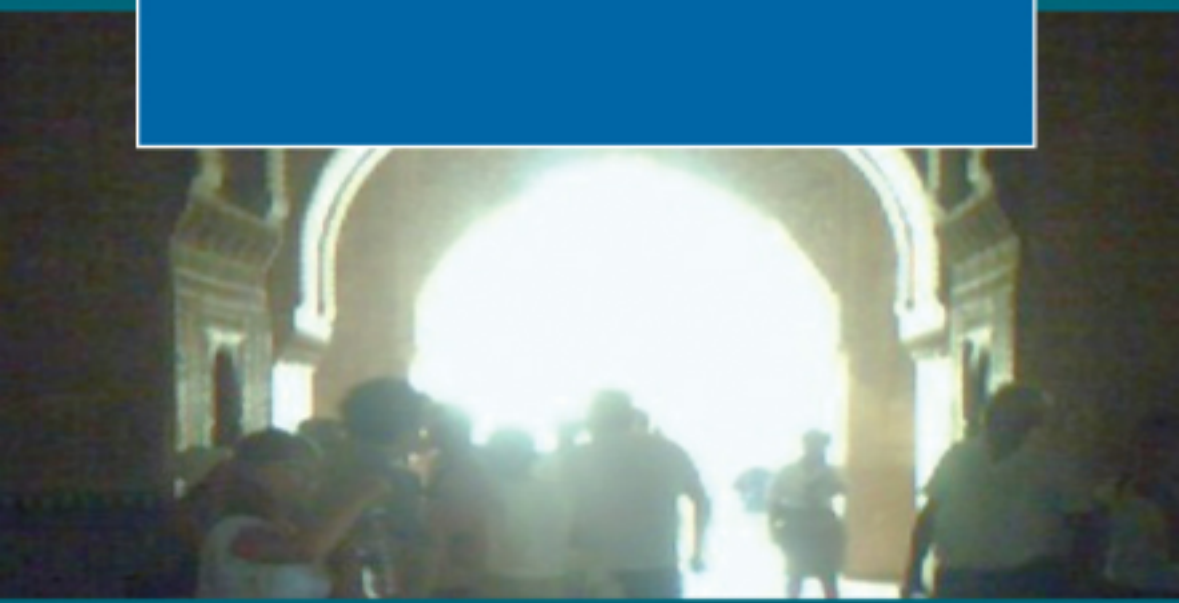
EDUCATIONAL FUTURES: RETHINKING THEORY AND PRACTICE

Threshold Concepts within the Disciplines

Ray Land, Jan H.F.Meyer and Jan Smith (Eds.)



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Threshold Concepts within the Disciplines

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EDITORS' PREFACE

Imagine that you are a raw potato – a Desirée potato. We don't know what it feels like to be such a raw potato, nor are we entirely confident that it is appropriate to consider the subjectivity of such a vegetable but, in terms of your chemical composition, we might imagine an ontological horizon defined in terms of being starchy, watery, and sugary. You are about to enter a state of liminality on the way to becoming a *roast* potato. Aspects of the journey thus far have been troublesome. You have lost your red skin. Your delectable yellow creamy flesh has been exposed. You have been parboiled to get rid of some of your starch. Your outer surface has been roughened. You don't know it, but there is still more trouble ahead. That first glimpse of other potatoes in the hot fat may be the first sign of what things may look like 'on the other side' of the portal. You are not yet a roast potato, and you do not know what it is like to *be* a roast potato. And in the preliminary stages of getting to where you are now you could have entertained other options. Such as keeping your skin on for a start. As a peeled, parboiled potato you still have options. You can, for example, be transformed into mash or something more exotic like *soufflé di patate.* With a bit of creative luck, you might even assume the mantle of *pommes boulangère* or *gratin dauphinoise*. But, once you hit the fat that's pretty much it. You are beginning to cross the portal that is the heat induced process of caramelisation: an irreversible chemical process that will transfigure your identity. You will look, feel, smell, and taste different. You will have entered a new space: the world of caramelised roast potatoes.

Sadly the potato has no self-determination, no control over experiences which might either encourage or discourage an understanding of a threshold concept, and we will leave it to its destiny at the point of caramelisation. But there is a serious side to this imaginary journey. As Glynis Cousin points out in Chapter 19 of this volume, threshold concept theory addresses 'the kind of complicated learner transitions learners undergo'. Generating a supportive learning environment to sustain learners whilst they negotiate such transitions involves, she says, 'a deep appreciation of a dialectic between knowing and being.'

> …mastery simultaneously changes what we know and who we are. Learning is a form of identity work. (Cousin, Chapter 19, p. 264)

In the period since the notion of threshold concepts was first presented at the 10th Improving Student Learning Conference in Brussels in 2002, the main characteristics of this conceptual framework have remained constant, and relatively straightforward. The basic idea underpinning this field of enquiry is that, probably

in all disciplines, there are conceptual gateways or 'portals' that must be passed through, however difficult that passage might be, to arrive at important new understandings. This was expressed in the seminal paper on thresholds as follows:

> 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. This transformation may be sudden or it may be protracted over a considerable period of time, with the transition to understanding proving troublesome. Such a transformed view or landscape may represent how people 'think' in a particular discipline, or how they perceive, apprehend, or experience particular phenomena within that discipline (or more generally). (Meyer and Land, 2003, p. 412).

In attempting to characterise such conceptual gateways it was suggested in the earlier work that they are *transformative* (occasioning a significant shift in the perception of a subject), *integrative* (exposing the previously hidden inter-relatedness of something) and likely to be, in varying degrees, *irreversible* (unlikely to be forgotten, or unlearned only through considerable effort), and frequently *troublesome*, for a variety of reasons. Discussions with practitioners in a range of disciplines and institutions led us to conclude that a threshold concept can of itself inherently represent what Perkins (1999) referred to as *troublesome knowledge* – knowledge that is 'alien', or counter-intuitive, ritualised, inert, tacit or even intellectually absurd at face value. It increasingly appears that a threshold concept may on its own constitute, or in its application lead to, such troublesome knowledge. This volume will analyse further the different ways in which knowledge can prove troublesome for students (and teachers) and will draw attention to the implications of this for the curriculum. Threshold concepts also tend to be *bounded* in that they serve as boundary-markers for the conceptual spaces that constitute disciplinary terrain. Later work (Meyer and Land, 2005) indicated the *discursive* nature of threshold concepts and further potential sources of troublesomeness arising both from language and from the ontological dimension of such threshold concepts. As we gain new knowledge, we are changed by it, and these shifts are manifested in a changed use of language.

For students who find the learning of certain concepts difficult, we have characterised such spaces as akin to states of 'liminality' which tend to be transformative in function, and usually involve an individual or group being altered from one state into another. As a result of such transformation the learner acquires new knowledge and subsequently a new status and identity within the community of practice. However, this state of 'liminality', the space of transformation, can also become a suspended state, or 'stuck place', in which understanding approximates to a kind of 'mimicry' or lack of authenticity (Meyer and Land, 2003). Insights gained by learners as they cross thresholds can be exhilarating but

might also be unsettling, requiring an uncomfortable shift in identity. Paradoxically this may be experienced as a sense of loss as an earlier, more secure stance of familiar knowing has to be abandoned as new and unfamiliar knowledge is encountered. A further complication might be the operation of an 'underlying game' or 'episteme' (Perkins 2006) which requires the learner to comprehend the often tacit games of enquiry or ways of thinking and practising (WTP) inherent within specific disciplinary knowledge practices.

Transformation can be protracted, over considerable periods of time, and involve *oscillation* between states, often with temporary regression to earlier status. It would appear, however, that once the state of liminality is entered, though there may be temporary regression, there can be no ultimate full return to the pre-liminal state. There would seem to be no re-winding of the transformative process.

Threshold Concepts have thus emerged as a set of transferable or portable ideas across disciplinary contexts, which offer new insights into teaching and learning, and as a theoretical framework which is both explanatory and 'actionable' (capable of translation into action). The significance of the framework provided by threshold concepts lies in its explanatory potential to locate troublesome aspects of disciplinary knowledge within transitions across conceptual thresholds and hence to assist teachers in identifying appropriate ways of modifying or redesigning curricula to enable their students to negotiate such transitions more successfully. It is principally an analytical framework for trying to understand how students learn, where the barriers to their learning lie, be they epistemological or ontological, and what appropriate pedagogical adjustments or modifications might overcome such difficulties.

It draws eclectically on a number of theoretical perspectives, some from learning theory, and some from other disciplines. It can be seen to some extent as a form of social constructivism; our colleague David Perkins at Harvard has drawn attention to the connection between threshold concepts and his own work on troublesome knowledge and, more recently, on dispositional knowledge. The approach reflects a 'conceptual change' model of learning. It addresses discipline-based learning and Perkins has referred to it elsewhere as a 'theory of difficulty' (Perkins, 2007). Threshold Concepts also, in its analysis of how learner identities undergo transformation as new knowledge is encountered, has affinities with social learning theory, particularly the work of Wenger (1998) on communities of practice, who in turn draws on Vygotsky's (1978) notion of a zone of proximal development. Many of the chapters in this volume show a particular interest in how students enter disciplinary communities of practice and acquire the knowledge practices and particular identities, or ways of being, needed to enter them.

Threshold concepts draw on, but also challenges in some ways, the phenomenographic tradition of studies of how students approach learning, and how they experience and conceive of learning. Noel Entwistle's chapter in this volume indicates connections between the phenomenographic tradition and threshold concepts. From the outset there has been a close relationship between threshold concepts and the tradition of variation theory associated with Ference Marton, and

his colleagues in Sweden and Hong Kong (Marton et al, 2004), though we propose a somewhat different model of variation from Marton's (see Chapter 5 in this volume by Meyer, Land and Davies).

In its notion of 'liminality', which is an important part of our analysis, the framework draws from a different tradition on the social anthropological theory of Victor Turner (1969), the originator of the concept. We also make use of notions of discourse and the discursive formation of subjectivity and disciplinary identity through learning. This draws on certain postmodern cultural theory as well as discourse analysis. The strong emphasis on the ontological dimension of learning – for which the graphic tale, earlier, of the desirée potato's transfiguration into roastedness and caramelisation stands as ready testament – reflects similar emphases and concerns in the philosophy of education, most notably in the influential work of Ron Barnett (Barnett, 2005). At the pragmatic level of attempting to identify the points and sources of conceptual difficulty, disjunction and troublesomeness, the work of Ian Kinchin and David Hay (2005), in turn drawing on the earlier studies at Cornell by Joseph Novak (1990), have proved extremely valuable.

So the framework is a varied, rich and occasionally heady cocktail of ingredients, a kind of conceptual *sangria*. It does not fit neatly into one particular niche or under one convenient label, but we feel that it perhaps does not necessarily need to. We hope that its eclecticism might make it of relevance and interest to a very broad range of practitioners, in all disciplines, and particularly those 'front-line' teachers who are frequently faced with the conceptual difficulties and 'stuck places' so often discussed in this volume, and who often bear the responsibility for course design. We also see the framework as not being restricted solely to learning within the context of higher education but of equal value and portability to all other educational sectors.

The first volume of studies on threshold concepts, *Overcoming Barriers to Student Understanding*, appeared in 2006 (Meyer and Land, 2006). This second book, which has its origins in a lively international symposium on thresholds at Strathclyde University, Glasgow in the autumn of 2006, builds and expands on the first in a number of important ways. It provides much more empirical data concerning the experience of threshold concepts and troublesome knowledge from the students' perspective. The volume also adds to the range of disciplinary contexts in which thresholds have been studied. We have in this volume substantial and compelling findings from subjects as diverse as economics, computer science, different branches of engineering, biology, teacher education, languages, art therapy, and transport and product design. The contexts range from England, Scotland, Wales, Northern Ireland and the Republic of Ireland to Sweden, Australia, Canada and the United States. The book also further develops the theoretical dimension of threshold concepts and reflects a migration of interest into wider spheres such as doctoral study, the professional development of academics as teachers, and issues relating to the methodologies that might prove productive in researching threshold concepts in specific disciplines. In regard to this latter point, there remain interesting issues around how we might best research threshold

concepts. There is, as yet, no established methodology, or doctrine, in this regard, and perhaps that is how it should be, given the epistemological diversity of disciplines. This remains, however, an avenue of inquiry meriting further exploration.

The book is divided into three sections to reflect these emphases. Part I, 'Theoretical Perspectives', contains extensions, further elaborations or re-examinations of the original framework. David Perkins opens the volume with a thoughtful analysis of learning in terms of *possessive*, *performative* and *proactive knowledge*, suggesting that 'The notions of proactive knowledge and threshold concepts make natural partners'. He goes on to point out how 'a collection of threshold concepts or an unusually pivotal one can provoke a kind of an epistemic shift, where the very "game" or epistemic enterprise of the discipline can come out looking somewhat different'. Threshold concepts, he argues, have a strong 'reorganising power'. However, he cautions that this can bring with it 'an unfamiliarity that sometimes proves acute and off-putting. You can't rebalance the boat without rocking it.'

In the second chapter Noel Entwistle provides a valuable definition of the features of threshold concepts in relation to influential educational research into student learning over the last three decades. This includes phenomenographic studies of conceptions of learning, and Perry's developmental stages in conceptions of knowledge and learning. He argues that threshold concepts have a natural fit with the second of three distinguishable ways in which students' understanding of a subject can be opened up: through certain basic concepts in the early stages of a course, through integrative threshold concepts within the discipline, and through acquiring the distinctive ways of thinking and practising (WTP) characteristic of the subject. He aligns his conclusions with the empirical work from undergraduate economics presented in the following chapter by Peter Davies and Jean Mangan. They have constructed a model, drawn from the findings of the national *Embedding Threshold Concepts* project based at Staffordshire University, which proposes that transformative learning is better conceived as the acquisition of a *web* of threshold concepts organized into three categories of conceptual change. The first is a *basic* view of *personal conceptual change* (newly met concepts some of which transform understanding of everyday experience through integration of personal experience with ideas from the discipline). The second is *discipline-based conceptual change*, a (threshold) conception involving understanding of other subject discipline ideas (including other threshold concepts) integrated and transformed through acquisition of a theoretical perspective. The third is *procedural conceptual change*, requiring the ability to construct discipline-specific narratives and arguments transformed through acquisition of ways of practising.

Bob McCormick, in Chapter 4, critically re-examines the thresholds framework but from the different angle of Sfard's *acquisition* and *participation metaphors*, noting that the thresholds framework tends to mix these metaphors, sometimes seeing knowledge 'as an object, independent of knowers and what they do with the knowledge' but elsewhere drawing on the language of participation with notions such as communities of practice, tacit knowledge, academic territories, and, central

to the participation metaphor, the 'transformation of personal identity'. Meyer, Land and Davies follow this in Chapter 5 with a further contribution to the original conceptual framework, suggesting that variation is a key component to the understanding of both how and where students might encounter conceptual difficulty. They provide indications as to how such variation might be assessed – at *pre-liminal*, *liminal*, *post-liminal* and *sub-liminal* stages of the learning trajectory – and consider how the use of variation within pedagogical practice (eg through illustrative example) can help students acquire new conceptual understanding. However the use of variation with some forms of troublesome knowledge (e.g. complex number in mathematics) is not always straightforward.

Maggi Savin-Baden's chapter closes the theoretical section by making a case that threshold concepts should be located in 'a broader conceptualisation of students' disjunction', with a greater emphasis on the relationship between learner identities and threshold concepts than there has been in the research literature heretofore. She concludes that the notion of 'learning spaces' and 'liquid learning' (after Bauman 2000) might be more useful for the construction of a model of transitional learning. Such an approach would allow, furthermore, 'for the recognition of the cyclical nature of learning'.

The central and largest section of the book, 'Disciplinary Contexts', draws on empirical studies undertaken across a range of subject areas. Observing the conceptual difficulties of 'operationally challenged' first year electronic engineering students struggling to come to terms with Java programming, Mick Flanagan and Jan Smith (Chapter 7) identify the 'nested' nature of the troublesome concepts facing this group. They identify the source of that troublesomeness, and any pedagogical resolution of it, within the semiotic complexities of language itself.

In a multi-national study (Chapter 8) Carol Zander, Robert McCartney and Kate Sanders from the USA, Jonas Boustedt, Anna Eckerdal, and Jan Erik Moström from Sweden, and Mark Ratcliffe from the UK used informal interviews and questionnaires to obtain data from teachers, and scripted, structured interviews to obtain data from students, to identify threshold concepts in computer science and to investigate how students might understand these concepts. 'Object-oriented programming' and 'memory/pointers' emerged as early candidates for thresholds, but their study also raises several broader issues with regard to future empirical studies of threshold concepts, such as at what point in a student's learning is data most profitably to be gathered, and what exactly does it mean for a concept to be *integrative?* As these researchers ask 'Is it integrative only if it integrates concepts the student already knows? Or can a concept be integrative if it connects a number of things that are only learned later?'

Also undertaking inquiry within computer science Dermot Shinners-Kennedy (Chapter 9) identifies 'state' as a further threshold concept. He sees this as exemplifying a 'simplicity and everydayness' that might characterise many threshold concepts. Everyday activities, he suggests, 'have a huge number of important concepts associated with them but they are rich with troublesome knowledge. Because they are so automated and compressed we find it difficult to

extract the component concepts'. In addition to the sources of troublesomeness identified within the thresholds framework he identifies further problems associated with 'layered knowledge' and 'knowledge in the world'.

Within engineering Caroline Baillie and Anne Johnson (Chapter 10) draw on the findings of a large-scale Canadian study. They used in-depth interviews, course artifacts and student evaluation feedback to identify professional 'ways of thinking and practising' as an engineer as an attitudinal threshold that many students found troublesome. A major source of this appears to be fear of uncertainty. 'Students of engineering enjoy the precision of maths and physics that they learned in high school and find uncertainty in real messy human problems difficult to deal with'. They identify two 'pathways through barriers' which might offer practical ways forward for engineering students.

In electrical engineering Anna-Karin Carstensen and Jonte Bernhard (Chapter 11) studied video recordings of lab-work with Swedish students to develop a way to identify troublesome aspects of any given concept. They considered troublesome concepts in the learning of electrical circuits and control theory, such as frequency response. They describe how their use of variation theory opened up new dimensions in the understanding of learning sequences. In particular they found that certain concepts, such as the Bode Plot in circuitry, can function like a specialist 'key' that opens up the disciplinary portal of understanding. Moreover teaching a 'key' concept, according to this definition, does not just open up that particular concept, but also *the learning of other concepts related to it*. This led to an observed improvement in the scores achieved by students on a test following the course.

In the subject of economics, a discipline in which there has now been considerable research undertaken into threshold concepts, Martin Shanahan, Gigi Foster and Jan Meyer (Chapter 12) gathered data from a first-year microeconomics course at the University of South Australia. They grouped multiple choice and examination questions to reflect the three categories of conceptual change proposed by Davies and Mangan in Chapter 3 of this volume. Their aim was to explore whether the web of threshold concepts proposed by Davies and Mangan can be 'made visible' by quantitative analytical means. More particularly they wished to determine how the Davies and Mangan categories of threshold concepts, as revealed through students' multiple choice responses early in the course, correlated with their final examination marks. They conclude that there is 'sufficient evidence of statistical association' to support the contention that students' prior acquisition of an interrelated web of threshold concepts can affect their performance in standard economics examinations. Moreover they contend 'that properly-constructed multiple choice questions are capable of capturing variation in students' acquisition of threshold concepts, and that evidence of such variation can inform the pedagogy of threshold concepts'.

Also in the discipline of economics Andrew Ashwin (Chapter 13) is concerned to examine the experience of conceptual difficulty amongst the many students who encounter economics before undergraduate level. Examining the understanding of a rise in oil prices with students in the 14-19 age group, he

employed the Biggs and Collis (1982) SOLO taxonomy initially 'because it was anticipated that it would more accurately reflect the quality of the learning outcome with respect to understanding and assessing threshold concept acquisition'. His findings identify a need for a 'transformed understanding of a subject' in the years before entrance to higher education. A focus on the idea of *thinking in the subject* is, he suggests, more useful than a primary focus on knowledge and content, if we wish to avoid ritualised knowledge and 'grade chasing'. He favours using the idea of a web of concepts (cf, Davies and Mangan, Chapter 3 of this volume) to gain an understanding of a discipline, where concepts have a degree of inter-relationship between them. 'To understand one concept one might require some understanding of another, and moreover an ability to recognise the relationship between the two'. Such qualitative understanding, he argues, would emphasise the ability to be able to recognise and interpret economic concepts and phenomena in a wide range of different contexts. Moreover, to 'see the similarities in the critical attributes that the concepts possess, and be able to relate these to the approach to a problem … would be seen as constituting *economic thinking*' at this important stage of learning.

Biology, suggests Charlotte Taylor (Chapter 14), is seen as being 'a more wide-ranging discipline than others, particularly in the sciences, since it encompasses a wide range of specialist fields'. Building on her earlier studies she undertakes a series of interviews with both teachers and graduates to explore the complexity of her discipline and attempt to identify the most salient areas of troublesome knowledge as well as the potential thresholds in biology. Both of these groups, she reports, identified a number of areas of biology which might be identified as candidates for threshold concepts, and these areas seem to be principally concerned with the *complexity*, *dynamics* and *variability* to be found in biological systems. 'The area of molecular biology was seen by many as particularly troublesome as it involved concepts which are constantly changing as new discoveries are made. Graduates are keenly aware of their new position at the cutting edge in science, and the inherent problems and challenges in this area'. These boundaries, she argues, have to be constantly re-assessed and the new knowledge and thinking integrated into the view of the discipline.

In the world of teacher education 'Knowledge and understanding are transformed in unpredictable ways for beginning teachers'. Researching in the context of a Scottish mentoring programme Moya Cove, Julie McAdam and James McGonigal (Chapter 15) recognise that the early establishment of classroom norms of behaviour, and gaining a personal sense of organisation and effectiveness within classroom life, can be a particularly troublesome and daunting prospect for novice teachers. As these researchers point out:

> Learning to confidently walk the social and pedagogical boundaries between firmness, direction and supportive engagement with young learners may well be a threshold concept that eases the pursuit of many other classroom aims.

As they listen to these beginning teachers' experiences and reflections they come to identify a sense of where ten recognised threshold concepts had begun to alter

the students' awareness of teaching and learning. This to some extent offers a simpler prospect than the current twenty-two benchmark statements and ten transferable skills in the government professional standards, which still remain complex for beginners to comprehend. The researchers thus draw a tentative conclusion that 'Threshold concepts might therefore assist in developing student teachers' confidence about their progression through the teacher education experience, and its often puzzling jargon'.

The remaining contributions to this central section of the book highlight the diversity of disciplinary contexts in which the application of threshold concepts is finding resonance. Marina Orsini-Jones, in her chapter on language learning (Chapter 16), investigates the troublesome concept of *rank scale* in the learning of grammar. She implemented a carefully constructed programme of support which involved the following: doubling the time allocated to explaining grammar in general, changed assessment practices, provision of more samples of grammatical analysis, more collaborative practice workshops to complement lectures, the use of supportive virtual learning environments and the encouragement of meta-reflection through students' learning journals. As a result some of the students who had managed to grasp the rank scale concept:

> became very aware that there was an extra dimension to grammar analysis which was new to them and that had opened new doors of linguistic understanding. The realisation that the *rank scale* unlocked the hidden architecture of a sentence *transformed* their perception of language learning and language analysis. Some students also stated that grasping the *rank scale* concept had helped them in analysing sentences in all the languages they were studying. They were now able to transfer the concept and this was enabling them to see grammar links that they had not seen before.

However, as the author goes on to report, the *integrative* nature of this concept and its *irreversibility* came under discussion when it emerged that certain students seemed able to understand and apply rank scale in one language (e.g. German) but not in another (e.g. English). This raises the intriguing question of whether this particular threshold concept can only be transferred within the same language and not across different languages, unless there is a chronological dimension to the acquisition of this understanding, requiring perhaps 'the crossing of more thresholds' in order for some students to see the connections between languages.

In a very different context, that of art therapy with cancer patients, Caryl Sibbett and William Thompson (Chapter 17) explain how 'Knowledge can be troublesome not just cognitively, but also emotionally, attitudinally, bodily and inter-personally or institutionally and socially.' They propose the generative idea of *nettlesome knowledge* which 'comprises elements of knowledge that are deemed taboo in that they are defended against, repressed or ignored because if they were grasped they might 'sting' and thus evoke a feared intense emotional and *embodied* response. The sting of nettlesome knowledge can make us uncomfortable and so it can be stigmatised.' The nettlesome aspects of cancer suffering may be excluded in that they are deemed taboo and hence *unthinkable*, *unspeakable*, *unhearable*, *unseeable*

and *untouchable.* Liminal states themselves (of which cancer itself is a potent example) were also found in this study to be associated with taboo for both the health professionals, the therapists and their clients. The authors go on to explain, through an analysis of the nature and complexities of play, how arts-based learning can successfully bring the unspeakable and unhearable into view and hence into reflection and therapy, with significant accompanying shifts in identity.

The tacit nature of visual design knowledge comes under scrutiny in the study of automotive and product design students by Jane Osmond, Andrew Turner and Ray Land (Chapter 18). They point out how the course they have been observing in a longitudinal four year study offers more than the accumulation of skills and information, and is viewed as 'a process of becoming – in this case becoming a certain kind of creative and critically minded design practitioner. Through this transformative practice a professional identity is formed, and, through the desire to become accepted within the community of creative design practitioners, learning can become a source of motivation, meaningfulness and personal and social energy'. The researchers have identified the development of spatial awareness as an important threshold concept that is both necessary to visual design and at the heart of this process of professional formation. However, the empirical data from their interviews with both design staff and students highlighted the troublesome nature of *tacit* and implicit understandings in the teaching of spatial awareness in design contexts. Moreover threshold concepts seem to be entangled with a much wider pattern of practice and enquiry, a set of games (reminiscent of Perkins' 'underlying episteme') that are played with the concepts, and which in turn can provide a further source of troublesomeness for the novice. The data they are gaining is being used to assess the relative advantages and limitations of the currently adopted *atelier* method as a learning environment for the development of spatial awareness and other related concepts, and to identify pedagogical modifications to this approach where appropriate.

The final section, 'Pedagogical Directions', indicates ways in which the threshold concepts framework is beginning to 'migrate' into wider areas of educational practice and policy. Glynis Cousin (Chapter 19), reviewing changing emphases in learning theory in recent decades, detects in the thresholds framework a turning away from what has been termed 'the mortification of the teacherly self', (McShane, 2006) which appears to have been an unintended consequence of student-centred approaches. She queries the 'dismantling and outlawing' of teacher-centredness in favour of student-centredness, and wonders whether a well-intentioned 'counter-position meant as a heuristic device' has been turned into 'a source of moralising'. She suggests that it might be time in terms of broader paradigms to swing the pendulum back to teachers, 'not as lone sages on the stage but to strongly position them with their students and educational researchers/developers as partners in an inquiry into disciplinary concerns'. She names such a partnership *transactional curriculum inquiry* and argues that threshold concept research can foster this kind of approach:

> because it squarely places subject specialists at the centre of an inquiry into the difficulty of their subject. In this way there is a restoration of dignity for academics and a promising reconfiguration of the research relationships between students, academics, educational researchers and developers.

Vernon Trafford (Chapter 20) carries the thresholds framework into the terrain of doctoral study. In a substantial empirical inquiry into the experience of many doctoral research students he concludes that understanding of the nature and purpose of *conceptual frameworks* acts as a threshold concept in doctorateness. Moreover, successful negotiation of this threshold seems to be a necessary condition of success in doctoral studies. 'The importance of this process', he points out, 'has been shown as a major determinant of how examiners assess the scholarship submitted by candidates'. The cameo accounts he provides from doctoral candidates vividly depict the associated phenomena of liminality and troublesome knowledge as they approach and pass beyond this particular threshold. This passing through the threshold concept to understanding of conceptualisation and doctorateness, he emphasises, is a crucial 'ontological perspective' hitherto underemphasised by supervisors and their candidates.

In the concluding chapter Mia O'Brien, working in the context of Australian higher education, has undertaken a detailed study of the professional development of university teachers and the ways in which the *teaching* of threshold concepts 'implies pedagogical knowledge and thinking that is itself threshold in nature and potentially troublesome'. At present, she argues, 'research on the kinds of pedagogical thinking teachers of threshold concepts undertake is limited, as is our empirical understanding of the transformative nature of this practice for teacher knowledge and expertise'. She questioned teachers in Arts, Health Sciences, Business Studies, Physical Sciences, Psychology and Biological Sciences. She asked them what the threshold concept is in their teaching and why it is important for students to learn it. What is difficult, challenging or problematic about learning this threshold concept? What do they do to support students to learn this concept and why? Her findings reveal that there are three threshold concepts central to university teaching and learning: *threshold concepts as subject matter, as learning,* and *as teaching.* But while these terms might be well known and soundly articulated within the literature, her data indicates that 'a deep and transformative understanding of these concepts *cannot be taken for granted* within university teaching.' If teaching is to be more effectively directed towards student learning, she concludes, there are two related gaps that university teachers will need to find their way across:

> (a) the gap between the assumed and taken for granted epistemological and ontological foundation from which an academic currently views the world, and the capacity to speak objectively about this view from a critical perspective, and (b) the necessity for pedagogical thinking, reasoning and action to be grounded within disciplinary epistemologies and ontology and to locate these centrally within the learning experience of students (often in the absence of a critical curriculum philosophy).

These many diverse studies, undertaken in a wide range of institutions, in various disciplines and in different cultures, would seem to indicate that the threshold concepts model offers a new way of engaging busy academics by encouraging them to resolve students' learning problems from *within* their discipline. The academic's knowledge and status, to some extent neglected by 'student-centred' approaches, are restored within a more balanced transaction between teacher and learner, occasioning to some extent, perhaps, a swing back of the pendulum. Certainly a significant appeal of the threshold concepts approach seems to be that it allows the academic to help the student negotiate conceptual thresholds from the perspective of their subject, and by using the language of their discipline. Academics tend to identify and take possession of threshold concepts quickly, as they have the specialist knowledge and expertise within their disciplinary discourses. They are not required to bring with them the extra baggage of a separate, and sometimes alien, discourse of 'education'. Conversely, threshold concepts are not shrouded in a doctrine of salvation from stuck places. As reported in the UK educational press recently:

> There are no five easy steps to teach threshold concepts. Rather, they are always analysed and resolved from, and within, specific and situated disciplinary contexts. This is not surprising, given that academics are always keen to discuss the nuanced meanings of their specialism. But identifying the sources of troublesome knowledge that constitutes a barrier to student understanding can prove a powerful way of adapting one's teaching or re-thinking course design issues. (Meyer and Land, 2007 p.14)

We believe strongly, as Glynis Cousin argues in her case for transactional curriculum inquiry, that 'the overwhelming strength of threshold concepts is precisely in the opportunities for co-inquiry it presents between subject experts, students and educational researchers'. This holds out for these key actors a 'pursuit of shared understandings of difficulties and shared ways of mastering them.' The thresholds framework, as one form of transactional inquiry, offers an approach 'which becomes neither student-centred nor teacher-centred but something more active, dynamic and in-between'.

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Glasgow and Durham
January 2008

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PART I: THEORETICAL PERSPECTIVES

DAVID PERKINS

1. BEYOND UNDERSTANDING

INTRODUCTION

What is knowledge? I found this fundamental epistemological question on my mind again when a number of months ago I asked for a few volunteers from a group to characterise something they understood really well. Among several good responses, one especially stood out. A gentleman stood up and reported on his understanding of Ohm's law.

He recounted how he had first encountered Ohm's law during formal studies of physics. Later on, someone he knew had explained to him that the same basic principles could be applied more broadly, for instance to the behaviour of heating systems. Then, more years later, he found himself with a puzzle about the layout of his own home heating system. The conduits were not providing the degree of throughput he desired. To be sure, heating ducts are not exactly electrical wires, the various impediments to the flow of hot air not exactly electrical resistance, but nonetheless he put Ohm's law to work to design an arrangement of ducts that might provide superior performance. And they did!

Whether his application was entirely technically correct is not so much the point. It was good enough to be useful. Not only did the fellow display substantial understanding of Ohm's law, he also demonstrated alertness to new opportunities to apply it and an energetic stretch to put it to work in an unfamiliar area. One might say that his knowledge of Ohm's law was not just active but *proactive*.

This small-scale example of the nimble use of knowledge might remind us of iconic models from the past. Leonardo da Vinci was notoriously a questing soul, exploring themes and making contributions across the arts, architecture, anatomy, physics, engineering, and military affairs. For a contemporary figure, Richard Feynman displayed a bold curiosity regarding all sorts of things in addition to quantum theory throughout his life. Such paragons help to sustain a vision of how vitally knowledge can function. However, there is no need to set the bar so high. We should also cherish the small generative connections that help to make sense of a complicated world and help to make it better ... like applying Ohm's law to heating ducts.

With connections small and large in the foreground, it is argued here that learning will only be truly effective when the conception of knowledge underlying it has a proactive character. Proactive knowledge goes beyond understanding to prepare the learner for the alert and lively use of knowledge. A key step in the argument connects proactive knowledge to the idea of threshold concepts in the

R. Land, J.H.F. Meyer & J. Smith (Eds.), Threshold Concepts within the Disciplines, 3-19.

disciplines in two ways. On the one hand, instructional attention to threshold concepts seems likely to foster proactive knowledge. On the other, the concept of proactive knowledge has something of a threshold character, with the potential to reorganise in significant ways how we think about teaching and learning.

POSSESSIVE, PERFORMATIVE AND PROACTIVE KNOWLEDGE

What is knowledge? Knowledge is information, or at least that seems to be the tacit view behind a good deal of learning. According to this *possessive conception*, knowledge is money in the cognitive bank – favourite phone numbers, today's Dow Jones, the dates of important historical events, the whereabouts of the nearest multiplex cinema, how to claim a particular exemption on your income tax. Certainly such knowledge can be handy, but it does not reach very far towards enlightenment or empowerment or a responsible life.

Of course the possessive view is not the only conception of knowledge with currency. Many educators, psychologists, philosophers and others have advocated a richer conception of knowledge, knowledge as understanding. A particular way of looking at that is helpful here, a *performative view* that interprets understanding as a matter of flexible thinking and action (Perkins, 1998; Wiske, 1998). The performative conception foregrounds not just how much knowledge you have but how much you can do with what you have. Performance depends on possession – you have to have it in order to think with it – but goes beyond possession – how well you understand something depends on whether you can reason with it, make predictions, offer critiques, build something, invent something. Back to Ohm's law, if you can recite Ohm's law and apply it to thoroughly routine problems, that demonstrates only knowledge as possession. However, if you can apply Ohm's law to novel problems within electronics, or outside such as to heating ducts, that demonstrates knowledge as flexible performance.

Educators generally see knowledge-as-understanding as an adequate corrective to the possessive conception. However the example of Ohm's law and heating ducts warns that this may not be enough. What's most striking about it is its proactive character – not just knowledge possessed or even knowledge performed but knowledge proactively deployed. Just as performative knowledge includes but goes beyond possessive knowledge, so proactive knowledge includes but goes beyond performative knowledge. For the fellow with the heating puzzle, there was no textbook with a surprise extra-credit problem on heating ducts at the end of the chapter. The fellow made his own connection. For the kind of learning we want, important as understanding is, we need to step beyond understanding.

WHAT KIND OF KNOWLEDGE WHEN

What is knowledge? Another lesson about the nature of knowledge came my way a few months ago during a dinner table conversation about cholesterol. The topic was the relative cholesterol content of different foods and how much it mattered, but at one point we all sat back and asked ourselves how much we really knew

about cholesterol. The answer: not much. However, the sketchy and superficial story we did have was rather handy for some practical self-management. Let's face it: a high percentage of the knowledge that gets every one of us through every day is "cholesterol knowledge" – relatively superficial possessive knowledge.

So what kind of knowledge do we need when? When we want to find our way to the bank, do a quick routine arithmetic calculation, make a deposit, and then head home, we are well served by a loose bundle of rather superficial facts and routines. Possessive knowledge does the job.

When we need real understanding, often we still do not need proactive knowledge. Performative knowledge is good enough because the circumstances assert a direct demand. A source we are reading or someone with whom we are conversing uses concepts we understand like the tragedy of the commons or Darwin's theory of evolution, so we can follow the argument and argue back. When we are negotiating a loan at a bank, the bank representative reminds us of the significance of compound interest. The world speaks to us with a loud voice and reminds us of what we know and understand.

However the world often speaks with a softer voice. Knowledge needs to function proactively if it is to function at all. For instance, it is relatively easy not to notice the moment or not to care enough to bother when:

- Politicians make exaggerated statements that might violate other things we already know about the topic.
- Ethical issues arise in small ways during everyday activities – matters of ethnic slurs, fair treatment, intellectual property, and the like.
- National or foreign events occur that would be illuminated by comparison with historical episodes we know about, if only we made the connection.
- Everyday interactions would benefit from better handling informed by ideas about stereotyping, reactance, attribution, and so on from social psychology we have studied, if only we saw the link.
- Medical decisions, insurance decisions, or purchase decisions would benefit from some very simple principles of statistics and probability, if only we thought to apply what we know.

It is not hard to add to this list. John Dewey was one ardent advocate of education for the alert and active use of knowledge. As he wryly remarked in his *Democracy and Education*, "Only in education, never in the life of farmer, sailor, merchant, physician, or laboratory experimenter, does knowledge mean primarily a store of information aloof from doing" (Dewey, 1916, ch. 14). In the complex contemporary world, the mobilisation of formally acquired knowledge beyond classroom settings is becoming ever more of an urgent and neglected priority. Levy and Murnane (2004; Murnane & Levy, 1996), exploring how education prepares learners for today's world of work, emphasise the importance of expert thinking and complex communication skills that in effect activate knowledge. In a synthesis of ideas about citizenship, Haste (2004) notes remarkably low correlations between what people know about areas relevant to citizenship and their actual engagement.

Eraut (1994) is severe in his examination of the degree to which professional education actually prepares graduates for effective functioning in an intricate and demanding information society.

In his visionary *The End of Education*, Neil Postman (1995) emphasises how grand narratives such as "spaceship earth" are needed to weave together diverse disciplines and prepare graduates for active participation in modern culture. Gardner's (2000) *The Disciplined Mind* looks to the three overarching themes of the true, the good, and the beautiful for an education that speaks deeply and honestly to both academic disciplines and today's world. One might even turn to *Consilience*, E. O. Wilson's (1998) epic plea for integrating knowledge, in which he argues that the Balkanisation of knowledge into disconnected disciplines misses one of the great opportunities and indeed necessities of a maturing civilisation. These lively visions of what knowledge can and should be contrast starkly with the silt of education deposited in many young learners' minds. In the words of Alfred North Whitehead (1929), the knowledge is simply "inert."

THE COMPARATIVE ANATOMY OF KNOWLEDGE

What is knowledge? The attitudes and behaviour of different students and teachers reflect different tacit answers to this question. There's nothing new about that. So how does the possessive-performative-proactive distinction compare with prior analyses? Without attempting an extended survey, one touchstone is surely William Perry's (1970) well-known account of the varied epistemological positions found among college students and also others. Perry proposed that students' sophistication develops through a number of phases. Least mature is a stance towards knowledge as answers: the facts and routines are there and it is our role as students to learn them. Through various levels, this leads towards recognition that some answers are contested, but one can reason within the parameters of a discipline to find answers suitable to particular contexts. All this leads through other gradations to Perry's most mature position. We need at least a provisional commitment to one or another framework, leavened by an appreciation that it is subject to challenge from other viewpoints and to ongoing reconstruction.

It is not difficult to align possessive and performative knowledge with Perry's scheme (see Table 1). The focus on facts, memorising, and straightforward application suits well the possessive conception. When students recognise that they can reason within disciplines and contexts, knowledge takes on a more active form, the performative conception. The later positions in Perry's scheme are perhaps a little more difficult to place. They could be understood simply as yet more sophisticated versions of performative understanding, the doing one does with knowledge becoming increasingly nuanced. On the other hand, the flexible thoughtful commitment characteristic of Perry's final position certainly constitutes something of a proactive stance towards knowledge and its use.

Table 1: A synthesis of existing frameworks of student learning

	Possessive	Performative	Proactive
Conception of knowledge, Perry	Absolute & multiple perspectives	Provisional & evidence and reasoning	Personal reasoned perspective
Conception of learning, Säljö	Facts, memorising, applying	Understanding	Seeing things in a different way
Approaches to learning, Entwistle	Surface	Strategic, Deep	Deep
Symptom	Delivery on demand	Performance on demand	Opportunistic deployment
Spirit	Utilitarian	Sense-making	Inquiry and creativity
Challenge	Hard to retain and apply	Hard to understand	Hard to keep alive and use actively

For another touchstone, Säljö (1979) identified a range of mindsets towards learning. On the reductive end is acquiring, reproducing, and applying factual information. Beyond that come more enlightened conceptions of learning, understanding the meaning for oneself and seeing things in different ways. As with Perry's scheme, Säljö's framework aligns readily with possessive and performative knowledge. Possessive knowledge corresponds to the first cluster and performative knowledge to the second. As suggested in Table 1, seeing things in a different way captures at least something of the spirit of proactive knowledge.

Yet another perspective on approaches to learning began with a broad distinction drawn between surface and deep approaches (Marton & Säljö, 1976; Marton, Hounsell, & Entwistle, 1997). Later research revealed another important variant, a strategic approach to studying (Entwistle & Ramsden, 1983). Entwistle (2003) characterises the three approaches in terms of their fundamental agendas. The surface approach aims to cope minimally with academic demands, adopting a focus on facts and routines that often reflects a fear of failure. The strategic approach aims at recognition of good performance through grades and other markers, with a focus on managing one's work well. The deep approach aims at understanding the ideas for oneself, drawing on intrinsic motivation to fuel a focus on systematised understanding of concepts, claims, and evidence.

Turning again to the possessive-performative-proactive distinction, the surface approach clearly fosters possessive knowledge. Built into the strategic approach is

a kind of limited understanding, whatever is necessary to score well in the academic context. But that is usually a far cry from the breadth of understanding called for by Gardner's (2000) the true, the good, and the beautiful or Postman's (1995) grand narratives. The strategic approach is proactive in a sense but not in our sense, proactive about doing well and looking good in the classroom. In contrast, the intrinsic motivation of the deep approach is more likely to cultivate truly proactive knowledge.

Although there is a rough fit between these frameworks and the possessive-performative-proactive triad, in some ways full bore proactive knowledge goes beyond what is strictly entailed by the top levels of the frameworks from Perry, Säljö, and Marton/Entwistle. The Perry framework focuses on the *grounds* of knowledge, how we know what we know. In contrast, the possessive-performative-proactive scheme focuses as much on the *uses* of knowledge -- recalling and applying it (possessive), reasoning with it flexibly (performative), and mapping it far and wide (proactive). The Säljö and Marton/Entwistle frameworks pointedly characterise stances towards learning in an academic context but with uncertain implications about the fate of knowledge beyond. In contrast, proactive knowledge emphasises what we do with what we know not only within but outside settings of formal study.

Besides comparing with other schemes, it's worth exploring some distinctions among possessive, performative, and proactive knowledge. For one, how do we know what kind of knowledge we have (*symptom* row of Table 1)? For the possessive conception, the primary symptom is delivery on demand. Can you recite Ohm's law? Can you apply it to a simple standard circuit? With the performative conception, the primary symptom is flexible performances that demonstrate understanding: Can you apply Ohm's law to predict how this novel circuit will behave or to design a circuit? Someone may lay out the challenge directly, or it may simply come up in a highly salient way, as when an electrical engineer faces the task of designing a circuit to specifications. Even the heating duct problem, if posed point-blank with the tip to apply Ohm's law, still sits in the performative category.

In contrast with these, the primary symptom of proactive knowledge is opportunistic deployment. A circumstance arises that could easily be missed, the person notices it, and follows through. Voilà, better heating ducts!

Not surprisingly, rather different attitudes mark the three kinds of knowledge (*spirit* row of Table 1). The spirit of possessive knowledge seems utilitarian, a matter of very direct retrieval and application in a routine way to get things done. As noted earlier with the cholesterol example, most of what we do has something of this character. The shift from possessive knowledge to performative knowledge involves a transition from a utilitarian to a sense-making spirit. Understanding rather than just getting something done now occupies the foreground. The further shift to proactive knowledge invokes yet another mindset, a disposition towards inquiry and creativity.

For a final three-way contrast, the different kinds of knowledge pose different characteristic challenges (last row of Table 1). What is troublesome about

possessive knowledge? – its volume, so much to know and apply with a kind of honed routine skill. We become acutely conscious of the problem of volume when orienting to new environments or studying a second language. In contrast, the characteristic performative challenge is one of understanding. The ideas seem bewildering, evasive, counterintuitive. And in further contrast with that, the characteristic challenge of proactive knowledge is lively connection-making across diverse contexts (on troublesome knowledge generally, see Perkins, 2006, 2007).

THE DISPOSITIONAL CHARACTER OF PROACTIVE KNOWLEDGE

The general idea of dispositions is well illustrated by everyday dispositional terms for qualities of mind such as open-mindedness versus closed mindedness, curiosity versus disinterest, or sceptical versus credulous. Qualities like these have to do less with knowledge or ability than with what might be called mindset. They concern not what people are able to do but what they are inclined to do. The open-minded person *could* turn away from other viewpoints but tends to consider them. The closed-minded person *could* ponder other viewpoints but tends to dismiss them. Considerable evidence exists for the role of dispositions of various sorts in thinking, learning, and social judgement (e.g. Cacioppo, Petty, Feinstein, & Jarvis, 1996; Dweck, 2000; Dweck & Bempechat, 1980; Gehlbach, 2004; Kruglanski & Webster, 1996; Stanovich & West, 1997).

Although dispositions are often interpreted simply as a matter of sustained attitudes or motivations, research by my colleagues and I urges attention to both alertness and attitudes (Perkins & Ritchhart, 2004; Perkins & Tishman, 2001; Perkins, Tishman, Ritchhart, Donis, & Andrade, 2000). Effective deployment of a particular pattern of thinking or disciplinary practice requires (1) *alertness* to occasions, (2) a positive *attitude* toward its potential relevance, and of course (3) possession of it and the *ability* to apply it. For instance, an open-minded person has to notice situations when other views are or even might be in play (alertness), take them seriously (attitude), and think them through (ability).

All that said, quotidian and technical conceptions of cognitive performance tend to be strongly abilities-centric. The importance of both alertness and attitude gets forgotten. People undermine themselves by figuring they do not have enough intelligence, which they view as a fixed resource (e.g. Dweck, 2000; Dweck & Bempechat, 1980). Formal studies of thinking and intelligence tend to foreground abilities over other aspects of intelligent engagement with the world (e.g. Dai & Sternberg, 2004; Perkins, 1995; Perkins & Ritchhart, 2004). Classroom interventions targeting cognitive skills emphasise building up repertoires of strategies much more so than fostering proactive attitudes and motivation. To take stock of the abilities-centric trend, see such overviews as Chipman, Segal, & Glaser, 1985; Grotzer & Perkins, 2000; Nickerson, Perkins, & Smith, 1985; Perkins, 1995; Resnick, 1987; Ritchhart & Perkins, 2005; Segal, Chipman, & Glaser, 1985.

Although an abilities-centric stance dominates both folk psychology and considerable academic psychology, shortfalls in cognitive performance can just as

easily reflect alertness and attitude. It's one thing to know in principle about the deceptiveness of advertising but quite another to keep up your guard in real situations. It's one thing to know in principle about politicians' manipulations of facts but another to care about and pick up such shell games on the fly. It's one thing to know that decision-makers often fixate on choosing between the apparent options and another thing to remind oneself to look beyond the given or obvious options in personal decision making.

A series of studies reported by Perkins, Tishman, Ritchhart, Donis, & Andrade (2000) demonstrates how dramatic this difference can be. We investigated how students ranging from 5th to 9th grade responded to vignettes about people thinking in everyday situations. We wanted to know whether the participants would detect some rather straightforward instances of hasty, narrow, or unimaginative thinking, and whether they could rethink the situations better themselves. When asked in an open-ended way what they made of the thinking in the stories, only about 10% of the time did the students notice a possible shortfall in the first place, and only about half the time did they respond to specific suggestions that something might be amiss. However, when asked point blank to offer better solutions, virtually all were readily able to do so. At least on these tasks, what limited performance was least of all ability, somewhat attitude, but overwhelmingly sensitivity to situations. The students were "problem blind."

Essentially the same three-way analysis applies to any cognitive resource, including relatively specific systems of knowledge such as Ohm's law. There too, flexible use in realistic situations requires alertness to occasion, a positive attitude towards following through, and of course the knowledge and ability to follow through. These ingredients are necessary and sufficient for proactive knowledge. Proactive knowledge is in effect a dispositional conception of knowledge.

One might view proactive knowledge as a rich mode of mental representation involving semi-specialised processes melded with relevant information (Perkins & Salomon, 1989). Such a representation is rich with pattern recognition "hooks" that help activate it in diverse circumstances. Such a representation is cognitively "hot" rather than "cool," promoting its energetic deployment. To gain a better sense of these characteristics, it's helpful to look to another area of research, transfer of learning.

TRANSFER WITH A TWIST

Two cognitive illusions trouble the way we often treat teaching and learning. The first and certainly the most destructive concerns the possessive conception of knowledge. It's not that the possessive mindset doesn't care about understanding; of course it does. Rather, the illusion is that possession will pretty much produce understanding. The performative conception of knowledge hosts another cognitive illusion. It's not that the performative mindset doesn't care about the use of knowledge far and wide; of course it does. Rather, the illusion is that performative knowledge will generate application far and wide.

Behind the first illusion is a neglected challenge of initial learning. The knowledge was never learned with any depth in the first place. Behind the second illusion is a neglected challenge of where the knowledge goes from there. The knowledge was not acquired in a way that would foster what learning theorists call transfer of learning. Transfer of learning means acquiring knowledge in one context and putting it to use in another. When we apply knowledge we have learned in the formal setting of the classroom to another unit or another subject or to practical settings beyond the classroom, this is transfer. When, having learned to drive a car, we rent a small truck for a move and find that we can drive it pretty well, this is transfer. Our opening example of applying Ohm's law to the design of the heating system is a case of transfer that bridges very different contexts and disciplines, what is generally called "far transfer."

The principal lesson from a century of studies of transfer raises a red flag for educators everywhere: Transfer often comes hard. During the first decades of the 20th century, the pioneer scholar of learning E. L. Thorndike conducted the first notable research in this area. Investigating the widespread belief that the study of Latin "trained the mind," he found that it did not. Students with plenty of Latin did no better in other disciplines than those less classically educated (Thorndike, 1923; Thorndike & Woodworth, 1901).

The parade of largely negative findings about transfer of learning has continued ever since. Knowledge demonstrably acquired and understood in one setting commonly lies fallow in another where it has relevance (e.g. Detterman & Sternberg, 1992; Salomon & Perkins, 1989). In one notable paper, Bransford, Franks, Vye, and Sherwood (1989) discussed the problem of "inert knowledge" (Whitehead, 1929). The authors reported an experiment where some students studied information about nutrition, water as defining the standard of density, airplanes that operated on solar power, and related matters. Their goal was to master the knowledge in a conventional didactic way. Later, the students faced the challenge of planning an expedition in a desert. They certainly understood the knowledge and retained it, as demonstrated by direct testing, but they made very little use of it despite its high relevance.

There is a positive side to this thread of inquiry as well: Transfer is not a lost cause. Transfer falters largely because typical learning experiences do not foster it. Returning to the research just mentioned, Bransford et al. (1989) included another group of students who encountered the same information within a problem-based learning structure: pondering plans for a journey through a South American jungle. Later presented with the challenge of planning the desert trek, the students found many applications for what they had learned earlier.

Salomon and Perkins (1989), in an analysis of the puzzles and prospects of transfer, identified two general mechanisms of transfer of learning: the "high road" of reflective abstraction and deliberate connection making and the "low road" of spontaneous activation of patterns rehearsed in a variety of applications. When instruction fostered one or the other or both, transfer was much more likely. This helps to explain the predominantly negative pattern of findings. Most instruction

neither promotes reflective abstraction and connection making nor provides practice in a deliberately disparate collection of cases. But it could!

Proactive knowledge is a transfer-rich view of knowledge. However, proactive knowledge is transfer with a twist. The relationship to the body of research on transfer is more complex than it might seem at first. The kind of transfer called for by proactive knowledge actually differs in several ways from how transfer is usually studied in formal research. First of all, the dispositional character of proactive knowledge means that the desired transfer has strong emotional and motivational dimensions. In contrast, the emphasis in studies of transfer tends to be doggedly cognitive, hardly looking at all at subjects' engagement with the content.

Second, proactive knowledge involves transfer under especially challenging cueing conditions, where it's not clear that any focused response is called for at all. Nothing demands that you assume an alert problem solving stance when you listen to a politician's speech or view a television ad or order burgers at a fast food joint. In contrast, typical investigations of transfer pose explicit tasks. Subjects know they are supposed to solve a problem. The experimenter's question is whether they will apply some specific content of interest they learned before or simply wing it.

Although responsive to subtle cues, proactive knowledge is less daunting in another respect, "far transfer." This term refers to transfer across domains, for instance applying Ohm's law to heating ducts. This actually is an exceptional case of proactive knowledge, albeit a welcome and dramatic one. The central business of proactive knowledge is not so much analogical application to remote domains as it is direct application in weakly cued circumstances.

Finally, studies of transfer normally are carried out in situations with minimum competition for the subjects' attention. The subject is sitting in a laboratory or a classroom with a task to undertake, in contrast with navigating a tentative way through a complex world with all sorts of distractions. It is just there, though, that proactive knowledge needs to earn its name.

THRESHOLD CONCEPTS FOR PROACTIVE KNOWLEDGE

The notions of proactive knowledge and threshold concepts (Meyer & Land, 2006a, b, c) make natural partners. In the metaphor of Meyer and Land (2006a), threshold concepts open up a portal in a domain, affording access to a newly integrative way of thinking about whole swathes of its territory. A collection of threshold concepts or an unusually pivotal one can provoke a kind of an epistemic shift, where the very "game" or epistemic enterprise of the discipline can come out looking somewhat different (Collins & Ferguson, 1993; Meyer & Land, 2006b; Perkins, 1997; Schwab, 1978). Three examples from Meyer and Land (2006a) representing diverse disciplines are *opportunity cost* from economics, *limits* from mathematics, and *signification* from literary and cultural studies. Opportunity cost, for instance, helps learners to recognise that making a choice has an often unrecognised cost. Committing attention and resources to one option generally deprives another of them. A cost of doing X instead of Y is whatever you forego

from neglecting Y, a powerful way of bringing into the foreground the intrinsic dilemma of choice in a context of limited resources where you can't "have it all."

The idea of threshold concepts carries an important pedagogical message: where we can find likely threshold concepts, we would do well to organise learning around them (Meyer & Land, 2006a). But there is a cost, in fact an opportunity cost but one generally worth paying. Threshold concepts are likely to be troublesome (Meyer & Land, 2006b; Perkins, 2006). Their reorganising power brings with it an unfamiliarity that sometimes proves acute and off-putting. You can't rebalance the boat without rocking it.

Turning back to the proactive knowledge connection, well-cultivated threshold concepts seem likely to foster proactive knowledge. Recall here the three ingredients of proactive knowledge: ability to apply the knowledge with understanding, serious energetic engagement with the knowledge, and alertness to where it applies. Organising instruction around threshold concepts should contribute to all three. First of all, the keystone character of threshold concepts puts the learner in a better position to think with the knowledge system in question, a clear asset to application. Secondly, knowledge structured around threshold concepts becomes richer and more meaningful, a contribution to engagement.

As to alertness, threshold concepts in many cases introduce cognitive hooks by means of which the learner can recognise relevant applications more readily. For instance, the idea of opportunity cost not only enables a certain kind of technical analysis but also projects a vivid informal generalised narrative. We encounter opportunities in the world, choice points that we might seize or not. However, choice of one path may have a cost in other paths neglected. This common sense story connects with the world much better than any technical rendition.

Or consider the concept of limits from mathematics. Students are often baffled by the epsilon-delta technical definition of limit. However, that formalisation sits on top of an everyday conception of limit, something approaching something else but never quite getting there (Perkins, 2006). It is this informal conception that provides the natural basis for the recognition of potential applications.

Nothing says that every threshold concept has to come with both a technical and an informal face. However, this appears to be quite common, perhaps because the centrality of threshold concepts leads to colloquial forms of expression to facilitate communication within and across disciplines. In any case, when the informal faces are there, threshold concepts help to enable the kind of wide ranging recognition called for by proactive knowledge.

PROACTIVE KNOWLEDGE AS A THRESHOLD CONCEPT

The partnership between threshold concepts and proactive knowledge takes another turn as well. Besides threshold concepts fostering proactive knowledge, the idea of proactive knowledge has something of a threshold character for how we think about teaching and learning. It draws our attention to how learning often falls short and characterises the nature of the gap. In keeping with the idea of an epistemic

shift, proactive knowledge suggests that our everyday sense of what knowledge is and how it works lacks an important dimension.

Typical settings of learning foreground a learning architecture that might be called *performance on demand*. Learners are asked directly and straightforwardly to do specific things. The doing in question may have a possessive character—state Ohm's law, name the three principal tenets of the theory of evolution, summarise the basic plot of *King Lear*. Better, the demanded doing may have a performative character – predict the behaviour of this circuit using Ohm's law, explain how giraffes might have come by their long necks using principles of natural selection, find and explain partial analogues of King Lear in political history.

But demand is demand. It does not serve proactive knowledge very well. Proactive knowledge requires an active alert questing mindset. Performance on demand gives little opportunity for freeform noticing and self-initiated engagement to occur and offers few structures that encourage it. The demand structure of typical institutional learning favours extrinsic motivation over intrinsic motivation, even though this does not serve achievement as well and seems likely not to foster sensitivity to occasion and self-initiated engagement (e.g. Lepper & Greene, 1978; Lepper, Corpus, & Iyengar, 2005).

Educating for proactive knowledge calls for a threshold-like shift from a culture of demand to a culture of opportunity. In a culture of opportunity, what learners do – the range of choice, the contexts of application, the spectrum of motives and feelings involved, and many other aspects – becomes more open and ranges more widely.

Here are some of the shifts of emphasis that might mark a learning culture of opportunity. There is nothing utterly novel in the following list, but learning that we would generally view as enlightened commonly lacks many of these features.

- *From very other-directed to significantly self-directed.* Learners will not develop proactive knowledge if they are always told what to do with what they are learning. A pedagogy for proactive knowledge asks learners to face frequent choice points and to search for connections rather than have them served up, fostering self-managed exploration, reflective decision-making, and personal responsibility. But not so much of this that the quest becomes bewildering and aversive!
- *From extrinsic motivation to intrinsic motivation.* Instruction should reduce the saliency of extrinsic motivators—heavy pressures for grades for example—and foreground the intrinsic interest, personal dimensions, the teacher's own passionate involvement, and so on. The sorts of choice points noted above also should enhance intrinsic motivation. This does *not* mean that extrinsic motivation has no place.
- *From cool to hot cognition.* Formal learning experiences tend to be cognitively cool. They emphasise a methodical approach, meticulous attention, and so on. A measure of this is fine, but overdone it tends to drain learning experiences of their zest and momentum.

- *From prototypical examples to include diverse and marginal examples and close counterexamples.* Even thoughtful instruction commonly focuses on prototypical examples, not giving a sense of the range of variation or how some putative cases "just miss."
- *From learning about to learning to do.* Even in reasonably constructivist settings of learning students often are still basically "learning about"—say learning about Darwinian theory and the evidence for it, discussing its nuances, critiquing it, and so forth. A step beyond this is to learn to think fluently within Darwinian theory. Instructional paradigms such as problem-based learning and project-based learning foreground learning to do.
- *From learning the pieces to "whole game" learning.* A good deal of learning, even learning for understanding, takes things by bits and pieces rather. It matters whether one studies algebra as a symbol manipulation game or more holistically as a modelling process. It matters whether one studies poetry for its ingenious tropes and other elements of craft or, recalling the threshold concept of signification, for its larger significations about the human condition.
- *From designing to specifications to designing the specifications.* Learning tasks sometimes have a design character—make a plan for this, propose a solution to that. Often rather strict specifications are given. The agenda of proactive knowledge is better served by engaging the learner in formulating some of the specifications or interpreting rather open-ended specifications.
- *From problem solving to problem finding, problem defining.* By and large, instructional tasks tend to focus on solving problems defined by the teacher or text. However, with some guidelines, learners can be encouraged to find and define their own problems some of the time.
- *From learning here and there to learning here, there, and elsewhere.* Academic work tends to occur only in the lecture hall and in the student's typical work setting. The characteristic intellectual setting is the particular class and topic in its technicalities. Activities that broaden out the physical and intellectual contexts are likely to foster proactive knowledge.

With all this in mind, it's important to preserve what is good about performance on demand. There is no real opportunity in a free-for-all. An effective culture of opportunity rather than eliminating performance on demand loosens its hold with more passion, openness, and options.

AGAINST EXCELLENCE

Excellence in learning is the Holy Grail, so we hear from many an ardent educator. But the emphasis on excellence makes for a double irony, first since we fall so far from achieving it and second because it may be altogether the wrong focus. You see, the excellence pursued is typically excellence with possessive and performative knowledge, the kind of excellence that aces the test or the term

project. There is an alternative. Imagine an education that invests not so much in performative excellence as in proactive competence.

To be sure, mere competence sounds like a lesser ambition than excellence, but that depends on what we are ambitious *for*. In the world beyond the classroom, proactive competence generally serves learners better than performative excellence. You are better off with proactive knowledge of a few threshold concepts about probability and statistics than with simply performative knowledge of a much more elaborate arsenal, because your more sophisticated knowledge is not very likely to get used -- the problem of inert knowledge again.

Raising our eyes to larger issues and recalling again Postman's (1995) grand narratives and Wilson's (1998) plea for consilience, the world would be a better place if more people energetically integrated merely competent knowledge from diverse sources on such fronts as political, economic, and ecological responsibility. Turning to John Dewey again, this time to his *Experience and Education:* "The central problem of an education based upon experience is to select the kind of present experiences that live fruitfully and creatively in subsequent experiences" (Dewey, 1938/1997, p. 28). By "subsequent," Dewey surely does not have in mind tests and term papers.

Pedagogues appalled by this argument against excellence may find relief in a further point: The case bears somewhat more on studies outside of students' ultimate professional direction than it does on studies squarely in the centre. While proactive knowledge has tremendous importance for a disciplinary focus, far more total learning time is available there towards grabbing the twin rings of performative and proactive excellence. Also, as students advance in a disciplinary focus, they are likely to encounter something closer to a learning culture of opportunity than students just studying "the basics."

That said, I venture that students would be better off with a culture of opportunity early on, whether they make the area their central commitment or not, and that often advanced disciplinary studies do not actually bring students into apprenticeship with the kinds of complex problem solving and patterns of application that they would encounter in professional life (Eraut, 1994). So I'm reluctant to let education in a disciplinary speciality entirely off the hook.

It's all about opportunity costs! Yes, we would like to have both performative and proactive knowledge in the fullest measure. But a culture of demand versus a culture of opportunity is a broad choice involving different investments. When limited resources make the tradeoff real, what is the better option? To answer that question, we only have to remember that education should prepare learners for encounters with a complicated and challenging world that does not reliably tell them what they should do.

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2. THRESHOLD CONCEPTS AND TRANSFORMATIVE WAYS OF THINKING WITHIN RESEARCH INTO HIGHER EDUCATION

INTRODUCTION

This chapter explores the nature of threshold concepts and transformative ways of thinking, initially against the general background of previous research and then, specifically, in relation to concepts used in research into teaching and learning in higher education. Two key concepts used in the literature are Perry's ideas on the development of *epistemological beliefs* or conceptions of knowledge (Perry, 1970, 1988), and the categories used by Säljö and others to differentiate between *conceptions of learning* (Säljö, 1979, 1982). These two descriptions not only parallel each other in describing important changes in students' ideas about the subject matter they are studying, they also show important thresholds, or pivotal positions, at which students' understanding is transformed. Sophisticated conceptions of learning are associated with deep approaches to learning, but the relational nature of approaches means that the threshold only increases the likelihood that a deep approach will be used. Approach to learning has, however, become a threshold concept for university teachers in opening up their thinking about how their own teaching can best support students' understanding, and even the notion of *threshold concept* itself seems to serve a similar function in thinking about the teaching of specific disciplines. The chapter concludes by looking again at the defining features of threshold concepts in relation to the research discussed in the paper, accepting the idea there are three distinguishable ways in which students' understanding of the subject can be opened up; through certain basic concepts in the early stages of a course, through integrative threshold concepts, and through acquiring the distinctive ways of thinking characteristic of the subject.

THE NATURE OF THRESHOLD CONCEPTS

The idea of threshold concepts emerged through discussions with university teachers of Economics as part of the ETL project (2005), a major investigation into teaching and learning in four contrasting subject areas. Among the array of concepts to which students are introduced within undergraduate degree courses, some seemed to have powerful influences on students' subsequent learning. Most of these were seen by staff and students alike as *troublesome knowledge* (Perkins,

R. Land, J.H.F. Meyer & J. Smith (Eds.), Threshold Concepts within the Disciplines, 21–35.

2006), proving difficult both to teach and to learn, but once understood they had an important transformative effect on students' understanding. Meyer and Land (2003) described these as 'threshold concepts', with the notion of 'opportunity cost' in Economics being a particularly clear example.

> 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. (Meyer & Land, 2003, p. 1)

Subsequent discussions with staff and other researchers refined the description of threshold concepts further by recognising that, as 'conceptual gateways' into more advanced ways of thinking about topics and subject areas, they are by definition *transformative*, but they are also typically:

> *irreversible* (unlikely to be forgotten, or unlearned only through considerable effort) and *integrative* (exposing the previous hidden interrelatedness of something) … it was also suggested that that the new 'conceptual space' opened up by such transfigured thought is in turn *bounded*, possessing terminal frontiers, bordering with thresholds into new conceptual spaces. (Meyer & Land, 2005, pp. 373-374)

The defining features of threshold concepts are, however, still being discussed, and for the purposes of this paper, our focus will be mainly on their transformative and integrative properties.

Any new concept introduced into the research arena has to be examined carefully to ensure that it is adding something important to what we know already. As a result, the notion of *threshold concept* has already come under considerable scrutiny (Meyer & Land, 2006). Here, the findings emerging from one particular project (Davies & Mangan, 2007) will be used to provide a framework for the rest of the chapter.

The 'Embedding Threshold Concepts' project is seeking to clarify the nature of threshold concepts within Economics and also develop materials to support student learning. It involves collaborative work with teachers in four universities. Initial discussions with staff suggested that it was quite difficult for them to grasp the essential transformative property of threshold concepts, with the term often being confused with the more commonly used idea of *key concepts*. From the evidence collected from both staff and students, it is now possible to recognise three different kinds of transformative thresholds in learning.

In the early stages of Economics degree courses, students have to understand how the meaning of the terms used in the academic study of Economics clarifies everyday thinking about the subject – distinctions between 'price' and 'cost', for example – and in the process they develop the basic conceptual raw material of academic discourse in Economics. These simple concepts transform students'

interpretation of everyday Economics and so clarify their thinking, but they do not have the integrative power expected of threshold concepts.

The second form of transformation involves concepts that not only transform thinking but are also integrative, bringing together several of the basic concepts. The transformative property is created through grasping crucial interrelationships between the basic concepts; 'opportunity cost' seems to come into this category. But if students are to enter fully into the academic discourse, they also have to see how to handle economic problems by reducing the complexity of situations through considering what would happen 'other things being equal'. They also have to learn how to interpret graphs, understand the function of models, and use the statistical and linguistic tools that allow academic reasoning to be developed and presented to others. And this is the third form of threshold identified by Davies and Mangan.

These three types of threshold will prove useful in looking at concepts and ways of thinking that have been widely used in research into higher education, but first we need to look briefly at earlier research into the nature of conceptions and understanding.

CONCEPTIONS AND UNDERSTANDINGS

There is, of course, a vast literature already available on conceptual change, particularly within the fields of cognitive and educational psychology (see, for example, Schnotz, Vosniadou, & Carretero, 1999). From a psychological perspective, conceptions are seen as developing by extracting and integrating similarities and differences among varied experiences of a concept (Ausubel, Novak, & Hanesian, 1978). Marton (2007) and Marton and Tsui (2004) has been developing a pedagogical theory of learning which elaborates these descriptions by seeing learning as depending on the *discernment* of the critical features of concepts, brought about through seeing the *variation* that is involved in those aspects. Discernment can then lead to an integration of those features into the *simultaneous* fusion that is experienced as understanding, or the opening up of the subject through grasping a threshold concept. As Marton (2007) explains:

> Our theory begins by exploring the nature of the awareness involved in coming to see a phenomenon or topic in an importantly new way, and leads to questions about what we need to do in order to learn how to handle new situations in more powerful ways. If we are to be able to handle a situation in a more powerful way, we must first *see* it in a powerful way, that is discern its critical features and then take those aspects into account by integrating them together into our thinking simultaneously, thus seeing them holistically. And to discern those critical features, we must have experienced a certain pattern of variation and invariance in the object of learning. A medical student, for example, has to listen to the hearts of many different patients before any sense can be made of the differences heard, while to say anything interesting about the taste of a certain wine, we must first have tasted many different wines. (p. 20)

One recent theme in the research on conceptual change is the implications of the co-existence of differing conceptions of the same concept within a person's memory (Halldén *et al*., 2002*)*. An Economics student may, for example, recognise the distinction between, say, 'price' and 'cost' and yet revert to the everyday equivalence of the terms when asked to explain an everyday economic event (Dahlgen, 1997). Students have to learn not only the technical meaning of the terms but also be able to recognise in what situations they should be used (Entwistle, 2006). So, conceptions seem to be constructed within long-term memory as a web of connections bringing together differing semantic aspects, such as defining features and illuminating examples, but with related contextual aspects – the situations to which the concepts relate.

The research on conceptual change tends to focus on isolated concepts, but in higher education we are also concerned about how students bring together groups of concepts so as to understand topics or theories. A series of interview studies looking at this experience among university students preparing for final examinations throws more light on the processes and feelings involved (Entwistle & Entwistle, 1992, 2003). In these interviews, the students emphasised that understanding involved relating ideas in their mind that also aroused feelings of coherence and connectedness. While students described a feeling of wholeness in their understanding, they also recognised that it was 'provisional'. They recognised that it was complete only in relation to the material they had covered and to the specific demands of the course on which they were to be examined.

I: How do you know that you understand something?

S: Well, with past experience you can relate it to something… But sometimes, when it's all clicked into place, later on you discover that it's not necessarily clicked into the right places, so you could have a feeling that you understand, but [it's not quite right]

I: And how do you know when you don't understand?

S: Because it just doesn't connect, because you can't make logical connections between the bits … You just don't feel at ease with whatever it is you are meant to be doing, you're confused … [When you understand] you do definitely get a feeling that the penny's dropped, it just all clicks into place … If you don't understand it's just everything floating about and you can't get everything into place, like jigsaw pieces, you know, suddenly connect and you can see the whole picture.

I: So what happens ... when you come across some other ideas or some other evidence?

S: That doesn't necessarily mean you did not understand it: you only understood it *up to a point*. There is always more to be added ... Yes, you have one theory, and then you add on the reaction to that theory; there might (then) be another one to add to that – so you keep (on) adding.

This extract illustrates how different facets of a topic come together simultaneously – 'click into place' – to create a satisfyingly complete picture, along with a feeling of confidence that the understanding can be used to provide adequate explanations that fulfil present requirements.

In the situation investigated in this series of studies, it is not a specific concept or theory that is responsible for the insight arrived at, but rather the students' attempts to make sense of topics for themselves. In the process, students who were carrying out their exam revision in a thorough way, using a 'deep strategic' approach, often reported sensing their understanding as an integrated whole, almost as an 'entity' which they could, in a sense, see. These entities were described by Entwistle and Marton (1994) as *knowledge objects*, and they had characteristics which involved 'opening up the subject', even if it was generally not through a specific 'gateway'. Table 1 indicates the characteristic features of knowledge objects, based on a subsequent analysis (Entwistle & Entwistle, 2003).

Table 1. Features of 'knowledge objects' as experienced in preparing for examinations

– Awareness of a tightly integrated body of knowledge	*A structured understanding developed through summary notes*
– Visualising the structure in a quasi-sensory way	*A pattern created to establish a memorable representation*
– Awareness of unfocused aspects of knowledge	*Details available for providing convincing evidence*
– Guiding explanations of the understanding reached	*Logical pathways used for linking steps in an argument*

We are still awaiting the detailed exploration of experiences of acquiring threshold concepts in a variety of subject areas, but it would be surprising if some of the experiences of the transformations in thinking about the subject created by grasping threshold concepts were not similar to those found in the studies of knowledge objects (Entwistle, 2006). It will be interesting, however, to see what difference is made by the framework for understanding being provided within the syllabus, instead of being worked out by the student more or less independently. By linking students' personal understandings directly to specific understanding targets, differences between students should also become easier to interpret.

THRESHOLDS WITHIN CONCEPTIONS OF KNOWLEDGE AND LEARNING

While there is burgeoning research into the nature of threshold concepts in several different subject areas, as demonstrated by the range of the chapters within this volume, previous studies of student learning have also described important thresholds which lead to crucial transformations of thinking. Such conceptual

change can be found, for example, in the work of Perry (1970) on conceptions of knowledge, and Säljö (1979) on conceptions of learning.

Perry identified important steps in epistemological development as students' *conceptions of knowledge* changed, and these changes were found to open up the student's thinking in important ways. He identified a recurring developmental pattern in students' beliefs about knowledge over the course of their student life. He described nine positions (or views) which are typically clustered into five sequential groups or stages (see top of Figure 1), ranging from a certainty that all knowledge is either right or wrong (*dualism*), to acknowledgement that there are many ways of looking at a situation (*multiplicity*), to awareness of knowledge as provisional, and then to a realisation that knowledge depends on interpretations of evidence with a variety of possible conclusions being drawn from it (*relativism*). This progression leads eventually to a readiness to make a personal stand on issues, based on justifiable interpretations of evidence, while accepting that all knowledge and ideas are ultimately relative (*personal commitment*). Perry saw the gradual emergence of relativism as a crucial transition that allowed students increasingly to enter into academic discourse. As one of the students commented:

> The more I work here, the more I feel that what I'm trying to do is to become what you might call a detached observer of ... any situation ... One who can ... detach himself emotionally ... and look at various sides of a problem in an objective, empirical kind of way – look at the pros and cons of a situation and then try to ... analyze and formulate a judgement ... bringing into consideration ... what the other person would feel and why he would feel so. (Perry 1970, p. 126)

Perry (1988) himself stressed the importance of this pivotal position in his scheme, and wrote enthusiastically about the different view of learning that emerged at that point.

> (Relativism) has taken us over a watershed, a critical traverse in our Pilgrim's Progress… In crossing the ridge of the divide, … (students) see before (them) a perspective in which the relation of learner to knowledge is radically transformed. In this new context, 'Authority', formerly a source and dispenser of all knowing, (becomes)… a resource, a mentor, a model … (Students) are no longer receptacles but the primary agents responsible for their own learning … (Perry 1988, p.156)

Perry did not see the developmental process as irreversible, however. Indeed, students regularly regressed back towards dualism, sometimes due to the difficulty of handing the idea of relativism, and at other times because the experience of relativism threatened their own strongly held beliefs. This could be seen as similar to the experience of *liminality* found with threshold concepts (Meyer & Land, 2005).

In his exploration of the nature of *conceptions of learning*, Säljö (1979) identified a series of distinguishable categories of description that have subsequently been seen as indicating another developmental progression (see

bottom of Figure 1). The first two conceptions describe the learning implied by the majority of quiz shows, which depends on remembering factual information, usually by rote learning. Within this conception, learning is seen as the process of accumulating the separate 'pieces' of knowledge provided, ready-made, by a teacher or other source, and then reproducing them on demand The third category marks the beginning of a qualitative change, as information is seen as having a purpose beyond acquisition: it also has to be applied.

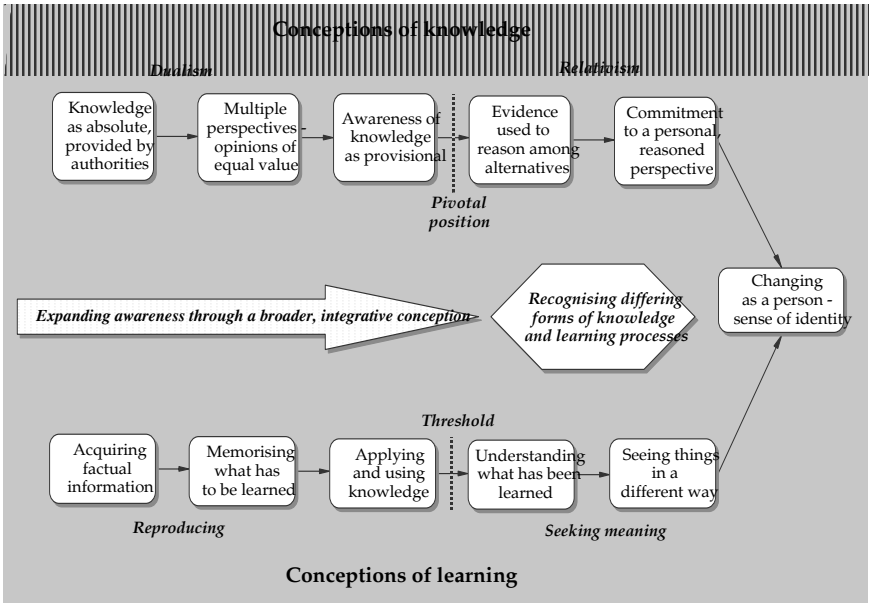

Figure 1. Developmental stages in conceptions of knowledge and learning

The progression reaches an important threshold when learning becomes equated with understanding. As people begin to see learning as involving the effort to make sense of ideas for themselves by relating it to their previous knowledge and experience, information becomes transformed into personal meaning. Beyond that, learning involves seeing things in an importantly different light, and so becomes fully transformative of understanding (Marton & Tsui, 2004). Finally, people may begin to experience learning as transformative in a broader sense, namely changing them as a person (Marton, Dall'Alba, & Beaty, 1993). While this final stage seems to be present in both developmental schemes, Perry links this to moral development, but it could also be seen as a change in the students' sense of their own identity.

Säljö found that people with advanced conceptions of learning became more aware of the different purposes for which alternative processes of learning could be

used. Subsequent research indicated that they are also able to regulate their learning processes more consciously, and so adopt those most appropriate to specific tasks (Vermunt, 1998, 2007). They may become aware, for example, that the two main learning processes – rote and meaningful learning (Ausubel, Novak, & Hanesian, 1978) – are both valuable, but for importantly different purposes and at different stages in learning a subject. This awareness can be seen as an emergent property of the development process at university; students acquire a metacognitive view of how knowledge is developed and how academic ideas are best acquired. And this broader overview has important consequences for students' approaches to learning. It helps them to take advantage, within a teaching-learning environment, of those activities that have been designed to encourage and support a deep approach (Entwistle & Peterson, 2005).

In Perry's and Säljö's categories, we have descriptions of crucial transitions in students' thinking which parallel each other quite closely. It seems unlikely that the actual thinking processes involved are as distinct as the separate conceptualisations perhaps imply; rather, these processes are interconnected as students become more aware of the nature of academic knowledge and of how their learning might be better adapted to developing those forms of knowledge. This implies a shift in focus – from the task itself to the process of learning.

Our consideration of the work on conceptions of knowledge and learning was carried out to show how a threshold might be the result of a series of transformations in how students make sense of their university experience. The nature of the changes described indicates that we are not dealing with any specific threshold concept, but rather with the broadest level of transformation identified by Davies and Mangan (2007), describing ways of thinking which help students to think about the subject as novice professionals. In our recently completed ETL project across four contrasting subject areas we found that university teachers were able to indicate what they *really* wanted their students to learn, and we came to see these as their essential high-level aims.

> The ETL team coined the phrase *ways of thinking and practising* in a subject area (WTP) to describe the richness, depth and breadth of what students might learn through engagement with a given subject area in a specific context. This might include, for example, coming to terms with particular understandings, forms of discourse, values or ways of acting which are regarded as central to graduate-level mastery of a discipline or subject area. (McCune & Hounsell, 2005, p. 257)

Although the pattern of development shown in Figure 1 indicates the existence of crucial thresholds, and ones that have been generally accepted in the literature, there is an important difference from the transformations that are expected from subject-specific thresholds. This opening up of the subject is not tied directly to any specific concept or theory within a course, and students may pass through this threshold without any conscious recognition of an enhanced understanding. The process seems to be both gradual and, for the most part, subconscious. Students themselves are unlikely to be aware of the existence of their conceptions of

knowledge and learning; these are constructs created by a researcher to describe important features found within interviews to other researchers and to teachers. The content-based concepts are, in contrast, the direct focus of the students' learning, and so the thresholds, and the consequences for future learning, can be directly experienced. The broadest level of threshold identified by Davies and Mangan seems to involve an appreciation of how evidence is found and used within the discipline, which is closely similar to one aspect of 'relativistic thinking'. The other aspect of relativism relates to the nature of knowledge in general terms, and so avoids the bounds created by any particular subject area; and that is also true of sophisticated conceptions of learning.

THRESHOLD CONCEPTS IN ACADEMIC DEVELOPMENT

The starting point for what has come to be called 'student learning research' (Biggs, 2003) was the original work of Marton and his team in Gothenburg in the mid-1970s, which led to the distinction between deep and surface *approaches to learning* (see Marton & Säljö, 1997). They also pointed out that such processes depended not only on the students' differing intentions but also on the content of the learning task and context within which it was set. Conceptions of learning are empirically related to approaches to learning, but as students with a sophisticated conception recognise that there are different learning processes to adopt for different purposes, they will not use deep approaches all the time. So, while conceptions of learning involve a threshold, approaches to learning do not seem to act, in themselves, in this way for students. The distinction can, however, act powerfully as a threshold concept for university teachers.

The extensive work on teaching-learning environments has unravelled some of the most important influences on deep approaches and high quality learning outcomes (Biggs, 2003; Entwistle, Nisbet, & Bromage, 2005; Meyer, 1991; Richardson, 2007; Vermunt, 2007), and has also found contrasting views of teaching (Prosser & Trigwell, 1999) which parallel the distinctions between deep and surface, and are to some extent related to them. Staff may see their role mainly as one of transmitting information or, alternatively, they may concentrate on encouraging conceptual change. But, like approaches to learning, approaches to teaching are relational, depending on the students and the stage in the degree course. Nevertheless, the strongest lever for change in staff conceptions is the ability to see teaching from the students' perspective, which allows a more sophisticated view of the relationship between teaching and learning to emerge.

Many of the courses now being taught as initial training for lecturers stress this perspective, often leading inexperienced staff towards crucial insights into the relationship between teaching and learning. These staff may come to recognise that their influence as teachers goes beyond making the subject accessible; they are also influencing how students think about the subject and, importantly, also affecting how they think about the nature of learning in general. This insight can fundamentally affect the outlook of teachers, and so qualifies as a powerful threshold concept. Indeed, it has been used effectively in this way by various

academic developers (Biggs, 2003; Prosser & Trigwell, 1999). As Meyer (2005) explains, such an approach to academic development can:

> empower newly appointed university teachers to begin the process of developing a mental model or conceptual framework … in a form that can initially serve, and be further developed, as a basis for professional practice … [This] framework … is … essentially defined by the 'student experience of learning' research literature. The threshold concept … − the transformative gateway to the reconceptualisation of practice − is *variation in student learning*. The aim is for colleagues to reconstitute aspects of generic theory within their own disciplines in terms of some of the classic patterns … in student learning engagement. In doing so, and in reflecting on their own gathered evidence, the theoretically underpinned focus … of professional practice shifts from that of teaching to that of *learning* and teaching. (pp. 360-361)

While this notion of variation in student learning may serve as a trigger for seeing teaching and learning in a different way, teaching-learning environments are complex interacting systems that university teachers only gradually come to understand in ways that can fully transform their thinking. It is presumably an appreciation of this complexity within a framework such as that shown as Figure 2, which may act as a threshold into a whole new way of thinking about the nature of teaching and learning in higher education. This conceptual map shows student characteristics at the top, with influences of the teaching-learning environment being arranged across the bottom (based on the findings from the ETL project, 2005). Each of the boxes in this diagram can be opened up in the way suggested for 'teaching that develops skills and understanding', but that would prevent the diagram acting as a (somewhat) simplifying map linking together some of the main influences on the quality of student learning. (For more details about a similar model, see Entwistle, 2007.)

In looking for other threshold concepts in academic development, an intriguing possibility has been recognised in the development project undertaken by Davies and Mangan and their collaborators. Introducing Economics lecturers to the notion of threshold concepts seems to open up their thinking about the nature of knowledge in Economics, and show how the subject can be presented to students in more interesting and effective ways. In other words the threshold concept itself is acting as a threshold concept in thinking about teaching and learning.

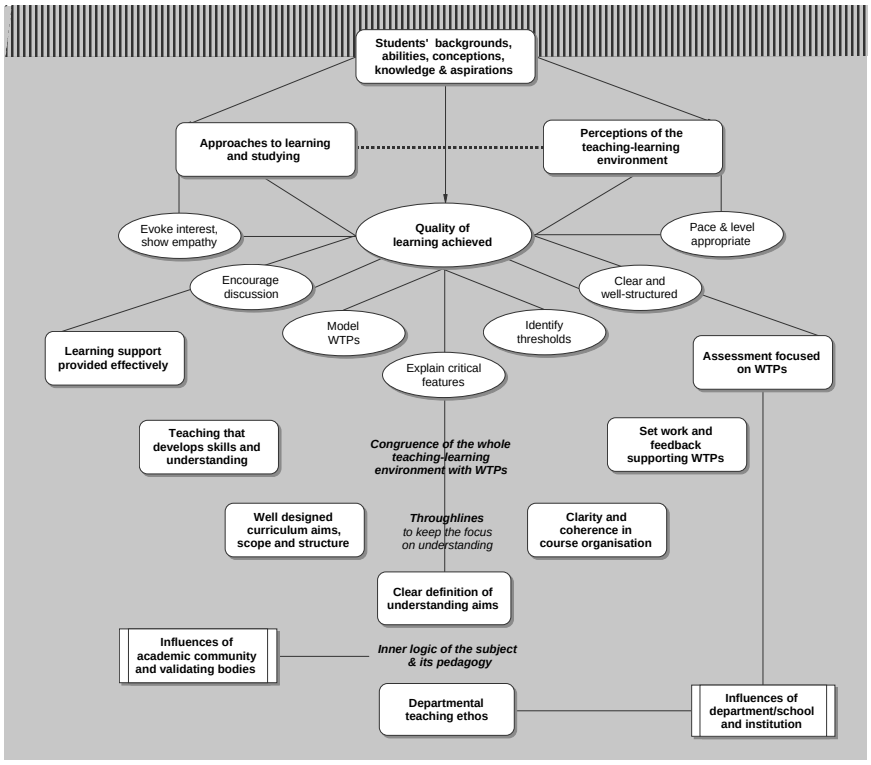

Figure 2. Interactions between influences on the quality of student learning

Marton (2007) sees his own pedagogical theory of learning as having a similar effect, and he has also found that encouraging teachers to work together in thinking about the forms of variation, which are important in a particular topic, has a powerfully beneficial effect on the quality of both teaching and learning. And this also seems to be true of discussions of threshold concepts.

> When university teachers start looking at their colleagues' ways of dealing with the same content that they themselves have taught, and when ways of dealing with content become a topic of conversation for them, then an important step towards the improvement of university teaching and learning will have been taken. (Marton, 2007, p. 28)

DISCUSSION AND CONCLUSIONS

The main purpose of this paper was to discover whether some of the concepts used in educational research are threshold concepts, and in the process to help to clarify the transformative nature of thresholds. It seems clear that there are differing

transformative thresholds, only one of which fits the definition of a threshold concept. Defining features of a threshold concept indicate that it must relate to a specific and important aspect of a syllabus, and that it also must be capable of opening up the subject in important ways through integrating other, lower-level concepts.

Drawing on the distinctions made by Davies and Mangan (2007), basic concepts that help students initially to see the subject in a different way are not integrative and so not threshold concepts as such, although they can act as transformative thresholds for individual students. The term *threshold concept* represents the second category identified by Davies and Mangan, as it opens up the subject through the integration of other concepts. The final category of threshold is too broad to be called a concept; it seems better to describe it as a disciplinarily specific *way of thinking*, but it still does serve as an important transformative threshold for students. It is unlikely, however, to be experienced as a single event, as can happen with a threshold concept, but rather as a growing awareness of the nature of the discipline as a whole, along with the steady build up of professionally relevant knowledge and skills. Conceptions of knowledge and learning represent thresholds of this broader kind, as do the frameworks linking approaches to learning to teaching-learning environments for university teachers.

So far, much of the research into threshold concepts has focused on identifying them within a syllabus and from the teacher's perspective but, if we are to understand the transformative function of thresholds of various kinds, we must find out a great deal more about how they are experienced by students. Staff have described how threshold concepts integrate lower-level concepts and so serve as a portal which opens up the subject in important ways. But how do students experience these concepts? How many of them experience the transformation in their thinking which the threshold concepts offer? Once the concepts have been introduced, what other work is necessary by the individual student to recognise the transformatory power of the concept? The answers to these questions would have to come from a thorough analysis of interviews with students about their experiences of learning specific concepts, in which the students' understanding of them is systematically probed through the progressive deepening in questioning that encourages students to explore their own understanding, as in the earlier research into the experience of understanding (Entwistle & Entwistle, 1992, 2003).

The earlier research into students' experiences of understanding and of their experiences of 'knowledge objects' indicates what may be involved in grasping threshold concepts and seeing the connections with other parts of the syllabus which flow from those understandings. Research into conceptual change, and into epistemological development, provides another example showing that concepts in students' minds may well have an unstable early existence. We need to discover to what extent *liminality* (Meyer & Land, 2005) occurs and whether this, and the claim of irreversibility, is supported empirically across a variety of subject areas. Such extension of the work on threshold concepts through research into the students' experience of them will allow our understanding of the nature of both

threshold concepts and transformative ways of thinking to be substantially improved.

The other development needed is, of course, to see how best to teach for transformations in student learning, and studies are already beginning to point the way (Meyer & Land, 2006). The research of Marton (2007), working with school-teachers to help students discern critical features, suggests one approach to teaching threshold concepts, while Perkins' (2007) exploration of *theories of difficulty* suggests other ways forward. He argues that staff can be aware of areas of the curriculum that regularly prove troublesome, and yet fail to act on these danger signs. Even when recognising the need for action, any change in teaching may simply take the form of spending more time in teaching those topics, but without any real understanding of what is causing the difficulty. Perkins argues that what staff need to do is to 'teach smarter'; in other words, they need to explore the reasons for any observed difficulty carefully before deciding on a course of action. Much current teaching, while often 'pretty good',

> always leaves a residue of persistent trouble spots … For *really* good pedagogy, we need to [have] a theory of difficulty that identifies the trouble spots in that particular content, strives to explain them, and points toward adjustments in the teaching-learning process to help with them. Thus, theories of difficulty become … a natural front for teachers learning about their students and their own craft, and a natural part of the considerable research on teaching and learning and human development. (Perkins, 2007, p. 44)

Concentrating on threshold concepts within a syllabus, in itself, is unlikely to lead to much improvement in students' understanding: the reasons for current difficulties have to be explored and used to guide changes in pedagogy. Moreover, although the potential that threshold concepts apparently have for transforming student understanding offers great promise for university teachers, staff will still need to be mindful of the many other sources of difficulty that Perkins, and others, have outlined.

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