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# Exploring practices, improving student learning: Threshold Concepts conference 2008

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## Introduction

In the summer of 2006, the GEES Subject Centre ran a residential conference entitled "What on Earth...? Student Learning in Geography, Earth & Environmental Sciences" (<http://www.gees.ac.uk/events/2006/ac06/ac06.htm>). The purpose of the event was to consider key concepts, student misconceptions, and bottlenecks in learning in higher education and, in particular, it explored the notion of 'Threshold Concepts'. Threshold Concepts are those key ideas in a discipline that offer the learner a gateway to new ways of thinking (Meyer & Land, 2003). Whilst the learner is developing their understanding of a threshold concept, they may find themselves temporarily stuck in a 'state of liminality' (literally 'on the threshold') where their grasp of the concept may be limited or confused with other (mis)conceptions. Meyer and Land suggest that threshold concepts can be characterised in the following ways:

- Transformative: they will change the way in students perceive and practice in their discipline;
- Irreversible: once grasped, it is unlikely that a Threshold Concept will be forgotten or 'unlearned';
- Integrative: they allow connections to be made between isolated pieces of knowledge;
- Bounded: they can help define the boundaries of a subject area or discipline;
- Troublesome: threshold concepts may be conceptually challenging to students.

The Subject Centre conference represented GEES's first exploration of threshold concepts and led to proceedings in the Centre's publication, 'Planet' (King (Ed), 2006), an introductory paper in the *Journal of Geoscience Education* (Stokes *et al.*, 2007) and a discussion at the Geological Society of America's annual meeting (October 2007).

More widely, conversations, research and theoretical and practical developments have been taking place both generically and across a variety of disciplines including economics, accounting, physics, computer science, healthcare and engineering.

These developments were discussed at the first international Threshold Concepts conference in Glasgow in 2006 (<http://personal.strath.ac.uk/ray.land/thresholds/home.htm>; Bradbeer, 2006) and in various literature including two books (Meyer & Land, 2006; Land *et al.*, 2008). Although there has been some criticism of the Threshold Concepts theory (e.g. Rowbottom, 2007), the momentum has been towards the development of a community of theorists, researchers and practitioners as illustrated by the 2nd International Conference held in Kingston, Ontario in June 2008 (<http://thresholdconcepts.appsci.queensu.ca/index.php>).

The following summary of the conference is given from the perspective of one participant, myself the author, who also convened the Geoscience session.

## The conference

Approximately 88 participants attended the three day conference which consisted of keynote talks, 20 minute presentations and 60 minute discussions. Sessions were held on 'Education Development and Threshold Concepts', 'Learning Outcomes: Threshold Concepts (Knowledge), Threshold Attitudes and Threshold Skills or Capabilities', 'Variations in States of Liminality', 'Threshold Concepts and Troublesome Knowledge in Different Disciplines', and 'Theory into Practice: Developing Teaching Strategies for Threshold Concepts'. Abstracts for all the presentations can be found on the conference website at <http://thresholdconcepts.appsci.queensu.ca/schedule.php>

Ray Land's keynote on the first evening discussed assessment of threshold concepts and outlined the further ideas in the theory of threshold concepts that he and Erik Meyer have been developing. The notion of a state of liminality in learning suggests that there is not necessarily one place in time where a student can be judged on their understanding of a concept. Threshold Concepts involve a 'liminal journey' and assessment requires students to demonstrate their understanding whilst they are still undertaking that journey. So perhaps assessment needs to be thought of "as a movie rather than a snapshot" and a more nuanced model

of assessment needs to be developed in order to account for the different states of learning during the liminal journey. Rather than assessing a static point in time, assessment needs to address the dynamics of learning - how it's changed or changing (or not changed). An important message for students in this reconceptualisation of assessment is that it is OK to be uncertain, to be stuck; that learning is a dynamic process that takes time.

Other memorable presentations I attended included Jonte Bernhard from Linkoping University, Sweden, who gave a thought-provoking talk starting with the derivation of the word 'absurd': from the Latin 'surdus' meaning deaf or mute, something that does not speak. He suggested that concepts and ideas 'speak' in some frameworks and are 'absurd' in others. Tensions between different frameworks, e.g. old and new ideas in a discipline, give rise to thresholds. To overcome thresholds, an awareness of these tensions are necessary, i.e. an analysis of ideas is essential. In addition, he noted that it is not surprising that learning issues arise as we are often trying to convey concepts to students in a few weeks that have taken years to be established and accepted!

Leah Shopkow from Indiana University in the USA discussed the notion of 'Decoding the Disciplines' (Pace & Middendorf, 2004). Through interviews with academic staff, the researchers identified particular sticking places or bottlenecks in student learning. They then used these to map and reconceptualise the curriculum.

13 participants were from the Geosciences and one strand of the conference was devoted to the discipline. It included 7 presentations, 1 garden discussion and 1 workshop:

- *Why is Geologic Time Troublesome Knowledge?* Kim Cheek (Valley Forge Christian College, USA) Kim discussed various aspects of geologic time including succession and duration; she suggested three possible reasons for student difficulties - the long durations compared to everyday experiences, a lack of understanding of large numbers, and a lack of subject matter knowledge.
- *Deep Time: A Critical Barrier, an Anchor or a Threshold Concept?* Roger Trend (University of Oxford, UK) Roger discussed the idea that deep time is at the very heart of the geosciences and yet remains poorly understood within (UK) society. "The oft-heard primary teacher's non-illuminating response of "millions and millions of years ago" to the inquisitive child sums up the current state of affairs." Deep time meets the defined characteristics of threshold concepts. Roger also noted that the notion of 'threshold concepts' is akin to critical barrier or anchor concepts found particularly within science education.
- *Interactive Approaches to Teaching First Year Geology Mapwork: 2-D, 3-D and 4-D Visualization.* Gillian Drennan (University of Witwatersrand, South Africa) Gill outlined a teaching intervention to support 3-D and 4-D visualisation that included hands-on modelling exercises which allowed students to construct 3-D geological structures and examine their projection on maps and cross-sections; these helped them to understand the interaction between geological processes such as faulting, folding, tilting, erosion and deposition.
- *"You can't see things on a flat bit of paper, you've actually got to see if for yourself in 3D": The role of geological mapping in helping to cross the threshold into spatial literacy.* Alison Stokes (University of Plymouth, UK) Alison also emphasised spatial literacy as a possible threshold concept in Geoscience. She described research undertaken during a 2nd year geology mapping fieldtrip during which students had the opportunity to both see 3-D geological features in the field, and then translate those features onto a 2D map. The students' immersion in the field environment seemed to be key to the development of their spatial literacy.
- *Uncertainty and Complexity: Thresholds in Climate Change Science.* Brendan Hall (University of Gloucestershire, UK) Brendan described his research project, looking at the perceptions of complexity and uncertainty held by academics and students in the teaching and learning of climate change science, with a view to interpreting these through the lens of threshold concepts.
- *Using Threshold Concepts to Promote Students' Integrative Learning on a First Year Residential Field Course in Geosciences.* Bettie Higgs (University College Cork, Ireland) Bettie described how a first year fieldcourse was transformed from a 'lecture-in-the-field' format to a series of field-based seminars. Opportunities were provided for students to integrate learning from different disciplines in science and to consider their own approach to learning. She discussed the possibility that there may be threshold concepts that connect

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different disciplines particularly within the context of Geoscience.

- *'Threshold Concepts' in Geology as Key Concepts Integrated Across Disparate Spatial and Temporal Scales: Student Learning Difficulties with the Concepts of Density and Erosion.* Andrea Bair (University of Colorado, Boulder, USA)  
Rather than discussing particular Geoscience topics, Andrea highlighted the problem of core concepts from other disciplines (such as physics and chemistry) that Geoscientists then apply in different ways. She suggested that directly addressing student difficulties with these concepts (e.g. density) may not always help and that they need support in bridging the gap between the concept and the Geoscience application.
- *Identifying Threshold Concepts in Geoscience: Taking Inventory with Students and Faculty alike (garden discussion).* Leslie Reid (University of Calgary, Canada)  
Leslie discussed her research project, which includes surveys and interviews with both staff and students to identify possible threshold concepts. The research is in response to concerns about the heavy content load of many Geoscience courses and a discussion amongst staff as to whether the content could be reduced to focus on the most important (possibly threshold) concepts.
- *What on Earth? Threshold Concepts and Troublesome Knowledge in the Geosciences (workshop).* Helen King (Higher Education Consultant)  
This workshop brought together the Geoscience participants at the conference and provided an opportunity for discussing personal interests in the topic and the way forward for the discipline in the area.

These sessions were well attended by participants from a variety of disciplines (not just the Geosciences) and the size of the Geoscience contingent made for some interesting and useful conversations over the three days. The presenters took a variety of approaches: some identified particular topics as possible candidates for Threshold Concepts, e.g. deep time and spatial literacy; others discussed teaching strategies for supporting the development of Threshold Concepts, in particular fieldwork and (inter)active learning.

Interestingly, the discussions around Threshold Concepts in the Geosciences raised some more general issues about learning and teaching in the discipline. These included:

- The issue of 'knowledge transfer' from other disciplines such as chemistry, physics and mathematics and the need for explicit links or bridging areas to be made between these and Geoscience concepts (just because the student understands the physics principle does not necessarily mean they will automatically understand the Geoscience application);
- The differences in scale between teaching and application. For example, students may study 'rocks in a box' in the laboratory and find it difficult to associate these to the scale of outcrops and exposures in the field;
- The integration of Geoscience concepts over time and space;
- What do we do in our teaching that may actually make concepts more troublesome? For example, using water to illustrate density (when discussing plate tectonics) may cause some students to make the assumption that the mantle is therefore liquid!;
- The nature of the 'stuffed curriculum' in Geoscience – can the identification of core or threshold concepts enable content-load to be reduced?

## Conclusions

This second international conference on Threshold Concepts was, for me, notable in its diversity of disciplines, nations and viewpoints. The convenors were, of course, strongly wedded to the idea of Threshold Concepts, had accepted their existence, defined them in their discipline, and were moving on with the theory. Other colleagues were interested in the idea but were still exploring its meaning: what actually is a Threshold Concept? Can it only be a concept or could it be a theory or skill? Are they really irreversible? What is a transformation? Discussions with the Geoscientists at the conference suggested that, in our discipline, we are still throwing around the idea, questioning assumptions and seeing how comfortable we are with it. We may (or may not) end up running with it, but the discussions it has provoked have been progressive and invaluable; not least because there has not previously been much (research-based) exploration around troublesome concepts in the Geosciences.

For some colleagues there was concern about 'fitting the data to the model' and looking too much through the lens of Threshold Concepts. A more iterative process of researching learning in the discipline and then identifying models that might fit the data might be a more comfortable approach. Future research in this area for the Geosciences would be very valuable, particularly in identifying

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'sticking points' in student learning and elucidating how experts think and practise in the discipline.

The next International Threshold Concepts conference is to be held in Sydney, Australia in July 2010; and the sixth International Geoscience Education conference on 28th August – 5th September 2010 in Johannesburg, South Africa (<http://www.geoscied.org/>).

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