Using concept mapping to locate the tacit dimension of clinical expertise: towards a theoretical framework to support critical reflection on teaching

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Abstract
The tacit dimension of expertise is given considerable prominence in the literature on clinical education. However, the concept of knowing more than you can tell is one that cannot be used explicitly to support student learning. In this paper, the authors contend that much professional knowledge that has been described as tacit can be surfaced for examination through application of concept mapping techniques. This allows the articulation of expert practice in a way that can be modelled for students. It also provides a new model of expertise that is based on connections between chains of practice (characterized by sequences of observable actions) and the underlying network of understanding from which they are extracted. These connections, often overlooked and automated in daily practice, represent the location of the tacit dimension.

Localizing the tacit dimension in this way allows the teacher and student to focus on the connections of tacit knowledge with formal knowledge and with practice in such a way that intuitive actions can be verified and connected to underlying knowledge frameworks. The act of concept mapping also slows reflection on actions that are normally automated and often overlooked. The resulting model includes an additional dimension that is missing from the traditional stage models of expertise. As such, it provides a conceptual framework upon which it would be possible to develop protocols to support the continuing development of clinical teachers through peer observation and/or guided self-reflection.

Keywords
clinical teaching, concept mapping, expert knowledge

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Introduction

Eraut (2000) distinguishes between tacit knowledge that is not communicated and that which cannot be communicated because it is impossible to articulate. In the context of clinical teaching, this paper is confined to a discussion of Eraut’s first meaning of tacit – that which is rarely communicated, but might be through application of appropriate methods or vocabularies. Eraut goes on to give reasons why we should want to make tacit knowledge more explicit, including improving the quality of performance, facilitating the accountability of performance, facilitating the communication of knowledge, maintaining control of professional actions and to construct artefacts to assist in decision-making (Eraut 2000, p. 134). The benefits of making the tacit explicit are also seen as a way of assisting novice academics in their development as teachers (Sandretto, Kane & Heath 2002). For these reasons, we argue that the visualization of expertise and the identification of the location of the tacit dimension within this would be extremely useful to the student in the clinical context.

Although Polanyi (1967, pp. 18–19) considers the surfacing of tacit knowledge as a ‘destructive analysis’ leading to ‘unbridled lucidity’ that will change the original meaning, he goes on to concede that subsequent reconstruction may improve upon the original understanding. Where university teaching is modelled on the sharing of expertise through scholarly dialogue, such processes of destructive analysis and personal reconstruction of understanding are essential (Kinchin, Lygo-Baker & Hay 2008).

However, although considerable attention is afforded to the development of expertise in professional learning (e.g. Eraut 2005), the literature is unclear about the nature of expertise and the attributes that may be justifiably taken as indicators of its existence. Our contention in this paper is that much of the literature on expertise has been implicitly based on the assumption that expertise is based on tacit knowledge and intuition that cannot be located, and hence, cannot be described. However, in order to defend intuitive judgements, the tacit dimension must be articulated. Once this happens, it can be subject to verification (Welsh & Lyons 2001).

Our response to this assumption is presented here through application of a model of teaching in higher education (Kinchin & Hay 2007; Kinchin et al. 2008), and supported by structured observations of teaching in various higher education settings. These observations and related interviews have allowed detailed examination of a particular situational context, striving to represent the participants’ world view in the form of a narrative enquiry (Beattie 1995). This was complemented through the use of concept mapping tools that act as windows into the mind (Shavelson, Ruiz-Primo & Wiley 2005), and enable the visualization of learning at university (Hay, Kinchin & Lygo-Baker 2008). This approach is compatible with the various curriculum models adopted by healthcare professionals (including guided discovery learning, collaborative learning and interprofessional learning), or combinations of these (e.g. O’Halloran et al. 2006).

Chains and networks

The ability to visualize the clinical reasoning process is considered by Hill & Talluto (2006) to represent one of the first steps in the formation of the cognitive skills that are necessary for professional practice. Visualization of knowledge structures through concept mapping has enabled us to separate the chains of practice that are manifest in teachers’ actions from the underlying networks of understanding (see Fig. 1).

Chains are indicative of procedural sequences that characterize observable clinical practice and have been described as indicators of ‘goal orientation’ (Hay & Kinchin 2006). This seems entirely appropriate in the clinical setting in that the goal of clinical competence is the effective treatment of patients. The chain illustrated in Fig. 1 shows the typical sequence that is learned by dental undergraduates when learning how to design a removable partial denture. It concentrates on the how to the exclusion of the why. However, such chains have to be embedded in networks of understanding so there may be appreciation of why the patient has (or has not) been treated successfully and what alternative treatments may be available. If there are no links with an underlying understanding, the chain may be seen as blindly following a recipe.
Networks are indicators of understanding which may be integrated and holistic. The network in Fig. 1 shows how the elements of removable partial denture design are linked to each other and starts to create the why that would complement the chain of practice. However, understanding does not necessarily equate to clinical decision-making ability. Knowing there are several alternative treatments with varying consequences is not the same as being able to select the most appropriate one within a clinical context. If this was the case, academic study would not need to be backed by clinical training.

From this, the differences between 'expert knowledge', 'competence' and 'expertise' are made available for scrutiny. The relationships between these components can be used to address current inadequacies in university teaching by adopting discipline specific lexicons and practical examples that may be adopted by academics (e.g. Kinchin, Cabot & Hay 2006; Cabot & Kinchin 2007).

**Developing expertise**
Among the many models of skills progression, that put forward by Dreyfus & Dreyfus (1986) is well known and has served as a template for subsequent models within clinical teaching (e.g. Benner 1984). Dreyfus and Dreyfus suggest that as a practitioner develops a skill, s/he passes through five levels of proficiency. These are novice, advanced beginner, competent, proficient and expert. These sequential levels reflect changes in three aspects of skilled performance. The first is a movement from relying on abstract principles to using past concrete experiences as paradigms. The second is a changing view in the practitioners' perception of the situation, which is seen less as a compilation of equally relevant parts and more as a complete whole in which only certain parts are relevant. The third is the passage from 'detached' observer to 'involved performer.' The performer is now engaged in the situation (Manley & Garbett 2000).

The significant attributes of the Dreyfus model are presented in Fig. 2. Their model has an emphasis on learning from experience, but as Eraut (1994) points out, Dreyfus and Dreyfus do not really explain how this actually occurs. There are only occasional references to theoretical learning or the development of fluency on standard tasks. Identifying where a practitioner is on this model is therefore
difficult. In fact, in their recent critique, Dall’Alba and Sandberg (2006) point out that a focus on the
defined stages of such a model veils or hides the
more fundamental aspects of skill development.
They argue that as such progression is taking
place, there is an ‘embodied understanding of
practice’ underpinning that progression. We suggest
that this criticism of, in particular the Dreyfus and
Dreyfus Stage model, supports the earlier work of
Cabot (2004). He highlighted the difficulty in
identifying the stages of observed professional
expertise, but suggested that the individual
attributes or strands were clearly identifiable and
very useful in signposting expert practice. Identifying
where a practitioner is on this model is therefore
difficult. Eraut argues that the strength of the
Dreyfus model lies in the case it makes for tacit
knowledge and intuition as critical features of
professional expertise. Critically, the progression
to expert requires that decision-making and
indeed an understanding of the particular situation
is intuitive.
A further criticism of the Dreyfus and Dreyfus
model (as depicted in Fig. 2) is that it represents only
one aspect of expertise (the linear chain of development
of observable practice), that must be complemented
by a personal context for each stage. This second aspect
is akin to the ‘embodied understanding of practice’
described by Dall’Alba & Sandberg (2006), who distin-
guish between ‘a vertical and a horizontal dimension’
of expertise. However, such a characterization sug-
gests an artificial separation of the two dimensions.
The key point is that in all staged models, the
expert practitioner has reached a completely different
level to his/her less expert colleagues. For Dreyfus
and Dreyfus, the performance of the expert is
viewed as largely automatic, and non-reflective
because of the speed at which it is undertaken:
An expert’s skill has become so much a part of him that
he need be no more aware of it than he is of his own

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**Fig. 2** The Dreyfus and Dreyfus skills acquisition model of expertise (indicating the significant attributes of each level).
...When things are proceeding normally, experts don’t solve problems, and don’t make decisions; they do what normally works. (p. 30)

The expert will only move out of this mode when the task in hand is particularly difficult or critical, or because they have critically reflected on their own intuition and are reconsidering the initial action.

Manley & Garbett (2000) suggest that in selecting expert practitioners, two assumptions seem to be made: expertise can be recognized in others by colleagues and significant practical experience is required as a pre-requisite for expertise. Both these assumptions can be challenged. These authors reveal that in an analysis of studies in which expert practitioners were selected, a range of criteria were used to identify expertise. These included identification by peers and/or senior colleagues, experience, educational attainment, personal qualities and status. They noted that there appeared to be little consistency between studies in the criteria that were employed and there were only a few examples of attempts, Conway (1996) is one, to account for the rationale behind the identification and/or selection of participants. Curiously, the identification of experts was not seen as being intrinsically problematic, although the obvious effort taken to select appropriate participants suggested that selection was an important issue. Were they selecting for expertise or experience? Bradley, Paul & Seeman (2006) are quite clear that experience alone is not an acceptable indicator of expertise and argue that other factors must also be present to define expertise. Within this framework, the cognitive ability to correctly structure experience is necessary to define expertise.

Benner (1984) avoids defining the expert clinical practitioner; she does, however, provide a comprehensive account of the term in the context of a nurse demonstrating her or his expertise in clinical practice. She describes the expert nurse in terms of the Dreyfus model. The expert nurse has an intuitive grasp of situations and immediately focuses on a problem without the wasteful consideration of a large range of unfruitful diagnoses and solutions. In contrast, a competent or proficient nurse faced with a novel situation must rely on conscious deliberate analytical problem solving. A common issue with the positions described by Dreyfus & Dreyfus (1986) and Benner (1984) is the difficulty they present in visualizing expertise. Visualization is often helpful to students to understand complex ideas and provides a language of common discourse, clarifying the semantics of desired constructs, and focusing on critical elements and excluding ‘noise’ (Copperman, Beeri & Ben-Zvi 2007). The tool we have employed to visualize such complex ideas is concept mapping.

**Concept mapping**

Concept mapping as developed by Novak (Novak 1998; Novak & Cañas 2006) is a graphical tool used to represent links between ideas. Ideas are written in boxes and linked with arrows carrying explanatory legends. Concept mapping has been used effectively in a variety of contexts as a classroom technique to enhance learning (e.g. Horton *et al.* 1993; Lawless *et al.* 1998; Nesbit & Adesope 2006). The ability to construct a concept map illustrates two essential properties of understanding, the representation and the organization of ideas. Halford (1993, p. 7) states that ‘to understand a concept entails having an internal representation or mental model that reflects the structure of that concept’. A concept map is an attempt to make explicit such a mental model so that it can be reviewed with others (Chang 2007). Organization of knowledge can facilitate learning by making the material to be learned more predictable and so reducing the learning effort required (Halford 1993). The construction of concept maps is an excellent way of helping to organize knowledge and so help understanding. Concept maps are increasingly used in teaching health professionals to summarize learning, promote critical thinking skills and meaningful learning or as an assessment strategy (e.g. Irvine 1995; All & Havens 1997; Caelli 1998; Daley *et al.* 1999; Akinsanya & Williams 2004; Hsu 2004).

McAleese (1994) has explored the mental activities in which students are engaged when producing concept maps. His work suggests that concept mapping may promote the development of thinking skills by providing an explicit point of focus for reflection. He describes this process as ‘auto-monitoring’. A key aspect of this is considered to be the visualization of the ‘learning arena’ as portrayed by the map.
The use of concept mapping is often linked to the ‘constructivist’ view of learning as a concept map makes a good starting point for constructivist teaching. This is a form of student-centred teaching in which understanding is considered to be constructed by the learner rather than absorbed from the teacher as a finished product. Concept maps depict constructed and reconstructed knowledge and teaching that helps this reconstruction process that will lead to meaningful learning. The action of mapping is also thought to help the process by revealing to the student connections that had not been recognized previously and by acting as a focus for communication between student and teacher. This is illustrated by Novak & Gowin’s (1984) observation that students and teachers often remark that they recognize new relationships, and hence, new meanings as a result of mapping activities.

An important function of the map is to help make explicit the overall framework of concepts. This is particularly important for complex topics where students may display a fragmentary understanding and are frequently unable to integrate all the components to form a meaningful overview. Identifying these fragments of understanding, termed ‘anchoring conceptions’ by Clement, Zietsman & Brown (1989), is vital as these form the foundations for future meaningful learning.

The model

The model that has been used here (summarized in Fig. 3) has been derived from the qualitative examination of several thousand concept maps produced by students and their teachers over the past nine years (Kinchin & Hay 2007). These maps have been classified according to their morphology (as described by Kinchin, Hay & Adams 2000). This focus resonates with the description of knowledge structure as providing ‘the essence of knowledge’ Anderson (1984, p. 5), and shown to be a characteristic of concept maps that is as influential on the learning process as the content that is portrayed within them (e.g. Hay, Kinchin & Lygo-Baker 2008).

The model in Fig. 3 may be read vertically or horizontally. The vertical dimension explains the characteristics and roles of each of the knowledge structures. Many students start their undergraduate
studies with firmly established chains of understanding that have developed during their secondary schooling (Martin 1994). Such chains may be composed of lists of characteristics and definitions that were required to pass a given examination. However, such goal-orientated learning may miss links which may enhance understanding if they are not explicitly rewarded in the short term (e.g. by examination grades). Previously acquired chains are often incomplete or inappropriate for their new context. Such chains are resistant to development (Hay & Kinchin 2006) and so students are faced with the dilemma of either trying to abandon their existing beliefs and starting again, or rote learning the new material as an adjunct to their existing prior knowledge. This may be problematic when the two chains may be in conflict and create too much cognitive stress for the student (Hay, Wells & Kinchin 2008).

The chain of appropriate understanding is indicative of strategically successful learners (students and lecturers). Such goal orientation enables these learners to select the essential information from that which is available while selectively ignoring the rest. This may be seen by some as an efficient way of studying although 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 environment, the development of chains of clinical reasoning is seen as one of the key aims (e.g. de Cossart & Fish 2005).

The demonstration of highly developed and integrated nets of understanding may be seen as characteristic 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. So for example, the clinician can move from patient to patient, each time presented with a problem to solve by making a series of judgements. Each of these judgements is verified either internally (through comparison with the clinician’s underlying network of understanding), or externally, by consulting a colleague’s understanding. Internal verification processes (often taking place so quickly as to appear intuitive) require the clinician to appreciate the links between the chain and the network.

A horizontal reading of the model suggests a progression in the development of knowledge structures from chains to nets. Such a directional development has been observed (Kinchin et al. 2000) although 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 chains of practice seemingly have more immediate utility than networks of understanding.

Knowledge structure

Rather than attributing expertise to a certain level of sophistication and integration within a knowledge structure (e.g. Bradley et al. 2006), expertise may be characterized by an individual’s ability to navigate between underlying networks of understanding and chains of practice that are appropriate to the context, analogous to the ‘professional artistry’ described by Manley et al. (2005). Application of Kinchin and Hay’s model provides a transparent mechanism for this artistry that goes beyond opaque assumptions involving intuition or tacit knowledge as explanatory factors. It is the link between these two components of expertise (practice and understanding) that indicates the location of the tacit dimension. The expert will oscillate between chains of practice and networks of understanding so quickly that it will appear intuitive to the casual observer.

Modelling such transformations for the student so they can develop their own expertise presents an additional dimension to clinical practice. The difficulty this presents is predicted by Novak & Symington (1982) who made the key point when they stated:

The problem of moving from linear [text] structure to a hierarchical [psychological] structure and back again is in some ways the fundamental educational problem.

Although Novak and Symington were not considering clinical education in particular when they made this comment, the transformation they describe appears most pronounced between the
clinical and non-clinical aspects of education for healthcare professionals. That experienced clinical practitioners cannot always articulate rational explanations for their clinical practice (e.g. Benner 1984, p. 32) resonates with Polanyi's view of tacit knowledge as a description of 'knowing more than we can tell' (Polanyi 1967, p. 4). Critics of Polanyi have considered the label 'tacit knowledge' as a way of avoiding addressing a whole class of mental events (e.g. Fodor 1968), and so rendering the development of expertise as a mystical event that defies adequate description that would help those who are trying to promote it. But the 'black box' of tacit knowledge and intuition does little to support the student or the teacher in the development of clinical 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 & Lintern (2006, p. 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 we depart from accepted views is that not all such knowledge need remain tacit and undescribed. This paper contributes to the understanding of clinical expertise by adding transparency to the processes (often presumed to be tacit), that link invisible expert knowledge to visible chains of practice. Such transparency, mediated by concept mapping, may help students and teachers appreciate the other's perspective and avoid the problem described by Perkins:

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. (Perkins 2006, p. 40)

To avoid such a mismatch, the links between developing practice and expert knowledge need to be made explicit. Figure 3 shows the relationships between chains of practice and the network of underlying understanding upon which they depend. The links between the two elements are rarely articulated by professionals who have not conceptualized understanding in terms of knowledge structures in this way and who therefore lack an appropriate vocabulary for its description. This model allows the difference between expertise and expert knowledge to be explained:

1. Expert knowledge describes an integrated/holistic framework of understanding.
2. Expertise describes the application of expert knowledge through selection of appropriate chains of practice (i.e. repeated movements between chains and networks that may occur so quickly as to appear tacit).

This provides a mechanism to explain the loss of expertise (know-how) experienced by teachers who are no longer practising, but who clearly hold expert knowledge structures (Dreyfus & Dreyfus 1986, p. 17).

Variable structure (clinical–non-clinical)

Although we have observed our model of expertise working across the spectrum of academic disciplines through structured teaching observations, it is in the context of clinical teaching that the separation of chains of practice and underlying networks of understanding is so pronounced and therefore easier for the observer to identify in this setting. Although expert knowledge structures are assumed to be holistic (e.g. Bradley et al. 2006), clinical reasoning skills have been shown to be linear in structure (de Cossart & Fish 2005). Possession of highly competent skills within a given chain of practice is not sufficient within a clinical teaching environment that aims to educate the next generation of professionals who are able to make informed choices when innovative clinical practice threatens established procedures. Such isolated chains of practice are what Stronach et al. (2002) have called 'broken stories'. These chains of practice or broken stories will not have the capacity to evolve with understanding unless they are related to an underlying network of understanding.

The clinical teacher needs to be able to capture the elements of his/her students’ broken stories and to contextualize each of them within an underlying network of understanding. This places a considerable
burden on the clinical teacher when, in addition to the individualized learning needs of the students, the clinical teacher also has to consider the needs of the patient. Although the student is encouraged to make links from his/her chain of practice to a developing network of understanding, the patient is typically given a discrete chain from which links that may complicate or confuse are obscured, or intentionally neglected (Katz 1988).

The dual purpose of this professional discourse may obscure the relationship between chains of practice and underlying networks of understanding for the observer/student. The clinician–patient discourse may include latent functions (sensu Eraut 2000, p. 120) to keep patients happy while asserting a professional role even though the manifest function would be to explain diagnoses and treatment options. Unless the student is aware of what is going on, such latent functions may impede the understanding of practice and inhibit the revealing of tacit links between practice and understanding.

Assessing expertise

Expertise may be determined on a ‘closeness-of-fit’ model of assessment. Where an expert is designated, using arbitrary criteria (e.g. Manley & Garbett 2000), to assess junior peers, the implication is that the expert holds the ‘right answer’. However, as experts often fail to agree, the ‘right answer’ is a moving target for the student to identify (Cabot & Kinchin 2007; Hay & Kinchin 2007). When there is considered to be sufficient overlap between the established expert view and the emerging expert view, then the designation, expert, may be safely applied to the junior partner. This model assumes the established expert is able to stand back and reflect upon his/her own practice and appreciate its dynamic nature. Some may be able to do this, but support from an observer with complementary expertise may be helpful.

Appreciation of the skills by which the expert is able to move from chain of practice to underlying network can only really be appreciated by an observer who holds at least one of those structures within his/her own knowledge structure and is able to appreciate the nature of the manipulations required to successfully navigate the transition from one knowledge structure to another. This would have implications for the roles played by students and by colleagues in educational development centres. The student (rather than exclusively the ‘fellow expert’) is in a good position as assessor, giving a real focus for student evaluations of teaching that go beyond questions such as, ‘was the course well organized?’, ‘were the lecturers’ slides clear?’. Student evaluations of teaching would need to focus on the lecturers’ success in demonstrating the link between linear and hierarchical structures (Novak & Symington 1982). Although colleagues within educational development units are placed in a position to support the development of strategies to move between structures, disciplinary colleagues may help in the development of the underlying network. This gives clear and complementary roles for the development of higher education pedagogy, and a clear purpose for those working in educational development (e.g. Gosling 1996, 2001).

We can only speculate whether previous studies of tacit knowledge in clinical education have really exposed the tacit dimension or highlighted aspects of the more easily viewed chains of practice and underlying networks of understanding. For example, interesting parallels can be drawn with the descriptions offered by Herbig, Büssing & Ewert (2001) of the organization of tacit knowledge as either sequential or holistic. If indeed these authors have simply described the chains and networks that we have shown to be linked by the tacit dimension, it would explain why they found the sequential structure to be ‘less successful’ than the holistic structure as it offers less scope for flexibility and development (Hay & Kinchin 2006). We have elaborated upon ideas put forward by Welsh & Lyons (2001) about the link between tacit and formal knowledge, but whether or not the links we propose between practice and understanding as the location for the tacit dimension can be characterized as exhibiting structures in their own right is an avenue that requires further research.

The centrality of tacit knowledge in clinical expertise as suggested by established models of clinical expertise (e.g. Benner 1984) is supported by the model given in Fig. 3. If we can go further and
confirm the location of the tacit dimension as that which bridges the divide between practice and understanding, then it becomes a tool for clinical education rather than an amorphous barrier to learning.

**Conclusions**

We have considered how the qualitative interpretation of knowledge structures through application of concept mapping reveals how complementary structuring as *chains of practice* and *networks of understanding* provides a way of explaining some of the anomalies that are described within the literature on expertise. We argue that it is the interaction between these complementary structures and the ease of transformation (from one to the other) that may be the hallmark of expertise rather than the existence of one or other structure in isolation. That such transformations are rapid and appear ‘routinized’ has awarded them the label ‘tacit’. The assumption that elements of such tacit expertise cannot be made concrete is reinforced when clinicians are unaccustomed to reflecting upon this practice, and lack vocabulary to explain their actions. The time taken to verbalize their actions is an additional barrier to making the details of their practice explicit. The concept mapping method provides a tool that facilitates this description, making it available for public scrutiny.

We consider the assumption of the central role of intuition (as described by Benner 1984 and Dreyfus & Dreyfus 1986) in the consideration of expertise as an opaque phenomenon that has provided a barrier to the description of expertise. The labels ‘intuitive’ and ‘tacit’ have consequently served to cloud the description of what actually takes place, and we support Hoffman & Lintern (2006) in their view that professionals have simply lacked the tools and vocabulary to uncover and explain their practice. We have observed our model (summarized in Fig. 3) to function in various clinical teaching contexts and provides a conceptual framework for the observer.

Our model is an improvement upon the amendment to Dreyfus and Dreyfus offered by Dall’Alba & Sandberg (2006), by showing how the dimensions of expertise interact. Our model concentrates on the links between the two elements (chains and networks that correspond to practice and understanding), and offers an explanation as to why linear progression is insufficient to describe the development of expertise. The underlying network of understanding (analogous to Dall’Alba and Sandberg’s vertical dimension) will develop as a personal construct that exhibits variation. Such variation may persist throughout professional education (Dall’Alba 2004), and will influence the progression through the stages of skills acquisition (Dall’Alba and Sandberg’s horizontal dimension).

The tensions we have observed in clinical settings can be explained by our model. The chains of clinical practice that are acquired by students are often taken as indicators of competence. However, when the utility of such chains are challenged, the clinician needs to refer back to a wider understanding of the field in order to select a revised chain of practice. This resonates with the comment made by Schmidt, Norman & Boshuizen (1990, p. 619):

‘The notion that expertise is associated with a qualitative transition from a conceptually rich and rational knowledge base to one comprised of largely experiential and non-analytical instances is a radical departure from conventional views of clinical competence’.

It seems that a decade and a half later, this is still a radical departure from orthodoxy. Such tensions come to the fore when chains of practice are seen as an end point by assessment regimes that promote rote learning. Such goal orientation (characteristic of linear learning sequences) is compatible with the intentional neglect of uncertainty that has been described within medical education (e.g. Katz 1988). However, clinical students and health professionals need to address the nature of uncertainty in their practice. This surely is the goal of professional practice and the key to the development of a clinical practitioner who has a commitment to continuing professional development.

**References**


