Light bulb moments: identifying information research threshold concepts for fourth year engineering students

Phil Yorke-Barber
University of Queensland, Brisbane, Australia
p.yorke-barber@library.uq.edu.au

Loretta Atkinson
University of Queensland, Brisbane, Australia
l.atkinson@library.uq.edu.au

Gisela Possin
University of Queensland, Brisbane, Australia
g.possin@library.uq.edu.au

Leith Woodall
University of Queensland, Brisbane, Australia
l.woodall@library.uq.edu.au

***Abstract**: The librarians in the Dorothy Hill Physical Sciences and Engineering Library undertook a project to identify information research threshold concepts which fourth year undergraduate students must know to produce high quality research assignments. The methodology used to identify threshold concepts was to survey students, librarians and academics. A suggested threshold concept in information research is the critical evaluation of information resources to establish their authority, quality and credibility. This paper aims to demonstrate how a threshold concept approach clarifies the student experience in information research and provides a framework for the design of future information skills training.*

Introduction

As future professionals in industry, graduating engineering students must be proficient in locating research information. To increase the learning outcomes of information research training, librarians in the Dorothy Hill Physical Sciences and Engineering Library surveyed academics and students to identify the threshold concepts in fourth year engineering students' information research. In this paper, threshold concepts are defined as troublesome knowledge and are identified as the stumbling blocks students encounter in their information research. Threshold concepts were first introduced in a seminal work by Meyer & Land (2003, p. 1) and are described as akin to a portal, "opening up a new and previously inaccessible way of thinking", the light bulb moment! Indeed, they may provide a new theoretical framework to better understand student learning and to develop an information skills training model that facilitates learning (Lucas & Mladenovic, 2007).

As part of their industry-related research or thesis projects, fourth year students in the School of Engineering and the School of Information Technology and Electrical Engineering are required to locate scholarly information. An essential graduate attribute is the "ability to locate, and organise information from a broad range of sources relevant to engineering practice" (The University of Queensland, 2006, p. 1). Each semester librarians run face-to-face information skills training for approximately four hundred thesis and project students, who are required to prepare annotated bibliographies and literature reviews. Library workshops introduce students to information databases and to the search strategies most appropriate for the exploitation of the available information resources.

Students and academic coordinators from chemical, civil, electrical, mechanical, minerals processing and mining engineering were surveyed. Librarians' perceptions were also canvassed. Analysis of the data is not yet complete but, so far, results indicate that students do find information for their research projects. However, they do not always know how to develop a search strategy e.g. finding alternative search terms and they are unsure of how to locate the right database. Students also grapple with understanding how to track information research on a topic and evaluate the resources found.

Identifying threshold concepts will foster collaboration and dialogue amongst academics, librarians and students in the design of training; the students' and academics' insights will be used to plan future workshops.

No previous research on threshold concepts in information skills appears to have been done.

Why threshold concepts?

Threshold concepts are a relatively new idea developed by Meyer & Land (2005) and can be applied to describe the key concepts students need to understand in order to find information to produce high quality projects and theses. Davies (2006, p.71) uses the phrase a "way of thinking and practising" in a discipline. He writes that threshold concepts are more than the acquisition of core concepts and skills; they are techniques of thinking that help the learner to draw conclusions. Being an approach rather than a rule-bound paradigm, threshold concepts can be linked to information skills learning and lifelong learning objectives, skills which are needed in today's engineering marketplace. Meyer and Land (2005) characterise a threshold concept in five ways:

1. It is transformative in that it represents a significant shift in the perception of a subject. The transformation can be sudden or protracted. The transformed view represents how people 'think' in a particular discipline.
2. It is probably irreversible in that it cannot be unlearned.
3. It is integrative in that it exposes relationships that were not previously visible e.g. students' understanding of their research topic is integral to their information research.
4. It is bounded as it helps to define the outlines of a subject area.
5. A threshold concept represents troublesome knowledge. Fosmire and Macklin (2002) write that students believe they already have information skills because they can find something on Google to answer almost any question but they are unable to critically evaluate that information at a deeper level. What they have acquired is the ability to search databases but they also need the capacity for critical reflection on and evaluation of, the large amounts of information found.

There are many reasons for a threshold concepts approach to information skills, amongst which is the need to understand the student perspective. Assumptions should not be made about students' prior knowledge or what they may find difficult in information research. Threshold concepts take into account students' prior knowledge e.g. students know how to find information; but the process of learning research skills takes this understanding from a basic level to a more sophisticated knowledge (Davies 2006). A threshold concept approach encourages active learning by engaging students in information research. Learners do not absorb information passively but actively construct it themselves. Threshold concepts imply that learners continually increase their knowledge by incorporating new information and concepts. When current knowledge is integrated then transformation occurs, revealing new perspectives. For instance student feedback indicates that learning about a wider range of available information resources is valued. The literature draws attention to the fact that students are given too much content, a phenomenon often referred to as the "stuffed curriculum" (Stokes, King, & Libarkin, 2007, p. 434). We should decide what students need to know about information research i.e. primarily, we need to understand our students.

The literature discusses the steep increase in the volume of scientific and technical information and how learning effective information gathering skills is necessary for coping with this growth (Feldmann & Feldmann, 2000). Fosmire and Macklin (2002) believe that librarians face a constant struggle to convince students of the value of information skills. Holliday and Li (2004) write that, understandably, the Internet has altered student expectations of the research process. The impact of online full text has changed students' information seeking behaviour; they expect finding research

information to be easy. Students no longer take notes, tend to download articles and may fall into the trap of copying and pasting "good quotes" (Holliday & Li, 2004, p. 365).

Engaging students in information research

Information skills training is designed to lay a foundation for independent and lifelong learning and imparts to students how to find and evaluate information from a variety of media and then to cite their sources. Identifying threshold concepts in information research will enable us to facilitate students' information skills training using constructivist learning theories (Perkins, 2006).

The emphasis in higher education has shifted from a teaching to a learning model. Constructivism and active learning move learning away from a transmission model of teaching, and instead engage the students in the learning process by using their prior knowledge and learning styles. For information skills training to be effective, instruction must be tailored to students' specific needs and librarians must align and integrate teaching, learning and assessment activities so that students are enabled to appreciate the relevance of information skills training (Biggs, 1996).

Methodology

Approval to survey project and thesis academic coordinators and their students was obtained from the UQ Ethics Committee. The survey questions for academics and students were similar. Librarians were also presented with set questions.

Results and Discussion

Academic Responses

Academics were asked what stumbling blocks their students encountered in gathering and using information and how they helped students to overcome these stumbling blocks. Academics cited information skills training as both relevant and highly relevant for their students. The following were identified as the most important information skills students required:

- How to gather and track information from journals and conference papers
- Critically analyse the information located
- Manage their research.

Academics commented that students were highly confident in their use of the Internet as a search tool but that they were not always informed enough about their topic. They lacked knowledge about where to start their research and how to identify and evaluate research articles.

Table 1: Academic identification of stumbling blocks

Stumbling blocks	How academics helped
• Too strong a focus on Google • Unfamiliar with their project topic and therefore they do not know where to start their research • Identifying scholarly peer-reviewed articles and tracking research • No organised strategy for exhaustive searches; they are unaware of the breadth of available information e.g. patents • Poor at critically evaluating information • Managing information located	• Not always an opportunity to communicate with students • Provide pertinent keywords and suggest information sources • How to track and use article references including academics' own research • Having regular meetings with students and asking them what they are trying to locate • Reinforcing everything • Telling them about EndNote

Table 2: Desirable information sources identified by academics

Information resource	Resources analysis
Web of Science (WoS)	The majority of academics highlighted the WoS as a key information source. In some instances, librarians were surprised at the WoS being chosen instead of the engineering database Compendex. Academics

	commented on the importance of tracking research information and identifying quality literature across all sciences and technology. This supports their choice of the WoS as a high quality impact research tool. UQ Library has recently subscribed to Scopus; however, academics did not appear to be as familiar with this database.
Library Catalogue	All academics strongly agreed with their students learning to use the library's catalogue.
Engineering Village (Compendex and Inspec)	Academics agreed that Compendex and Inspec are important research databases. One academic commented that students have problems locating conference papers in Compendex.
Google Scholar	Google Scholar was identified by the majority of academics as a highly relevant research tool. Google and Wikipedia were considered by all academics as starting points for students' information research.

Student Responses

Survey questions probed students' understanding and experience of information research. The aim was to discover which sources and techniques the students used in searching for information and what stumbling blocks they encountered. Students who had not received information skills training since first year found the library workshops very relevant whilst the majority who had completed sessions in second or third years found their fourth year workshop relevant. Many noted that they learnt of databases of which they were previously unaware. They found learning EndNote added value to their research.

Table 3: Student identification of stumbling blocks

Stumbling blocks	**Student solutions**
• Obtaining information online in full-text was students' top stumbling block • Where to start finding information • Once started, how to refine searches if too much information located • Finding reliable sources other than Google • Limiting articles located on a database • Finding the right database and right keywords • Finding too much information and the opposite, not finding enough • Searching for conference papers • Citing correctly and choosing an appropriate citation style • Using referencing software, such as EndNote	• Choosing articles available electronically • Too early to say and unsure what to do • Asking the librarian and/or lecturer • Searching and using as many search engines and databases as possible • Asking other students doing the same project • Doing it the hard way, keeping on trying • Learning how to reference and to use EndNote • Learning to improve searches by using alternative search terms • Looking through an excessive amount of journals • Locating journals by title in the library catalogue • "Slogging it out by trying different search methods"

Students and academics mentioned the same information resources; students were more likely to search Compendex/Inspec whilst academics recommended the WoS. Both academics and students suggested that the principal ways to refine search results were:

- Words in the title of the articles
- Document type e.g. journal article or conference paper
- Adding or removing keywords to reduce or increase results
- Author searches

Librarians' Responses

Librarians agreed that students know enough to get started but that they were not familiar enough with what they were expected to do. Students expect to find the perfect article specifically on their topic but seem unable to grasp the need to extrapolate from what they do find. Lack of knowledge about their topic is an obstacle. Providing students with too much information was seen as a problem by librarians. Students often return to see their librarian whilst researching their project, with queries on locating particular articles or on referencing.

The main stumbling blocks identified by librarians are:

- Students knowing their topic and compiling a search strategy
- Refining a large set of results to a manageable number
- Critical evaluation of information
- Obtaining information online in full-text

Students do not understand abstracting and indexing databases such as the Web of Science and Compendex which index thousands of scholarly journals nor that the library does not necessarily subscribe to all of them. Although the Library tries to make database article links to subscription journals seamless many students get confused at the additional 'clicks' in a database search.

Information Research Threshold Concepts

The stumbling blocks identified by academics, students and librarians are proposed as threshold concepts in information research. Further data analysis may change these results. The recurring theme in the analysed data is the need for students to know their topic and to have started thinking about it so that the relevance of information skills training is immediately apparent. Survey responses demonstrate similar perceptions from students, academics and librarians.

Table 4: Information Research Threshold Concepts

Thresholds Concepts	Identifiers
1. Knowing the research topic and compiling a search strategy	Students, academics and librarians
2. Locating, critically evaluating and tracking information research	Academics and librarians
3. Referencing and citing information	Students, academics and librarians

Information research is not a discipline and does not have discipline-specific threshold concepts such as 'opportunity cost' in economics or 'spin' in engineering (Meyer & Land, 2003; Cousin, 2006; Reilly & Hunt, 2008). Information research is itself a threshold concept in that it is an integral step in students' research projects. Perkins (1999) writes that knowledge might be troublesome for different reasons; information research is troublesome in that it can be taken for granted by students. Students' top research priority is access to full-text online papers. Tracking research was highlighted as a stumbling block by academics. Information research is integrative as without it students' theses and projects cannot progress. Davies (2006) writes that if the concepts are integrative they are also transformative and irreversible and will assist in defining the boundaries of the subject.

Where to from here?

Lucas and Mladenovic (2007) write that threshold concepts require merged perceptions. The lecturer has expectations of what the student should be able to achieve which may differ from the student's actual experience. By surveying the student experience, we discovered that students did not identify the need to critically evaluate information or to track research. This discovery can be incorporated into future information skills training. The need to be aware of student project topics prior to information skills training is evident; familiarity with their topic can be used as a way of engaging students.

Conclusion

In this paper threshold concepts are defined as the stumbling blocks students encounter in their information research. Threshold concepts, like the educational theory constructivism, place the learning focus on the student experience and can be used to enhance the learning outcomes of information skills training. The survey has identified a number of information research threshold concepts that will be used in planning future information skills workshops.

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