Routledge
Taylor & Francis Group

Reconsidering the dimensions of expertise: from linear stages towards dual processing

Ian M. Kinchin[a]* and Lyndon B. Cabot[b]

[a]*King's Learning Institute, King's College London, UK;* [b]*Dental Institute, King's College London, UK*

This paper explores the developing concept of expertise, taking the Dreyfus and Dreyfus staged model as its starting point. It analyses criticism of the Dreyfus model and considers more recent attempts to resolve the tensions implicit within it. The authors go on to suggest ways some of the later modifications can be improved. The traditional notion of intuition is revisited and thereafter a new and novel way of visualising expertise is presented as a dual-processing relationship between chains of practice and the underlying networks of understanding. These chain and net knowledge structures have been revealed through the analysis of concept maps produced by numerous cohorts of students and teachers. It is argued that a visualisation of the dynamic relationship between the dimensions of expertise provides an emerging theoretical framework for a more general reappraisal of teaching in higher education. This reconsideration of expertise may be the catalyst for dialogue about educational practice within disciplines (between lecturers and between lecturers and students), and between lecturers and educational developers. This dialogue will strengthen disciplinary communities of practice and place the agenda for pedagogic change within the context of the academic disciplines.

Keywords: knowledge structures; concept mapping; university pedagogy; clinical teaching

Introduction

The development of university pedagogy needs to consider the nature of expertise and how this can be modelled for students in such a way that teaching reflects the values of each academic discipline (Kinchin, Baysan, and Cabot 2008). This development aims to find a practical solution to the constraints within the system that tend towards the maintenance of the status quo, by challenging the 'safe systems' that have dominated the development of university pedagogy (Canning 2007) that can result in cycles of non-learning that embody the antithesis of the purpose of higher education (Kinchin, Lygo-Baker, and Hay 2008).

Whilst offering a critique of the work of Dreyfus and Dreyfus here, we freely acknowledge that development of our current thinking is totally dependent upon the triggers offered by their work and by others who have contributed to the field. As such, this paper does not offer a systematic review of previous literature, but uses it to revisit the steps in the development of our own thinking to offer the reader an insight to the pathways we have taken to arrive at this point.

Whilst concepts of expertise have a role in higher education, previous studies have been critical of the lack of acknowledgement given to the part played by the teacher in supporting students in their development from novice to expert (see Dunphy and Williamson 2004). This paper sets out to develop a view of expertise that can be used to inform curriculum design and

*Corresponding author. Email: ian.kinchin@kcl.ac.uk

teaching practice in which the teacher has a clear role: to facilitate dialogue between the complementary knowledge structures that contribute to expertise (see Norman 2005). The resulting model is based not only on the re-examination of influential models from the literature, but also on extensive direct observation of learning in a variety of university teaching contexts (see Kinchin, Lygo-Baker, and Hay 2008; Kinchin, Cabot, and Hay 2008b). Whilst much of the research underpinning our arguments has been conducted in clinical teaching, we have explained elsewhere how the fundamental ideas presented are equally applicable to other, non-clinical university disciplines (Cabot and Kinchin 2008).

It may also be helpful to the reader to locate our argument in the recent work of Collins and Evans (2009). These authors have developed a 'Periodic table of expertises' where tacit knowledge is an underpinning and central theme. The view of expertise that we are considering here could be considered as falling into the 'specialist expertise' category of the Collins and Evans table.

The stage model of Dreyfus and Dreyfus

There have many models of skills progression but perhaps the most influential has been that of Hubert and Stuart Dreyfus (1986). This model posits that as a practitioner develops a skill, s/he passes through five stages or levels of proficiency. These are novice, advanced beginner, competent, proficient and expert. These changing 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 key attributes of each stage have been summarised by Eraut (1994) and these are outlined below:

(1) *Novice.* Rigid adherence to taught rules; little situational perception; no discretionary judgement.
(2) *Advanced beginner.* Guidelines for action based on attributes or aspects; situational perception still limited; all attributes and aspects are treated separately, with equal importance.
(3) *Competent.* Coping with crowdedness; actions seen at least partially in terms of long-term goals; conscious deliberate planning; standardised and routinised tasks.
(4) *Proficient.* Sees situations holistically, rather than in terms of aspects; sees what is most important in a situation; perceives deviations from normal patterns; decision-making less laboured. Uses maxims for guidance, whose meaning varies according to the situation.
(5) *Expert.* No longer relies on rules or guidelines; intuitive grasp of situations based on a deep tacit understanding; analytic approaches used only in novel situations or where problems occur; vision of what is possible. (Summary from Eraut 1994, 124)

This model, as befits its philosophical underpinning, has an emphasis on learning from experience. However, Eraut (1994) points out that Dreyfus and Dreyfus do not really explain how this actually occurs, offering only occasional references to theoretical learning or the development of fluency on standard tasks. As with any stage model of skills progression, identifying where a practitioner is on this model will therefore be difficult, but the clearly defined attributes have the potential to provide a clear path for progression. Eraut (1994) agues that the strength of the Dreyfus model lies in the case it makes for tacit knowledge and intuition as critical features of professional expertise. However, this is only of value if tacit knowledge is considered

as 'knowledge that has yet to be revealed' (Eraut 2000), rather than 'the supreme mystery of clinical reasoning' (Sox et al. 1988, 11). The authors have argued elsewhere (Kinchin, Cabot, and Hay 2008a) that intuition based on tacit knowledge must be viewed simply as poorly articulated links between chains of practice and underlying networks of understanding. There are significant similarities in the Dreyfus and Dreyfus concept of professional expertise and the early work of Ryle (1963). The expert no longer relies on rules or guidelines; the rules are in fact forgotten. There is instead an intuitive grasp of situations based on a deep tacit understanding.

If practitioners are approaching 'proficient', they will be taking a more holistic approach to their work and will see what is important in a situation. He/she still has an analytical approach to decision-making. The progression to expert requires that decision-making and indeed an understanding of the particular situation is intuitive. This perhaps takes longer to reach than any of the intermediate stages, if it is ever reached at all.

Returning to Dreyfus and Dreyfus:

> The proficient performer, while intuitively organising and understanding his task, will still find himself thinking analytically about what to do. Elements that present themselves as important, thanks to the performer's experience will be assessed and combined by rule to produce decisions about how best to manipulate the environment. (29)

But the expert has reached a completely different level. Most of the performance of the expert is automatic, and non-reflective:

> 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 body… When things are proceeding normally, experts don't solve problems, and don't make decisions; they do what normally works. (30)

The expert will only move out of this mode on the occasions that 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.

We suggest that the fact that a practitioner can identify the attributes that indicate developing expertise is the model's greatest strength. It has the potential to guide to the path to becoming an expert. This is, perhaps, more important than being able to place a practitioner at a certain point on the skills acquisition model.

The Dreyfus model has now been developed and used in a range of different contexts, for example in teaching (Berliner 1994) and nursing (Benner 1984; Benner et al. 1996). Interestingly Benner embeds the Dreyfus and Dreyfus model in clinical nursing (1984) but avoids defining the expert clinical practitioner. She does however provide a comprehensive account of the term in the context of a nurse demonstrating her/his attributes of 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.

Intuition and tacit knowledge

One of the difficulties in developing a pedagogy of expertise is the central position given to intuition and tacit knowledge in some of the models of expertise used within clinical education (see Benner 1984; Dreyfus and Dreyfus 1986), despite the observation that there has been little consensus in the literature about the nature of intuition (Hodgkinson et al. 2008). Interpretation of Benner's work has been the focus of some debate, exemplified by the divergence of views aired by English (1993) and Darbyshire (1994), illustrating tensions between the 'art' or 'science' of clinical practice (Seymour, Kinn, and Sutherland 2003).

If intuition and tacit knowledge cannot be explained or modelled for students, they would not make a good basis for a pedagogy for clinical education. However, we do not see tacit knowledge as a barrier to developing a pedagogy of expertise so long as it is viewed as the poorly articulated links between chains of practice and underlying networks of understanding, and agree with Welsh and Lyons (2000) that it would not be possible to use intuition in the clinical context unless it was linked to formal knowledge: 'The use of intuition without reference to a sound knowledge base would reduce it to the sort of thinking which might be expected of an uninformed lay person and has no place in professional practice'.

The issue of intuition has been addressed by Hammond (1988) in the development of his *cognitive continuum theory*, which sets *intuition* and *analysis* as two poles on a continuum. This has been applied to clinical education, and particularly to issues surrounding clinical decision-making (see Cader et al. 2005; Offredy et al. 2008). This theory relates the intuition-analysis continuum with the properties of the problem, particularly its level of structure. In essence, Hammond considers that structure induces analysis whilst lack of structure induces intuition. We would not contest that this can occur, but would challenge the idea that structure always induces analysis. Our observations of clinical students often indicate the opposite relationship, in which a highly structured task can induce unreflective recipe-following in which analysis is not a feature. Therefore, whilst we feel there is some utility in Hammond's theory, we feel it lacks the predictive power to stand alone as an explanation of the cognitive processes that are exhibited in expertise. This has been further complicated by observations that people display differences in the way they 'rely upon their heads or their hearts' – or between intuition or deliberation (Betsch 2008).

If colleagues are unable to verbalise 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 or self-awareness to articulate it (Jarvis 1996). Didierjean and Gobet (2008) illustrate the importance of language in expertise and the utility of developing 'verbal expertise' that allows the observer to appreciate the processes employed by the expert practitioner. Hoffman and Lintern (2006) 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 appropriate tools can support colleagues in identifying and clearly describing their practice with the aim of improving teaching effectiveness (Mcleod et al. 2004). Rolfe comments that rather than considering intuition as a magical process of knowing, it should be considered as the unconscious workings of the prepared mind. By revealing structured external representation of expert knowledge through the application of concept mapping (Basque et al. 2008), the tacit can be made explicit (Hoffman and Lintern 2006). The application of concept mapping has also allowed us to propose a location of the tacit dimension within the expert framework – as a bridge between knowledge structures. This has previously been discussed at some length (Kinchin, Cabot, and Hay 2008a), and it would be inappropriate to duplicate that analysis here.

Beyond stage models

Dall'Alba and Sandberg (2006) present a critical view of stage models of professional development and that of Dreyfus and Dreyfus in particular. They recognise the contribution of the Dreyfus model in 'highlighting progression that often accompanies experience' (399). They also accept that Benner and colleagues (1984, 1996) have provided 'rich narrative accounts of nursing for each stage of the Dreyfus model'. However, Dall'Alba and Sandberg argue that 'their significant contribution lies not in the treatment of the stages, but in their insights about the nature of nursing practice. … These insights are achieved despite rather than through the use of the Dreyfus stage model' (388).

Dall'Alba and Sandberg's primary concern with the Dreyfus model and indeed any stage focused model is that:

> The focus on stages veils more fundamental aspects of development; it directs attention away from the skill that is being developed. [Dall'Alba and Sandberg] argue that a fundamental dimension of professional skill development – namely, understanding of, and in practice – is overlooked. (2006, 388)

They argue (2006) that these form the basis of professional skill and its development and on the basis of their recent research (Dall'Alba 2002, 2004), that an embodied understanding of practice, rather than attributes, forms the basis of professional skill and its development:

> More specifically, the knowledge and skills that professionals use in performing their work depend on their embodied understanding of the practice in question. The professionals' way of understanding their practice forms and organizes their knowledge and skills into a particular form of professional skill. (2006, 390)

As the most influential stage model of expertise, that of Dreyfus and Dreyfus (1986) and others developed from this, specifically Benner (1984) and Benner et al. (1996), are subject to a detailed critique. Dall'Alba and Sandberg argue that there is a growing body of research that suggests the key to success is to encourage increasingly active participation by novices, rather than having them adopt a position of observer or follower of rules (see Dall'Alba 1993, Dall'Alba and Sandberg 2006; Lave and Wenger 1991; Schön 1995; Wenger 1998). Our reading of Dreyfus and Dreyfus seems to be odds with that of Dall'Alba and Sandberg. For example, at no point do Dreyfus and Dreyfus place novice/advanced beginners as mere observers. And it is not others who demand that the novice must be a follower of rules – it is the novice status itself that draws the practitioner into employing this strategy. Surely the stages and associated attributes are merely signposts on a path that is seamless but not necessarily one on which the practitioner's progression is constant – neither, as we have argued, is it easily identified. Nor does our interpretation of Lave and Wenger (1991) and Wenger (1998) match that of these authors. We cannot see anything in their work that undermines the authenticity of the stage model.

On the contrary, an understanding of 'communities of practice' and a practitioner's legitimate position within that community has the potential to enhance our understanding of practitioner progression and how expertise develops or on occasions, does not. That said it would be unusual for the Dreyfus and Dreyfus model, and similar models, to be accepted without criticism during the 20 years since publication. We therefore applaud the critique, and Dall'Alba and Sandberg's presentation of an alternative model of professional development.

While accepting and acknowledging the contribution of the Dreyfus model, they suggest that: 'Along with Dreyfus and Dreyfus, we recognise that a necessary, but not sufficient, condition for achieving skilful know-how is embedded within the situations encountered, which demands experience of those situations' (2006, 399).

Dall'Alba and Sandberg refer to the skill progression with increasing experience as the 'horizontal dimension' of skill development. And they stress that no assumption is made that such progression follows a fixed sequence of stages.

Development of the Dall'Alba and Sandberg model

Figure 1(a) outlines the Alternative Model of Professional Development proposed by Dall'Alba and Sandberg (2006). They have depicted their model as a graph of two dimensions. They refer to the skill progression with increasing experience as the 'horizontal dimension' of skill
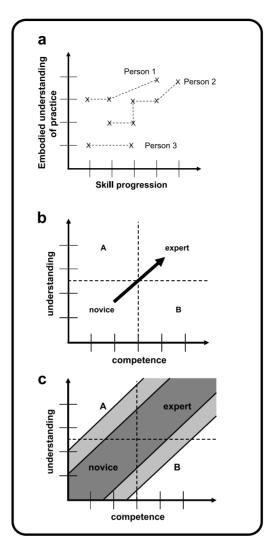
Figure 1.   Developing the work of Dall'Alba and Sandberg (2006).

development and stress that no assumption is made that such progression follows a fixed sequence of stages. An 'embodied understanding of practice' is their second (and vertical) dimension of the model. This dimension recognises that professional practice is understood and performed in different ways. The terms 'vertical' and 'horizontal' are merely an artefact of the figure and do not describe critical features of these dimensions.

The dimensions are separated by this graphical interpretation. This separation is emphasised by the asymmetrical development of the three cases (Persons 1–3) represented in the figure. For example, Person 3 develops along the horizontal dimension without any apparent development in the vertical dimension. Underlying the occasional unequal development of the two dimensions depicted, is an implicit time line that appears rather arbitrary and tends only to confuse the relationship described.

Each of the two axes is divided by markers (five marks on the horizontal axis to distinguish the five stages of development in the Dreyfus and Dreyfus model of skills development and four

marks along the vertical axis to describe development of understanding). Whilst the attributes of the five stages of the Dreyfus and Dreyfus model have been well-articulated, these stages are not absolutes, and an individual may simultaneously occupy more than one stage at any one time, particularly in a fluctuating environment. A simple linear progression through these stages is therefore a false image of the developing professional.

The marks on the vertical dimension are less well described. The notion of an 'embodied understanding of practice' is difficult to articulate and impossible to usefully reduce to a four point scale. There is no evidence that the development of such an embodiment would occur along a linear vector. We therefore have a graph of two non-linear variables plotted along linear axes.

We have tried to develop this model to see if some of the issues described can be overcome. In Figure 1(b), we have reduced the significance of the linear scales along the axes by dividing the graph into four quadrants (A, B, novice and expert), to lessen the significance of the scales on the axes.

In Figure 1(c), we have overlaid three zones on to the quadrants. Development within the dark grey zone would require parallel development of competence and understanding. In the light grey zone, the cohesion between development of the two dimensions would be weaker, whilst in the white zone there is little or no cohesion between the dimensions, so that an individual developing along one axis only (such as Person 3 in Figure 1(a) who is heading towards Quadrant B), would be developing competence, but not expertise.

Even with these modifications, the model remains problematic because of its fundamental bi-polar opposition of the contributing dimensions. This issue is less prominent in other models, such as that developed by Yielder (2004).

Development of the Yielder model

Yielder (2004, 2009) has developed a model that considers the elements that compose expertise rather than the stages of its development. We appreciate Yielder's move away from the focus on intuition that has been put forward by Benner (1984) and Dreyfus and Dreyfus (1986), towards the *intentionality* that is key to transformation theory (Mezirow 1991). However, the arrows linking the five elements of Yielder's model are unlabelled and so leave too much uncertainty about the relationship between the elements. This is addressed, in part, by the extensive bulleted list of attributes given by Yielder in a related table, but does not contribute to her aim of describing an *integrated* and *seamless* model.

Yielder (2004, 68) puts 'professional practice' centrally in her model (Figure 2(a)) to signify it as the 'focal point through which integration and transformation occur in forming the synergy of expert professional practice'. In our re-interpretation we have moved this (Figure 2(b)) to show 'professional practice' and 'knowledge base' as the two attributes of expertise that may be most readily surfaced for examination (i.e., competence and under-standing). For us, the 'focal-point' of expertise is the link between the two dimensions, with cognitive processes, internal integrative processes and interpersonal relationships providing part of the context in which this linking occurs. Hence our overall simplification of the Yielder model (Figure 2(c)), with increased emphasis on the complexity of the links. This interpretation is starting to get to the point where the two components (knowledge base and professional practice) are shown to be working in synergy, but still lacks details of the nature of the two components that might be seen to contribute to a process of interaction and integration. Not only do we need to know *what* is interacting, but we need to see *how* they are interacting (Kinchin, Cabot, and Hay 2008a). Only then can such a model have utility in teaching.
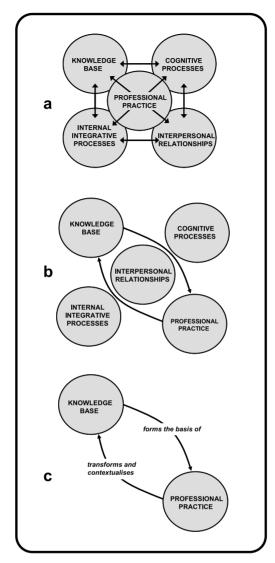
Figure 2.   Developing the work of Yielder (2004, 2009).

Our model of expertise

While we have reservations about the Dall'Alba and Sandberg model, we accept that it is a significant step forward in aiding our understanding of skill development. What follows is our proposed model that builds on the stage models of Dreyfus and Dreyfus and others and on the alternative model proposed by Dall'Alba and Sandberg (2006), and the integrative model put forward by Yielder (2004, 2009). Our development of the model of expertise is not intended to signal that work presented by previous authors is wrong. On the contrary, they all contribute to our understanding of the phenomenon. However, our perspective on the phenomenon is a particular focus on university teaching. From this standpoint, the previous models leave questions that we are attempting to answer to facilitate a student-engaged university pedagogy that may have generalisable utility within the sector. It is with this aim that we are attempting to

visualise a model based on direct observations made within the context (Kinchin, Cabot, and Hay 2008b).

The model described here (visualised in Figure 3) has been derived from the qualitative examination of several thousand concept maps produced by students and their teachers over the past 10 years (Kinchin and Hay 2007; Kinchin, Cabot, and Hay 2008a). These maps have been constructed along the lines described by Novak and Cañas (2007) and have been 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 clinical and non-clinical settings (Kinchin, Baysan, and Cabot 2008).

The vertical dimension of Figure 3 (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. 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 and 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, and 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
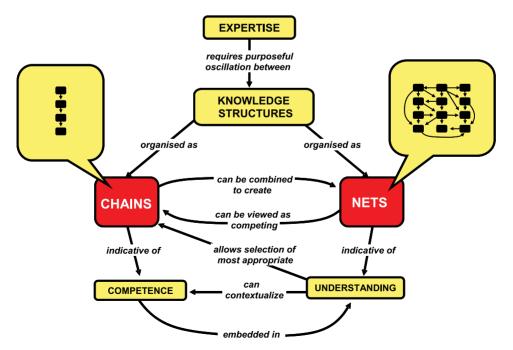

Figure 3.   A dual-processing knowledge structures perspective on the nature of expertise.

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 nets 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 Norman's 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) 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' (232).

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, and Adams 2000) though the mechanisms of change are complex and have been discussed 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 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.

Application to teaching

Patel, Arocha, and Kaufman (1999, 89) have explained that 'an effective clinical teacher needs to be able to articulate knowledge that would normally be tacit for a practitioner not engaged in instruction'. It is precisely the articulation of this tacit knowledge that is facilitated by the model providing students with the key information they need to 'move up a notch or two on the road toward excellence' (Lovitts 2007, 50).

The tacit knowledge that needs to be placed in the public arena for teaching is found connecting the chains of practice that are manifest in the clinical teacher's actions and the underlying network of understanding that is usually held privately (Kinchin, Cabot, and Hay 2008b). The

clinical student needs to gain experience in converting between complementary chains and networks (Figure 3). Such structural transformations can be modelled for the student, once the teacher has recognised them. Engagement in concept mapping activities, considered by Novak and Cañas (2007), allows the teacher to recognise the existence of the structures and allows him/her to make them public to the students within the course of teaching (Kinchin and Cabot 2009). The concept mapping tool also slows down intuitive processes (that are usually automated) to facilitate their examination. So, for example, the typical structure of a practical procedure would be a chain of practice that would be communicated to the student. The student's competence would be assessed through his/her ability to reproduce that chain under varying conditions and with various patients. The student's expertise, however, must be assessed through his/her ability to relate the chain of practice to the underlying network of understanding as a form of dual processing. The student must explain how the elements are linked, and how and why the chain of practice should be modified in response to changes of context.

Further implications for teaching

In higher education, formative assessment and feedback are still largely controlled by and seen as the responsibility of the teacher, with feedback still generally conceptualised as a transmission process (Nicol and Macfarlane-Dick 2006). Within an expertise-based pedagogy that draws upon our interpretation of expertise described above, the transmission of feedback as a one-way process would be as redundant as the transmission of content. In addition, the model described above provides a mechanism to contextualise earlier observations and start to explain why traditional methods of assessment that concentrate on a single professional dimension have not necessarily identified candidates' true level of expertise (Hodges et al. 1999).

One of the key features of clinical practice is that of uncertainty (Hall 2002). Shulman (2005) has described education in the professions as requiring *pedagogies of uncertainty*, as professional practice typically requires individuals to make decisions on available evidence, however incomplete that might be. If then, we are to align assessment practices with teaching, feedback mechanisms need to model the uncertainties that are inherent in the discipline unless a mismatch is to occur. The implementation of a pedagogy of expertise (as we have described it here), therefore needs careful planning to align all the elements of a curriculum. The challenge is to develop mechanisms and procedures that can be adopted and adapted by university teachers, building on their existing repertoire of skills. Taking a line from Yielder (2004, 64) to consider the expertise of teachers in addressing this challenge: 'One of the critical features of their expertise… is the way in which they are continuously making sense, or meaning, out of their experiences in order that they can make modifications that actively meet and manage change'.

We hope the continuing development of our model will not be used to contribute to what has been described as *discourses of incompetence,* by continuing the dominant overemphasis on either knowledge or performance (Hodges 2006), but will offer a new lens through which to consider university pedagogy across the disciplines. A concentration on the manipulation of knowledge structures provides a focus for dialogue between subject experts (who have an integrated understanding of the domain) and educational developers who may support the development of curriculum tools to facilitate the transitions between the linear and non-linear. This will be the subject of further research and development by the present authors.

Acknowledgement

Notes on contributors

Ian Kinchin is Assistant Director of King's Learning Institute, King's College London, where he is programme leader on the MA in clinical pedagogy. His main research focus is on the application of knowledge structures in higher education, as revealed by the qualitative analysis of concept maps.

Lyndon Cabot is Senior Lecturer, Director of Admissions and Head of Undergraduate Programmes at King's College London Dental Institute. His primary research interest is the development of theoretical models that reveal the nature of expertise; models that are particularly appropriate for use in the clinical environment.

References

Basque, J., G. Paquette, B. Pudelko, and M. Leonard. 2008. Collaborative knowledge modelling with a graphical knowledge representation tool: A strategy to support the transfer of expertise in organisations. In *Knowledge cartography: Software tools and mapping techniques,* ed. A. Okada, S. Buckingham Shum, and T. Sherborne, 357–82. London: Springer-Verlag.

Benner, P. 1984. *From novice to expert: Excellence and power in clinical nursing practice.* Menlo Park: Addison-Wesley.

Benner, P., C. Tanner, C.A. Chesla, S.E. Dreyfus, and J. Rubin. 1996. *Expertise in nursing practice; caring, clinical judgement and ethics.* New York: Springer.

Berliner, D. 1994. Expertise: the wonder of exemplary performances. In *Creating powerful thinking in teachers and students: Diverse perspectives,* ed. J. Mangieri and C. Block, 161–86. Fort Worth, TX: Harcourt Brace College.

Betsch, C. 2008. Chronic preferences for intuition and deliberation in decision making: Lessons learned about intuition from an individual differences approach. In *Intuition in judgment and decision making,* ed. H. Plessner, C. Betsch, and T. Betsch, 231–48. New York: Lawrence Erlbaum Associates.

Bradley, J.H., R. Paul, and E. Seeman. 2006. Analyzing the structure of expert knowledge. *Information and Management* 43: 77–91.

Cabot, L.B., and I.M. Kinchin. 2008. Clinical teaching as a template for university pedagogy. Paper presented at the Second Excellence in Teaching Conference, March 5, King's College London.

Cader, R., S. Campbell, and D. Watson. 2005. Cognitive continuum theory in nursing decision-making. *Journal of Advanced Nursing* 49: 397–405.

Canning, J. 2007. Pedagogy as a discipline: Emergence, sustainability and professionalisation. *Teaching in Higher Education* 12: 393–403.

Collins, H., and R. Evans. 2009. *Rethinking expertise.* London: University of Chicago Press.

Conway, J. 1996. *Nursing expertise and advanced practice.* Dinton: Quay Books.

Dall'Alba, G. 1993. The role of teaching in higher education: Enabling students to enter a field of study and practice. *Learning and Instruction* 3: 299–313.

Dall'Alba, G. 2002. Understanding medical practice: Different outcomes of a pre-medical programme. *Advances in Health Sciences Education* 7: 163–77.

Dall'Alba, G. 2004. Understanding professional practice: Investigations before and after an educational programme. *Studies in Higher Education* 29: 679–92.

Dall'Alba, G., and J. Sandberg. 2006. Unveiling professional development: A critical view of stage models. *Review of Educational Research* 76: 383–412.

Darbyshire, P. 1994. Skilled expert practice: Is it 'all in the mind'? A response to English's critique of Benner's novice to expert model. *Journal of Advanced Nursing* 19: 755–61.

Didierjean, A., and F. Gobet. 2008. Sherlock Holmes – an expert's view of expertise. *British Journal of Psychology* 99: 109–25.

Dreyfus, H.L., and S.E. Dreyfus. 1986. *Mind over machine: The power of human intuition and expertise in the era of the computer.* New York: The Free Press.

Dunphy, B.C., and S.L. Williamson. 2004. In pursuit of expertise. *Advances in Health Sciences Education* 9: 107–27.

English, I. 1993. Intuition as a function of the expert nurse: A critique of Benner's novice to expert model. *Journal of Advanced Nursing* 18: 387–93.

Eraut, M. 1994. *Developing professional knowledge and competence.* London: Falmer Press.

Eraut, M. 2000. Non-formal learning and tacit knowledge in professional work. *British Journal of Educational Psychology* 70: 113–36.

Hall, K.H. 2002. Reviewing intuitive decision-making and uncertainty: The implications for medical education. *Medical Education* 36: 216–24.

Hammond, K.R. 1988. Judgement and decision making in dynamic tasks. *Information and Decision Technologies* 14: 3–14.

Hay, D.B. 2007. Using concept mapping to measure deep, surface and non-learning outcomes. *Studies in Higher Education* 32: 39–57.

Hay, D.B., and I.M. Kinchin. 2006. Using concept maps to reveal conceptual typologies. *Education and Training* 48, no. 2/3: 127–42.

Hay, D.B., H. Wells, and I.M. Kinchin. 2008. Quantitative and qualitative measures of student learning at university level. *Higher Education* 56: 221–39.

Hodges, B. 2006. Medical education and the maintenance of incompetence. *Medical Teacher* 28, no. 8: 690–6.

Hodges, B., G. Regehr, N. McNaughton, R. Tiberius, and M. Hanson. 1999. OSCE checklists do not capture increasing levels of expertise. *Academic Medicine* 74, no. 10: 1129–34.

Hodgkinson, G.P., J. Langan-Fox, and E. Sadler-Smith. 2008. Intuition: A fundamental bridging construct in the behavioural sciences. *British Journal of Psychology* 99: 1–27.

Hoffman, R.R., and G. Lintern. 2006. Eliciting and representing the knowledge of experts. In *The Cambridge handbook of expertise and expert performance,* ed. K.A. Ericsson, N. Charness, P.J. Feltovich, and R.R. Hoffman, 203–22. Cambridge: Cambridge University Press.

Jarvis, P. 1996. Commentary on chapter twelve: A case study of a patient-centred nurse. In *Essential patient care,* ed. K.W.M. Fulford, S. Ersser, and T. Hope, 193–7. London: Blackwell.

Kinchin, I.M., A. Baysan, and L.B. Cabot. 2008. Towards a pedagogy for clinical education: Beyond individual learning differences. *Journal of Further and Higher Education* 32: 373–87.

Kinchin, I.M., and L.B. Cabot. 2009. An introduction to concept mapping in dental education: The case of partial denture design. *European Journal of Dental Education* 13: 20–7.

Kinchin, I.M., L.B. Cabot, and D.B. Hay. 2008a. Using concept mapping to locate the tacit dimension of clinical expertise: Towards a theoretical framework to support critical reflection on teaching. *Learning in Health and Social Care* 7: 93–104.

Kinchin, I.M., L.B. Cabot, and D.B. Hay. 2008b. Visualising expertise: Towards an authentic pedagogy for higher education. *Teaching in Higher Education* 13, no. 3: 315–26.

Kinchin, I.M., and D.B. Hay. 2007. The myth of the research-led teacher. *Teachers and Teaching: Theory and Practice* 13: 43–61.

Kinchin, I.M., D.B. Hay, and A. Adams. 2000. How a qualitative approach to concept map analysis can be used to aid learning by illustrating patterns of conceptual development. *Educational Research* 42: 43–57.

Kinchin, I.M., S. Lygo-Baker, and D.B. Hay. 2008. Universities as centres of non-learning. *Studies in Higher Education* 33: 89–103.

Lave, J., and E. Wenger. 1991. *Situated learning: Legitimate peripheral participation.* Cambridge: Cambridge University Press.

Lovitts, B.E. 2007. *Making the implicit explicit: Creating performance expectations for the dissertation.* Sterling, VA: Stylus.

Manley, K., and R. Garbett. 2000. Paying Peter and Paul: Reconciling concepts of expertise with competency for a clinical career structure. *Journal of Clinical Nursing* 9: 347–59.

Mcleod, P.J., T. Meagher, Y. Steinert, L. Schuwirth, and A.H. Mcleod. 2004. Clinical teachers' tacit knowledge of basic pedagogic principles. *Medical Teacher* 26: 23–7.

Mezirow, J. 1991. *Transformative dimensions of adult learning.* San Francisco: Jossey-Bass.

Nicol, D.J., and D. Macfarlane-Dick. 2006. Formative assessment and self-regulated learning: A model and seven principles of good practice. *Studies in Higher Education* 31: 199–218.

Norman, G. 2005. Research in clinical reasoning: Past history and current trends. *Medical Education* 39: 418–27.

Novak, J.D., and A.J. Caňas. 2007. Theoretical origins of concept maps, How to construct them and uses in education. *Reflecting Education* 3: 29–42.

Offredy, M., S. Kendall, and C. Goodman. 2008. The use of cognitive continuum theory and patient scenarios to explore nurse prescribers' pharmacological knowledge and decision-making. *International Journal of Nursing Studies* 45: 855–68.

Patel, V.L., J.F. Arocha, and D.R. Kaufman. 1999. Expertise and tacit knowledge in medicine. In *Tacit knowledge in professional practice: Researcher and practitioner perspectives,* ed. R.J. Sternberg, and J.A. Horvath, 75–99. Mahwah, NJ: Lawrence Erlbaum Associates.

Ryle, G. 1963. *The concept of mind.* Harmondsworth: Peregrine Books.

Schön, D. 1995. The new scholarship requires a new epistemology. *Change* 27: 27–34.

Shulman, L.S. 2005. Pedagogies of uncertainty. *Liberal Education* Spring: 18–25.

Seymour, B., S. Kinn, and N. Sutherland. 2003. Valuing both critical and creative thinking in clinical practice: Narrowing the research-practice gap. *Journal of Advanced Nursing* 42: 288–96.

Sox, H.C., M.A. Blatt, M.C. Higgins, and K.I. Marton. 1988. *Medical decision-making.* Boston: Butterworths.

Talbot, M. 2004. Monkey see, monkey do: A critique of the competency model in graduate medical education. *Medical Education* 38: 587–92.

Vance, C., D. Zell, and K. Groves. 2008. Considering individual linear/nonlinear thinking style and innovative corporate culture. *International Journal of Organizational Analysis* 16, no. 4: 232–48.

Welsh, I., and Lyons, C.M. 2001. Evidence-based care and the case for intuition and tacit knowledge in clinical assessment and decision making in mental health nursing practice: An empirical contribution to the debate. *Journal of Psychiatric and Mental Health Nursing* 8: 299–305.

Wenger, E. 1998. *Communities of practice: Learning, meaning and identity.* Cambridge: Cambridge University Press.

Yielder, J. 2004. An integrated model of professional expertise and its implications for higher education. *International Journal of Lifelong Education* 23: 60–80.

Yielder, J. 2009. *Professional expertise: A model for integration and change.* Saarbrucken: VDM Verlag.