

Learning Portals: Analyzing Threshold Concept Theory for LIS Education

Virginia M. Tucker

School of Library & Information Science, San José State University One Washington Square, San Jose CA 95192-0029 Email: virginia.tucker@sjsu.edu

Judith Weedman

School of Library & Information Science, San José State University One Washington Square, San Jose CA 95192-0029. Email: judy.weedman@sjsu.edu

Christine S. Bruce

Queensland University of Technology, 3 Gona Parade, Kelvin Grove, Brisbane, Australia 4059, Email: c.bruce@qut.edu.au

Sylvia L. Edwards

Queensland University of Technology, 3 Gona Parade, Kelvin Grove, Brisbane, Australia 4059, Email: s.edwards@qut.edu.au

This paper explores the theoretical framework of threshold concepts and its potential for LIS education. Threshold concepts are key ideas, often troublesome and counter-intuitive, that are critical to profound understanding of a domain. Once understood, they allow mastery of significant aspects of the domain, opening up new, previously inaccessible ways of thinking. The paper is developed in three parts. First, threshold concept theory is introduced and studies of its use in higher education are described, including emergent work related to LIS. Second, results of a recent study on learning experiences integral to learning to search are presented along with their implications for search expertise and search education, forming a case illustration of what threshold concept theory may contribute to this and other areas of LIS education. Third, the potential of threshold concept theory for LIS education is discussed. The paper concludes that threshold concept theory has much to offer LIS education, particularly for researching critical concepts and competencies, and considerations for a research agenda are put forth.

Keywords: grounded theory, LIS education, online searching, search education, search expertise, threshold concept theory

Introduction

Threshold concept theory is a relatively new framework (Meyer & Land, 2003) that deepens our understanding of critical learning experiences. The theory provides a framework of characteristics for identifying crucial conceptual knowledge that represents learning portals within a subject area or discipline. These learning portals are considered to be threshold concepts as their mastery in-

volves learning to see some aspect of the world in a totally new, transformative, and often counter-intuitive manner. Following such transformed understanding, continued and profound learning associated with the concept becomes possible. This article argues that much may be gained by viewing core curricula, learning objectives and LIS competencies through such a theoretical lens.

As LIS educators, we are often confronted with the question of what is required to

make learning possible, a question given center stage by Marton and Booth (1997), who framed it broadly and epistemologically: “How do we gain knowledge about the world?” (p.1). They described epistemology itself as presenting an inherent paradox between the knowledge gained and the “truth value of the knowledge gained,” explaining that “education has norms—norms of what those undergoing education should be learning” (p. 2). Threshold concept theory represents an approach to identifying necessary learning outcomes, the concepts critical to deep understanding—a high truth value of knowledge—for a domain or discipline. Other early research includes the work of Donald Schön (1983; 1987) who wrote about deep disciplinary understandings when describing a stark contrast between knowledge acquisition and learning at a level he called ‘professional artistry’. Schön stated that

Artistry is an exercise of intelligence, a kind of knowing, though different in crucial respects from our standard model of professional knowledge. It is not inherently mysterious; it is rigorous in its own terms; and we can learn a great deal about it—within what limits, we should treat as an open question by carefully studying the performance of unusually competent performers. (1987, p. 13)

As educators, our responses to questions about what makes learning possible are shaped by the learning theories we adopt. Cognitivists may establish the kinds of mental models they would like learners to adopt; behaviorists may identify the knowledge, skills and attitudes necessary to curricula; constructivists may frame the learning experiences desirable to foster particular outcomes (Bruner, 1960). Adopters of the variation theory of learning (Marton & Booth, 1997) would respond in terms of seeking to understand learners’ different ways of seeing key constructs and bringing about awareness of these ways of seeing. For example, Ed-

wards (2006) adopted the variation theory of learning (in practice) in her research that resulted in the Net Lenses model for describing variation in the ways university students experience web-based searching. Theoretical models such as these have formed an important part of the repertoire of tools available to LIS educators. Threshold concept theory gives us a new lens through which to consider fundamental aspects of our discipline, as well as education for that discipline and its associated professions. The transformative properties of threshold concepts resonate with Marton and Booth’s characterization of the learning experience as seeking meaning and involving “changing as a person” (1997, p. 38) and with Schön’s depiction of professional artistry (1987).

The theory of threshold concepts is introduced next and studies relevant to how it is being used in higher education are described. Following this, new research, into learning experiences integral to learning-to-search, forms a case illustration of what threshold concept theory may contribute to LIS education. The learning-to-search research is presented, followed by its implications for search expertise and search education specifically. With this as a basis, the potential of threshold concept theory for LIS education more broadly is presented and discussed.

Learning Portals: What is Threshold Concept Theory?

Threshold concept theory deepens our understanding of critical learning experiences. These critical learning experiences are those involving threshold concepts. Their mastery involves learning to see some aspect of the world in an entirely new, transformative, and often counter-intuitive, manner, thus serving as portals into the knowledge of the discipline. After acquiring such transformed understanding, continued professional learning associated with the concept becomes possible—in fact, it is not possible without it: a thresh-

old concept “represents a transformed way of understanding, or interpreting, or viewing something *without which the learner cannot progress* [emphasis added]” (Meyer, Land, & Smith, 2008, p. x).

Meyer and Land draw on studies of cultural rites of passage by Victor Turner, and use his insights as a way of understanding threshold concepts, in that they constitute disciplinary or learning rites of passage. Turner used the word “liminality” to describe the state between the pre-ritual status and the status held when the ritual is complete. He referred to people in the liminal state as *threshold people*, “slip[ping] through the network of classifications that normally locate states and positions in cultural space” (Turner, 1969, p. 95). This article argues that much may be gained by viewing core curricula, learning objectives, and LIS competencies through this theoretical lens.

Threshold concept theory grew out of a study by Erik Meyer and Ray Land that explored learning environments for undergraduate courses in economics (Cousin, 2006). They found that “certain concepts were held by economists to be central to the mastery of their subject” (p. 4). Meyer and Land asserted that these concepts were “threshold” that “once understood . . . occasion a significant shift in the perception of a subject, or part thereof” (2003, p. 5); they may be “akin to a portal” or conceptual gateway that provides access to “previously inaccessible way of thinking about something” (p. 1). Meyer and Land’s view of a transformative learning experience supports Marton and Booth’s description of learning, discussed earlier, of “seeing something a different way” (1997, p. 38).

Dimensions of a Learning Portal

A portal by its nature opens up new territory once it has been traversed. A learning portal defined by threshold concepts “represent[s] a transformed way of understanding, or interpreting, or viewing some-

thing and opens up previously inaccessible ways of thinking” (Meyer & Land, 2003, p. 1). Because these new ways of thinking cannot be accessed until the student has moved through the portal, the threshold concept is an obstacle for the learner who is unable to pass through it. This dual role is inherent in learning portals and creates instability. The liminal learning space occupied by a student in the process of traversing a learning portal has been compared to adolescence:

an unstable space in which the learner may oscillate between old and emergent understandings just as adolescents often move between adult-like and child-like responses to their transitional status. But once a learner enters this liminal space, she is engaged with the project of mastery unlike the learner who remains in a state of pre-liminality in which understandings are at best vague. (Cousin, 2006, p. 4)

A liminal learning experience is thus transformative: the student undergoes profound identity shift, change in use of discourse, and ambiguity about and in recalling the experience itself. The latter introduces particular challenges to researchers in identifying threshold concepts.

Transformation is at the core of a threshold learning experience and coupled with this is a significant ontological shift stemming from the experience of traversing threshold concept territory. Cousin asserted that “mastery of a threshold concept is likely to involve both cognitive and identity shifts in the learner” (2008a, p. 201). Land referred to a shift in the learner that entailed “a repositioning of self in relation to the subject” (Land, Cousin, Meyer & Davies, 2006, p. 200). The element of ontological repositioning is essential to the transformative characteristic: “Grasping a threshold concept always involves an ontological as well as a conceptual shift. Reduced to its essential, this simply means that we are what we know” (Cousin, 2008a, p. 202). Cousin continued with the following illustration:

If I learn French, this does not simply involve an acquired skill set. My new knowledge becomes assimilated into my biography and thus my sense of self. I become a French speaker—and probably a Francophile. In the first stages of struggling with French, I do not self-identify as a French speaker but, later, once certain understandings have ‘clicked’ I start to think of myself as a French speaker rather than a learner of French. This is an important identity shift. The grasp of any subject, argue Meyer and Land, is likely to involve turning points that both deepen our understanding and bond us more closely to the subject. (2008a, p. 202)

Ontological shifts accompany conceptual shifts that are significant enough to be considered threshold learning experiences.

Shift in a learner’s discourse may be another element of the threshold learning experience. Research is beginning to suggest that a student’s use of the language of a discipline is enhanced when a shift in understanding and perspective occurs. Flanagan and Smith (2008) report on this discursive aspect of threshold concepts in their research with engineering and science students. Their work supports Meyer and Land’s proposition:

It is hard to imagine any shift in perspective that is not simultaneously accompanied by (or occasioned through) an extension of the student’s use of language. Through this elaboration of discourse new thinking is brought into being, expressed, reflected upon and communicated. (2005, p. 374)

In addition to the portal-or-barrier and ontological shift elements, a liminal learning experience is characterized by ambiguity: people who have traveled across a threshold may not be able to describe the experience clearly. The ambiguity that accompanies a threshold experience was recognized by Turner, mentioned earlier, who described the liminality present during cultural rites of passage and whose

research is foundational to the threshold concept theory propounded by Meyer and Land. “The attributes of liminality or of liminal personae (‘threshold people’) are necessarily ambiguous, since this condition and these persons elude or slip through the network of classifications that normally locate states and positions in cultural space” (Turner, 1969, p. 95). Indeed, identifying a threshold concept is problematic due to the very ambiguity of the liminal state. “Because of the transformative nature of threshold concepts, we may feel that we’ve always known something or looked at the world in that way. It is very difficult to remember what it looks like from the other side of the threshold” (Townsend & Brunetti, 2009, p. 6). Cousin notes that educators deal with a particular challenge in this regard because “one of the difficulties teachers have is that of retracing the journey back to their own days of ‘innocence’, when understandings of threshold concepts escaped them in the early stages of their own learning” (2006, p. 1). Knowing this, researchers must look to the learners as well as to the educators when investigating threshold concepts.

Characteristics of Threshold Concepts

Threshold concepts are considered to have five defining characteristics; they are transformative, irreversible, integrative, troublesome and bounded. Each of these characteristics is described further below:

- *Transformative: causing a shift in perception and identity.*

The concept, once understood, causes a significant change in the person’s understanding, simultaneously with a shift in identity. This could include a shift in values or attitudes, such as a fundamental change in world political view, or it could take the form of the acquisition of confidence, e.g. aquatic confidence radically changes a person’s appreciation of water sports and boating (Meyer

& Land, 2006). “New understandings are assimilated into our biography, becoming part of who we are, how we see, and how we feel” (Cousin, 2010, p. 2).

- *Irreversible: unlikely to be forgotten or unlearned.*

The concept or changed perspective is not likely to be forgotten or unlearned. This is a bit like the adage “It’s like riding a bike”—once learned, the lesson is irreversible. Meyer and Land liken the experience to a postlapsarian state, stating that the “change of perspective occasioned by acquisition of a threshold concept is unlikely to be forgotten” (2003, p. 5). They cite the irreversibility characteristic in how the study participants “pointed to the difficulty experienced looking back across thresholds . . . and attempting to understand (from their own transformed perspective) the difficulties faced from (untransformed) student perspectives” (p. 5).

- *Integrative: exposing something previously hidden or where the connectedness was not understood.*

Integration involves the accommodation of new information or understanding; it can also mean that the newly understood concepts become unified in the person’s understanding. The person is not grasping a set of separate tools, but working with them as integrated knowledge. The integrative characteristic is usually present “in varying degrees” (Land, Meyer, & Smith, 2008, p. x). For example, researchers exploring threshold concepts in electrical engineering put forth the idea of complex concepts in which key understandings—such as current, voltage, and impedance—are both interrelated and interdependent and “constitute a bridge to the learning of other concepts” (Bernhard, Carstensen, & Holmberg, 2011, p. 4).

- *Troublesome: initially counter-intuitive or uncomfortable.*

Threshold concepts are often troublesome, and students may have to wrestle with a concept in order to grasp it. This may be because the threshold concept itself is difficult or counterintuitive, or because it represents troublesome knowledge, or because it leads to troublesome knowledge when it is applied (Meyer & Land, 2006). A learner’s wrestling may be due to preconceptions and, indeed, a student may “problematiz[e] their mastery [of threshold concepts], exposing earlier preconceptions (troublesome knowledge) of the subject which were getting in the way of mastery” (Cousin, 2010, p. 4). Threshold knowledge is troublesome because it entails letting go of a prevailing understanding or even a prior ontological stance, a form of prior subjectivity. Other researchers in learning theory have focused on the troublesome nature of essential knowledge as being critical to transformative learning experiences (Mezirow, 2003).

- *Bounded: having “terminal frontiers” that border other thresholds into new conceptual areas.*

The “bounded” characteristic is considered to be present less often than the other four characteristics of threshold concepts (Meyer & Land, 2003, p. 6). When it is present, it serves to define the border between conceptual areas that serve specific purposes and can also “indicate the limits of a conceptual area or the discipline itself” (Boustedt *et al.*, 2007, p. 504). Boundedness may be distinguished by the use of “specialized terminology that acquires a meaning in one subject that clashes with everyday usage” (Flanagan & Smith, 2008, p. 101).

Methodological Issues

Methodologies for identifying threshold concepts are still being actively explored. “To move forward in our understanding of the acquisition of threshold concepts, from

both teachers' and students' perspectives, we need to devise methods of observation and enquiry that allow us to explore variation in students' experiences of threshold concepts in rather special ways" (Meyer & Land, 2005, p. 384). Since this statement, considerable research has been done on evidential criteria as well as methodologies to enlist in investigating and recognizing threshold concepts. Yet it remains true that "the question of how we go about identifying threshold concepts is an interesting one, and one which we expect to trigger some lively future debates" (Stokes, King & Libarkin, 2007, p. 437).

Cousin reported on ways to recognize threshold concepts, explicating the five characteristics, but taking particular care to be cautious about the troublesome characteristic:

I have explored some of the emotional issues that make learning troublesome, since it is important to temper the implicit suggestion in the idea of a threshold concept that the difficulty of its mastery inheres in the concept itself. While this is very often the case, we need to be aware that this difficulty cannot be abstracted from the learner or the social context. (2006, p. 4).

In looking at ways to recognize threshold concepts, she focused on emotional issues that make learning troublesome and emphasized that "this idea of liminal states provides a useful metaphor to aid our understanding of the conceptual transformations students undergo, and the difficulties or anxieties that attend these transformations" (p. 4). Evidence of anxiety, therefore, provides a criterion to use in confirming that a troublesome threshold in learning is being or has been crossed; however, the learner's context must be taken into account as well.

A learner's ability to reconfigure existing conceptual schema or mental models has been proposed as another indicator of grasping a threshold concept. This includes being able to unlearn mental models that no longer hold true or cannot ac-

commodate new knowledge. Jan Smith has described this ability as a reconstitutive feature of threshold concepts, observing that "reconstitution is, perhaps, more likely to be recognized by others, and also to take place over time" (Smith, 2006, p. 1).

Other researchers have studied the academic context of the learning experience as a factor in exploring threshold concepts and evidence thereof. Cousin emphasized that, particularly in the social sciences and humanities, the aspect of epistemological perspectives should be fully acknowledged (2008b). "For instance, a Keynesian economist and a Marxist one may propose different threshold concepts for the economics they respectively teach because they have quite different views about what is central to their subject" (p. 263).

These identifying elements—emotional factors, such as anxiety, reconstitutive abilities, and contextualization—provide useful criteria and baselines for recognizing threshold concepts.

Research on Threshold Concepts in Higher Education

The theoretical framework of threshold concepts has been influencing higher education studies since it emerged a decade ago. Research using threshold concept theory extends across a range of subject areas and academic disciplines. As evidenced by presentations at the most recent international conference dedicated to threshold concept studies, current research fronts are focused on professional development, methods for engaging students, and interdisciplinary concepts (Higgs, 2012).

In one multi-disciplinary study that explored threshold concepts in doctoral-level research education, the researchers were particularly interested in the transformative character of threshold concepts, stating that without a "new way of seeing, the learner cannot progress at the level required for more advanced study or research" (Kiley & Wisker, 2009, p. 432).

They suggested several potential benefits to understanding threshold concepts in research education:

In addition to being able to better assist students during their period of being ‘stuck’ in the liminal state...it is likely that the learning experiences for the student and the supervisor will be considerably enhanced. Furthermore, if students acquire a more sophisticated understanding of research and the research process, they are likely to be more insightful and skilled researchers. (p. 433)

The researchers interviewed were experienced supervisors of doctoral students in several disciplines, including engineering, information technology, humanities, science, health science, and social sciences, and focused on the transformative characteristic of threshold concepts. Their research is also representative of studies that examine only a few—and sometimes only one—of the characteristics of threshold concepts.

In a similar way, Blackmore’s research into information literacy (2010) focused on the troublesome aspect of threshold concepts, identifying the perception of patterns (such as in database structures) as a threshold concept (p. 6). Hofer, Townsend, and Brunetti (2012) also explored threshold concepts in information literacy, likewise focusing on troublesome characteristics. Using findings from a survey of information literacy librarians, they proposed seven threshold concepts, including metadata as equal to findability and information as commodity.

Further examples of threshold concepts in higher education abound as they have been studied in a wide variety of disciplines and professions, including economics (the earliest study by Meyer and Land, 2003), engineering, grammar, mathematics, product design, and biology. Table 1 lists threshold concepts that have been suggested for a range of academic disciplines and subjects. The first seven entries in the table were extracted from Stokes *et*

Table 1. Threshold Concepts in Academic Disciplines
(Stokes et al., 2007; Tucker, 2012).

Discipline/Subject	Suggested Threshold Concept(s)	Reference
Economics	Opportunity cost; elasticity	Reimann & Jackson (2006)
Pure mathematics	Complex numbers; limits	Meyer & Land (2003)
Electrical engineering	Frequency response	Carstensen et al. (2006)
Statistics	Sampling distribution	Kennedy (1998)
Health care	Care; pain	Clouder (2005)
Law	Precedence	Land (2005)
Biology	Process, e.g., energy transfer	Taylor (2006)
Biology	Evolution	Taylor & Cope (2007)
Information systems	Information systems as social systems	Cope & Staehr (2008)
Computer science	Object-oriented programming	Zander et al. (2008)
Economics	Efficiency; market equilibrium	Dulleck & Tang (2009a;2009b)
Physics	Energy quantization; atomic structure	Park & Light (2009)
Doctoral research	Argument; theorizing; knowledge creation; analyzing & interpreting	Kiley & Wisker (2009)
Calculus	Limit; integral	Sheja & Pettersson (2010)
Information literacy	Systemic thinking, pattern perception	Blackmore (2010)
University teaching	Structural transformation (knowledge structures)	Kinchin & Miller (2012)

al., (2007); the other entries were derived from the wider literature.

In the following section, a case illustration of threshold concept theory in LIS is discussed, presenting recent research into the experiences of learning to search and acquiring search expertise.

Research on Learning to Search: An Illustration of Threshold Concept Theory in LIS

Research on threshold concepts in search expertise was recently completed, exploring this theoretical framework for broadening understanding of critical learning portals in LIS. The study is used here to demonstrate how threshold concepts can be identified, and how these may then inform curriculum development and re-design; this illustration is then used to suggest a research agenda for threshold concept theory within LIS education.

Online searching forms a fertile area for exploration of threshold concepts in LIS education because of its strong base of theory, data and application built over 30 years of research. Research literature extends back to the command-based interfaces of the 1970s that assumed a professional search intermediary and have continued through to web-based search engines designed for the greenest novice. The curriculum for online searching today is in a stage of flux as both search technologies and learning environments continue to change. Online searching was thus an ideal area in which to study the existence of threshold concepts, add to our understanding of how they contribute to expertise, and explore implications for enhancing the development of professional-level searching abilities in MLIS students.

LIS graduate education programs have included coursework in searching skills and concepts for at least three decades. The objective of these programs is to teach what is necessary to the professional searcher—the type of searcher who typically performs searches on behalf of oth-

ers and uses highly advanced techniques, strategies, commands and knowledge of database content critical to sophisticated research, often on scientific, legal and business topics. Careers for the MLIS graduate, whether in libraries, research, digital media, web development, archives, or other information science pursuits, demand searching skills far exceeding that of “good enough Googling” (Plosker, 2004, p. 34). The study set out to address our understanding of concepts involved in acquiring search expertise in today’s information environment, concepts that transcend the particulars of an individual search engine and are critical to transforming how search is conducted.

Aims and Methods

The research objective of the study was to improve our understanding of how search expertise is acquired and how novice searchers, intent on becoming experts, can learn to search in more expertlike ways. The research added to the body of literature on searcher characteristics and was unique in that it focused on the learning experiences that lead to expertise. Information professionals—and those who instruct them—can benefit from a greater understanding of search expertise that builds on an integration of library and information professional search skills literature, Web-based search behavior research and literature in relevant areas of novice-expert studies and learning theory. With dramatic shifts in learning environments, particularly the growth of distance education, new lenses for understanding how core concepts are learned may help reveal important factors for developing programmatic materials.

The participant sample drew from two population groups: (1) highly experienced searchers with a minimum of 20 years of relevant professional experience, including LIS faculty who teach advanced search, information brokers, and search engine developers (11 subjects); and

(2) MLIS students who had completed coursework in information retrieval and online searching and demonstrated exceptional ability (9 subjects). Using these two groups allowed a nuanced understanding of the experience of learning to search in expertlike ways, with data from those who search at a very high level as well as from those who may be actively developing expertise. The study used semi-structured interviews, search tasks with think-aloud narratives and talk-after protocols. Searches were screen-captured with simultaneous audio-recording of the think-aloud narrative. Grounded theory was used, allowing categories and themes to emerge from the data. In accord with grounded theory method, once theoretical saturation was achieved, during the final stage of analysis the data were viewed through lenses of existing theoretical frameworks. Data were coded and analyzed using NVivo9 and manually.

Findings

After this analysis was completed, the coded data were re-examined to discover themes that represented the “meaningful essence that [ran] through the data” (Morse, 2008, p. 927). During this stage, the researcher looked for themes according to the characteristics of threshold concepts: transformative, irreversible, integrative, troublesome, and bounded. Themes that emerged provided evidence of four concepts which had the characteristics of threshold concepts. The first three were: (1) information environment: the total information environment is perceived and understood; (2) information structures: content, index structures and retrieval algorithms are understood; (3) information vocabularies: fluency in search behaviors related to language, including natural language and controlled vocabulary and finesse using proximity, truncation, and other language-based tools.

Information environment as a threshold concept for search expertise is a profound

understanding of the broad and complex information environment and the ability to apply this knowledge to effective and efficient searches. For example, the processes in the creation of a data source—such as the practices of a publisher, aggregator, content creator or tagger—are understood and accommodated in search decision-making. An expert searcher may also use outlier sources such as grey literature and alternative resources. Bates’s “berry picking” model (1989) provides a useful metaphor to explicate this threshold concept. An essential part of the nature of berry picking is that searchers adapt the strategy to their particular need at the moment. For the expert searcher, this would mean extending the model to explain that she understands how the berries came to grow on the bush, why they grew where they did, where there might be clusters of berries hidden away under foliage and even who planted the bush, tended it, amended the soil and how this impacted its growth and harvest. This knowledge of the information environment is *integrative* and *transformative* and affects the searcher’s activities before, during and after a search.

Information structures as a threshold concept means that database and document structures, for example, and how retrieval algorithms work, are understood and that the searcher integrates this understanding into producing superior results. Information structures are present at different levels: document structures may include the components within an individual page, record, or object within a database, such as fields, segments, subfields, metadata, XML markup or other tagging; there might also be weighting of sub-structures or value-added features applied by indexers or by automated processing. Grasping underlying structures of information content has a *transformative* effect on the searcher’s perspective and abilities.

Information vocabularies is a fluency in search activities related to language, including natural language and controlled vocabulary, as well as finesse us-

ing proximity operators, truncation, and other language-based tools requiring an understanding of word relationships and formats. The *information vocabularies* threshold concept was found to be *transformative* as well as *troublesome*. For example, learning to consider synonyms was counterintuitive for novice searchers.

The fourth threshold concept, *concept fusion*, is the integration of the other three threshold concepts and further defined by three properties: visioning (anticipating next moves), being light on one's 'search feet' (dancing property), and profound ontological shift (identity as searcher). This was described by study participants as being a "magical thing", "almost organic" or having "synergy".

In addition to the threshold concepts, there were themes from the findings that were not specific to threshold concepts, including praxes and traits of expert searchers. Praxes were centered on skills, tools,

and strategies customarily applied as part of the search process or search preparation; for example, collaboration, reference interview, analytical tactics, or considering costs. Traits of expert searchers were personal qualities, characteristics, and attitudes; most prominent were extreme perseverance, curiosity, being willing to adventure, enjoying the hunt, and knowing when to stop.

A model of search expertise was advanced (Figure 1), with the four threshold concepts at its core that also integrated the traits and praxes elicited from the study, attributes which are likewise long-recognized in LIS research as present in highly experienced searchers (Fidel, 1984; Bates, 1987, 1992).

Discussion: Potential for LIS Education

The search expertise study demon-

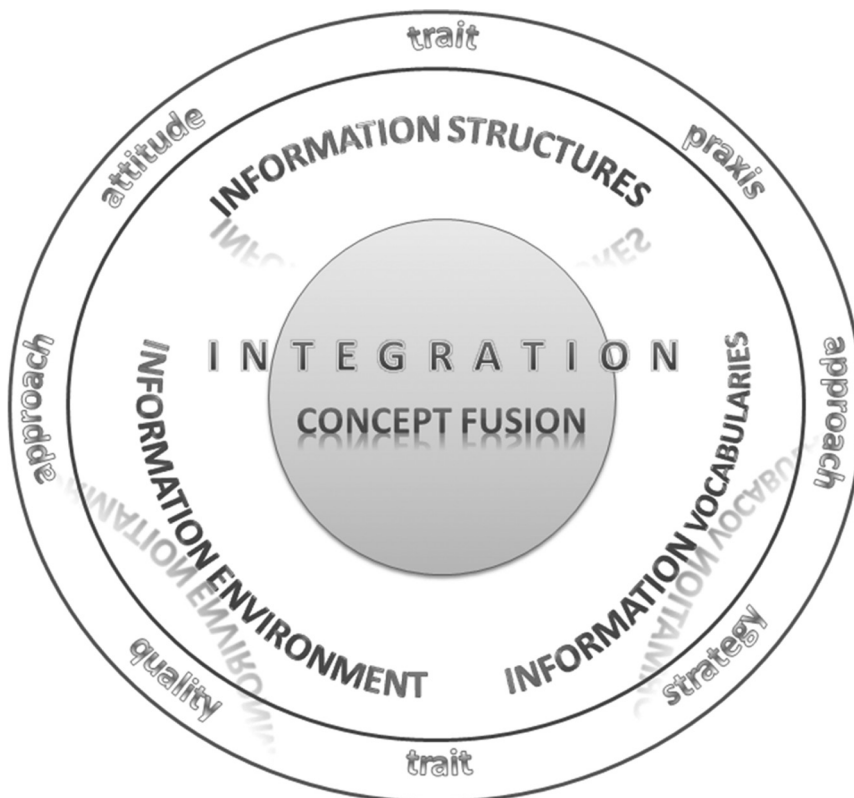


Figure 1. Tucker Model of Search Expertise (Tucker, 2012).

strates the rich potential for threshold concept theory for other areas within LIS education. Both the theoretical potential for research and the pedagogical potential are promising; the intersection of these areas represents the richest potential for researchers, educators, and practitioners. In this discussion, considerations emerge for a research agenda for threshold concept theory in LIS education, paralleling the broad interest in threshold concepts in other disciplines and areas in higher education noted by Perkins:

Discourse around threshold concepts has proven to offer something of a common language, provoke reflection on the structure of disciplinary knowledge, and inspire investigations of learners' typical hangups and ways to help (2010, p. xliii).

Theoretical Potential

Perkins described the utility of threshold concept theory for categorizing essential knowledge within a discipline and how this aids teachers in managing what is most essential. "Most fundamentally, concepts function as categorizers. They carve up the world we already see and often posit the unseen or even the unseeable" (2006, p. 41). He argued further that concepts can represent the episteme of the particular discipline, stating: "The disciplines are more than bundles of concepts. They have their own characteristic epistemes . . . a system of ideas or way of understanding that allows us to establish knowledge" (p. 41–42). It is as if threshold concepts represent a way to describe critical junctures in the learning experience, moving a person forward into new territory of understanding. This may be experienced as a leap, troublesome, an "ah-ha" moment in learning or it may be gradual—but it is nevertheless transformative and irreversible. Perkins summarized:

Teachers struggle to decide what will prove most meaningful and useful. Through their notion of threshold concepts,

Meyer and Land (2003) offer an insightful perspective and powerful heuristic technique for looking at this puzzle. Threshold concepts are pivotal, but challenging concepts in disciplinary understanding (2006, p.43).

Using threshold concept theory in the search expertise study made it possible to identify conceptual knowledge that represented learning portals. It also provided a way to sift through the data that created a depth of meaning and clarified potential implications for how we teach the topic of advanced search. Because one of the study's primary research objectives was to investigate ways to contribute to LIS education, these processes not only created new theory for search expertise, but also developed a solid theoretical foundation on which to base further studies of information use and search behaviors. As one example, the search expertise study elicited evidence of threshold concepts for the development of search expertise by exploring the learning experiences of highly proficient searchers; this suggests a study with searchers who are not highly experienced professionals or high-performing graduate students in LIS. What learning portals are there for a college student who is not intent on becoming a search professional, but who wants to reach a deeper understanding of the search environment and to achieve better search results? Would these same threshold concepts hold true? Would others?

Pedagogical Potential

Threshold concept theory has taken hold in higher education in large part for what it may bring to enhancing curriculum. It is a natural consequence of studying threshold concepts that researcher-educators look for ways to improve the learning of these concepts. Indeed, this is considered the aim of the research: "Broadly, the purpose of threshold concept research is to explore difficulties in the learning and teaching of

subjects to support the curriculum design process” (Cousin, 2008a, p. 201). In laying the groundwork for the theory, Meyer and Land referred to the troublesome “stuck places” or “conceptual difficulties” indicative of threshold concepts and simultaneously described both the possibility of transforming the learner’s perspective and the potential these concepts hold for educators:

The task for course developers and designers is to identify, through constructive feedback, the source of these epistemological obstacles, and subsequently free up the blocked spaces. This might be achieved, for example, by redesigning activities and sequences, through scaffolding, recursiveness, provision of support materials and technologies or new conceptual tools, through mentoring or peer collaboration (Meyer & Land, 2005, p. 377).

Selected examples where researcher-educators have implemented and tested new curricula based on threshold concepts are discussed next.

Land, Cousin, Meyer, and Davies addressed the implications of threshold concept theory for course design, articulating three broad considerations: “(a) sequence of content; (b) processes through which learners are made ready for, approach, recognize, and internalize threshold concepts; [and] (c) ways in which learners and teacher recognize when threshold concepts have been internalized” (Land *et al.*, 2006, p. 199). They described nine specific considerations for curricula in higher education, summarized in Table 2.

Curriculum changes based on threshold concepts in physics and law were studied by Akerlind and McMahon. The researchers had determined the threshold concepts in advance and studied both (1) the impact on the thinking and practice of the teachers; (2) the impact on students’ learning (Akerlind, McKenzie, & Lupton, 2011). They concluded that more than one iteration of curriculum design and implementation would be needed (Akerlind, 2012,

para. 4-5). Enlisting input from faculty and students when implementing curriculum changes based on threshold concepts is also considered essential (Cousin, 2008a).

A related learning construct, developed in parallel with threshold concept theory, has focused on “bottlenecks” of troublesome knowledge. This research emerged from the Decoding the Disciplines project at Indiana University (Pace & Middendorf, 2004; Glenn, 2009) where researchers had investigated disciplines as diverse as astronomy, biology and physiology. The researchers had interviewed faculty to elicit their perspectives on which concepts their students found most problematic. The concepts identified were used as “starting point[s] for studies that not only explored what must be explicitly taught to increase learning [in history courses] but also what the faculty perception of bottlenecks to learning tells us about the students themselves” (Díaz, Middendorf, Pace & Shopkow, 2008, p. 1212). The objective of the Decoding the Disciplines strategy is “the idea that [the students] are learning the modes of thought of a new discipline” (Burkholder, 2011, p. 110). While the similarities between the bottlenecks of the decoding-the-discipline model and the troublesome knowledge of threshold concepts are conspicuous, there are differences, too (Díaz & Pace, 2012). A key difference is that threshold concepts are characterized by more than their troublesome nature. Díaz and Pace view their model as having potential to contribute to threshold concept theory by providing a method for deconstructing disciplinary tacit knowledge (2012, p. 2).

Considering a Research Agenda

Considerations for a research agenda for threshold concept theory in LIS education may be bifurcated according to (1) specific characteristics, for example, through research that focuses on transformative or particularly troublesome knowledge, and (2) threshold concepts within broad areas

Table 1. Threshold Concepts: Considerations for Course Design in Higher Education (Land et al., 2006).

Consideration for Course Design	Key Points
"Jewels" in the curriculum	Threshold concepts can define powerful transformative points in the learning experience and may also serve a diagnostic purpose related to troublesome knowledge. (p. 198)
Importance of engagement	Courses need to have "active student engagement with, and manipulation of, the conceptual material"; instructors should "ask students to explain it, to represent it in new ways, to apply it in new situations, and to connect it to their lives." Course designers should consider "what provocation might we be seeking through these forms of engagement." (p. 199)
Listening for understanding	Teaching must be preceded by listening for understanding as instructors cannot "second guess where students are coming from or what their uncertainties are." (p. 199)
Reconstitution of self	Because grasping a threshold concept involves both a cognitive shift and a repositioning of self in relation to the subject, attention has to be paid to the "discomforts of troublesome knowledge." (p. 200)
Tolerating uncertainty	Metacognition and self-regulation are indispensable so that learners do not abandon their studies when encountering uncertainty and troublesomeness. (p. 201)
Recursiveness & excursiveness	Learners may need to "adopt a recursive approach to what has to be learned, attempting different 'takes' on the conceptual material until the necessary integration and connection...begins to take place." Similarly, learning "as a journey or excursion" in which there will be "deviation and unexpected outcome within the excursion" is to be expected. (p. 202)
Pre-liminal variation	Attention to the question of why some students "productively negotiate the liminal space of understanding...and others find difficulty doing so" has implications for course sequencing, structure, and forms of engagement. (p. 202-203)
Unintended consequences of 'good pedagogy'	Established forms of pedagogy may not be productive for the acquisition of threshold concepts. Example: simplified interpretation of the concept may operate as a "false proxy, leading students to settle for the naïve version and entering into a form of ritualized learning or mimicry." (p. 203-204)
The underlying game (or episteme)	Where there are authorized and alternative understandings of threshold concepts, "students may be required to play an important, more sophisticated epistemological game in order to recognize the difference." (p. 204)

of the discipline, such as ethical principles and intellectual freedom—do characteristics such as transformation and troublesomeness help for exploring the learning experiences involved? Do liminal experiences take place for the LIS learner that mark threshold knowledge for the profession? Are there implications to be drawn

from findings about a student's ability to reconstruct the components of these principles or aspects of ontological shift when LIS ethics are integrative and their connectedness is understood?

How can we use threshold concept theory to better understand learning experiences that lead to a grasp of emerging

trends? Is this a moving target or is there conceptual knowledge that provides abilities for receptiveness and lifelong learning for, and contributions to, new technologies and approaches to information paths? In addition, threshold concepts may exist at superordinate levels as was seen in the search expertise research—in that research, information vocabularies emerged as a higher level concept that included clusters of language-based concepts and tools relevant to searching, such as controlled vocabulary and word proximity connectors. As a case illustration, the study may suggest other areas to be explored within LIS as having the characteristics of threshold concepts: disciplinary level concepts (ethics, intellectual freedom) as well as subject level (collection management). Some of these align with core competencies for the MLIS graduates (ALA, 2009), for example, “concepts, issues, and methods related to the management of various collections” (p. 2).

Are there threshold concepts for the information profession as a whole (and how would threshold concept theory help to define them)? Would this include knowledge organization, collection management, heuristics for information architecture—other core areas? Can threshold concept theory provide a useful framework for studying what is truly “core”? The theoretical lens has clear potential for exploring the core competencies required of LIS students—and for understanding the learning experiences that lead to acquiring same.

Conclusion

This paper has presented the dimensions and characteristics of threshold concept theory and discussed its research and pedagogical potential for LIS education. The findings from a new study of learning-to-search experiences, involving MLIS students and professional searchers, were reported and viewed through the lens of threshold concept theory. The implications of this new research extend to

understanding search expertise and search education, as well as to what threshold concept theory can contribute to LIS education more broadly.

References

- Akerlind, G., McKenzie, J., & Lupton, M. (2011). *Final report: A threshold concepts focus to curriculum design: Supporting student learning through application of variation theory* [PDF document]. Retrieved from http://www.olt.gov.au/system/files/resources/PP8_885_Final_Report_Akerlind_2011.pdf
- Akerlind, G. (2012). *Project outcomes: Threshold Concepts Project* [PDF document]. Retrieved from <http://thresholdvariation.edu.au/content/project-outcomes>
- American Library Association. (2009). *Core competencies of librarianship*. Retrieved from <http://www.ala.org/educationcareers/careers/core-comp/corecompetences>
- Bates, M.J. (1987). How to use information search tactics online. *Online*, 11(5), 47–54.
- Bates, M.J. (1989). The design of browsing and berry-picking techniques for the online search interface. *Online Review*, 13(5), 407–424.
- Bates, M.J. (1992). Search and tactic ideas. In H.D. White, M.J. Bates, & P. Wilson (Eds.), *For information specialists* (pp. 183–200). Norwood, NJ, USA: Ablex Publishing.
- Bernhard, J., Carstensen, A.K., & Holmberg, M. (2011, October). Analytical tools in engineering education research: The ‘learning a complex concept’ model, threshold concepts, and key concepts in understanding and design for student learning. In W. Hernandez (Ed.) *Proceedings of the Research in Engineering Education Symposium* (pp. 51–60). Madrid, Spain: Universidad Politécnica de Madrid.
- Blackmore, M. (2010, July). Student engagement with information: Applying a threshold concept approach to information literacy development. Paper presented at the *3rd Biennial Threshold Concepts Symposium: Exploring transformative dimensions of threshold concepts*, Sydney, Australia.
- Boustedt, J., Eckerdal, A., McCartney, R., Moström, J.E., Ratcliffe, M., Sanders, K. & Zander, C. (2007). Threshold concepts in computer science: Do they exist and are they useful? *ACM SIGCSE Bulletin*, 39, 504–508.
- Bruner, J.S. (1960). *The process of education*. Cambridge, MA, USA: Harvard University Press.
- Burkholder, J. (2011). Decoding the discipline of music history for our students. *Journal of Music History Pedagogy*, 1(2), 93–111.

- Carstensen, A.K., Holmberg, M., & Bernhard, J. (2006, December). Threshold concepts and key concepts in electrical engineering education. *Fourth CeTUSS Workshop*, Lecture conducted from Uppsala University, Uppsala, Sweden.
- Clouder, L. (2005). Caring as a threshold concept: Transforming students in higher education into health(care) professionals. *Teaching in Higher Education*, 10, 505–517. DOI: 10.1080/13562510500239141
- Cope, C. & Staehr, L. (2008). Improving student learning about a threshold concept in the IS discipline. *Informing Science: the International Journal of an Emerging Transdiscipline*, 11, 349–364.
- Cousin, G. (2006). Introduction to threshold concepts. *Planet*, 17, 4–5.
- Cousin, G. (2008a). Transactional curriculum inquiry: Researching threshold concepts. In G. Cousin (Ed.), *Researching learning in higher education: An introduction to contemporary methods and approaches* (pp. 201–212). New York, USA: Routledge.
- Cousin, G. (2008b). Threshold concepts: Old wine in new bottles or new forms of transactional curriculum inquiry. In R. Land, J.H.F. Meyer, & J. Smith (Eds.), *Threshold concepts within the disciplines* (pp. 261–272). Rotterdam, Netherlands: Sense Publishers.
- Cousin, G. (2010). Neither teacher-centred nor student-centred: Threshold concepts and research partnerships. *Journal of Learning Development in Higher Education*, 2, 1–9.
- Díaz, A., Middendorf, J.K., Pace, D., & Shopkow, L. (2008). The history learning project: A department 'decodes' its students. *Journal of American History*, 94(4), 1211–1224.
- Díaz, A. & Pace, D. (2012, June). Introduction to decoding the disciplines. Preconference workshop. *Threshold Concepts 4th Biennial Conference*, Lecture conducted from Trinity College, Dublin, Ireland.
- Dulleck, U. & Tang, T. (2009a). *Teaching the economic way of thinking*. [PowerPoint slides]. Retrieved from <http://www.atec2009.bus.qut.edu.au/papers/Program.jsp>
- Dulleck, U. & Tang, T. (2009b, July). Teaching the economic way of thinking: A new approach to teaching introductory economics in a business degree. In T. Robinson, T. Tang, & Fletcher A. (Eds.), *Proceedings of ATEC2009 14th Annual Australasian Teaching Economics Conference* (pp 63–71), Australia: Queensland University of Technology.
- Edwards, S.L. (2006). *Panning for gold: Information literacy and the Net Lenses model*. Adelaide, Australia: Auslib Press.
- Fidel, R. (1984). Online searching styles. *Journal of the American Society for Information Science*, 35, 211–221.
- Flanagan, M. T. & Smith, J. (2008). From playing to understanding: The transformative potential of discourse versus syntax in learning to program. In R. Land, J.H.F. Meyer, & J. Smith (Eds.) *Threshold concepts within the disciplines* (pp. 91–104). Rotterdam, Netherlands: Sense Publishers.
- Glenn, D. (2009). A teaching experiment shows students how to grasp big concepts. *Chronicle of Higher Education*, 56(13), A1–A10.
- Higgs, B. (2012, June). Foreword. *Threshold Concepts 4th Biennial Conference*, Lecture conducted from Trinity College, Dublin, Ireland.
- Hofer, A. R., Townsend, L., & Brunetti, K. (2012). Troublesome concepts and information literacy: Investigating threshold concepts for IL instruction. *Portal: Libraries and the Academy*, 12 (4), 387–405. DOI 10.1353/pla.2012.0039
- Kennedy, P. (1998). Using Monte Carlo studies for teaching econometrics. In W.E. Becker & M. Watts (Eds.), *Teaching economics to undergraduates: Alternatives to chalk and talk*. Aldershot, UK: Edward Elgar.
- Kiley, M. & Wisker, G. (2009). Threshold concepts in research education and evidence of threshold crossing. *Higher Education Research & Development*, 28(4), 431–441. DOI: 10.1080/07294360903067930
- Kinchin, I.M. & Miller, N.L. (2012). Structural transformation as a threshold concept in university teaching. *Innovations in Education and Teaching International*, 49(2), 207–222.
- Land, R., Cousin, G., Meyer, J.H.F., & Davies, P. (2006). Implications for course design and evaluation. In J.H.F. Meyer & R. Land (Eds.), *Overcoming barriers to student understanding: Threshold concepts and troublesome knowledge* (pp. 195–206). New York, USA: Routledge.
- Land, R., Meyer, J.H.F. & Smith, J. (2008). *Threshold concepts within the disciplines*. Rotterdam, Netherlands: Sense Publishers.
- Marion, F. & Booth, S. (1997). *Learning and awareness*. Mahwah, NJ, USA: L.Erlbaum Associates.
- Meyer, J.H.F. & Land, R. (2003). Threshold concepts and troublesome knowledge (1): Linkages to ways of thinking and practising within the disciplines. In C. Rust (Ed.) *Improving student learning: Ten years on* (pp. 1–16). Oxford University Press. Originally published as *ETL Occasional Report 4*. Retrieved from <http://www.etl.tla.ed.ac.uk/publications.html>
- Meyer, J.H.F. & Land, R. (2005). Threshold concepts and troublesome knowledge (2): Epistemological considerations and a conceptual framework for teaching and learning. *Higher Education*, 49, 373–388. DOI: 10.1007/s10734-004-6779-5
- Meyer, J.H.F. & Land, R. (2006). *Overcoming barriers to student understanding: threshold con-*

- cepts and troublesome knowledge. New York, USA: Routledge.
- Meyer, J.H.F., Land, R., & Smith, J. (2008). *Threshold concepts within the disciplines*. Rotterdam, Netherlands: Sense Publishers.
- Mezirow, J. (2003). Transformative learning as discourse. *Journal of Transformative Education*, 1(1), 58–63. DOI: 10.1177/1541344603252172
- Morse, J.M. (2008). Confusing categories and themes. *Qualitative Health Research*, 18(6), 727–728. DOI: 10.1177/1049732308314930
- Pace, D. & Middendorf, J.K. (2004). *Decoding the disciplines: Helping students learn disciplinary ways of thinking*. San Francisco, USA: Jossey-Bass.
- Park, E.J. & Light, G. (2009). Identifying atomic structure as a threshold concept: Student mental models and troublesomeness. *International Journal of Science Education*, 31(2), 233–258. DOI: 10.1080/09500690701675880
- Perkins, D. (2006). Constructivism and troublesome knowledge. In J.H.F. Meyer & R. Land (Eds.), *Overcoming barriers to student understanding: Threshold concepts and troublesome knowledge* (p. 33–47). New York, USA: Routledge.
- Perkins, D. (2010). Foreword. In J.H.F. Meyer, R. Land, & C. Baillie (Eds.), *Threshold concepts and transformational learning* (p. xliii–xlvi). Rotterdam, Netherlands: Sense Publishers.
- Plosker, G. (2004). Making money as an aggregator. *Online*, 28(2), 34–38.
- Reimann, N. & Jackson, I. (2006). Threshold concepts in economics. In J. H.F. Meyer & R. Land (Eds.), *Overcoming barriers to student understanding: Threshold concepts and troublesome knowledge* (pp. 115–133). New York, USA: Routledge.
- Schön, D.A. (1983). *The reflective practitioner: How professionals think in practice*. New York, USA: Basic Books.
- Schön, D.A. (1987). *Educating the reflective practitioner*. San Francisco, USA: Jossey-Bass Publishers.
- Sheja, M. and Pettersson, K. (2010). Transformation and contextualization: Conceptualizing students' conceptual understandings of threshold concepts in calculus. *Higher Education*, 59(2), 221–241. DOI: 10.1007/s10734-009-9244-7
- Smith, J. (2006, June). Lost in translation: Staff and students negotiating liminal spaces. Presented at SEDA Spring Conference, Liverpool, UK.
- Stokes, A., King, H., & Libarkin, J.C. (2007). Research in science education: Threshold concepts. *Journal of Geoscience Education*, 55(5), 434–438.
- Taylor, C. (2006). Threshold concepts in biology: Do they fit the definition? In J.H.F. Meyer & R. Land (Eds.), *Overcoming barriers to student understanding: Threshold concepts and troublesome knowledge* (pp. 87–99). New York, USA: Routledge.
- Taylor, C. & Cope, C.J. (2007). *Are there educationally critical aspects in the concept of evolution?* [PDF document]. Retrieved from <http://science.uniserve.edu.au/pubs/procs/2007/21.pdf>
- Townsend, L. & Brunetti, K. (2009). *Save a horse, ride a new train of thought: Using threshold concepts to teach information literacy*. [PDF document]. Retrieved from http://dr.archives.pdx.edu/xmlui/bitstream/handle/psu/7418/Save_a_horse_ride_a_new_train_of_thought_LOE.pdf?sequence=2
- Townsend, L., Brunetti, K., & Hofer, A.R. (2011). Threshold concepts and information literacy. *Libraries and the Academy*, 11(3), 853–869. DOI: 10.1353/pla.2011.0030
- Tucker, V.M. (2012). *Acquiring search expertise: Learning experiences and threshold concepts*. Ph.D. Dissertation, Queensland University of Technology, Brisbane, Australia.
- Turner, V. (1969). *The ritual process*. Chicago, USA: Aldine.
- Zander, C. et al. (2008). Threshold concepts in computer science. In J.H.F. Meyer, R. Land, & C. Baillie (Eds.), *Threshold concepts and transformational learning* (p. 105–117). Rotterdam, Netherlands: Sense Publishers.