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Research Report RES-139-25-0361

Transforming Perspectives: Technologies to Support Teaching and Learning of Threshold Concepts

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Contents

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Background

The project can be located at the intersection of two research agendas: the first being the development of technology-enhanced learning informed by a range of views of teaching and learning, and the second being the role of threshold concepts and troublesome knowledge in learning in higher education. The first of these has been highlighted by recent reviews of theoretical underpinnings of technology-enhanced learning which have attempted to survey the range, reach and impact of different conceptualisations of teaching and learning, and have identified a variety of associationist, constructivist and situated models. At the same time, these reviews and other sources have continued to highlight concerns about the range and quality of the teaching and learning activities supported by technology. The second, for this project in particular, stemmed from research into teaching and learning more generally in undergraduate courses, including work specifically dealing with small-group teaching. 'Threshold Concepts' is one of the key ideas which had been found to be useful in analysing 'what works' in undergraduate teaching and learning environments. They are described as being transformative, probably irreversible, integrative, 'bounded' or domain specific, and sometimes problematic; they 'open up' areas of domain knowledge and link areas of disciplines. From the learners' perspective they help them make sense and 'constructively align' prior knowledge, curriculum content, course elements and assessment activities.

The notion of threshold concepts has proved appealing and useful across a number of disciplines, and some detailed accounts of their nature and role have emerged, together with discussions of how they might be conceptualised and researched. Threshold concepts are also potentially important in social, situated models that make use of the 'participation metaphor' of learning. However, lack of understanding of threshold concepts and of their role in discipline-specific discourse and practice may confine learners to a liminal state in which understanding is restricted to a kind of mimicry with only limited meaning to the learner. This aligns well with ideas of learners as 'peripheral participants' and suggests that threshold concepts can be seen not only as key elements of a community's shared repertoire, but also the 'points of focus' around which specialised meanings, identity and membership are negotiated. This suggests that the curriculum may need to be oriented towards these points of focus and addressed through activities which are doubly authentic: authentic to the learner themselves, but also authentic representations of disciplinary practice.

Given the concern about the validity of claims that constructivist/situated learning models could be supported by technology, threshold concepts (with their associated demand for conceptual change and revisiting of prior understanding) appear to present a challenge for technology enhanced learning. They appear to demand sophisticated and flexible learning environments with the potential to support reflection and 'revisiting' of knowledge that support the problematisation of subject knowledge, and also which allow discourse and collaboration around significant points of focus. The project was conceived as being explicitly interdisciplinary in character. From the outset it was recognised that threshold concepts, as an emerging idea (or set of ideas) was not simply something against which candidate technologies might be measured; the notion of threshold concepts itself would be interrogated from a range of perspectives including educational, philosophical, psychological and technological. This broader set of perspectives would then provide a basis for the specification and future development of technology-enhanced learning tools and environments.

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Objectives

The general objectives of the project were as follows:

- establishment of an interdisciplinary network (including representatives from education, computer science, psychology and a range of subject domains) to explore perspectives on the teaching and learning of threshold concepts across a number of disciplines.

- exploration of opportunities offered by a range of technologies (including, but not limited to, the adaptive intelligent tutoring systems being researched and developed at the University of Cambridge Computer Laboratory) to support the teaching and learning of threshold concepts across a range of disciplines.

Specific objectives included:

- A review of literatures related to threshold concepts across disciplines in order to identify common elements and discipline-specific research, conceptual and frameworks and case studies

- organisation of a series of practitioner seminars to define the nature and role of threshold concepts in a range of disciplines and teacher and student perspectives on teaching and learning threshold concepts

- construction of a series of case studies of teaching and learning threshold concepts in the disciplines

- organisation of a series of multi-institutional interdisciplinary events to explore areas of commonality and difference in conceptual models, ontologies and methodologies related to threshold concepts, and develop interdisciplinary approaches to further research

- establishment and management of an online environment to support work in both seminar series and to allow links to be established across seminar series, as well as to provide a location for interdisciplinary activities between seminars

Methods

Literature Review

The project conducted a literature review of areas related and relevant to threshold concepts; given the emergent nature of the research area and the resulting small literature set, this extended into more general studies of conceptual development and teaching and learning environments and practices, and its scope also extended beyond higher education into school, workplace and professional learning and informal learning. Further details of the conduct and findings of the literature review are to be found in Annex 3 of this report and in the review itself, attached as a nominated output.

Seminar Series A: Threshold Concepts in the Disciplines
This series took the form of three practical seminars based in Cambridge, involving senior and junior academic staff from a range of disciplines and institutions: Engineering, English Literature, Comparative Religion, Social Anthropology, Materials Science, Computer Science, Plant Science, Biomedical and Health Science, and Sports Science. These seminars explored teacher and student perspectives on the teaching and learning of threshold concepts, and participants were supported in developing case studies of potential threshold concepts in their disciplines.

Case Studies
Nine participants (or pairs of participants) developed case studies of potential threshold concepts; in doing so, they were supported by seminar-based activities; though online and face-to-face contact with project team members; and through the provision of a 'toolkit' of research tools and techniques (see Annex 1 of this report). Case studies involved staff and student interviews, documentary analysis, focus groups and practical activities. Participants reported research approaches and findings in the form of large posters which subsequently provided a focus for further discussion within seminar series A and also in the interdisciplinary seminar series B. Examples of the posters are included as Annex 2 of this report; a full set is available from the project website at http://www.caret.cam.ac.uk/tel and the process of case study development as a specific case of practitioner research is described in the attached conference paper (Irvine and Carmichael, 2007).

Seminar Series B: Interdisciplinary Perspectives on Threshold Concepts
These seminars brought together representatives of different disciplines with the intention of exploring areas of commonality and difference in conceptual models, ontologies and methodologies related to threshold concepts, and developing interdisciplinary approaches to further research. The first seminar established the disciplinary starting points of participants from Education, Social Anthropology, Psychology and Philosophy, who presented short position papers. The case studies generated in Seminar Series A - which formed a poster display before and during the seminar itself (see an example, left) - served as points of focus for participants and presenters, and formed the basis of a series of discussions and other activities designed to identify areas of commonality and difference in conceptualisations, models of learners and learning, ontologies and methodologies for further study.

A second seminar took as its starting point the ESRC/EPSRC/E-Science e-Learning Research Agenda, and focussed specifically on technologies with the potential to support teaching and learning of threshold concepts and troublesome knowledge. The first session consisted of papers on the space and discourse of social software, including the relationship between software developers and users, and the second session consisted of realisations and implementations of domain knowledge within online resources. These included examples of concept mapping software, adaptive tutors, peer-learning environments and collaboration environments.

Postgraduate Seminar
The aim of this seminar was for graduate researchers to reflect on the experiences of writing a PhD, exploring in particular the notion of threshold concepts in higher education. The seminar sought to address a number of issues: first, in terms of the student demographic, work on threshold concepts tends to focus on undergraduates;

second, graduate students do not follow a set curriculum and select their own area of study, which has implications for their transformation in understanding; third, the state prior to this transformation in understanding is held to be liminal, a transitional state through which one has to pass in order to understand things in a new way. In this sense the state of being a PhD candidate might be considered to be liminal. In collaboration with the 'Interdisciplinary Research Training Network' at the Centre for Research in Arts, Social Sciences and Humanities at the University of Cambridge, and Professor Vernon Trafford from Anglia Ruskin University, 14 PhD students participated in this seminar. Participants were split into groups with the collaborators and discussed their conceptualisations of their PhD topics and their experiences of the thesis writing process, as well as their perspectives on the ideas of threshold concepts and troublesome knowledge.

Technical Development
While the project was not primarily concerned with developing new technologies (but rather with scoping existing technological frameworks and developing specifications), the close links between the University of Cambridge Computer Laboratory and CARET allowed the development of a pilot project based on the existing IVC adaptive tutoring system used to support the learning of the Verilog language. A series of interfaces were built to allow students to engage with a specially constructed knowledge-base representing an area of Plant Science which was regarded as complex and potentially 'troublesome' to many learners (See Annex 5 for further details).

Results

The project achieved the following results, measured against the objectives set out in the project proposal and summarised above.

Organisation of a series of practitioner seminars exploring perspectives on teaching and learning threshold concepts and the construction of a series of case studies of teaching and learning threshold concepts in the disciplines: these seminars were successful in initiating and supporting engagement in and with the research agenda on the part of participants from a range of disciplines. Participant evaluation of these seminars and the experience of carrying out the case studies was very positive; the role of threshold concepts as a 'point of focus' for practitioner reflection and enquiry, and of the various seminar activities, is explored in detail in Irvine and Carmichael (2007) attached as a project output to this report.

Organisation of a series of multi-institutional interdisciplinary events: a second series of seminars engaged with a broader range of participants from the University of Cambridge, the Institute of Education, Kings College London, the University of Strathclyde, the University of Durham, the University of Sheffield, the Open University and the Massachusetts Institute of Technology. Disciplines represented included: Education, Philosophy, Psychology, Social Anthropology, Computer Sciences, Biological and Physical Sciences, Health Sciences, Engineering, Aeronautics and others, including most of the participants in Seminar Series A. The proposed project residential meeting was not held, with the time alloted being spent instead in a series of more focused day meetings with potential research partners from other institutions and across disciplines.

Establishment of an interdisciplinary network: the project was successful in that it created an interdisciplinary network within the university involving representatives from a wide range of disciplines. The project design, with its two seminar series, allowed interdisciplinary dialogue and working to be established both around specific case studies of threshold concepts and around the idea of threshold concepts more generally. Extended project activities such as work within the engineering faculty and the collaboration between plant scientists and software developers around the development of the adaptive tutor (see Annex 5) provide examples of how interdisciplinary working might be sustained beyond the initial seminar series and case study work.

Exploration of opportunities offered by a range of technologies to support the teaching and learning of threshold concepts across a range of disciplines: the elaboration, through case studies, of detailed examples of threshold concepts and troublesome knowledge across disciplines provided a basis for exploration of the affordances of different technologies in supporting teaching and learning of threshold concepts. A key theme to emerge from the case studies and seminars was the importance of discourse both in the teaching of learning of threshold concepts, and some participants made the argument that threshold concepts themselves were discursively constituted. This was reflected in project discussions and seminar activities around software selection and development, in which discrete teaching and learning applications were envisioned as being 'embedded' within social software environments, allowing individual conceptual development, problem formulation and learning strategies which were the focus of broader discourse and review. The theme of discourse also emerged in the evaluation of the ontology-based adaptive tutor which was developed as pilot activity: students who evaluated the various interfaces preferred those in which discussion or knowledge construction and representation was highlighted over those which fulfilled 'check and review' self-assessment functions.

A review of literatures related to threshold concepts across disciplines in order to identify common elements and discipline-specific research, conceptual and frameworks and case studies: the literature review has been completed and is included as one of the exemplary outputs from the project. It has been instrumental in supporting the seminar series (progress reports were presented at seminars) and the work of participants involved in case studies. It has also drawn on the work of the seminars, as exemplified by its extension to cover research concerned with social models of learning and learning in workplace and professional contexts.

Establishment and management of an online environment: the online environment was established and served as a focus for collaborative project activities as a well as acting as a resource centre for participants (see Annex 4).

Additional Results

In addition to the objectives set out in the proposal, the project generated additional results and outcomes in a number of areas.

The seminar series on threshold concepts in the disciplines and the associated case studies developed by participants were successful on several levels. They were expected to allow the exploration of the idea of threshold concepts in different disciplines, but they also acted as a focus for more general discussion and cross-case

analysis which in turn led to better collective understanding of the role, nature and scope of threshold concepts in general. This experience also provided useful pointers to the development of a more generic model of practitioner research in HE – see the paper submitted to BERA by Irvine and Carmichael (2007 forthcoming) for further details, which may be introduced as an element of staff induction and continuing professional development within the University.

One of the themes which emerged from the seminars was the importance of threshold concepts in transitions – from school to university; from undergraduate to postgraduate study; and from university to work. This recognition informed the organisation of a 'Graduate Seminar' on threshold concepts, held jointly with the University of Cambridge Centre for Research into Arts, Social Sciences and Humanities (CRASSH), and has initiated potential further areas for research and development activity.

The project's use of a Virtual Research Environment (see Annex 4) has not only supported the project itself, but has served as a useful model for other projects within the University and more widely. It has been featured in induction and training events and the approaches used within it have been successfully replicated by other projects, seminar series and research groups. The tools developed by the project, including the research toolkits and the literature review have been disseminated and shared with other projects who have begun to implement them as part of their own practice.

Summary of Results
In summary, the activities of the project have led to:

- theory development around the role, nature and importance of threshold concepts

- the elaboration of the requirements of technology-enhanced learning tools and environments to support teaching and learning of threshold concepts and troublesome knowledge, which will necessarily involve not only support for individual learning as conceptual change, but also space and support for critical engagement, reflection and enquiry

- development of a better models of how to initiate and support practitioner enquiry and reflection in higher education

- capacity building within and beyond the host institution and the development sharing of tools and expertise in technology-enhanced research

Activities

In addition to the seminar series and associated case study and technological developments, members of the project took part in the following activities:

20-21 September 2006: TEL Conference, Wolverhampton: Members of the project team attended the TEL Conference and made a presentation of the project aims and activities.

19 October 2006: TEL Seminar, London Knowledge Lab: Members of the project team attended the TEL Seminar on Knowledge Cumulation.

9-12 November 2006: ISSOTL Conference, Washington DC: Patrick Carmichael and Keith Johnstone attended the ISSOTL conference and engaged US project participants.

20-22 November 2006: TLRP Annual Conference, Glasgow: Members of the project team attended the TLRP Annual Conference and presented a paper on Initiating Interdisciplinary Discourse.

8 December 2006: TEL Seminar, Sussex University, Brighton: Patrick Carmichael and Richard Procter (CARET) attended the TEL Seminar on Technology Enhanced Research and presented an account of their work researching user activity and collaboration in online spaces.

15 January 2007: Visit by senior staff from MIT to discuss Cambridge-MIT collaboration in teaching and learning; Patrick Carmichael presented work of project and discussed sharing of approaches, resources and outcomes with MIT faculty.

16 January 2007: TEL Seminar, Edinburgh: Naomi Irvine attended the TEL Seminar on Capacity Building.

9 May 2007: Visit of Delegation from Open University of Finland to CARET, Cambridge. Patrick Carmichael and Naomi Irvine presented the work of the project.

May-June 2007: Initiation of discussions and inter-project meetings between project team and the 'Personalisation of Learning' project based at City University.

Throughout the project (and subsequently), the project team have initiated and maintained network links in the UK and internationally; the work of the project has been a key focus of the Cambridge-MIT Institute 'Teaching for Learning Network'. It has also informed the work of other activities including the work of the Reusable Learning Objects CETL in their selection and design of curricular foci for their TEL resources; and the redesign of courses and practical classes in the University of Cambridge Faculty of Engineering.

The project has maintained online and offline links with other groups and individuals involved in the research of threshold concepts and technology-enhanced learning.

Outputs

The following represent substantive outputs from the project. The project literature review (Burchmore, Irvine and Carmichael) and the paper accepted for presentation at BERA 2007 (Irvine and Carmichael) are included as nominated outputs associated with this report.

Book Chapter
Carmichael, P., Johnstone, K., Tracy, F. and Burchmore, H. (2007) 'Threshold Concepts: an Emerging Interdisciplinary Research Agenda in Higher Education

Research' in: D. Good, S. Greenwald, R. Cox, and M. Goldman (eds.) *University Cooperation for Innovation: Lessons from the Cambridge-MIT Institute* (Rotterdam: Sense Publishers)

Conference Papers
Irvine, N. and Carmichael, P. (2006) 'Initiating Interdisciplinary Discourse about Student Learning: some early challenges for a TEL Development Project' Presentation at Teaching and Learning ResearchProgramme Conference, November 2006, Glasgow.

Taylor, K., Carmichael, P. and Irvine, N. (2006) 'Developing an Adaptive Tutoring Environment to Support the Teaching and Learning of Threshold Concepts' Paper presented at the BCS Special-interest Group on Artificial Intelligence Workshop: AI and Education, December 2006, Peterhouse, Cambridge.

Irvine, N. and Carmichael, P. (2007 forthcoming)'Initiating and Supporting Practitioner Research in Higher Education', paper to be presented at BERA Conference, September 2007, Institute of Education, London.

Project Report
Burchmore, H., Irvine, N. and Carmichael, P. (2007) 'Threshold Concepts: A Review of Literature from the Transforming Perspectives Project' (Cambridge: CARET)

Case Studies
The case studies produced by seminar participants represent significant project outputs in their own right: as representations of the work of project participants; as a stimulus for engagement of new participants; and as a point of focus for interdisciplinary discourse. See Annex 2 for further details and examples.

Impacts

In addition to the formal outputs listed above, the project has had a number of significant impacts:

It allowed the identification of potential research partners and team members who brought with them theoretical perspectives, methodological frameworks and other research experience leading to the development of a research bid under the second round of ESRC/EPSRC TEL funding.

As described above under 'Results', it generated a model of practitioner research and professional development for higher education which is currently under further development and which has informed staff development and training in a number of departments.

It provided a theoretical basis for research, curriculum development and interventions on the part of participants, including the systematic adaptation of the undergraduate practical course in Engineering and associated training of staff. This course will, from 2007-8, use threshold concepts as a guiding principle in the design and sequencing of learning activities.

Technological developments from the project have been more widely used and the

'adaptive tutor' pilot work is to be extended in other disciplines and settings; including potential applications in other educational sectors (school and 16-19).

Several of the participants in the project have subsequently written accounts of disciplinary applications or perspectives on threshold concepts for conference presentation or publication (Sports Science, Engineering, Education). The paper presented at the interdisciplinary seminar series exploring educational perspectives on threshold concepts will appear as:

R. McCormick (2007 forthcoming) 'Threshold Concepts and Troublesome Knowledge: reflections on the nature of learning and knowledge' in: R. Land, J.Meyer and J. Smith (eds). *Threshold Concepts within the Disciplines* (Rotterdam: Sense Publications)

Future Research Priorities

For the Project

The project team have subsequently collaborated with researchers at four other universities (City University, University of Stirling, University of East Anglia and the Economic and Social Data Service at the University of Essex), to develop an outline proposal 'Semantic Web Technologies for Case Based Learning' which builds on the work of the 'Transforming Perspective' project. This proposal draws on the work of the project and locates threshold concepts and troublesome knowledge as elements of discursively constituted notions of the 'case' across a range of disciplines and educational settings. It also highlights the need for any technological support for teaching and learning of troublesome concepts to allow for discussion, review and transfer across disciplines. A summary of the proposal (Reference ES/F030630/1) is included in this report as Annex 6.

The project team will continue to work, through their associations with the Teaching for Learning Network and other university projects and programmes to develop innovative practitioner research activities based around theorised 'points of focus' such as threshold concepts. This will remain a focus of ongoing collaboration and development work with the Massachusetts Institute of Technology and HEA networks such as the NTFS scheme.

The emerging research agenda around the development of postgraduate learning and identities initiated by the project in association with CRASSH at Cambridge will continue and is the focus of an application by Dr. Carmichael and Dr. Irvine to the Nuffield Foundation under its Early Career Fellowship Scheme.

For Research into Threshold Concepts

The findings of the project suggest that the research agenda around 'threshold concepts' is potentially a very fruitful one but that to date has concentrated on definition and identification 'in the disciplines'.

The project has highlighted the value of other dimensions such as:

- learner perspectives and their relation to teacher perspectives
- the role of threshold concepts and troublesome knowledge in cross-

disciplinary dialogue
- accounts of interventions based on supporting conceptual change and discursive practice across disciplines
- implications for course design and assessment
- exploration of threshold concepts and troublesome knowledge in informal educational settings

For TEL Research

The project has highlighted the importance of discursive practices amongst both teachers and learners both in understanding the nature and role of threshold concepts and troublesome knowledge in their disciplines and in interdisciplinary activities. This points to the importance of technology enhanced learning tools and environments that engage teachers and learners in enquiry and reflection as an essential element of practice – both disciplinary and pedagogical. In this respect the project has provided a partial basis for the major TEL development and research project proposed under the second round of the ESRC/EPSRC TEL programme.

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Annex 1: The Case Study Toolkit

Participants in Seminar Series A were provided with a 'toolkit' of potential approaches to assist them in identifying, characterising and exploring the importance of threshold concepts. Approaches were derived from pilot work carried out in the Department of Plant Sciences at Cambridge and from the literature review?on threshold concepts.

The documents were deliberately designed to be accessible but well grounded in theory and/or established practice, and were no more than 2 pages long.

The toolkit was made available via the online collaboration environment and comprised:

Reviewing Course Documentation
A guide to assist in reviewing course documentation, learning objectives and teaching resources, with a focus on constructivist practice, making learning explicit and flagging potential troublesome knowledge and threshold concepts.

Reviewing A Candidate Threshold Concept
A review of Meyer and Land's characterisation of threshold concepts, designed to encourage reflection on the character and potential role of candidate threshold concepts.

Student Focus Groups
An outline of a focus group activity with follow-up questions and discussion points, designed to help students identify troublesome knowledge and threshold concepts. Focussed specifically on the idea of integrative concepts as linking apparently unrelated curriculum content and learning activities.

Teacher Interviews or Focus Groups
A set of questions and conversation starters designed to help teachers reflect on what students find difficult to learn.

Comparing Teacher and Student Perspectives
A guide to designing questionnaire items involving ranking items (e.g. in order of perceived difficulty) and using appropriate statistical approaches to analysis data.

Poster Template
A blank A1 case study poster for participants to use as the basis of their own poster display.

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Annex 2: Case Studies

Participants in Seminar Series A undertook case studies of candidate threshold concepts in their disciplines, using the poster template and case study toolkit as a starting point. These case studies then formed the basis of discussion and engagement throughout the remainder of the project.

The full list of participants, disciplines and candidate threshold concepts is as follows:

Participant	**Discipline**	**Candidate Threshold Concept**
Clare Folkes	Biomedical and Health Sciences	The International Classification of Functioning, Disability and Health
Dan Sheppard	Computer Science	Y and Recursion
Aidan Reilly and Hugh Hunt	Engineering	Spin
Christopher Burlinson	English	Ethical Reading
Lucy Taylor and Keith Macaulay	Plant Sciences	C4 Photosynthesis
Fran Tracy, Katy Jordan and Keith Johnstone	Plant Sciences	Photoprotection
Lee Wilson and David Leitner	Social Anthropology	Reflexivity
Richard Procter	Sports Science	The Static Paddle
Andrew Brown	Comparative Religion	Biblical Texts as Literary Texts

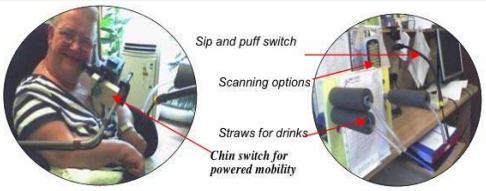
All of the case studies are available as A1 posters to download from the project website at http://www.caret.cam.ac.uk/tel: Figures 1 to 3 (below) are selected examples (Biomedical and Health Sciences; Theology and Engineering).

The International Classification of Functioning, Disability and Health (ICF)

A Threshold Concept in Teaching and Learning about Disability

Clare Folkes, Department of Biomedical and Health Sciences, Kings College London

International Classification of Functioning, Disability & Health



Anne has Cerebral Palsy, she has been married and widowed and now lives with her pet Labrador which she walks using her powered wheel chair controlled with a chin switch. Anne lives in her own house and uses an environmental control system with the aid of a sip and puff switch in order to perform tasks such as opening the door and answering the telephone. The drinking straws allow Anne to have the different drinks that her carers prepare. The computer (to the right) is controlled with a head mouse and limited voice recognition.

Anne's and all of our functioning and disabilities are classified by the World Health Organization's International classification of Functioning Disability and Health (ICF). The classification of functioning and disability is applicable to all people, and 'mainstreams' the experience of disability, recognizing it as a universal human experience. **We are all on this continuum**. The view of disability as generated by the ICF overturns the medical model which sees the disabled person and 'their condition as the problem'. This radical shift (WHO 2001) in the definition of disability from a medical model to a 'biopsychosocial' approach has both reflected an evolution in awareness and understanding of a new paradigm of disability but is now in itself a driver for change.

Understanding this view of disability as something shared and based on the 'person living in their world' is a threshold concept.

The graphic representation of the conceptual framework adopted by the ICF. From the International Classification of Functioning, Disability and Health World Health Organisation 2001

'The ICF may serve as the overarching framework to study disability from the perspective of architecture,engineering, information technology, law, rehabilitation, literature, medicine, etc.'

Teacher Perspectives

A teacher on an MSc course in Assistive Technology reports that introducing the ICF and exploring its significance with students (including many who have extensive experience on working with disabled people):

'When I teach the ICF I look around and the students have big eyes- it is a shift in their awareness'.

Learner Perspectives

This shift from a medical model to a biopsychosocial one parallels (at least to some extent) the learner's development of understanding of disability, 'handicap' and illness.

Rather than seeing disability as an unproblematic concept and the disabled person as a problem or a challenge to organizations and processes, they come to understand disability as a broad and socially-defined spectrum on which the disabled person, they themselves, and world-class athletes may all be located.It may be personally transformative in terms of personal attitudes and behaviours. Some people 'learning to live' with acquired disability observe that they find themselves liberated when they change their focus from the limiting factors of their condition and begin participating again in sports and social events they enjoy.

Why a Threshold Concept?

Why is this a threshold concept?

The experience of learning about the ICF and its implications are **transformative** in that it makes learners (including disabled people) fundamentally reassess their ideas about disability as 'the other'. In this respect it is probably **irreversible**. It is transformative not only in conceptual sense but also in terms of behaviours and attitudes towards others and oneself.

While it is **integrative** in that it provides a common language for discourse about disability across contexts, and integrates the medical, psychological and social aspects of peoples' lives, it is also 'disintegrative' and **troublesome** in that it reveals the complexity of individuals' lived experience. It is not really '**bounded**' – particularly given that the intention that the ICF breaks down disciplinary, contextual and international boundaries.

Implications

The ICF has deliberately been made gender- and culture-neutral, and has the potential to be used as the basis of international and interagency dialogue and comparisons.

This does demand that all agencies not only use the common vocabulary, but subscribe to the underlying biopsychosocial perspectives.

"Transforming Perspectives: Technology to Support Teaching and Learning of Threshold Concepts" is an ESRC/EPSRC Technology Enhanced Learning Project and is part of the Teaching and Learning Research Programme.

It is directed from the Centre for Applied Research into Educational Technologies by Dr. Patrick Carmichael.

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Email: 01223 765362 Project Website: http://www.caret.cam.ac.uk/tel

Figure 1: The ICF - A Threshold Concept in Bio-Medical Sciences

The Biblical texts as literary texts:
A Threshold Concept in Theology

Andrew James Brown

The Biblical texts as literary texts

The biblical texts (here I am referring to the Hebrew Scriptures/Old Testament *and/or* the Christian Scriptures/New Testament) have been understood, in various complex ways, as being in some *special* way the 'word of God' and *intrinsically different* from other kinds of texts. In the mid nineteenth-century there began to develop what initially became known as the "Higher Criticism." This movement began to understand that the Biblical texts were *literary*, rather than exclusively *sacred*, products. This radical change of perspective allowed scholars to begin to explore the texts in terms of, inter alia, literary form, historical accuracy, philological qualities, as well as the texts' reception and interpretation within different religious communities. It also allowed the voice of the sciences to be heard more clearly and accurately within communities of faith.

These studies have revealed (conclusively in my opinion – which is, at least in most academic and mainstream religious circles, the consensus opinion) that the Biblical text is to be understood in the first instance as a human product, however one may then go on to talk about how God's 'voice' may, or may not, be discerned *in* or *through* them (either in the act of writing the texts or in their reception). It should be obvious that this basic idea can be extended to other religious tradition's holy texts. In relation to Islam and its holy scripture, the Qur'an, this viewpoint remains exceptionally problematic and controversial.

Once anyone has accepted the idea that Biblical texts are firstly humanly authored literary ones, the weight of their authority and their relationship to the religious institutions that claim them as normative inevitably change. Initial *authority* for such organizations consequently has to be based upon something other than just the Biblical texts. A variety of theological/ philosophical/psychological responses to this have developed.

Adopting/crossing this threshold concept (about religious texts in general – not just the Bible) inevitably changes a person's relationship with, and understanding of, every other concept within the study of theology.

Teacher Perspectives

Within contemporary secular mainstream academic circles it would be very difficult to teach Biblical studies effectively without having adopted/stepped over this threshold concept or, at the very least, accepted that it is a legitimate one to hold. Teachers who do not accept this will, mostly, only teach within clearly *confessional* contexts – e.g. the so-called Bible Colleges. Problems for the 'mainstream' secular teacher arise when they encounter students who cannot or will not accept that the text can be read in this manner and who then go on artificially to divide their thinking about the text – thereby potentially being disingenuous in both their personal faith and in their academic studies. It should be noted that something similar is true for a teacher in a Bible College who is faced with a student who has adopted/crossed over this threshold concept!

Learner Perspectives

Some students begin to study the Bible already understanding/accepting this concept. Some start without this understanding/acceptance but, sometimes with difficulty but also sometimes with relief, come to adopt it themselves. The real difficulty comes when a student, for whatever reason, will not adopt or even accept this viewpoint as legitimate. It can create in the student some very odd tensions and behaviour. One anecdotal example, from my own under-graduate years at Oxford, reveals this well. A group of conservative evangelical Christians gave answers in their Old Testament papers which accurately reflected the academic consensus but they concluded their papers with brief statements of faith stating that they did not 'believe' their answers.

There are many other anecdotal examples of students' carrying on two utterly disconnected discourses about the text, one in their churches and the other in the classroom.

Why a Threshold Concept?

Because the Biblical text is so fundamentally linked to the way Judaism and Christianity (and Islam in an extended way) developed and has understood itself (a fact which can be stated both from an emic and etic perspective) adopting this concept is clearly to cross a threshold. In this sense it is quite clearly **transformative**. It is **integrative** in that it can help pull other academic disciplines (such as social anthropology, literary studies, psychology, philosophy etc.) into creative and mutually supportive relationship with the text. However, it is also **'disintegrative'** to someone whose world view is that the Biblical texts are radically different from other literary texts. Once the concept is adopted/crossed the effects are, rationally, probably **irreversible** though emotionally they may not be. I ought to add, importantly I think, that rhetorically it is temporarily reversible. It is **bounding**, in that it creates a clearer idea of what the text actually is and to what it refers but it also breaks down many boundaries that formerly existed between disciplines. For many obvious reasons this is deeply **problematic** for those holding 'traditional' religious viewpoints.

Implications

If it this concept is genuinely held as being truer (i.e. being the most rounded and complete way of approaching the complexities of text that we presently have) than other ways of understanding the text then the most profound implication of adopting/crossing this threshold is that, necessarily, other ways of understanding the text become insufficient and incomplete.

Adopting/crossing such a threshold concept can bring a person into some challenging relationships with people/communities that simply refuse to accept this concept as even vaguely legitimate.

There can be real personal costs in crossing this threshold. For example, for some students it can be a chief reason for deciding to leave a faith community that, in many ways and until this 'crossing', might have been very supportive of and valuable to them.

"Transforming Perspectives: Technology to Support Teaching and Learning of Threshold Concepts" is an ESRC/EPSRC Technology Enhanced Learning Project and is part of the Teaching and Learning Research Programme.

It is directed from the Centre for Applied Research into Educational Technologies by Dr. Patrick Carmichael.

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Figure 2: The Biblical Texts as Literary Texts - A Threshold Concept in Theology

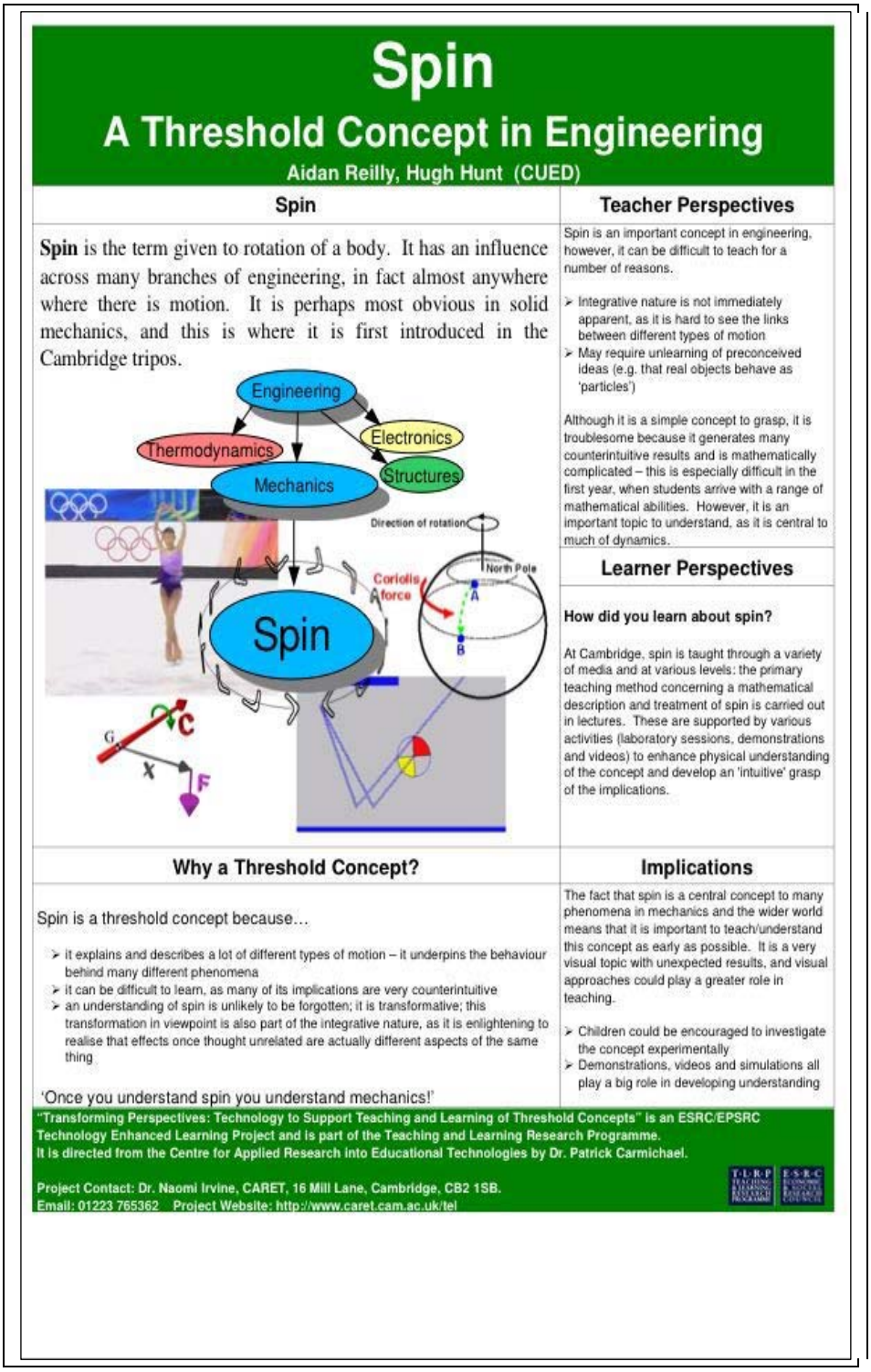

Figure 3: Spin - A Threshold Concept in Engineering

Annex 3: Literature Review

The project compiled a literature review of articles, conference papers, reports and other resources relevant to the study of threshold concepts. Our thinking about the literature review involved exploring a wider context in which to situate Threshold Concepts, in terms of their specific curricular context, differing disciplinary perspectives, the pedagogical context they occupy and the interpretive framework or lens through which they are studied, communicated and utilised.

We were also interested in the practical applications of the wider viewpoint the initial search has given us; especially how to define, identify and discuss threshold concepts and ultimately how to specify, construct or use technology to support or enhance the teaching and learning threshold concepts in different disciplines.

Specifically, this review was intended to:

- situate threshold concepts within a broader conceptual framework
- extend the discussion surrounding threshold concepts beyond the process of identification, and into their implications for pedagogical practice, teacher and learner identity and assessment
- investigate how threshold concepts arise within a discipline or community, how they are made manifest and how they are then communicated and used within different contexts

This literature review was also intended to support an interdisciplinary network of co-researchers in higher education. As a response to this evolving research agenda, the review became a resource intended to:

- support the establishment of an interdisciplinary network drawn from a number of disciplines to explore threshold concepts
- document the changing perceptions of threshold concepts arrived at by early reviews of the literature and the research activities of participants engaged through the seminar series
- explore and demonstrate this changed perspective by collating the literature and presenting it in a framework that is easily accessible (both practically and conceptually) to this wider research community.

The review was compiled using a novel set of technologies – the Connotea online bibliographical management system (http://www.connotea.org) and a series of custom Perl scripts producing a searchable interface to review contents from within the project virtual research environment (see Annex 4).

The literature review, which includes an account of the review process, an overview of the technologies used, and commentaries on main themes to emerge, is included as a nominated output with this report.

Annex 4: Virtual Collaboration Environment

The project has established an online collaboration environment hosted within the Cambridge University 'Camtools' Virtual Learning and Research Environment. This uses Sakai, an open-source modular environment that allows the aggregation of tools and services appropriate to the purposes of projects, groups and courses. These are arranged into 'worksites' with configurable patterns of access and authorisation (Figure 4).

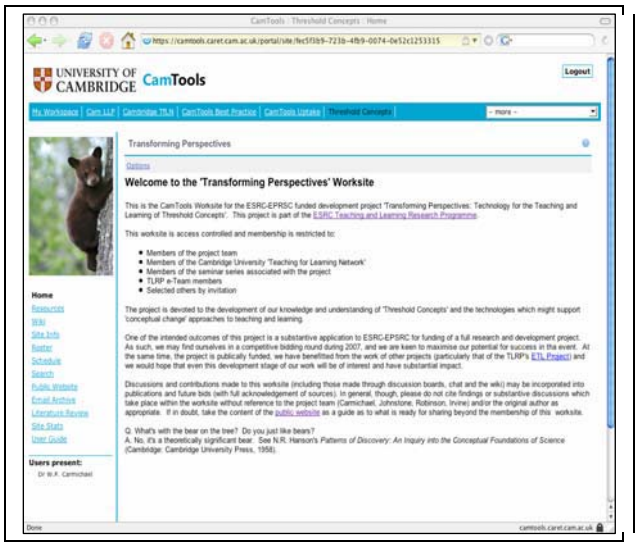

Figure 4: Front Page of Project Worksite with Multiple Tools

The project worksite includes a wiki, which was used for planning, documenting project activities (Figure 5):

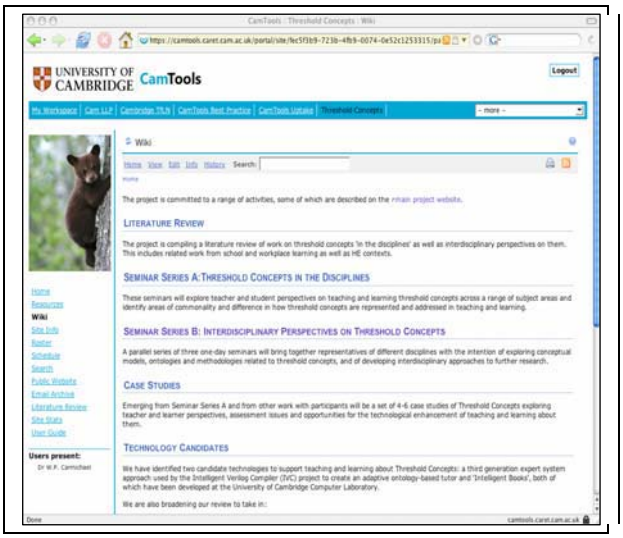

Figure 5: The Project Wiki

Project resources, research support materials for participants and outputs (including presentations from each of the seminars) are contained in a resources area (Figure 6).

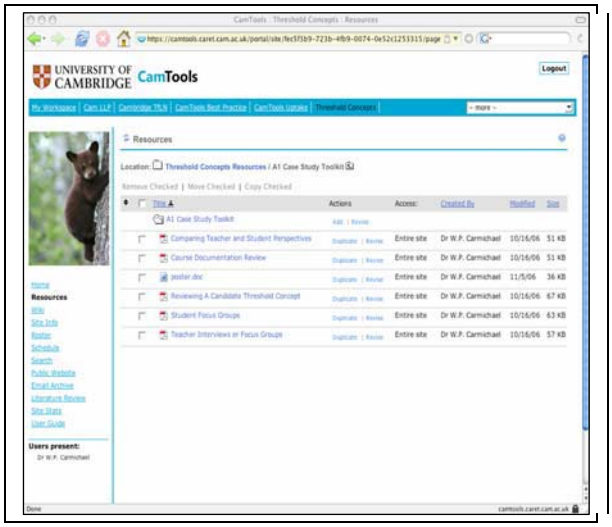

Figure 6: The Project Resources Area showing one subfolder

The project literature review, as well as being visible in Connotea, is also exposed as a tool within the worksite. The interface allows display of all publications (sorted by author and date); listing of all keywords used to describe the contents; and a search-by-keyword facility (Figure 7).

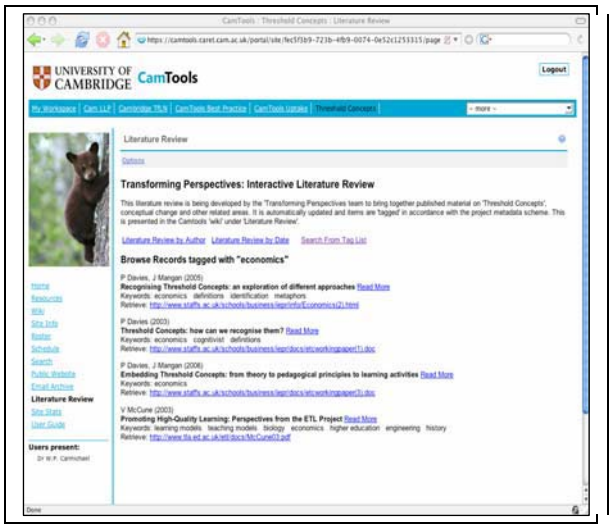

Figure 7: The Project Interactive Literature Review showing the results of a search

Other tools in use include a schedule with project activities; a roster tool listing members; an email archive for project communication and site administration tools. The user community grew to 35 members over the course of the project, with the highest level of use from project members themselves (who used it to support planning, collaborative writing and communication) and participants in case study activities.

Annex 5: Adaptive Tutor Development and Evaluation

A range of interfaces to an underlying ontology were developed, each having the capability to display sections of the ontology as a direct graph. The ontology was built up in Prolog, based on existing concept maps and other literature, and was designed to cover one of the areas of Plant Sciences identified within the project case studies as being troublesome and complex, and involving several potential threshold concepts.

An important issue was the time overhead in converting the loosely-defined associations characteristic of concept maps into the tightly-defined relationships in a technical ontology, particularly when this was required not only to convey structural information (as in the published ontologies of the Plant Ontology Consortium: http://www.plantontology.org/), but also functions (such as regulation or catalysis), sequences of events, causal relations and correlations.

The three interfaces developed were:

- Test your knowledge: an interface to elicit and assess propositions about the relationships between ontology elements
- Chatbot: an interface allowing users to 'question' an expert 'chatbot'
- Draw your own: an interface allowing users to link ontology elements into their own 'maps'

Figure 8 shows the 'Chatbot' interface and Figure 9 the 'Draw your Own' interface midway through a session, after the student has begun to construct a map.

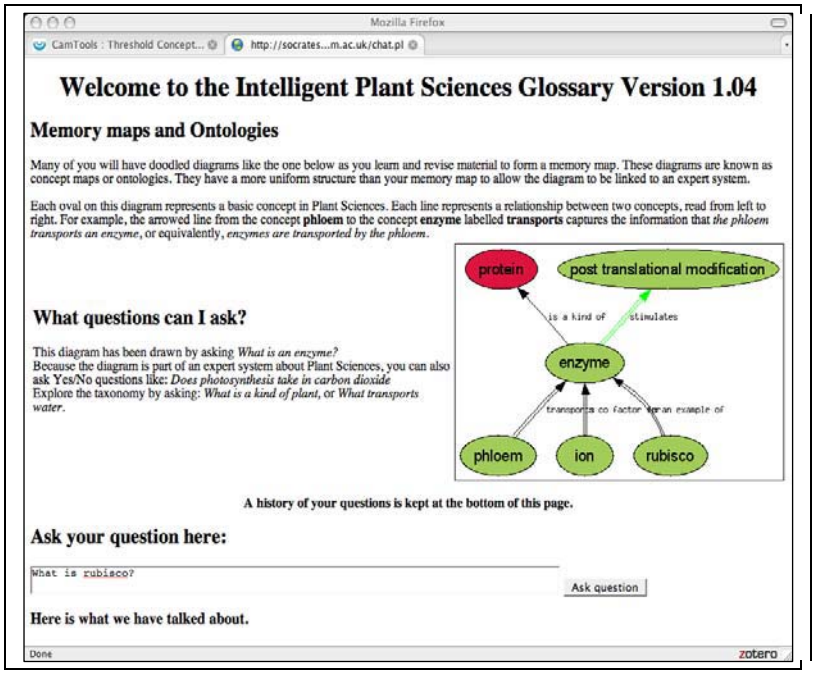

Figure 8: The Adaptive Tutor: Chatbot Interface

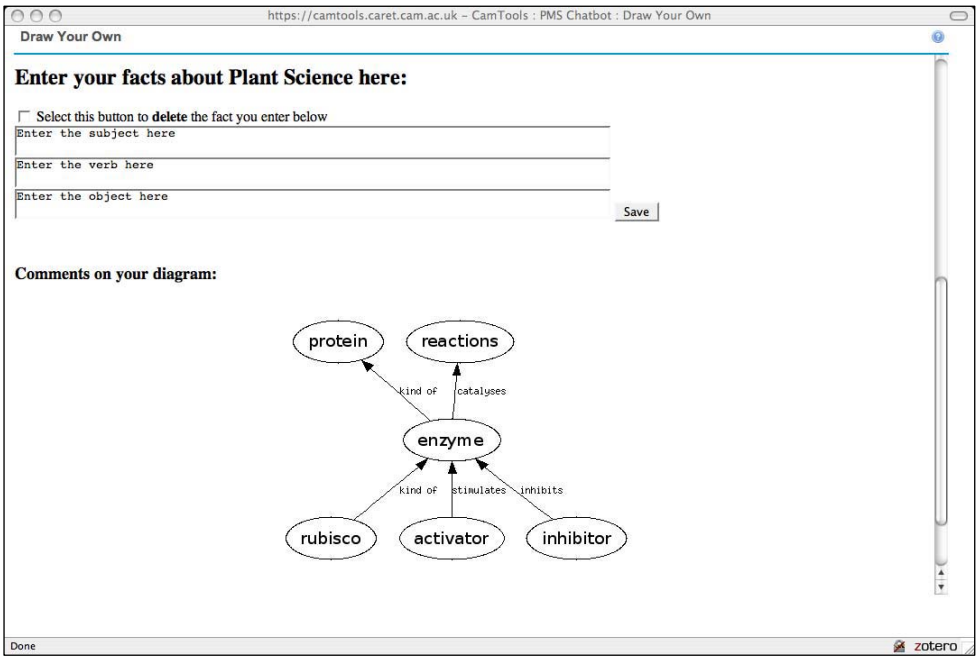

Figure 9: The Adaptive Tutor: 'Draw Your Own' Interface

Student evaluation of the interfaces, carried out with a group of first-year undergraduates who had followed natural science courses including 'Biology of Cells' revealed a number of key findings:

- The 'Test Your Knowledge' tool was least popular, with the 'Chatbot' most popular.
- Students wanted to use existing models as well as having the capability to add their own information, leading to enthusiasm for the idea of syllabus-based interfaces with additional 'draw your own' features
- While 'visualisation' was seen as important (all students rating this important or very important), it was felt that images alone were generally insufficient to answer the questions; instead, a mixed-mode representation involving concept map, images and text was preferred.
- For a majority of students, the conceptual level of interaction changed over time, initial questions of definition (which may have played a 'scoping' role as they tested the boundaries of the knowledge base) being replaced with more exploratory questions and those designed to check links between concepts.

A more complete exploration of the relationship between ontology-based systems and conceptual change (including threshold concepts and troublesome knowledge) is contained in a paper about the project: Taylor, K., Carmichael, P and Irvine, N. (2006) 'Developing an Adaptive Tutoring Environment to Support the Teaching and Learning of Threshold Concepts' Paper presented at the BCS Special-interest Group on Artifical Intelligence Workshop: AI and Education, December 2006, Peterhouse, Cambridge.

Annex 6: Summary – Semantic Web Technologies for Case-Based Learning

This is the summary of the outline proposal (Ref: ES/F030630/1) submitted by the project team and other institutions to the second round of ESRC/EPSRC TEL Programme.

This project aims to research multimedia case construction in order to support the production of relevant and adaptable case studies for learning in professional development and higher education settings. This will be achieved by drawing on semantic web and social software technologies to develop flexible tools and associated pedagogies in which substantive knowledge is developed, represented, adapted and then transferred within and between diverse learning environments. The project responds to some critical issues in contemporary curriculum design and the pressing need to develop pedagogical practices that work with the ongoing changes in knowledge, education, work and professional learning.

Case-based learning is already used in learning contexts dealing with complex problem-based scenarios. However case studies are often rooted in the past and can lose their contemporary relevance. At the same time while there is some imaginative use of social software in educational settings, there has been minimal research on its potential use within case construction and case usage in teaching and learning settings. Furthermore while semantic web technologies are revolutionising the curation of large data sets, productive use is limited by their lack of flexibility, ease of access and user control.

The project will engage with groups of teachers and learners in two contrasting higher education settings (City University and the University of Cambridge) and across a range of disciplines (at least three in each setting) in which case based learning is an integral part of teaching and learning. The research will focus on the conceptualisation, construction and application of cases and the role of case-building as an individual and group activity. In particular research questions will include:

- how can case study construction be designed for sustainable yet flexible use and reuse?
- what are the pedagogical affordances of bringing together social software and semantic web technology?
- what new tools are needed to allow users (learners, teachers, researchers) to access, adapt and manage case based learning?
- what are the theoretical framings for researching technology enhanced learning when knowledge, technologies and pedagogies are in a state of flux?

In combining key elements of digital repository, social software, semantic web technology and case based learning, we propose to generate a momentum of reuse by reconfiguration, continual adaptation, and collective action. This will be further enabled by the use of grid technologies across disciplines, institutions and educational contexts. Cumulation and long term curation of rich case records will build a collection to support longitudinal and secondary analyses of rapidly changing educational landscapes.

To achieve this the project brings together a team of researchers from computer and information science and social science. It builds on the interdisciplinary work of existing TLRP projects. It will generate research outcomes of significance to a wide range of academic, practitioner, organisational and policy audiences.

The project will address complex learning outcomes where learners need to solve messy problems in unpredictable environments. This will be facilitated by the evolutionary construction of rich case records and learning activities requiring systematic analysis and creativity, sound judgement, and initiative. More broadly, the project aligns with programme priorities (flexibility, personalisation, productivity) as well as addressing current priorities for e-Learning and e-Science. As a result, the project itself will act as a case study and a point of focus for inter-professional and interdisciplinary discourses between social scientists and technologists and more broadly across the technology-enhanced learning domain.