example, this might be seen in terms of enhanced performance in sports, or increased competence within clinical practice.
b. Probably *irreversible*, in that the change of perspective that results from acquisition of a threshold concept is unlikely to be forgotten. Meyer and Land (2003) consider responses from their studies that point to the difficulty experienced by expert practitioners looking back across thresholds they have personally long since crossed. Attempting to understand (from their own transformed perspective) the difficulties faced from (untransformed) student perspectives is difficult. This links to the comments made by Fontaine (2002) about the need for teachers to maintain a novice's view of their subject in order to be able to teach it in a way that students can access.

c. *Integrative*; exposing the previously hidden interrelatedness of something that may represent a key component of a discourse within a community of practice. As such, the threshold concept may not always appear front-and-centre within a curriculum as it may be seen by the experts within that discipline to be ‘a given’ that simply underpins everything else. This makes it even more difficult for the novice student to recognise its importance within their studies as it may not be verbalised explicitly, but may form part of the tacit knowledge of the discipline. The nature of a threshold concept may vary depending on the structure of the discipline in question. Within the sciences which are generally seen to develop very hierarchical structure (Donald, 2002), a single threshold concept may be considered for the discipline. So, for example, given his assertion that ‘*nothing in biology makes sense, except in the light of evolution*’, Dobzhansky (1973) seemed to be anticipating the notion of threshold concepts and make a claim for evolution being the leading candidate in the field of biology. Whilst evolution is a key component of the discourse within the community of biologists (often assumed as a ‘given’ within the discipline), the reach of the concept goes beyond biology and extends into other cultural contexts (Anderson, 2007). In such contexts, the concept may ‘lose’ its ‘threshold’ status.
d. Possibly (though not always) *bounded* in that any conceptual space will have terminal frontiers, bordering with thresholds into new conceptual areas. Whilst some subject areas have well demarcated boundaries (e.g. physics), others will have much weaker boundaries (e.g. education, sociology) as they have to overlap with other disciplines and listen to other voices (Wignell, 2007). In order to relate to a variety of other related disciplines, subjects exhibiting weak boundaries may have to accommodate linear and hierarchical models, with the threshold concepts taking on the role of integrating the two. In the case of ‘caring’ within the clinical sciences (e.g. Clouder, 2005), the concept may link the salient points of the personal perspective (patient-centred discourse) with the biomedical (treatment) discourse (Figure 32).

Here ‘care’ is seen to occupy the space that links caring as a therapeutic intervention (to the left) and caring as the nurse-patient interpersonal relationship (to the right), as described by Morse et al. (1990). This positioning enables the carer and the patient to be active partners in linking the chains of clinical practice with the networks of understanding that relate to the patient’s wider needs. The key factor within this model is the ‘care’ that includes consultation with the patient and carer that allows them to relate the two halves of the model – something that is required for learner agency (Kinchin & Wilkinson, 2016).

THE ROLE OF THRESHOLD CONCEPTS

The central role of threshold concepts opens up a range of possibilities and challenges for teaching in higher education. If the failure to acquire the threshold concept within a discipline means the learner cannot progress, then this may present a bottleneck for further learning. If students do not really understand what is being presented in a meaningful way, they will have to resort to rote learning, raising the spectre of non-learning as the norm (Kinchin, Lygo-Baker, & Hay, 2008). A further question then arises about the positioning of threshold concepts within the curriculum. Should they be introduced early in the curriculum in order to provide a framework for other ideas, or do they depend on the application of factual knowledge that needs to be acquired in advance. In either case, the position of threshold concepts needs to be considered at an early stage of curriculum design (e.g. Loertscher, 2011).

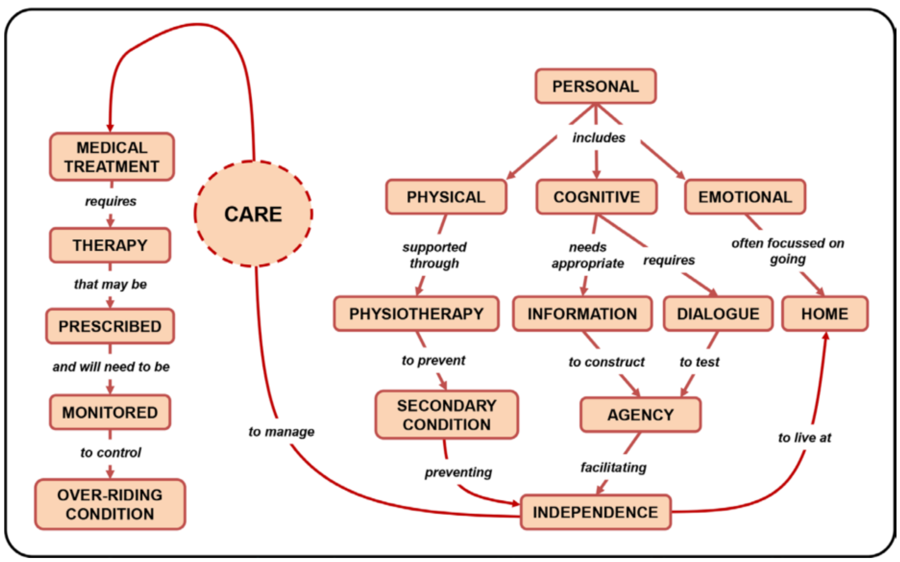

Figure 32. Chain of medical treatment (the health professional focus) juxtaposed against the network of personal understanding (the patient/carer focus). Care is seen to link the two perspectives (From Kinchin & Wilkinson, 2016)

Davies and Mangan (2007) have identified three important implications for teaching that stem from a consideration of threshold concepts:

1. The successful sequencing of threshold concepts requires that students have sufficient related prior knowledge for the threshold concept to have an integrative function. In other words, for integration to happen, students need the appropriate cognitive 'raw materials' to work with. Therefore, the curriculum needs to provide opportunities for segmental and cumulative learning in ways that will allow the two to be complementary (Maton, 2009).
2. The benefits of spending time on integrating prior understanding are likely to exceed the benefits of acquiring new knowledge that may remain isolated and

unconnected. The degree of connectedness is an important issue that needs to be addressed when designing a curriculum to support the students' construction of productive knowledge structures (Kinchin, Lygo-Baker, & Hay, 2008). This provides an argument for not overloading the curriculum with content.

3. The devices used by experts to define and interpret problems in the context of their wider understanding often remain implicit in the course of teaching. By making the links explicit between expert understanding and teaching sequences, the process of theorising can be modelled for students, so they can themselves start to think like disciplinary experts.

Barradell and Kennedy-Jones (2015: 538) see threshold concepts as a tool to help academics '*engage more comfortably with the teaching and learning discourse*', whilst Entwistle (2008: 30) has commented that introducing the notion of threshold concepts to teachers seems to '*open up their thinking about the nature of knowledge*' so that '*threshold concepts act as a threshold concept about teaching and learning*'. As such, discussion about threshold concepts can have an integrative and transformative influence on the development of teaching practice, for example helping teachers to view students as producers of personal understanding rather than consumers of accepted information (e.g. Gamache, 2002). In order to open up this thinking, there is an obligation upon discipline specialists to demonstrate their expertise by identifying the threshold concepts in their disciplines. This will then allow an interrogation of the field of study through a critically reflective process, '*to question pedagogical practices, teaching methodologies and domain content to uncover the tacit processes that students must be privy to so that they can 'crack the code' of their learning*' (Behari-Leak & Williams, 2011: 11).

Meyer and Land (2003: 5) comment that '*given the centrality of such concepts within sequences of learning and curricular structures their troublesomeness for students assumes significant pedagogical importance*'. Knowledge is referred to as troublesome for different reasons by Perkins (1999; 2006). It may be seen as ritual knowledge (that forms part of the routine of the discipline, but whose underlying meaning may remain opaque to the novice observer); inert knowledge (that may remain isolated and disconnected from real-world problems); conceptually difficult knowledge (that is hard to grasp and whose acquisition may be impeded by commonly held misconceptions); alien knowledge (which comes from a perspective that is not held by the student and may be counter-intuitive); tacit knowledge that can remain hidden from view and is rarely verbalised, even by experts in the discipline; and linguistically inaccessible knowledge where disciplines utilise specialist terminology, or jargon, to help brevity in communicating complex ideas within the community, but which may exclude 'outsiders' from that community. Evidently, many instances of troublesome knowledge will feature overlap in these forms of troublesomeness, with some characteristics creating more 'trouble' for some students than for others, depending on the nature of the prior knowledge that the student is able to bring to bear on the situation.

FROM CONSUMPTION TO PRODUCTION & TRANSFORMATION – AN ANALOGY

Analogies are often helpful in making a point. Here I describe the learning of photosynthesis as an analogy for the kind of conceptual shift that is required among university teachers to consider the full benefit of the knowledge structures approach to teaching and learning.

Within secondary science education, photosynthesis is known to be a 'troublesome' topic within the curriculum for a whole variety of reasons (see Driver et al., 1994, for a review). Taylor (2006: 90) comments that '*students will memorise details of the process of photosynthesis rather than take the opportunity to think, in a holistic framework, about the significance of photosynthesis*'. Students who have learned details of photosynthesis by rote are able to switch between frameworks to suit the context (Kinchin, 2000b), with students answering an examination question saying that plants make food using sunlight, only to tell you later that in their garden at home, plants absorb food from the soil. The elements that compose photosynthesis and combine to make it a difficult topic for students have been identified, but are considered in a manner that infers equal importance in gaining an overall picture of the topic (e.g. Kinchin, 2000a). In order to fully appreciate photosynthesis, students have to disengage from the common belief that plants fundamentally act like animals and consume food from their environment. The concept of production in photosynthesis is one that needs to be acquired. However, even this is insufficient for the student of biology to appreciate the dynamic role of photosynthesis. Both production and consumption suggest a linear process. Carlsson (2002a, 2002b) has demonstrated how an understanding of photosynthesis in terms of transformation is required to be able to place photosynthesis in context alongside other non-linear environmental processes.

This shift in ecological understanding from a consumption model to a production model is troublesome for many students, but once grasped is transformative, not only of plant nutrition but also of the wider understanding required to appreciate the energetics of ecosystems. This is analogous with a shift in teachers' perspectives from students as consumers to students as producers, and eventually to students as transformers of knowledge. The concept of dynamic transformation may provide a threshold to the understanding of photosynthesis and other biological processes as well as of learning processes. Dynamic transformation is not a concept that would immediately spring to the minds of most biology teachers. The tacit nature of many threshold concepts is predicted by Ross et al. (2010: 170) who emphasise that '*while academics and teachers identify content knowledge as troublesome or problematic, the threshold concepts which underlie the difficulty receive the least attention in teaching*'. Similarly, the transformation of knowledge receives little consideration in the typical university curriculum, in which 'students-as-producers' is still seen as an innovative pedagogic stance. Moving from the linear consumer-producer dichotomy towards a non-linear 'student-as-transformer' model will require continued effort, and will challenge the commodification of education (Land, 2016).

CHAPTER 6

SEMANTIC GRAVITY

One of the most well-developed conceptual frameworks for the generic consideration of the variation in knowledge structures is that based on Bernstein's sociology of education (Bernstein, 1999, 2000). Bernstein describes '*horizontal knowledge structures*' and '*hierarchical knowledge structures*'. When elaborating upon horizontal knowledge, Bernstein (2000: 159) refers to a '*segmental organisation*' in which '*there is no necessary relation between what is learned in different segments*'. This resonates with the recognition of rote learning of content without understanding. In contrast to horizontal structures, Bernstein (2000: 161) sees hierarchical knowledge structures as attempting '*to create very general propositions and theories, which integrate knowledge at lower levels and in this way show underlying uniformities across an expanding range of apparently different phenomena*'. This resonates with the view of integrated expert knowledge structures that are often hierarchical in structure (Bradley, Paul, & Seeman, 2006).

Bernstein's work has been developed by Maton (2009) to consider how '*curriculum structures play a role in creating conditions for students to experience cumulative learning, where their understandings integrate and subsume previous knowledge, or segmented learning, where new ideas or skills are accumulated alongside rather than build on past knowledge*'. The segmented learning described by Maton equates to a surface approach that on its own would result from the serial acquisition of knowledge chains, ultimately leading to cycles of non-learning (Kinchin, Lygo-Baker, & Hay, 2008). The cumulative learning that is described by Maton equates to the meaningful learning espoused by Novak (2010) that is typically represented by integrated knowledge networks. The combining of hierarchical and linear knowledge structures has been described as a fundamental problem in education (Novak & Symington, 1982) and is considered necessary to develop expertise (Kinchin & Cabot, 2010). Making links between these complementary knowledge structures is therefore a major issue in curriculum design and delivery.

Within this framework, Maton (2014) has developed the concepts of semantic gravity and semantic density which resonate with the knowledge structures approach. Semantic gravity (SG) refers to the '*degree to which meaning relates to its context*' (*ibid*: 129). This may be seen to be relatively stronger (+) or weaker (–) along a continuum. Therefore a concrete example of something tied to a particular context may be seen to exhibit a stronger semantic gravity (SG+) than a more abstract generalisation that may be derived from it (SG–). Importantly, the dynamic nature of semantic gravity needs to be acknowledged so that oscillations between theory and practice, or between principles and examples, can be referred to in terms of weakening (SG↓) or strengthening (SG↑) semantic gravity, depending on the direction of travel. So for example, analysis of political theory followed by description of the practicalities of voting in local elections would be an example of SG↑, whilst fieldwork looking at patterns of banding in snail shells followed by a lecture on the principles of natural selection would be an example of SG↓. Repeated oscillations back and forth in this way are described by Maton as semantic waves (see Figure 38).

The concept of semantic density (SD) refers to '*the condensation of meaning*' (Maton, 2014: 129) that may be determined by socio-cultural practices, symbols, terms, concepts, phrases, gestures, actions etc. Within specialist texts or practices of a discipline, there are highly nuanced and detailed meanings that are embedded. These are recognised by 'insiders' but may be overlooked by novices who fail to pick up on the appropriate cues. For novices to start to gain access to the richness of understanding, some 'unpacking' is often necessary so that students can make links to at least some parts of the wider body of disciplinary knowledge. This is also complicated where some terms cross into everyday discourses. So from the ecological analogy given above, the everyday use of 'plant food' has a low semantic density, however, in the more scientific context of photosynthesis, 'plant food' can be further unpacked to reveal understanding about soluble minerals and their active transport across cell membranes that allows them to fulfil their role in the biochemical processes of photosynthesis. So in the right context, the term has greater semantic density.

The relative strengths of semantic gravity and semantic density can vary independently along continua of strengths to form what Maton refers to as a semantic plane (Figure 33). Here the semantic plane has been annotated to suggest the types of knowledge that might be plotted within the quadrants. Practical knowledge (SD– SG+) relates to the competencies that are often described within the disciplines that are tied to a given context (when you see x, you do y) and can be summarized by a linear protocol. This is often the kind of knowledge that is learned in practical exercises that students are then required to link to the theoretical knowledge, (SD+ SG–) that they have obtained from their books and lectures. The successful combination of conceptual and procedural (SD+ SG+), may be seen as the hallmark of professional knowledge in which the links between theory and practice become second nature to the disciplinary expert. The stages of expertise development have been traced against the semantic plane by Shay and Steyn (2016), who see the novice-beginner occupying the top left quadrant and the expert-master occupying the bottom left quadrant of the plane. As a teaching tool within the knowledge structures approach, this becomes more useful if we can visualise the structural arrangements of knowledge that are likely to be found populating the quadrants (Figure 34).

Extending the applicability of this tool beyond its sociological origins, Blackie (2014: 468) has applied the use of the semantic plane to the teaching of Chemistry. By applying the knowledge needed to understand examples such as the dissolution of sodium chloride in water, she has been able to increase her consciousness of the '*kinds of complexity that different sections of chemistry require*' and the '*extent of the leap required by the students at any particular stage*'. The process emphasises the importance to the teacher of moving from the comfort of the top right quadrant of the plane (SG– SD+), which may be a comfortable place for the subject expert, but an intimidating arena for the subject novice. Navigating the semantic plane in this

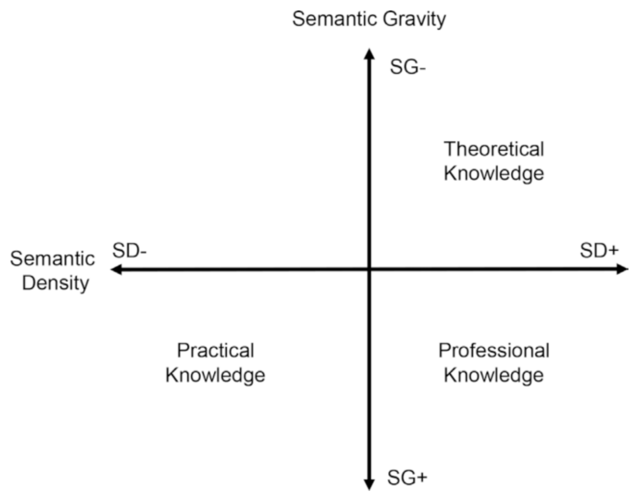

Figure 33. The semantic plane indicating the types of knowledge that may populate the quadrants (After Maton, 2014)

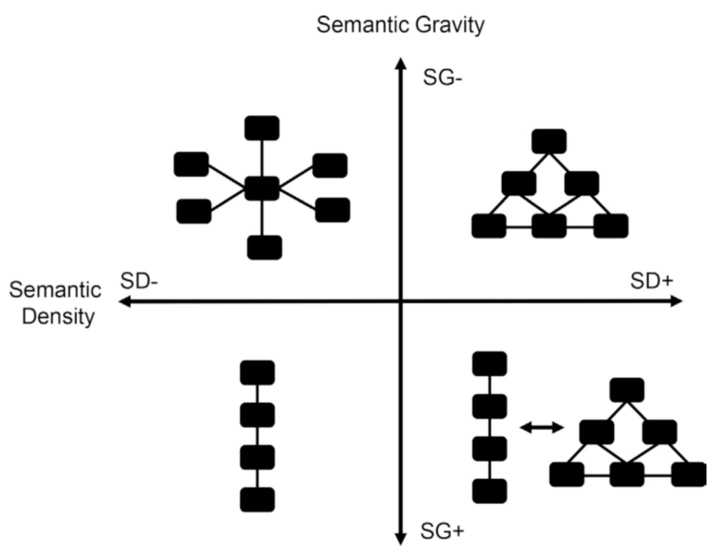

Figure 34. The semantic plane indicating the typical knowledge structures that are likely to populate the quadrants

way provides teachers with a '*way to make the organising principles of knowledge visible to students through explicitly teaching discipline-specific language resources that create and shape the knowledge of their disciplines*' (Macnaught et al., 2013: 61). As such, it may provide a route for the navigation of threshold concepts within a discipline.

As we have seen in the earlier chapters, practical knowledge is often dominated by chains of practice, whereas theoretical knowledge is more likely to be structured as an integrated network of understanding. The professional knowledge that is needed to function as an expert in many fields requires the individual to oscillate between the chains and networks (Figure 28), allowing an apparently simultaneous access to theory and practice. It may therefore be more 'correct' to say that these expert individuals oscillate between the practical and theoretical quadrants, but as structural shorthand here, it makes practical sense to consider the professional knowledge to exhibit high semantic density and high semantic gravity, as appropriate. The region of the plane that describes low semantic density (relatively little information held), and low semantic gravity (not linked with a particular context) to describe the novice who has not yet gained any degree of competence in the discipline. This is most likely to be depicted by a spoke – type concept map. I have to acknowledge that these are extreme structural types and most of the maps that are observed will tend to offer mixtures of the main morphological types shown here.

LEARNING AS CHANGE

In learning, it is the change, the dynamism between knowledge structures that is of greatest interest. Therefore, the transitions between structures as learning progresses and as the student moves between learning contexts should be the focus of attention. The cycles between the linear and the hierarchical (described by Novak & Symington, 1982) and the movements across the semantic plane (Maton, 2014) resonate with the cycle of experiential learning developed by Kolb (1984). Kolb described a cycle of experiential learning in which the abstract conceptualisation creates hierarchical knowledge structures and concrete experience creates linear structures. The passage between these two complementary structures would be undertaken through periods of active experimentation and reflective observation.

Kolb's cycle has been particularly popular within the educational literature and its simple visualisation appears to make it accessible to many who are embarking upon scholarly reflections of their teaching. Engeström and Sannino (2012: 49) consider the frequency of this continual reproduction and simplification to '*testify to a widespread wish to find genuinely dynamic process models of learning*.' I am happy to support this goal and the simplification of Kolb's cycle in Figure 35, may be a starting point for many before considering the more complex double Kolb cycle presented in Chapter 1. However, a limitation of this cyclic view is that it suggests that learning proceeds at an even and gradual pace as the student makes the transitions around the cycle. In practice, this is often seen not to be the case, with learning observed to occur in fits and starts.

The importance of change is emphasised by Dall'Alba and Sandberg (1996: 422) who consider the development of competence for professional practice to require

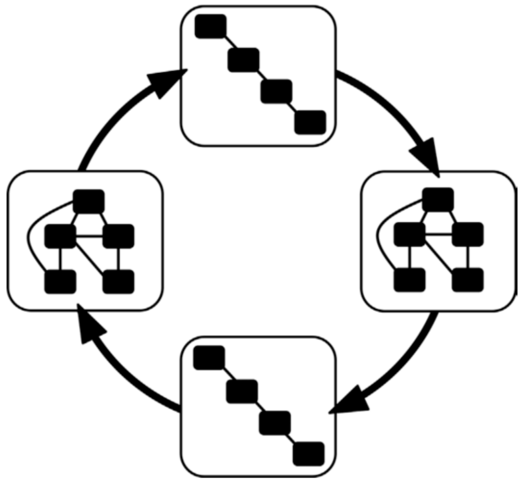

Figure 35. A typical learning cycle in which the learner passes through repeated episodes of linear and hierarchical knowledge construction

more than just the acquisition of new knowledge, but '*change in the structure of meaning*' so that the practice evolves as learning progresses. This change can be visualised by concept mapping the evolution of hierarchical structures through cycles of learning (Figure 35).

PUNCTUATED LEARNING

The punctuated pattern of student learning has been hiding in plain sight. Whilst curriculum documentation seemed to assume that student learning occurs in an even and gradual manner, it is evident to anyone who has worked in a classroom that there are periods where students don't seem to be making any progress and short bursts of activity where progress is rapid (Figure 36). The term 'punctuated' is borrowed from evolutionary biology, where Gould (1993; 2002) explains the textual silence in the world of palaeontology around the evolutionary stasis that was evident to anyone examining the fossil record. The palaeontology literature tended to focus on the comparatively brief moments of change that could be documented, rather than the longer periods of stasis, as it is a more interesting story to tell. Similarly, the educational research literature on conceptual change is extensive, but there is almost nothing documenting the occurrence of conceptual stasis or what happens 'beneath the surface' during these periods.

Gould (2002: 957) comments on the similarities between his work on the development of the concept of punctuated equilibrium in evolutionary biology with his observations on the nature of human learning, '*only years later … did I*

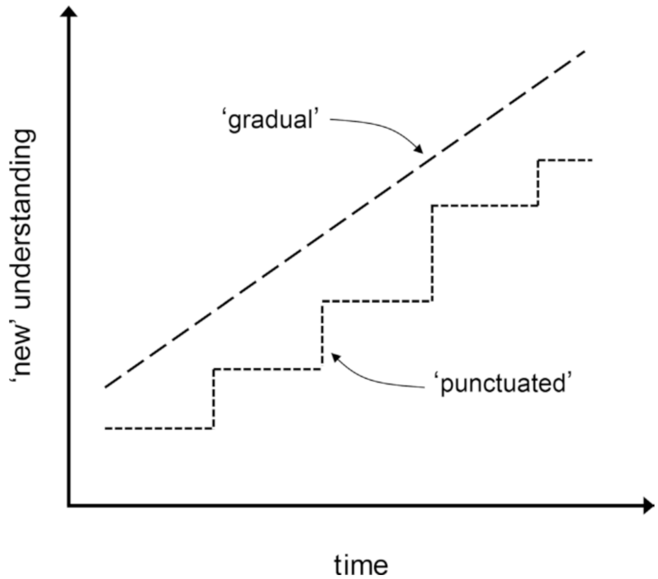

Figure 36. Patterns of learning (gradual vs. punctuated), in which long periods of conceptual stasis are punctuated by brief moments of insight

conceptualise the possibility that plateaus of stagnation and bursts of achievement might express a standard pattern for human learning.' This has been developed into a punctuated model of conceptual change by Mintzes and Quinn (2007) who have recognised the long periods of stasis that are punctuated by explosive bursts of knowledge construction. Because of the focus on conceptual change within the research literature, we know relatively little about what goes on in the minds of students during the periods of stasis. We can only speculate at the moment that at least some of the time whilst the students are experiencing conceptual stasis, students are acquiring information that may contribute to an emerging knowledge structure.

Mintzes and Quinn (2007: 303) have identified a number of characteristics of a curriculum that acknowledges the role of punctuated learning:

1. It would be founded on the principle that significant strides in learning are highly individualistic and idiosyncratic.
2. It would acknowledge significant differences among students in the structure of their prior knowledge.
3. It might offer different benchmarks for different students.
4. It would emphasize meaningful learning, knowledge re-structuring and conceptual understanding rather than 'covering material'.
5. It would emphasize formative and diagnostic assessment rather than evaluation of student performance at pre-determined times for the purposes of 'accountability'.

A number of these ideas have been explored in the literature, but usually in isolation. In order for these factors to be researched effectively in an ecologically valid environment, they need to be considered as interrelated factors which offer a combined curriculum view.

IN CONCLUSION

The ideas of threshold concepts, semantic gravity and punctuated learning combine to reinforce each other and to inform the knowledge structures approach that enables us to visualise the development of the expert student (Figure 3). Some parts of a student's knowledge structure are more important than others and it is crucial that these are identified within the curriculum so they may receive appropriate attention. Rather than seeing the theoretical perspectives explored here as isolated, the knowledge structures perspective employs them as complementary in the way that can inform the emerging adaptive expertise of university teachers and a basis for academic faculty development – explored further in Chapter 8.

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CHAPTER 7

IMPLICATIONS FOR STUDENT FEEDBACK

Changing the Game

INTRODUCTION

Student feedback is currently at the fore-front of higher education discourse, with students apparently less satisfied with feedback than with most other aspects of the student learning experience (Evans, 2013). In this chapter I will not attempt to review the extensive literature on this topic, but only to consider key aspects that relate to the knowledge structures approach that is the focus of this book. In this context feedback is seen as a vital link between the theory that supports teaching (Chapter 6) and the focus of development of academics in dialogue with their students (Chapter 8). Many authors writing in the specialist feedback literature, as well as those appearing in the disciplinary literature, are keen to emphasise the importance of feedback and to provide tips on enhancing processes of feedback delivery (e.g. Clynes & Rafferty, 2008; Koh, 2008, 2010). These studies consider various attributes of feedback that may contribute to its effectiveness (timing, frequency, positive/negative voice etc.). However, they do not consider the relationship between the structure of the feedback given and its context-dependency with the knowledge structure of the discipline upon which the feedback is focussed – particularly in terms of semantic gravity (Maton, 2009). This chapter considers feedback in a way that may help to integrate the process of feedback into the curriculum, to increase its effectiveness by aligning feedback initiatives to a knowledge-structures perspective of teaching and learning.

STUDENT CONCEPTIONS OF FEEDBACK

The literature on assessment and feedback appears in many ways to be separate from the literature on teaching. For example, the analysis of feedback effectiveness does not seem to acknowledge the environmental range in which feedback may be delivered. So students faced with a teacher who demonstrates a 'knowledge transmission' conception of teaching, in which the emphasis is on imparting information, may benefit from a different mode of feedback from those students faced with a teacher who adopts a 'learning facilitation' conception of teaching where the emphasis may be on knowledge creation. Considering feedback theoretically, in the absence of contextual factors, would seem to have limited potential utility for the student.

In complex learning environments students do not always recognise feedback when it is offered. In the minds of many students feedback is synonymous with written feedback on formal assessments rather than anything else. Informal and verbal feedback if often lost in the noise of the classroom. McLean et al. (2015) have focussed on students' conceptions of feedback and the ways in which these views overlap with student and teacher conceptions of teaching. These authors have identified four qualitatively different experiences of feedback:

1. *Feedback as telling*, in which the uni-directional transmission of 'correct' answers puts emphasis on a single, expert voice. This view of feedback assumes a passive role for the student in which dialogue does not contribute to understanding.
2. *Feedback as guiding* in which the students are being pointed in the right direction so that they may learn by applying knowledge to practice. In such instances students may start to think about feedback to help them work out the answer.
3. *Feedback as developing understanding* which requires students to be more active, using feedback as a tool in the construction or adjustment of knowledge structures.
4. *Feedback as opening up a different perspective* in which it deliberately introduces different views and requires students to be actively engaged in interpreting and evaluating knowledge. McLean et al. (2015) recognise a strong resemblance here with the perspective of Marton et al. (1993) of learning as seeing something in a different way. This, in turn, resonates with the idea of acquiring threshold concepts.

The first two conceptions of feedback are largely passive and uni-directional, moving students towards an agreed, and possibly fixed, knowledge structure. The last two conceptions of feedback require more active student engagement and tend towards the construction of personal knowledge structures. The increased levels of metacognition that are implicit in the last two perspectives encourage a better fit with the development of adaptive expertise and the emergence of the expert student. The analysis by McLean et al. (2015) stops short of considering the relationships between the four perspectives, how they may fit into different points of a student learning cycle (Figure 35) or contribute to the development of complementary knowledge structures (Figure 28). This is research that still needs to be developed, though we can anticipate that each perspective has a role to offer. Feedback 'as telling' is valuable where comment is needed immediately on procedures, for example where issues of safety may be important (e.g. 'don't touch the live wire!', or 'don't give this patient aspirin'.). Feedback as 'opening up different perspectives' may take longer to process and influence practice, requiring a period of reflection (e.g. 'is that the only way to teach Physics?', or 'how would the cold war have played out differently if JFK had not been assassinated?').

FEEDBACK WITHIN A KNOWLEDGE STRUCTURE

The knowledge structures perspective of learning and teaching lays emphasis on the ways in which ideas are linked – recognising the differences between the linear (practical) knowledge that is acquired through experience, and the theoretical (hierarchical) knowledge that is more conceptual in nature (e.g. Kinchin, 2013). Feedback needs to be considered as part of this perspective rather than as an adjunct to it. This is touched on by Nicol (2013: 36):

> As well as identifying the need for local repairs in the assignment at hand, ideally students would also need to create some permanent revisions to their knowledge networks that can be brought to bear when they are asked to tackle a new but similar assignment in the future. The latter is necessary if learning is to be transferred to new contexts.

This can be viewed from a knowledge structures perspective in which the immediate, context-bound comments about factual inaccuracies and expressive errors can be viewed as the linear/procedural components of feedback, whilst the more profound, general comments about theoretical weaknesses can be viewed as the networked/conceptual components of feedback. Therefore, if feedback is to serve the function of progressively enabling students to better monitor, evaluate and regulate their own learning independently of their teachers (as suggested by Nicol & Macfarlane-Dick, 2006), then students must learn to navigate between the linear/procedural and the networked/conceptual (Kinchin & Cabot, 2010). As this process is repeated over time, students will negotiate the 'semantic wave' described by Maton (2013). If this process is integral to the student's progress through the curriculum, then it is also important for the process of feedback to replicate this pattern so that it is seen as an activity '*to permeate the curriculum rather than an activity that appears within it from time to time*' (Molloy & Boud, 2013: 25).

Molloy and Boud (2013; 30) are critical of formulaic processes in which they see students and teachers as complicit in participation of transmissive rituals that have been observed within higher education, and have been cited by Kinchin, Lygo-Baker and Hay (2008) as contributing to cycles of non-learning. Where feedback is seen as ineffective, there seems little point in simply repeating the same practices with greater frequency or intensity – the process needs to be reconceptualised at a more fundamental level.

SEMANTIC PROFILES

This perspective on feedback is enhanced by consideration of work by Maton (2013) which adds the dimension of time by considering understanding as being generated by a series of waves as the learner navigates a path through cycles of learning. Maton refers to the concepts of semantic gravity and semantic density (as discussed in Chapter 6).

When changes in semantic profile (Gravity and Density) are presented as a time curve, a semantic wave is made visible as the learner oscillates between peaks and troughs (Figure 37). This oscillation resonates strongly with the structural transformations between chains of practice (SD–, SG+) and networks of understanding (SD+, SG–) observed by Kinchin and Cabot (2010). As the learner moves from a chain of practice to a network of understanding s/he has to move from a concrete example to a more abstract idea. When considering the effectiveness of feedback we need to think about how feedback comments reflect movements between knowledge structures and along the semantic wave. This is considered here in terms of feedback on teaching as well as feedback on learning – again, two linked ideas that are not often connected in the literature.

FEEDBACK ON TEACHING

Many of the barriers to effective feedback given to learners are heightened when feedback is given to teachers on the quality of their classroom 'performance', and reflections on practice are often preceded by comments about lack of training, time and incentives that impede engagement and change (e.g. Brownell & Tanner, 2012). Despite what Gormally et al. (2014) have described as '*heroic dissemination of evidence-based teaching practices and their documented improvement on student learning*', many faculty members are reluctant to adopt new practices or to 'come out' as teachers (Brownell & Tanner, 2012). And yet Gormally et al. (2014: 188) argue that '*providing faculty with formative teaching feedback may be the single most under-appreciated factor in enhancing education reform efforts*'.

Feedback on teaching might be from the observable and practical acts of teaching in a particular context (including developing outcomes, classroom strategies and assessment techniques), to the more conceptual elements that underpin those acts (Figure 27), including less tangible concepts such as 'theories', 'values' and 'beliefs'. The transformatory oscillations between knowledge structures (Kinchin & Miller, 2012) would then appear to offer a direct parallel to the formation of a semantic wave (Maton, 2013). As learners are required to 'unpack' meanings as they move from technical terms to everyday meanings, the visualisation of the structure of knowledge by concept mapping (Novak, 2010) offers a practical tool to support this.

Without this oscillation between structures (Kinchin & Cabot, 2010), and hence between segmental and cumulative learning (Maton, 2009), teaching is likely to develop through exclusively context-specific segmental learning as a 'tips-for-teachers' approach, working entirely in areas of high semantic gravity (SG+) and low semantic density (SD–) that would consequently lack academic rigor and avoid engagement with the underpinning pedagogy (Kinchin, 2013). Participants might initially favour a programme that allows them to privilege and protect the more practical outcomes that might be seen to offer immediate practical utility that are closely aligned to a particular professional identity (e.g. Green & Little, 2013). However, such a programme would not prepare academics for a career in an evolving teaching environment by developing adaptive expertise or give them the tools to actively contribute to the direction of its evolution (i.e. it would exclude them from the 'powerful knowledge' of the profession as described by Wheelahan, 2010). Other implications for teacher development are explored more fully in Chapter 8.

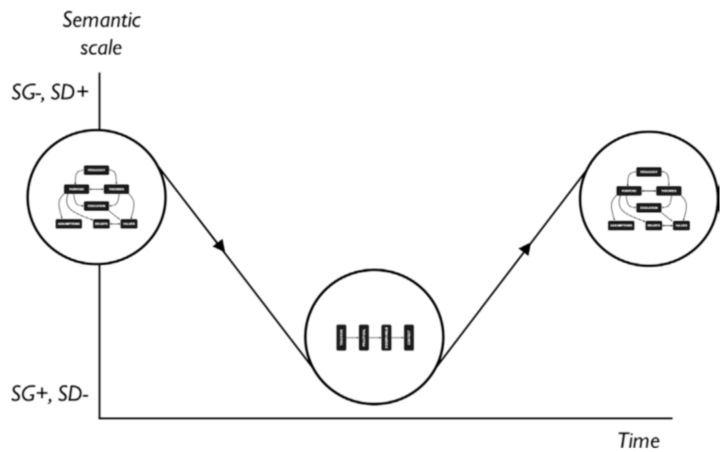

Figure 37. A semantic wave to indicate the structural implications of moving up and down the semantic scale over time and the resulting oscillations between networks of understanding at the peaks, and chains of practice in the troughs (details of the concept maps within this figure can be seen in Figure 27)

FEEDBACK ON LEARNING

When considering feedback in undergraduate learning, the distinction between feedback on formative and summative assessments is often centre-stage, with encouragement for academics to insert more formative assessments in their teaching even though this may seem counter-intuitive to the strategic student who wants to invest time and energy in high-reward activities represented by summative assessments. Formative assessment, defined as information communicated to the learner that is intended to modify thinking or behaviour to improve learning (Shute, 2008), then also has a role in helping to cultivate the appropriate gaze amongst students so they may be able to master semantic gravity. Maton (2014: 123) sees this as the key for successful meaningful learning:

> A growing number of studies are showing that the key to academic achievement in many subjects lies neither with stronger nor with weaker semantic gravity, but with extending the range of movements between them….These movements in semantic gravity provide a necessary (though not sufficient) condition for the decontextualization and recontextualization of knowledge and thus the possibility of cumulative knowledge-building and learning.

Figure 38 depicts three semantic profiles. A1 represents a *high sematic flatline* which is indicative of teaching that is context-independent and features high conceptual condensation (i.e. lots of theory, but no opportunity to operationalise this in practice). A2 represents a *low semantic flatline* which is indicative of teaching

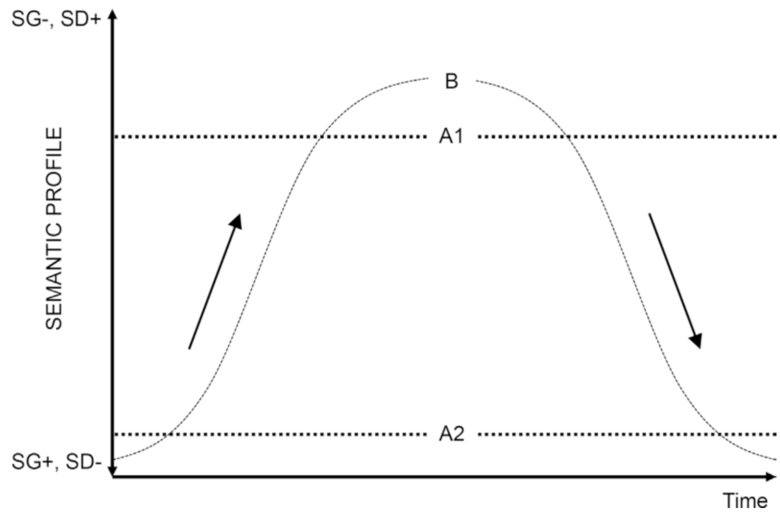

Figure 38. Three semantic profiles (Redrawn from Maton, 2014)

that is context-dependent and descriptive, but with little theoretical underpinning. In contrast to these, B represents a semantic wave in which the upward arrow represents the abstraction of organising principles into a condensed language that rises above the concrete particulars of a given context. In contrast the downward arrow represents the fleshing out of theory into concrete examples. This could be seen as the packing and unpacking of the subject.

The distance between A1 and A2 could be seen to represent the theory-practice gap across which students are required to operate within many disciplines, with theory having low semantic gravity and practice having high semantic gravity. Whilst teaching needs to allow students to operate across the semantic plane, feedback also has a role in supporting this movement. Feedback that reproduces information from teaching examples or re-words or re-structures input into a clearer form tends towards a stronger semantic gravity. Feedback that introduces general principles or generalizations about concepts or events tends towards a weaker semantic gravity. By modelling these movements in student feedback, comments will draw the student gaze across the theory-practice gap and help them to navigate the semantic wave. This is a highly significant point as '*The theory-practice gap is arguably the most important issue in professional practice today, given that it challenges the concept of research-based practice*' (Scully, 2011: 94).

FEEDBACK AND THRESHOLD CONCEPTS

Powerful knowledge is a product of learning described variously as deep (Marton & Säljö, 1976), meaningful (Ausubel, 2000; Novak, 2010) and cumulative

(Bernstein, 2000; Maton, 2009), in order to generate qualitatively rich understanding that is in turn related to appropriate practice knowledge (Kinchin & Cabot, 2010) – see Chapter 5. Maton (2013) described a universal desire for the construction of this type of knowledge that aims to generate ideas that have utility beyond the specifics of their originating contexts. Characteristics of teaching that will support this learning have been specified by Biggs (2003: 17), including:

- Make the structure of the subject explicit
- Encourage the active participation of students
- Build on what the students already know
- Assess for structure rather than independent facts

This resonates with Land and Meyer (2010: 76) whose 'desiderata' for a manifesto for change in assessment practices includes '*seeking new modes of mapping, representing and forming estimations of students*' *conceptual formation in all modes of liminality*' and not just 'before and after' teaching. Sadler (1983: 74) has argued that processes of delivering iterative feedback are largely lacking, and that '*students should be given an opportunity and incentives to rework and resubmit papers, with continuous rather than single-shot access to evaluative feedback during the reworking*'. The dialogue that can be supported during this interaction is important to help students develop new conceptual understandings (Orsmond et al., 2013).

Feedback on minor contextual or procedural matters of learning might be less crucial than feedback on issues that relate directly to students' acquisition of threshold concepts. If the threshold concepts of a discipline are not acquired, then the disciplinary structure into which other aspects of the subject should fit will not develop appropriately. In the absence of a structure into which the feedback is supposed to contribute, the feedback is likely to appear as a collection of isolated anecdotes about disconnected facts and figures. And yet the literature on assessment and feedback has paid little attention to the issue of feedback on emerging threshold concepts. Walker (2013) has considered the synergies that exist between schema theories of learning and threshold concepts. Assuming that an academic's knowledge will be different in structure to that of the students, Walker offers three ways that these differences can be imagined (Figure 39).

In considering 'incompatibilities', Walker (2013: 258) states that not only is the knowledge incompatible between the academic and the student, but the perception of the learning situation is also incompatible so that feedback is likely to misinterpreted by students. In such cases, it is suggested that the threshold concept will be inaccessible and the student will become 'stuck' at this point in the curriculum without necessarily understanding why – other than '*it's hard!*'. Unless the situation is understood by the parties concerned, it is likely that at this point the student will retreat into a non-learning approach in which conceptual development will be arrested. However, where student and academic knowledges are different but compatible the threshold concept can be made accessible to the student by relating

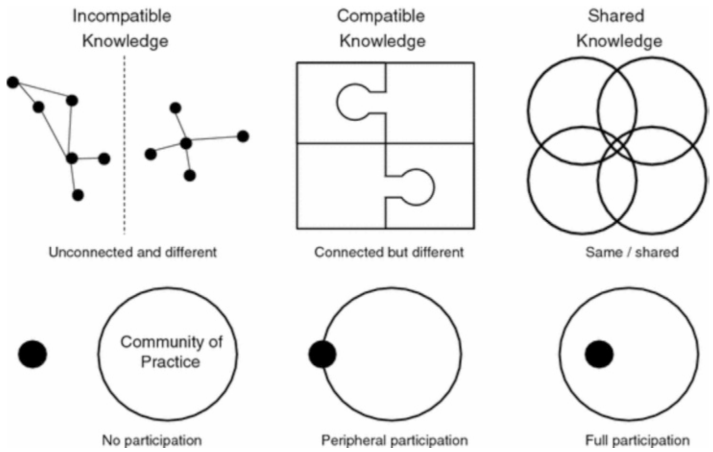

Figure 39. Shared and compatible concepts (From Walker, 2013)

it to appropriate prior knowledge and exploring any contextual familiarity that the student brings with them. Where student and academic's knowledge is shared then the perceptions of the stakeholders is likely to be aligned in a manner that facilitates participation and productive dialogue within a community of practice.

This raises questions about the relationship between the values underpinning the teaching, being aligned with the nature of feedback supplied and the complexity of the *work being* undertaken by the students. Is there a relationship between speed and complexity such that assessments requiring higher order thinking skills (evaluating, synthesising, theorising etc.) within a knowledge creation paradigm should receive feedback more slowly, whilst assessments that require simple factual recall within a students-as-consumers paradigm benefit from quick feedback? We also need to consider the 'distance' that students need to travel in order to gain the new insights that are being triggered through the content being presented. The literature says very little about this issue. An exception is the following comment by Hoffman et al. (2014: 39):

> In the literature on the learning of simple tasks, it was sometimes assumed that feedback is best when provided close in time to performance, but this is not necessarily the case. While immediate feedback may improve performance in the near term, it can also have the opposite effect on long-term performance. When learning a skill that is knowledge or reasoning-intensive, the learner benefits from having time to think back on their poor performance and cogitate on what was done right, what was done wrong, and what might be done differently in the future. Immediate outcome feedback can prevent such post-task metacognitive skills.

The speed that feedback is offered may, therefore, have implications for the way in which students react to it. If students do not have time sufficient to reflect upon their work, external commentary may not be well-received, or may be ignored.

RECIPIENCE

A few years ago, a colleague spoke to me of her frustration caused by marking and giving written feedback. After having spent several days marking over 100 essays and providing a page of written feedback on each, she was upset that only half of the students had bothered to collect their feedback sheets. Having received their grades electronically, collection of further critique (offering insights to how to improve their grade next time) was simply not on the student agenda. Her embittered conclusion was that '*if students don't want it, I won't waste my time writing it*'. This lack of a culture of 'recipience' is not unique to this one individual and other colleagues have moaned about student demanding feedback, but not really wanting to engage with it. Winstone et al. (2016) have explored the issue of recipience (Figure 40) and have identified a number of barriers:

1. Students have a poor awareness of what feedback means and what it is for. If students are not aware of the meaning of feedback and cannot 'decode' the academic language that is embedded in feedback then it rapidly becomes a useless exercise. I recall one master's level student a few years ago who, after a year of receiving feedback on her assignments, said to me, 'I have never really understood what you mean when you write things like "you need to be more critical in your analysis". Clearly all my 'well-considered' comments had been fairly meaningless to this particular student. The value of comments given also depends on the students 'mental models' of feedback and why they think teachers are providing it at all.
2. Students need to understand (be cognisant of) behaviours and strategies they could use to engage with feedback (such as proof reading each other's essays), and the opportunities that may exist for seeking further support, such as surgeries and drop-in sessions.
3. Students may feel disempowered when they have had prior experience of unsuccessfully implementing feedback and see little point in addressing the feedback given in one assessment for the next assessment that may be perceived as unconnected. This can also be related to the difficulties students have in translating the feedback into concrete action.
4. Students need to be ready to engage with feedback in order to make the most effective use of it. Where students lack the volition to scrutinise feedback, they may develop a more reactionary and defensive approach to comments made, in which the 'commitment to change' and develop their understanding does not register within the dialogue. The feedback is only related to learning that has already happened rather than to learning that is about to happen. Feedback and teaching then become two opposing rather than complementary activities.

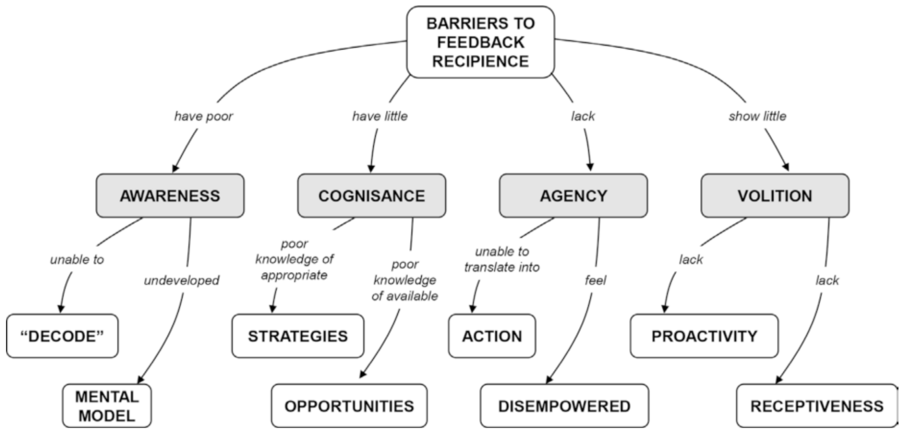

Figure 40. Four psychological processes that lead to a lack of feedback recipience (Based on Winstone et al., 2016)

Recipience to feedback is likely to be increased when students appreciate where the assignment under scrutiny fits into the wider structure of the subject. If feedback is not situated, then students will be discouraged from developing their proactivity and receptivity as they cannot see where this would take them. To expect students to be proactive in navigating a route in the absence of any direction or notion of where it might lead them may present an unrealistic expectation. Additionally, students benefit from feedback preparation activities that acknowledge the importance of students' emotions in formal feedback situations and may help to reduce student anxiety about the process (Värlander, 2008).

Winstone et al. (2016: 9) comment on the problems that stem from the modular arrangement of many degree courses where content and assignments in neighbouring modules are perceived by the students to be unrelated. This provides an additional barrier to engagement. In such instances the route through the module has already been navigated and so feedback on summative assessments may appear to the student as unnecessary.

IN CONCLUSION

As pointed out by Handley et al. (2011: 543), '*'Doing time' by complying with the norm of collecting, but then only skim-reading, feedback is a long way from the 'mindful' engagement associated with reflection, interpretation, deepening understanding and changes in later behaviour*'. Those authors argue that the literature's focus on feedback attributes that has attempted to isolate variables has been misplaced. This misdirection of effort has resulted in the relative neglect of student engagement with feedback. However, in exploring the idea of '*readiness-to-engage*', Handley et al. (2011) have not considered the engagement with feedback to be part of the students' wider engagement with the disciplinary structure. This absence of structural appreciation is likely to reduce the potential for engagement as the students will not be able to locate the teachers' comments within the wider structure of the discipline. They need to know where this assessment fits in the map of the discipline and where this feedback will be directing them next. The notion of self-regulation (e.g. Williamson, 2015) is a difficult one to enact without adequate location in the disciplinary structure. Without a map of the disciplinary terrain, it will be difficult to generate a concept of active recipience among students.

In practical terms, generating sufficient capacity for widespread dialogic feedback probably requires greater investment in peer feedback (Nicol, 2010; Sadler, 2010). Rather than seeing this as a compromise, it better reflects the trend towards student-centredness in teaching and will help to align teaching and feedback processes. Parallel discussions about terminology ('feedback', 'feed-forward', 'peer-review' etc.) have also been a distraction from the evolution of effective learning dialogues, whether between peers or between teachers and students. The 'backwards' or 'forward' obsessions have maintained a linear view of the dialogue which aligns with dominant views of 'competence', but is at odds with the development of expertise and creativity that would be the products of powerful knowledge.

It is clear that we need to be able to discriminate between conceptions of feedback and how they relate to learning in terms of temporal sequencing along semantic waves, and structural compatibility with procedural and conceptual knowledge. The optimization of feedback cannot, therefore, be seen as a generic issue where a single feedback protocol will offer common utility across diverse curricula. Whilst there may be some sensible underpinning principles, the approach has to be context-sensitive.

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CHAPTER 8

REPOSITIONING ACADEMIC/FACULTY DEVELOPMENT OF UNIVERSITY TEACHERS

Adaptive Expertise, Pedagogic Frailty, and Exaptation

INTRODUCTION

Until relatively recently, the idea of systematic and formalized professional development for university teachers would have been unheard of. The accepted qualification for becoming a teacher at university was an expert-level knowledge of the content, demonstrated by possession of a degree, and preferably a PhD in an appropriate subject. However, in an evolving university context that has developed from an elite system to become a mass market system in the past few decades, that view is no longer fit for purpose. It is recognized that a PhD is not a teaching qualification, and many of us will remember from our own undergraduate days, academics that were very clever, but apparently unable to connect with their student audience or to adequately explain the subject.

Academic professional development was introduced to induct new entrants to the profession into the discourse of teaching (e.g. Gosling, 2009). Typically this was through generic courses that took participants through the major concepts of higher education theory (Kandlbinder & Peseta, 2009). This generally included ideas considered core to current practice in university teaching including reflective practice (Schön, 1983), constructive alignment (Biggs, 1996), and deep and surface learning (Marton & Säljö, 1976). However, academic development programmes have not always made appropriate connections with participants, sometimes failing to link with their subject knowledge and research orientation of academics on one hand, whilst academics, expecting to receive 'tips for teachers', seemed to fail to grasp the relevance of anything beyond their immediate practical needs in the class room on the other hand (e.g. Cameron, 2003). The 'scholarship of teaching', appeared as little more than an aspiration for many, and has therefore been a 'hard sell' in a number of instances (Boshier, 2009). Academic development has evolved since its introduction, becoming increasingly scholarly, professional and discipline-sensitive over the years (Gibbs, 2013), with a number of identifiable factors being shown to elicit positive responses from participants (Steinert et al., 2006).

Generic workshops that failed to connect with the academic audience were likely to result in surface learning about teaching (Rowland, 2001) where academic engagement with the programme may have been seen as non-agentic and this could reinforce the naive notion that teaching was a purely practical activity that did not require a scholarly approach. Support for academic development among senior academics was often even harder to obtain. Many long-serving teachers (many, but not all, of which are excellent classroom practitioners) tend to become routinized experts when it comes to teaching, '*learning merely to perform their teaching skills faster and more accurately, without constructing or enriching their conceptual knowledge*' (Crawford et al., 2005: 5). Encouraged by an increasingly consumerist higher education agenda, these colleagues typically value efficiency over innovation in order to release more time for the high stakes activities of research that offer greater reward and prestige (Young, 2006; Cretchley et al., 2014). Such a routinized view of teaching may achieve a level of success within a stable university environment. However, universities have undergone considerable change in the past thirty to forty years (a situation that shows no sign of settling down), and in such an unstable environment there is a danger that routines that once worked well eventually become obsolete. Established routines of traditional university teaching have therefore been challenged, to move away from the '*stand-and-deliver lectures by god-Professors that would make Friere weep with despair*' (Hay, 2015: 1), to more creative and engaging forms of teaching.

ADAPTIVE EXPERTISE

Bohle Carbonell et al. (2014: 26) have commented on how '*The frequent changes in the current work environment driven by task and knowledge volatility calls for experts who possess the required domain expertise and can quickly overcome changes. Such experts are known as possessing adaptive expertise*'. Whilst it clearly makes sense to have experts teaching within universities, some attributes of expertise can create problems within the teaching arena. Many experts find it difficult to remember the novice state of mind to pitch their teaching at the appropriate level (Fontaine, 2002), and process information and solve problems so quickly that their actions are not visible to students who are trying to emulate their expertise. Gauder and Jenkins (2012) have found that when undergraduates visualize a problem using concept maps, it can offer insights into how students view information sources and connections in ways that experts do not see. Access to these perspectives can be a useful route into teacher-student dialogue.

Academics tend to separate teaching and research in their minds so that the expert thinking that is evident in their research is not always seen as part of the teaching discourse (Kinchin, Hatzipanagos, & Turner, 2009). With disciplinary experts not always applying their notions of personal learning through their research to their students learning in the classroom, it can be difficult for students to develop the skill of thinking in the same ways that experts do (Sternberg, 2003). In order for novice university teachers to become adaptive experts it is clear that '*teacher educators [academic developers] must learn how to leverage discourse to promote development of adaptive teaching expertise*' (Soslau, 2012: 768), so that we may at least help guide students to '*learn like experts*' (Klein, 1998: 104). We must also acknowledge this will take time and effort.

Salmon and Kelly (2015) offer a very clear explanation of how adaptive expertise can be developed among teachers by using concept mapping. However, active engagement in the mapping process is essential for it to have any value. Simply producing a map as a one-off exercise would be akin to surface learning about teaching (Rowland, 2001). As Salmon and Kelly (2015: 59) point out, "*active monitoring, reflection and revision of the concept map in relation to practice, is an essential component*." These map revisions are aimed at increasing the conceptual coherence of the map, developing from simple spokes and chains towards more complex networks that exhibit greater explanatory power (Kinchin, Hay, & Adams, 2000). Salmon and Kelly (2015: 134) consider '*the generative nature of the network structure [to be] one of the characteristics that aligns with the knowledge bases and thinking of adaptive experts*.'

PEDAGOGIC FRAILTY

To add conceptual coherence to reflections on teaching and to maintain a simultaneous focus on key elements of the teaching ecology, Kinchin (2015) has introduced the concept of pedagogic frailty. There are concepts from other disciplines that can sometimes be helpful in making useful analogies in the field of educational research – to help illustrate and develop emerging ideas within education. Just such a concept that has gained recognition in the medical care of the elderly in recent years is that of 'frailty' (e.g. Heuberger, 2011; Xue, 2011; Zaslavsky et al., 2012). There is currently no internationally agreed definition for this concept, but a consensus view is emerging in which frailty is considered to develop as a consequence of a decline in a range of factors which collectively results in an increased vulnerability to sudden adverse actions triggered by relatively minor stressor events (Clegg & Young, 2011). As an analogy, some of the characteristics and definitions of clinical frailty that have been proposed in the literature have powerful resonance with difficulties that academics experience when trying to grapple with the scholarship of teaching – such as inability to integrate responses to change in the face of stress (Rockwood et al., 1994); loss of adaptive capacity due to loss of complexity (Lipsitz, 2002); 'wear and tear' that results over time by efforts to adapt to change and persistent stressors (Seeman et al., 2002). So in the context of higher education, one might observe a concept of *pedagogic frailty* when hassled colleagues find the cumulative pressures of academia (persistent stressors) eventually inhibit their capacity to change and respond to an evolving teaching environment, leading them to adopt what they consider a 'safe' and sustainable pedagogic approach (Canning, 2007). This can result in the convergence of teaching around traditional practices that seem contradict contemporary research findings. There may be a combination of personal and institutional factors that may lead towards pedagogic frailty. This is summarised in Figure 41, showing degeneration in the 'components level' from a rich network to a relatively impoverished chain structure. Simultaneously, behavioural levels move from a rich and varied repertoire to a more stable and less innovative regime that corresponds to a transition from 'scholarly' to 'frail'. That is not to say that the 'frail' profile cannot be efficient, but increased efficiency (i.e. routinization) comes at the expense of reduced variety and reduced adaptive expertise.

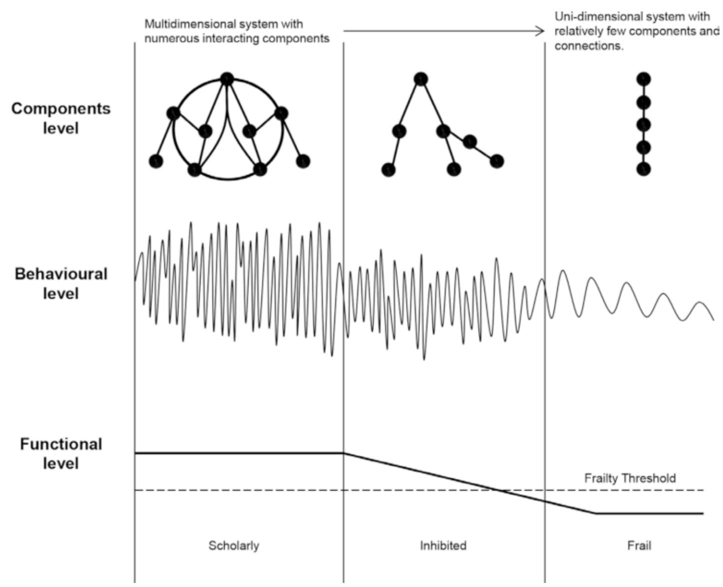

Figure 41. Dimensions of frailty (an interpretation developed from Lipsitz, 2002; Sleimen-Malkoun et al., 2014)

When there is convergence on a traditional view of teaching in which the transmission of content is seen to dominate, a linear view of teaching persists and makes the evolution of practice more difficult. As Salmon and Kelly (2015: 128) point out, "*a chain structure presents more constraints than opportunities for new thinking*". Linear models of teaching do not invite reflective practice and leave no room for academic/faculty development (Kinchin, 2011). In addition, the adoption of innovative technologies into such a restrictive model means that any transformative potential is often corrupted to perform utilitarian tasks, maintaining the *status quo* of non-learning (Kinchin, 2012), described as the domestication of technology (Salomon, 2002). Within such an environment, it is not difficult to see why colleagues may find the idea of the 'scholarship of teaching' to feel like an unhelpful distraction from their daily tasks (e.g. Boshier, 2009).

New academics who may have their horizons broadened through introduction to a variety of research into teaching and learning (e.g. Kandlbinder & Peseta, 2009) may succumb to the conventional wisdom of the dominant group.

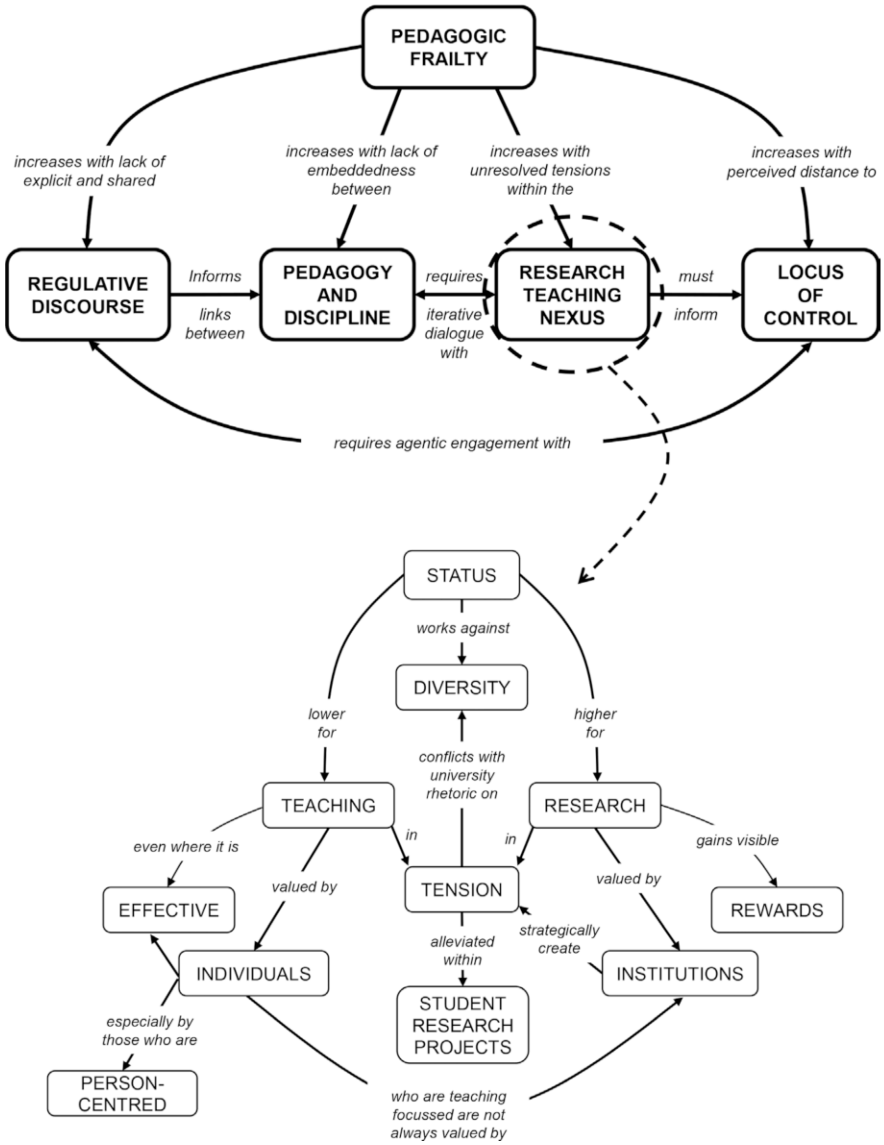

Figure 42. Dimensions of pedagogic frailty with (inset below) one academic's view of the elements within the research-teaching nexus dimension. (After Kinchin et al., 2016)

Where this 'wisdom' is seen as counter-productive (supressing innovation and change), it has been referred using the colourful acronym, COWDUNG by Waddington (1977). This may result in the erosion of new academics' emerging dynamic and progressive teaching frameworks by the stresses of the job and the indifference (or active negativity) of jaded senior colleagues. This allows academics to settle into a comfortable cycle of non-learning (Kinchin, Lygo-Baker, & Hay, 2008), with the aim of giving them more time to focus on their research activities. In turn, this leaves the institution open to a state of pedagogic frailty. This frailty will result in institutions having a limited repertoire of responses to demands of the teaching and learning environment, such as the impotence of universities to address students' on-going dissatisfaction with assessment feedback practices (Evans, 2013). The institutional response to student complaints about the quality of feedback has been typically 'just do more and do it faster', as if increasing the dosage of an inappropriate medicine will eventually become a cure for the underlying ailment.

The overall model proposed for pedagogic frailty (see Figure 42) summarizes connections between the key dimensions: the lack of an explicit regulative discourse to promote a shared values literacy; a perceived separation of pedagogy and discipline; the tension caused by the asymmetry between teaching and research; and the distance between teaching practice and the locus of control within the university (Kinchin et al., 2016). We need to be clear that pedagogic frailty is not considered to be an internal quality or capacity of an individual. Indeed, such a personal characterization would be unhelpful in promoting openness to support academic development. Rather, pedagogic frailty results from the quality and degree of interaction within and between aspects of the professional environment (Kinchin et al., 2016). When considering the impact of frailty, it may be viewed at different levels of resolution, from the individual, to the departmental and the institutional. In extreme cases it will lead to the maintenance of conservative methods of teaching (e.g. Bailey, 2014) even where these can be seen to be less than ideal. The organisation of elements within the major dimensions is a crucial factor in promoting adaptive expertise within the overall profile, where chains will be found to be inhibiting interactions and promoting frailty. The organisation of the structures within the four main dimensions can be explored through academics' concept maps that reveal much about colleagues' perceptions of teaching.

SEPARATION OF INSTITUTIONAL AND INDIVIDUAL GOALS

Academic life is generally full of tensions and compromises. The author of the map in Figure 43 has emphasised the importance of a number of oppositional binaries, with a focus on the tensions between the institution and the individual, and the tension between teaching and research. The potential clash between the values system expressed by an institution (for example through investment in staff development) is seen to be something that is not always reflected in the indicators of a successful career in academia (seen to be measured through the traditional markers of publication and funding). The question is then raised whether the intellectual curiosity that might encourage someone to embark upon a career in academia remains an asset in career development, or if it is in tension with the expectations of the university? The outputs generated through the production of an MA dissertation (as indicated in the map) might be seen as one way of straddling this apparent divide. This map emphasises the difficult choices that academics have to make when considering whether or not to make an investment in time to studying for an MA in Higher Education as a route for their professional development; taking their career more towards the teaching perspective than the research perspective, where an additional publication or grant application may be seen as more valuable.

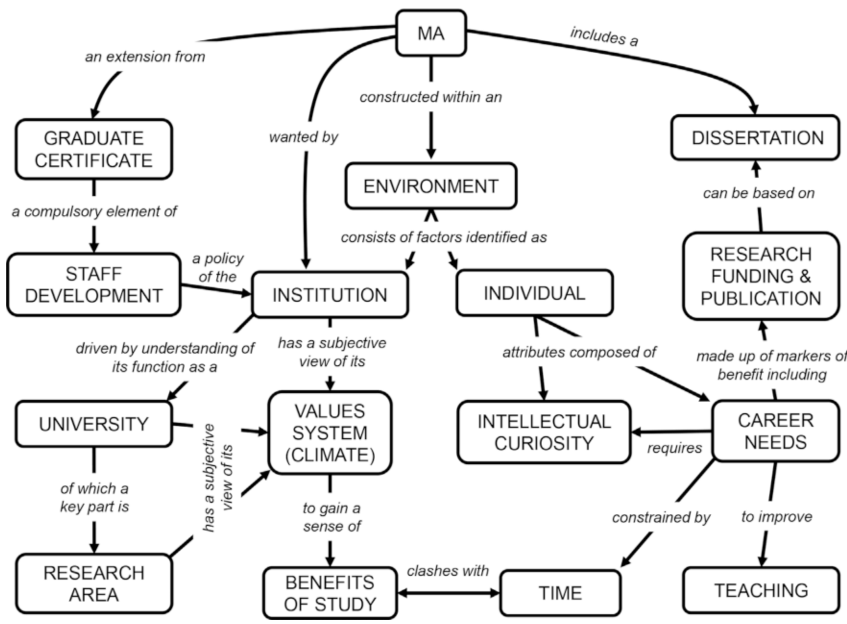

Figure 43. Map showing an academic's personal perspective on the conflict between institutional and individual goals (After Kinchin et al., 2015)

There can also be a tension between an academic's aspirational view of their discipline and the teaching as practiced within the practical constraints of a university. The two main clusters of concepts within Figure 44 (the section to the left starting with 'pedagogy' and the chain to the right starting with 'professionalism'), indicate a structural divide that suggests a conceptual component and a procedural component that also reflects a difference in semantic gravity. The pedagogy section that considers 'fundamental principles' indicates a low semantic gravity (*sensu* Maton, 2014), whilst the professionalism chain indicates a high semantic gravity (a close link to practice). The challenge for teacher development programmes is to build a bridge between these opposing elements that provides an indicator of expertise (Kinchin & Cabot, 2010).

It is important to note that the amount of space afforded to a certain idea within a concept map may not always indicate the degree of significance to the author. It is possible that the author is unsure of the vocabulary to express their thoughts about a certain point, and this is why it is always preferable to discuss the meaning of the map with the author to further probe their understanding. In the case of Figure 44, the small cycle at the top left of the map (between pedagogy and discipline) is of great significance to the author of this map who explained that for them the pedagogy of the discipline needed to be embedded in the discipline rather than being perceived as an external construct that was imposed on the discipline from the outside. Indeed, the links between pedagogy and discipline provoked more discussion than the rest of the map.

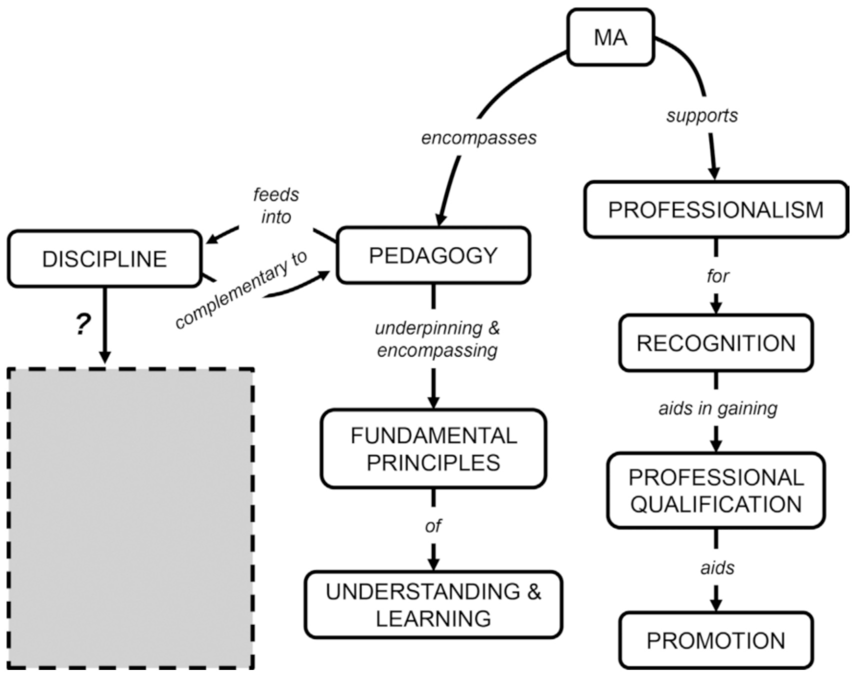

Figure 44. Map showing a n academic's perceptions of the link between discipline and pedagogy within an MA in Higher Education. (After Kinchin et al., 2015). Here the structure of the discipline (bottom left) has been left blank as an invitation to the reader to insert their own disciplinary knowledge structure

The map author saw this as a major obstacle in getting academics to see teaching as an integral part of their role within the university, rather than something that is in conflict with their role as researchers. This view resonates strongly with the position outlined by DiCarlo (2006) when he stated that '*biology should be taught* *as science is practised*', and also with the study by Aydeniz and Hodge (2011) who found that the identities of a professor as a teacher or a disciplinary expert can be in tension with structural elements of the workplace that discourage the enactment of teacher identity. A similar phenomenon has been noted in the Arts where tutors report experiences of '*being in two camps with tension and separation between them*' (Shreeve, 2011: 89). Therefore, whilst the dynamic tension illustrated between 'pedagogy' and 'discipline' is framed in a very positive and mutually beneficial manner in Figure 44 (e.g. 'complementary to', 'feeds into'), if this relationship becomes more negative, it may put the enactment of the whole pedagogy network (on the left hand side of the map) under threat.

The culture of the workplace could be seen to favour 'discipline' in a manner that is detrimental to the development of reflection on the fundamentals and principles that are seen to underpin learning, with research productivity perceived to be of higher value than teaching productivity (as described by Young, 2006; reiterated recently by Alpay & Verschoor, 2014). It is exactly this sort of tension that has been seen to drive institutions towards reliance on 'non-learning outcomes' (*sensu* Kinchin, Lygo-Baker, & Hay, 2008). Procedural foci of non-learning (such as number of hours spent teaching or average results achieved by students) are easy to quantify and measure for accountability and management purposes and so may be preferred to the less tangible indicators of meaningful learning (such as the quality of student understanding or the reciprocal benefits between teaching and research). Novice university teachers have been shown to view teaching and research within the same discipline to be epistemologically separate (Kinchin et al., 2009), with conceptions of their own learning through research activity to be dominated by the discourse of cumulative learning, whilst that of the students under their guidance being dominated by the discourse of segmented learning – memorization and rote learning through repetition. Unless this issue is addressed, and the pedagogy of the discipline is recognized as being a fundamental *part of the discipline* (as described by DiCarlo, 2006), the structural separation of teaching and research is likely to persist. The author of the map in Figure 44 appears to be suggesting that if an academic is not an expert in the pedagogy of his/her discipline, they are not expert in the discipline.

Whilst academics might be able to articulate the relationship between teaching and research, or between pedagogy and discipline, it is clear that students often find the relationships between the activities of a university difficult to untangle. In an undergraduate research project that was designed to reveal research-teaching links from the student perspective (Kandiko & Kinchin, 2013), it was evident that in the absence of any sort of institutional pedagogic framework, the students uncovered a whole spectrum of academics' beliefs and activities. Cleary (2013: 19) makes the observation that universities tend to be '*self-proclaimed research-led teaching centres*', with no real way of evaluating the veracity of the claim, or even what the claim means. Whilst some academics appear to be using their students in a one-way relationship '*My PhD students are making my research … they are generating all of* *my data*.' (Cleary, 2013: 25), others see it as an increasingly reciprocal arrangement as students move from undergraduate to postgraduate studies '*I collaborate with students … they have more part to play within my research and I in theirs*' (Hall, 2013: 85); whilst others see a clear relationship between their teaching and research at all levels: '*I learn through teaching… [it] is actually quite important to me in terms of my own research*' (Abrahamsson, 2013: 94).

EXAPTATION

Concept map-mediated reflections on teaching can highlight concepts from the practitioner's own discipline that may confer a degree of pre-adaptation [or to use a more widely accepted term, exaptation] towards pedagogic change. The term exaptation was originally coined by Gould and Vrba (1982). It is used to describe instances in evolutionary biology where useful attributes '*did not arise as an adaptation for their present role, but were subsequently co-opted for their current function*' (Gould, 1991: 43). The classic example from biology is often considered to be the evolution of feathers in birds. Their original function is assumed to be for thermal insulation, with flight only evolving later, after the characteristic had been acquired. In such exaptive instances, function follows form, rather than form following function as is normally observed in adaptive evolution. The concept of exaptation has been successfully translated into social systems (e.g. Larson et al., 2013; Bonifati, 2015) and in particular to the ways in which technologies have been co-opted for uses that were not originally intended. Garud et al. (2016) consider the human capability of *inducing exaptation* as a distinction from biological evolution, as humans have the power to attribute new functionalities to elements under their control. Concept map-mediated reflections may offer a mechanism to '*sensitize us to exaptive possibilities, which in turn enhance the possibilities of capitalizing on their occurrences*' (Garud et al., 2016: 19). The dialogic concept mapping approach to visualising the elements of pedagogic frailty highlights the connections between facets of the academic role and increases the likelihood of occurrence of exaptive events. Hence, the practitioner is able to re-purpose disciplinary knowledge and apply it to social systems so that concepts may take on a new function in the field of pedagogy.

This has been observed in a number of instances where reflection upon the structure and content of a concept map can sensitize the observer to potential for exaptation. The re-purposing (or exapting) of disciplinary knowledge to forge active links with the pedagogic frailty model may offer a general route into the professional development of university teachers. The framing of narrative reflection with concept mapping is likely to draw upon the academic's personal knowledge of their discipline and may highlight disciplinary concepts that may be exapted to enhance and frame professional development. For example, the profusion of 'ecological models' in educational research (e.g. Kinchin, 2000; Keiny, 2002; Biesta & Tedder, 2006; Stelma, 2011; Priestley et al., 2015) demonstrates that in some instances, exaptation is occurring widely at the disciplinary level. Framing reflective narrative with concept maps could help provide the benefits of exaptation for professional development at the level of the individual teacher (Kinchin & Francis, 2016).

RESILIENCE

One of the concepts that has emerged repeatedly from the visualisation of pedagogic frailty is 'resilience' (Kinchin et al., 2016; Kinchin & Francis, 2016). This has arisen from disparate disciplinary origins and has been interpreted in personal ways that have owed provenance to the mappers' home disciplines. An academic from psychology summarised her view of pedagogic frailty in the map given in Figure 45, and went on to discuss her personal perspective (Kinchin et al., 2016: 18):

> If academics continually feel that they have no control over events (such as institutional change), they are likely to experience learned helplessness (Seligman, 1975). It is resilience that supports individuals in remaining optimistic, rather than helpless, as an outcome of events (Seligman, 2011). Resilience, defined as "The capacity of individuals to cope successfully with significant change, adversity or risk" (Lee & Cranford, 2008, p. 213), matters because the same event can be reacted to very differently amongst individuals. Small issues can be catastrophic for some, whereas others thrive on an intensely challenging environment (Fletcher & Sarkar, 2013). Resilience is important beyond our own wellbeing. It also becomes an important aspect of the learning environment, that we model (or fail to model) to students. It is not simply the case that if academics are less resilient, students suffer. Crucially if academics are less resilient, they are not supporting students in positively developing resilience for their future careers.

The academic from geography who produced the map in Figure 46 reflected:

> Resilience of the department depends on redundancy of expertise and role in particular. My disciplinary background in ecology gives me a predilection to examine a university department through the lens of system resilience, seeing the department as the functional unit rather than individual academics.

Within the geographer's map of pedagogic frailty (Figure 46), the concept of resilience is central and highly connected to other key concepts such as sustainability, change, integration, ability, diversity and redundancy of expertise. The interactions between resilience and other concepts therefore appears very important to this colleague's overall conception of frailty. As stated by Mansfield et al. (2012: 361), it is not helpful to simply list attributes of teacher resilience and expect academics to be able to construct an appreciation of their situation from a selection of disconnected elements, as '*on their own, they do not account for resilience as a dynamic process of interactions*.' Pedagogic frailty here provides a higher order framework that

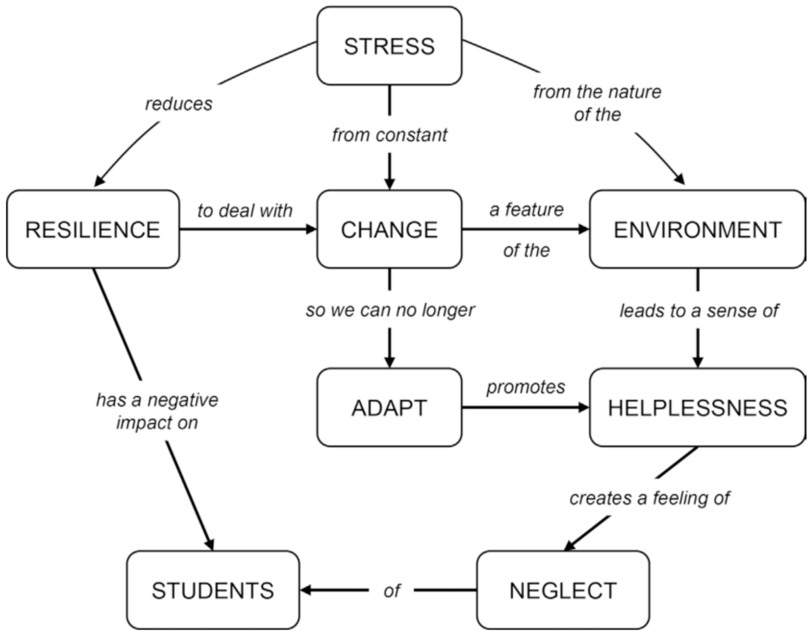

Figure 45. One academic's view of pedagogic frailty from the perspective of psychology (After Kinchin et al., 2016)

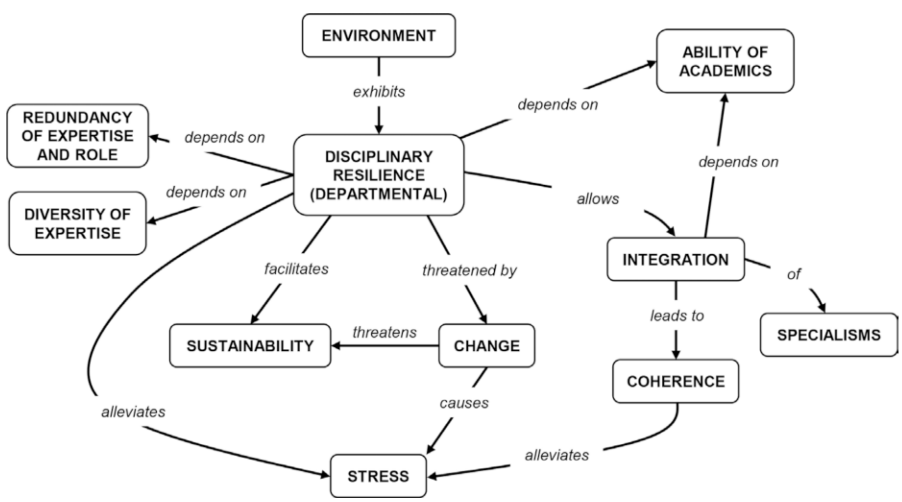

Figure 46. One academic's view of pedagogic frailty from the perspective of geography (After Kinchin & Francis, 2016)

offers the '*capacity to show the overarching and overlapping dimensions of teacher resilience*'. We can see in Figure 46 that the interactions are explicit in the mind of the academic.

Drawing from the map author's home discipline of ecology, we can draw some analogies with the concept of resilience within higher education. In their consideration of the importance of ecological resilience, Mumby et al. (2014: 22) state:

> Ecosystem management is fundamentally charged with maintaining desirable levels of ecosystem function in a cost effective and socially responsible manner. The ability of an ecosystem to function depends on its state and the processes that support it.

We can see here that classroom management could be substituted in this text for ecosystem management to confirm the analogy. By selecting concepts that facilitate analogy with their home disciplines (e.g. resilience), academics can strengthened their links with the pedagogic frailty model and allows them to engage in a level of reflection that would be difficult if it required acquisition of alien (educational) jargon. The concept map-mediated interview provides the prompt and helps in the deconstruction that then supports reflection to help colleagues to articulate their understanding. The ability to articulate skills in teaching is important for senior teaching colleagues who may be charged with mentoring and supporting junior colleagues through their early years of teaching:

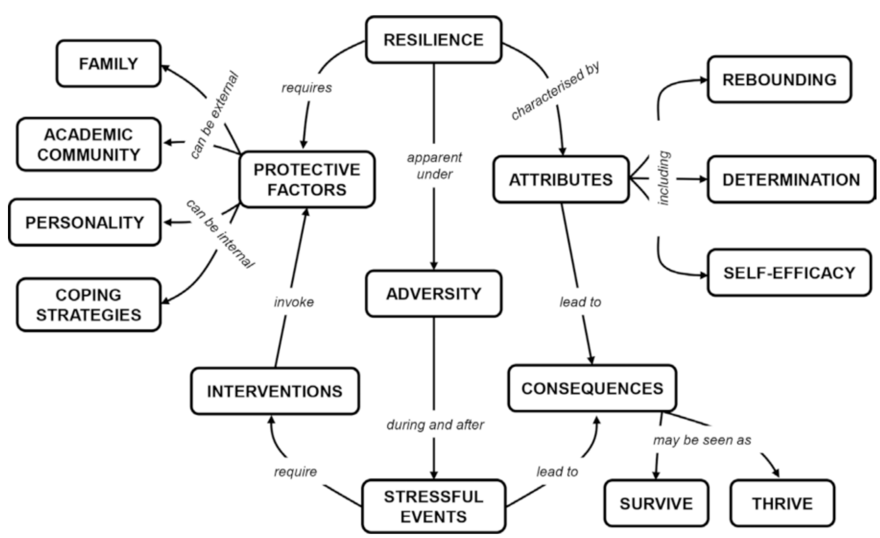

Figure 47. A generic concept map of 'resilience' (Simplified and redrawn from Garcia-Dia et al., 2013)

> teachers can express a generalised, generic concept of resilience in their own words but it takes prompting, reflection, and deconstruction before they can identify the explicit skills that they themselves possess. Nevertheless, they display tacit knowledge as they talk about their resilience where tacit knowledge is taken to mean an ability to perform skills without being able to explicitly articulate them. (Vance et al., 2015: 5)

Accessing personal narratives has been found to be of value in developing supportive relationships within an academic community as a step towards building teacher resilience (e.g. McDermid et al., 2016). Whilst the production of personal and context-specific concept maps to act as frames may be the optimum way of releasing powerful personal knowledge, the use of a generic concept map as a starting point to highlight the dynamic nature of the interactions between the concepts involved may also be helpful in initiation dialogue. Figure 47 is a generic concept map of the concept of resilience, highlighting links between some of the protective factors and attributes involved.

IN CONCLUSION

Ecological perspectives on educational change (Keiny, 2002), teacher agency (Priestley et al., 2015) and even the commentary on departmental resilience (Figure 46) all suggest that a focus on individual teacher excellence may be counter-productive in attempting to raise the overall quality of teaching experienced by students (Madriaga & Morley, 2016). A focus on isolated individuals does little to generate a shared values literacy (*sensu* Barnes, 2014: 179) that would '*result in a shared direction for resilient behaviour*' that is a key factor in the avoidance of teacher burnout (Howard & Johnson, 2004) and pedagogic frailty (Kinchin et al., 2016).

The final factor that needs to be mentioned here is the intention of the learner, whether we are considering the development of the expert student or the development of the teachers who will mentor the emergence of student expertise. Expertise does not typically emerge by accident. Without the explicit intention to learn and the acceptance that it will take time and effort to negotiate a number of threshold transitions in teaching and learning (Rattray, 2016), then the *status quo* of non-learning is likely to persist.

Consideration of pedagogic frailty, adaptive expertise and the process of exaptation of disciplinary concepts to support teacher development may help to reposition academic/faculty development. These concepts will help to make teacher development more learner-centred and discipline-sensitive. The avoidance of pedagogic frailty and the development of teachers' adaptive expertise (the structures of which are both revealed by concept mapping), are likely to foster the higher order teacher-student dialogues that facilitate engagement with the students' evolving knowledge structures. This offers a mechanism for teachers to support the manipulation of students' knowledge structures and the development of the expert student.

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