THRESHOLD CONCEPTS IN FINANCE

Susan Marie Hoadley

Bachelor of Arts (Honours)

Postgraduate Diploma of Education

Macquarie University

Department of Marketing and Management

This thesis is presented for the degree of Doctor of Philosophy

Declaration

I certify that the work in this thesis entitled “Threshold Concepts in Finance” has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree to any other university or institution other than Macquarie University.

I also certify that the thesis is an original piece of research and it has been written by me. Any help and assistance that I have received in my research work and the preparation of the thesis itself have been appropriately acknowledged.

In addition, I certify that all information sources and literature used are indicated in the thesis.

The research presented in this thesis was approved by Macquarie University Ethics Review Committee as follows:

Threshold Concepts in Finance: Reference No: 5201200284 approved on 16 May 2012, amendment approved 19 June 2013

Threshold Concepts in Finance (Part 2): Reference No: 5201300475 approved on 4 July 2013

'Threshold concepts in finance (Part 3): Reference No: 5201300793 approved 19 November 2013 amendment approved 1 October 2014.

_____

Susan Marie Hoadley (Student ID: 30541328)

Acknowledgements

In completing this study I am grateful to have received the help and support of a great number of people. Without exception, everyone I approached has been generous with their time and expertise and I give my heartfelt thanks for this support.

I especially thank my supervisors Leigh Wood and Leonie Tickle, Leigh most of all for her unremitting faith in me but also for everything else, and Leonie particularly for consistently giving meticulous and insightful feedback. I have also benefited from the calming counsel and confidence of the other member of the research team, Tim Kyng.

Colleagues at Macquarie University I thank for fantastic practical help include Yvonne Breyer, Sue Carter, Lurion De Mello, Antonia Dykes, Emily Inglis, Jennifer Lai, Drew Nixon, Anne Ross-Smith, Anna Rowe, Lindsay Stubbs and Deanna Wong.

People who have been very kind in listening to me along the way and responding with good advice are Jen McPherson, Glyn Mather (also editor extraordinaire) and Chris Baumann.

Finally, I thank my family (Malcolm and Emma Wallace) and friends for all their support through the process, especially Maria Herke who is both a friend and a colleague, so has been doubly burdened.

This thesis was professionally copy edited by Glyn Mather in accordance with the Australian Standards for Editing Practice.

Table of Contents

List of tables and figures

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Abstract

This thesis investigates staff and student perceptions of threshold concepts in finance to inform curriculum design, pedagogical practices and professional development, and hence improve student engagement and outcomes. Threshold concepts are the essential conceptual knowledge that underpin well-developed capabilities in finance. Finance capabilities are essential in our society and in increasing demand, as indicated by industry trends and recent significant growth in students undertaking finance programs. However, research into what should be taught in finance programs to develop these capabilities is extremely limited.

For the first time, this thesis uses threshold concept theory both as a theoretical framework and a research methodology to investigate the threshold concepts that are central to the mastery of finance. Data from a focus group, interviews and questionnaires with finance academics and students are analysed and compared using a combination of qualitative and quantitative techniques.

The thesis makes proposals for threshold concepts in finance, locates these within the finance curriculum and investigates the extent to which students are aware of the threshold concepts in finance. In addition, the thesis explores the role of mathematics in finance and the value of threshold concepts for learning and teaching finance as perceived by finance academics. The general applicability of threshold concept theory as a means of curriculum inquiry is demonstrated and critically reviewed.

Chapter 1 – Introduction

Aims and objectives

The research seeks to investigate the finance curriculum and conceptualise it in new and inspiring ways, by identifying the transformational "threshold" concepts (Meyer & Land, 2003) in finance. These threshold concepts are the essential conceptual knowledge that underpin well-developed capabilities in finance and are central to the mastery of finance (Cousin, 2006). At the same time, these concepts are most likely to engage students and involve deep learning because they transform the way students think and view the world. Thus, the identification of the threshold concepts in finance has the potential to achieve better quality educational outcomes for students by informing curriculum design and delivery.

Significance and background

Graduates with well-developed finance capabilities are invaluable to our society and finance programs need to develop these capabilities in ways that meet the needs of large and diverse student cohorts, as well as the requirements of other stakeholders. In Australia, there is significant and increasing demand for finance programs particularly by international students largely from Asia. For example, enrolments in the specialist finance degree at Macquarie University increased by over 200% from 2002 to 2012, with a nearly 300% increase in international students (Macquarie University, 2012). This demand is predicted to increase as the finance industry sector increases in size and as Australia's role as a regional hub for finance and education continues to grow (Deloitte, 2013). In addition, recent education policy changes in Australia, such as the shift from degree entry requirements to "assumed" and "recommended" knowledge, have resulted in increasing diversity in the domestic student cohort. At the same time, finance programs have to comply with multiple and multifaceted accreditation requirements, such as the Australian Securities and Investments Commission Regulatory Guide 146 and the Australian Qualifications Framework, and the US-based Chartered Financial Analyst Institute and Association to Advance Collegiate Schools of Business. This increased demand, diversity and accreditation are very positive for the future of finance as a discipline, but it is now even more important that learning and teaching in finance, a hitherto under researched area, is researched and fully developed to successfully take finance programs into this future.

Finance is a relatively new discipline and finance programs have only been offered by higher education institutions since the 1980-1990s (Macquarie University, 2015; Partington, 2014). Prior to this, finance was taught within other disciplines, such as accounting and business, and indeed, finance is considered to be interdisciplinary, drawing on economics, accounting, mathematics and statistics (Finance Learning Standards Working Party Australian Business Deans Council, 2014). Like many other disciplines, the finance curriculum has developed and grown organically and is generally considered to be overcrowded. Thus, there is an opportunity to inform and improve the design of the finance curriculum, in order to reduce this overcrowding and associated surface learning, as well as better understand and define finance as a discipline by identifying the knowledge that underpins well-developed finance capabilities.

Theoretical approach

This research uses threshold concepts both as a theoretical framework and as a research methodology (refer to methodology section below). Originally developed by Meyer and Land in relation to economics in 2003 (Meyer & Land, 2003), threshold concept theory has been rapidly and widely applied to other disciplines (Flanagan, 2015) to research and inform curriculum design, pedagogical practices and professional development of teaching staff.

The premise of threshold concepts is that in any discipline there are a limited number of concepts that are fundamental to mastery in the discipline (Cousin, 2006). "Understanding" a threshold concept involves passing through a conceptual gateway that "permits new and previously inaccessible ways of thinking and practising" (Land, Rattray & Vivian, 2014, p. 200). Thus, research into the threshold concepts in finance is a way to define and understand the essential conceptual knowledge required to be a finance practitioner.

Threshold concepts are associated with a number of interrelated characteristics or features. As originally described by Meyer and Land (2003), five characteristics are associated with threshold concepts:

1. Transformative – occasions a shift in the perception of the subject
2. Integrative – exposes the previously hidden interrelatedness of something
3. Irreversible – unlikely to be forgotten, or will only be unlearned by considerable effort
4. Troublesome – conceptually difficult and/or counter-intuitive

5. Bounded – serves as boundary markers for the conceptual spaces that make up the disciplinary terrain.

More recently, the discursive, reconstitutive and liminal aspects of threshold concepts have been increasingly described as characteristics or features (Barradell, 2013; Flanagan, 2015; Land et al., 2014). The research reported on in this thesis primarily focuses on the transformative, integrative, irreversible and troublesome characteristics in order to identify and describe threshold concepts in finance.

The advantages of threshold concepts as a theoretical approach are that it:

- promotes the discussion, understanding and definition of the conceptual knowledge that is most fundamental and central to ways and thinking and practising in a discipline
- encourages collaboration between discipline and education specialists, enabling the former to theorise learning and teaching in their discipline and the latter to develop learning and teaching theory in authentic, discipline-specific contexts
- promotes an explicit and shared understanding of the most important concepts in the discipline between students and staff
- directly addresses curriculum overcrowding and associated surface learning
- appeals to academics as discipline specialists in that it recognises their expertise in the discipline.

At the same time, being a relatively new and emerging theoretical framework, there are also aspects of threshold concept theory that can be informed by further research. In particular, recent literature highlights issues involved in identifying and defining threshold concepts, especially with regards to whether the various characteristics or features are obligatory or optional (Barradell, 2013; Quinlan et al., 2013). Further, Rowbottom (2007) argues that the way threshold concepts were originally described by Meyer and Land makes them impossible to identify and, because "concepts are not reducible to abilities", difficult to assess. As an instance of the application of threshold concept theory, this research explores these issues and so its findings inform threshold concept theory. The study specifically tests whether the transformative, integrative, irreversible and troublesome characteristics are associated with a concept being identified as a threshold concept. The research also surveys academics on their views as to the value of the (four) characteristics, as well as threshold concepts more generally, providing evidence-based feedback on the theory.

Whilst the power of threshold concept theory is its focus on identifying the limited number of transformative concepts that are essential to the mastery of a discipline, this is also a potential weakness if these concepts are not considered in the broader context of the curriculum (Shinners-Kennedy & Fincher, 2013), and the capabilities required to act effectively in professional roles (Baillie, Bowden & Mayer, 2012). Therefore, as well as identifying threshold concepts, this thesis is concerned with locating threshold concepts (Shinners-Kennedy & Fincher, 2013) within the finance curriculum to better describe and understand the curriculum and, in turn, use this to inform the design and delivery of finance programs. In order to do so, the research follows Baillie et al. (2012), drawing on capability theory, with its emphasis on the ability of graduates to be effective in future professional roles, and the distinction between *episteme* – conceptual understandings, *teche* – craft, technical skills, and *phronesis* – value judgements and decision making in context. This approach is also informed and supported by the framework developed by Wood et al. (2012) which identifies three types of knowledge – conceptual, procedural and professional based on students' perceptions. Thus, this study demonstrates the role of threshold concept theory not only in defining the conceptual knowledge that underpins a curriculum but also *how* it underpins the different aspects of a curriculum.

Terminology

Just as the precise definition and exact nature of threshold concepts is subject to debate, other terms used in this thesis may be understood in different ways in different contexts. In this section, key terms are discussed and the sense in which they are used in this thesis is explained.

Concept – According to Rowbottom (2007), the prevailing view of a concept is a word-like mental representation. Entwistle and Nisbet (2013) link mental representations to understanding. Thus, to continue the word analogy, a concept consists of the word or phrase used to denote it (ie the signifier) and an associated discipline-specific understanding or conceptualisation (ie the signified).

Course – A single unit of study taken as part of a program, sometimes referred to as a subject. Both terms are used in previous research and by participants, so both terms are used in this thesis.

Idea – Although Davies and Mangan (2007) seem to use "idea" and "concept" to refer to the same thing, albeit in a motivated way, they also use "idea" in a more general sense, and the sense in which it is used in this thesis, to refer to a proposal or proposition. In contrast

to “concept”, “idea” does not imply any particular way of understanding or conceptualisation.

Knowledge – The term knowledge is used in the broadest sense to refer to what students need to understand and be able to do.

Program – A program is a combination of a number of courses or subjects leading to an award, for example a bachelors or masters degree.

Threshold concept – The working definition of a threshold concept used in this thesis is a concept that is central to mastery of the discipline and that changes the way students perceive the world. These two features in combination distinguish a threshold concept from other concepts, including core concepts. Being a type of concept, the comments made above in relation to concepts also apply to threshold concepts. Whilst some of the other characteristics or features of threshold concepts discussed previously are referred to and explored in the research, they are not assumed to be defining characteristics of threshold concepts.

Theory – The term theory is used to refer to a set of ideas or concepts developed as a result of observation or experimentation that can be used to explain or describe the phenomenon being investigated, as well as applied to other contexts. Thus, for example, threshold concept theory was developed as a result of researching into the teaching and learning of economics and has been used to explain and inform learning and teaching in other disciplines.

Topic – A topic is a sub-section of a discipline based on areas or fields of knowledge, as opposed to types of knowledge.

Subject – A single unit of study taken as part of a program, sometimes referred to as a course. Both terms are used in previous research and by participants, so both terms are used in this thesis.

Literature review

The literature review is divided into two sections. The first section critically reviews previous research on the finance curriculum. The second section explores research on threshold concepts in finance and related disciplines. Overall, the area is under researched from both perspectives.

Finance curriculum

Finance is a relatively new discipline. The first academic journal dedicated to finance research was the Journal of Finance, first published as American Finance by the American Finance Association in 1942, itself established in 1939 (American Finance Association, 2012). Although the curriculum and teaching of finance was discussed as early as 1966 (Walker et al., 1966), specific finance programs were established later in the 1980-1990s (Macquarie University, 2015; Partington, 2014). Thus the early literature on the finance curriculum is concerned with finance courses taught within other disciplines.

The close association of finance with other disciplines continues today, with finance still referred to as a sub-field of economics closely related to accounting (Finance Learning Standards Working Party Australian Business Deans Council, 2014). In addition, an emphasis on the use of quantitative methods (ibid.) has meant that finance has traditionally been considered to involve a significant amount of mathematics (and statistics as a type of mathematics). However, it should be noted that more recent research argues that the extent to which roles in finance involve mathematics varies, and further, greater regulation is associated with less mathematics in finance roles and vice versa (Philipon & Reshef, 2012). In addition, quantitative methods may be of less importance given the acknowledgement of decision biases and non-rational behaviour, leading to the emergence of behavioural finance (Coleman, 2013).

Whilst some researchers refer to a body of literature in finance education (Balachandran, Skully, Tant, & Watson, 2006; Krishnan, Bathala, Bhattacharya, & Ritchey, 1999; Lai, Kwan, Kadir, Abdullah, & Yap, 2009) only a limited proportion of this research specifically investigates the finance curriculum; thus, as Lakshmi (2013) states, the area is under researched. Furthermore, the research that does specifically investigate the finance curriculum has a number of characteristics that both limit its relevance to and reinforce the need for this study. Firstly, much of the literature focuses on introductory finance rather than the curriculum of an entire finance program (eg Balachandran et al., 2006; Berry & Farragher, 1987; Cooley & Heck, 1996; Gup, 1994; Krishnan et al., 1999). This is, in part, due to the fact that finance was and continues to be taught as courses within other programs. Secondly, some research focuses on the finance curriculum from the point of view of preparing students for specific professional roles (eg Jackling & Sullivan, 2007 – financial planners; Lakshmi, 2013 – accountants or chief financial officers; Roth, Envick, & Anderson, 2002 – entrepreneurs). This can be seen as a result of the way finance has evolved from other disciplines. For example, the fact that finance was (and continues to be)

taught within accounting programs that prepare students for the roles of accountants and chief financial officers has led to research into the finance curriculum required to prepare students for those roles. Finally, research into the financial curriculum tends to take a more topic or generic skill approach than a concept approach. Notwithstanding these points, the finance topics and concepts identified in the finance curriculum research are a point of comparison with the threshold concepts identified in this study. It should be noted also that there is some slippage (see Lai et al., 2009) and overlap between finance concepts and finance topics in the literature. For example, Cooley and Heck (1996) make the distinction between topics and concepts, whilst Gup (1994) exclusively uses the term concept. However, Gup's concepts are more like Cooley and Heck's topics than their concepts. The results of relevant studies regarding topics and concepts are shown in Table 1.

Table 1. Finance topics and concepts

Berry & Farragher 1987	**McWilliams & Pantalone 1994**	**Gup 1994**	**Cooley & Heck 1996**	**Krishnan et al. 1999**
Academics	**Executives**	**Academics & Executives**	**Academics**	**Students**
Topics	**Topics/subjects**	**Concepts**	**Topics**	**Topics**
Time value of money Capital budgeting techniques Cost of capital/capital structure Valuation theory Working capital	Working capital management Capital budgeting Financial institutions and markets Investments International finance	Present value Cost of capital/CAPM Cashflow and financial statements Risk-Return Capital markets Capital budgeting Capital structure Valuation Accounting	Time value of money Capital budgeting Risk and return Security valuation Cost of capital Financial statement analysis Capital structure	Time value of money Financial statement analysis Security valuation Financial forecasting Investment banking Capital budgeting
			Concepts	
			Present/future value annuity Present/future value single amount Net present value Internal rate of return Valuing stocks Valuing bonds	

Only the research of McWilliams and Pantalone covers the whole finance curriculum; however, the topics referred to are subjects to be included in a finance program (only those identified as required by more than 50% of the respondents in their study are listed here) and so are generally broader than the other topics and concepts listed. Topics for McWilliams and Pantalone, Cooley and Heck and Krishnan et al. are shown in ranked order. Concepts for Gup are generally in ranked order, but academics' and executives' responses have been combined and Gup argues there is little agreement between executives and academics on the top five concepts in finance beyond present value. The topics for Berry and Farragher are based on time spent teaching. The results of the research by Balachandran et al., 2006 and Lai et al., 2009 are not included in the table as they are student rankings of (a sub-set of) the seven most important concepts identified by Cooley and Heck.

Whilst the topics and concepts shown in table 1 are the result of research with different aims, scopes and participants in different contexts, there is a significant amount of overlap. Thus, the topics and concepts can be grouped as follows:

- **capital budgeting** (techniques), internal rate of return
- **capital structure**
- **capital asset pricing model**
- **financial statement analysis**, cashflow and financial statements
- **financial institutions and markets**, capital markets, investment banking, investments
- **risk and return**
- **time value of money**, present value, present/future value annuity/single amount
- **valuation**, valuation theory, security valuation, valuing stocks/bonds, capital asset pricing model
- **working capital (management)**, accounting.

The only topics in the table omitted from these grouping are international finance, which is a subject identified in McWilliams and Pantalone and so too broad to categorise, and financial forecasting, which is only identified by students in Krishnan et al.

Given the partial and fragmented nature of the research into the financial curriculum, whilst not academic research, descriptions of the finance curriculum developed by accrediting bodies can also inform this research. In particular, the Chartered Financial Analyst Institute (CFA), established in the United States in 1947 (CFA Institute, 2014) and

recognised as the leading global accreditation body (Macquarie, 2012), offers its own programs and as such provides a detailed "Candidate Body of Knowledge" (CFA Institute, 2014). The program consists of ten broad topic areas as follows:

1. Ethical and professional standards
2. Quantitative methods
3. Economics
4. Financial reporting and analysis
5. Corporate finance
6. Equity investments
7. Fixed income
8. Derivatives
9. Alternative investments
10. Portfolio management and wealth planning

In addition, increasing mandatory accreditation for higher education programs by government agencies has led to the development of benchmarks or standards. Such standards do not aim to precisely specify the finance curriculum but rather to provide high-level guidelines in relation to minimum outcomes of finance programs (Finance Learning Standards Working Party Australian Business Deans Council, 2014). Therefore, these documents tend to give examples of finance knowledge only. In relation to the Quality Assurance Agency for Higher Education finance benchmark (2007) for the UK, Lakshmi (2013) summarises the example topics as follows:

- market efficiency and role of the markets
- capital budgeting and cost of capital
- behavioural theory of the firm relating to value maximisation
- agency theory, information asymmetry and principal-agency relationship
- risk management practice and theory, including pricing of options
- capital structure and valuation of securities
- international and national environment and impact on the firm
- corporate restructuring
- performance and value
- relationship of finance with the rest of the business
- dividend policy
- accounting and financial data.

Only three examples of knowledge are used in the Australian Academic Learning Standards for Finance in the Australian Higher Education Context prepared by the Finance Learning Standards Working Party Australian Business Deans Council (2014). These are capital budgeting, portfolio risk and return, and credit risk.

Threshold concepts

Previous research on threshold concepts in finance is limited to the work of Diamond and Smith in relation to quantitative finance (Diamond, 2014; Diamond & Smith, 2011) and business statistics (Diamond, 2011). Diamond and Smith's work on quantitative finance focuses on approaches to teaching threshold concepts, with five threshold concepts provided as examples: incomplete markets, Ito's lemma, change of measure and risk neutrality, and cointegration analysis. In Diamond 2011, threshold concept theory is used as a framework to understand the nature of the content of the business statistics curriculum to explain surface versus deep learning. Diamond identifies eight examples of business statistics threshold concepts and maps these concepts using the three category framework developed by Davies and Mangan (2007). Whilst this research informs the current project to a certain extent, it is limited in scope to particular specialised sub-sections of the finance curriculum. The current project goes beyond Diamond's research to investigate threshold concepts in finance more broadly.

Given the limited amount of research specifically on threshold concepts in finance and the interdisciplinary nature of finance, the literature on threshold concepts in economics, accounting, mathematics and statistics is also relevant to the current research. As mentioned previously, threshold concept theory was originally developed in relation to economics, and so the work of Meyer and Land (for example 2003; 2005) and Davies and Mangan (2005; 2007; 2008) is of both general and specific relevance to this project. In particular, Davies and Mangan propose a comprehensive range of examples of economics threshold concepts as well as the three category framework that can be used to understand the threshold concepts in terms of the type of conceptual change they bring about, that is basic, discipline or procedural. According to Davies and Mangan, basic conceptual change involves replacing common sense, everyday understandings with discipline-specific ways of thinking; discipline conceptual change involves understanding and integrating concepts so that a discipline-specific perspective is developed; and procedural conceptual change is the ability to construct narratives and arguments in a discipline.

In the research on threshold concepts in accounting, the primary focus is on more general or generic threshold concepts, and mostly in relation to introductory accounting. Lucas and

Mladenovic (2006; 2007) discuss accepting subjectivity, uncertainty, contextualised meaning and thinking; understanding the organising structures of accounting such as periodicity; and overcoming negative perceptions of accounting as thresholds. Overcoming negative perceptions of accounting is also discussed as a threshold in the work of the McGuigan and Kern (2010) and McGuigan and Weil (2011). Weil and McGuigan (2010) argue that cognitive operations to use data effectively relating to thinking skills are threshold conceptions as opposed to concepts. Stoner and Milner (2010) propose that a move towards a relativistic way of thinking, which is required for modelling, is a threshold concept in accounting. Magdziarz, Myers and Bellamy (2012) explore the interdisciplinary nature of the duality of transactions as a threshold concept in financial accounting. This research informs this project in relation to conceptualising threshold concepts in finance more generally.

In relation to mathematics and statistics (as a type of mathematics) previous research makes proposals for specific threshold concepts. In addition, some research addresses the particular concerns of identifying and developing threshold concepts when the mathematics is "in service" to another discipline as it is in finance, for example, mathematics and statistics for engineers, medical and science students.

In relation to specific proposals for mathematics threshold concepts, at tertiary level Easdown (2007) explores proof as a threshold concept in mathematics, which is also explored in Jooganah (2009). Pettersson (2011) proposes function, limit, derivative, integral and complex numbers and Breen and O'Shea (2012) also explore function as a threshold concept in mathematics. Easdown and Wood (2014) propose fractions, division and algebraic manipulation as secondary to tertiary stage mathematics threshold concepts, with set theory and number theory as a professional or metacognitive stage threshold concept. Bloom et al. (2011) cite linearity, complex numbers and limit as examples of threshold concepts in mathematics.

In relation to statistics, Bulmer, O'Brien and Price (2007) identify confidence intervals, the concept of significance testing (p values), hypothesis testing, analysis of variance and knowing how and when to apply statistical tests and formulas as threshold concepts for introductory level statistics. Dunne, Low and Ardington (2003) propose that threshold concepts in statistics include the notion of patterns of spread or variation, randomness, sampling, central limit theorem, linear regression, and introductions to Bayes' theorem. Dunne et al. (2003) also mention hypothesis testing as a difficult concept, albeit not threshold.

The research on mathematics in other disciplines includes Pettersson (2008) and Scheja and Pettersson (2010) who examine engineering students' understandings of mathematics threshold concepts, showing the link between developing understanding and contextualisation. Galligan, Wandel and Hartle (2010) identify thinking mathematically (which requires the analytical dissection of problems and a degree of trial and error) and making connections to the context as two more general threshold concepts for engineering students. In addition, they argue that functions as a symbolic representation of relationship is a fundamental underlying threshold concept. Wandel (2010) emphasises the importance of making connections between the threshold mathematics concepts in foundation subjects and engineering concepts in later subjects. Also in work related to mathematics for engineering students, Worsley (2011) seeks to identify threshold concepts and students' progression through concept image to concept definition and concept usage. Interviews with academics reveal different emphasis on content or concepts, versus being able to think like a mathematician or critically. Whilst not identifying any specific threshold concepts, Masouros and Alpay (2010) specify identifying and developing resources to teach mathematics threshold concepts as a key aspect of developing the mathematics skills of engineering students.

For statistics in other disciplines, MacDougall (2010) argues that uncertainty is a threshold concept in learning statistics that is troublesome for medical students. Thompson (2008) identifies sampling theory, normal distribution, statistical significance and the concept of effect size as threshold concepts in medical statistics. Quinnell and Thompson (2010) propose hypothesis testing and statistical significance as threshold concepts for science students and argue that unpacking numerical concepts to underlying non-numerical concepts and improving students' confidence in their numeracy skills reduces medical and life sciences students' resistance towards, and anxiety about, mathematics.

The research discussed in the previous two paragraphs identifies mathematics and statistics concepts that are threshold concepts for students studying a discipline other than mathematics ie engineering, medicine and life sciences. Some of these concepts (eg functions and hypothesis testing) are identified as threshold concepts in the research on students specialising in mathematics and statistics, whilst others (eg uncertainty) are also likely to be threshold concepts for all students regardless of specialisation. Thus, identifying threshold concepts in interdisciplinary disciplines, such as finance, enables the extent and exact nature of the "interdisciplinarity" to be described/understood in terms of the essential conceptual knowledge required.

Methodology

Cousin (2009) identifies researching threshold concepts as a methodology for researching learning in higher education, involving collaboration with and participation by discipline specialists, educational specialists and learners. My thesis adopts this methodology and involves collaboration between two finance discipline specialists and two educational specialists as members of a research project team, and other finance specialists and students as participants. The research was conducted in three iterative stages: initial identification of finance threshold concepts by academics, subsequent verification of finance threshold concepts by academics and the extent to which students are aware of finance threshold concepts. These stages are reported in series of three papers which form the body of this thesis.

In common with previous threshold concepts research, data were collected using a range of methods; a combination of focus groups, interviews and questionnaires involving academics and students. However, in this case, the use of questionnaires is primarily motivated by the preference within the finance discipline for quantitative evidence as well as the difficulty experienced in getting students to participate in focus groups and interviews. As a result, different types of data were collected and analysed using a combination of qualitative and quantitative approaches and techniques. Thus, the overall research approach can be described as mixed methods (Johnson & Onwuegbuzie, 2004). A general discussion of the different data collection methods and associated analytical techniques for the overall thesis is provided below. Detailed discussion of methods used in each of the three stages is provided in the methodology section of each paper.

Focus groups – Following Cousin's (2009) identification of the benefits of getting discipline specialists together to identify threshold concepts, focus groups were chosen as an effective way to investigate staff and student perceptions of threshold concepts in finance.

A focus group with finance teaching and research staff was well attended. A brief introduction to threshold concepts (Appendix 2) was given at the start of the focus group (Cousin, 2009) and the discussion was recorded and transcribed. The transcription was analysed linguistically using a bottom-up and top-down approach. For the former, this involved identifying the nominal groups that represented proposals for threshold concepts in finance eg "short-selling", "market efficiency". For the latter, this involved using content (ie change of topic) and structural indicators (eg "Well", "So") to identify distinct sections in the discussion (Halliday & Hasan, 1976; Matthiessen, 2004). The purpose of

this was to gain an understanding of the (semantic) content of the entire discussion (Halliday & Matthiessen, 1999).

Planned focus groups with students were not successful due to lack of attendance by students. Eleven focus groups (with lunch or refreshments provided) were scheduled at times when students would be on campus to attend scheduled classes for subjects prescribed in the finance programs. The focus groups were publicised frequently using multiple channels. Despite this, only five students came to three focus groups – one student for each of two "groups" and three students for another group. The three focus groups were recorded and transcribed.

Interviews – In addition to the staff focus groups, individual interviews were conducted with three key staff using a semi-structured format (Cousin, 2009). A brief introduction to threshold concepts was given at the start of each interview using a visual stimulus (appendix 3) (Cousin, 2009) and the interviewees were asked to consider the threshold concept framework and to make proposals for threshold concepts in finance. Two of the interviews were recorded, transcribed and, as per the staff focus group, the proposals for threshold concepts identified. For the other interview, the interviewee provided a written summary of essential finance concepts.

Questionnaires – Questionnaires enabled the collection of data suitable for more quantitative analysis from finance academics beyond the University faculty and from a greater number of students.

For finance academics an extended questionnaire (Appendix 4) was developed and administered online to finance academics at multiple universities in Australia, Canada, New Zealand, South Africa and the United Kingdom. The questionnaire was used to verify whether the proposals for threshold concepts in finance identified in the focus groups and interviews are threshold concepts and investigate the applicability of the transformative, integrative, irreversible and troublesome characteristics. This questionnaire was also used to investigate the general applicability of threshold concept theory to curriculum design and learning and teaching in finance. A combination of closed (including Likert scale), short answer and open questions was used. Responses to closed and Likert scale and short answer questions were analysed using quantitative techniques. The open ended questions were analysed by identifying the key themes and overall whether the response was positive, negative or neutral.

A short questionnaire (Appendix 5) seeking students' views as to the most important concepts in finance was administered to finance students at Macquarie University. This questionnaire was deliberately brief to encourage participation and so the threshold concept framework was not introduced or referred to. As such, the key data collected by this questionnaire was student nominations for the three most important concepts in finance. The responses were categorised by the project team in relation to the findings of the research with finance academics, namely proposed threshold concepts, type of knowledge (Wood et al., 2012) and the role of modelling in finance. Quantitative techniques were used to summarise and interpret the results of the categorisation process.

Research project team

The research project was originally conceived by Professor Leigh Wood (Associate Dean Learning and Teaching, Faculty of Business and Economics, Macquarie University); and Associate Professor Leonie Tickle and Dr Tim Kyng (Department of Applied Finance and Actuarial Studies, Faculty of Business and Economics, Macquarie University). I joined the research team before any research commenced

I was invited to join the research team by Leigh Wood after conducting some pilot studies on threshold concepts in other disciplines, For me, the appeal of the project was the use of the threshold concept framework. Notwithstanding the debate in the literature about the identification and definition of threshold concepts, particularly in relation to the associated characteristics, discussed above, my own experience of higher education is that is it transformative. In addition, other students have reported to me that they have found particular university subjects to be transformative. Therefore, I believe education can and should be transformative, and I am motivated to investigate what is transformative in academic disciplines, and how this can be made explicit to students to ensure they have a transformative experience of higher education. Both my personal philosophy and the original conception of the research project presuppose the existence of concepts in disciplines that are transformative, that is, threshold concepts. At the same time the project seeks to test and inform threshold concepts both as a theoretical framework and a methodological approach.

The research project team worked as a collaborative group with all members actively involved in the research, particularly key decision making. Generally, the research project, including administration and management, was undertaken by me under the guidance of my supervisor Leigh Wood and associate supervisor Leonie Tickle. The precise research questions, ethics approval, data collection and methods were designed by me in

consultation with my supervisor. In addition, Leonie Tickle and Tim Kyng provided expertise in relation to the finance discipline, as well as learning and teaching in finance. Other specific activities were undertaken as below.

The slide presentation introducing threshold concepts for the staff focus group was prepared by me with input from other members of the project team, particularly Tim Kyng. The staff focus group was organised by Leonie Tickle and facilitated by Tim Kyng and myself; all other focus groups and interviews were organised and conducted by me.

The idea to use a staff questionnaire was originally conceived by Tim Kyng and Leonie Tickle, and then jointly developed by the project team. This was based on their experience as finance experts and their knowledge of research methodologies preferred in finance. The database of finance academics was constructed by Yongqing (Ree) Chen, and the questionnaire was issued by Leonie Tickle, who is a recognised authority in the area, in order to encourage a higher response rate. The student questionnaire was designed and implemented by me.

Finance (discipline) expertise to interpret and classify data as well as guidance in interpreting results was provided by Tim Kyng and Leonie Tickle.

The findings of the research are reported in three co-authored papers (see Findings section below) drafted by me, incorporating feedback from Leigh Wood, Leonie Tickle and Tim Kyng with editorial assistance from Glyn Mather.

The research was supported by funding from the Faculty of Business and Economics (PhD candidate funding and the Learning and Teaching office) and the Macquarie University Competitive Grants Scheme (grant number 9201200424).

Findings

The findings of this research are reported in three papers submitted for publication. A brief summary of the three papers is given below and the papers are presented in chapters 2-4.

Threshold concepts in finance and the role of mathematics – This paper reports on the first stage of the research: the focus group and interviews with University finance academics. The paper contributes to the overall research problem by making proposals for threshold concepts in finance based on primary research involving finance academics for the first time. In addition, the paper makes the role of statistics in finance explicit, while at the same time reporting on the problematic nature of the role of mathematics more generally in finance.

Threshold concepts in finance: conceptualising the curriculum – This paper reports on the second stage of the project: an online questionnaire administered to finance academics from universities in Australia and overseas. Whilst the proposals for threshold concepts in paper 1 represent a significant and original development in the research into threshold concepts in finance, the proposals were uncontested in the focus group discussion and untested in relation to threshold concept theory. This paper makes a significant contribution to the research problem by verifying and refining the proposals for threshold concepts from paper 1 based on quantitative data from finance academics from multiple institutions and countries. Further, it proposes a conceptual model of the finance curriculum and located threshold concepts within this model. The paper also reports on the application of threshold concept theory to (learning and teaching in) finance both specifically – in relation to particular concepts and the transformative, integrative, irreversible and troublesome characteristics; and more generally – using both quantitative and qualitative data as evidence.

Threshold concepts in finance: students' perspectives – This paper reports on the third stage of the project: questionnaires completed by finance students at Macquarie. This paper contributes to the research problem by identifying the extent to which students are aware of the threshold concepts in finance proposed by academics. In addition, it reports on the extent to which different types of knowledge are evident in the students' responses, and hence, students' disposition towards different types of knowledge and their relative location on the conceptual model of the curriculum.

Conclusions

The thesis contributes to the literature on the learning and teaching of finance in that it identifies, for the first time, threshold concepts in finance. Further, it proposes a new conceptual model of the finance curriculum based on different types of knowledge whilst mapping typical topic areas, and locates the finance threshold concepts within this model. The research also identifies the extent to which students are aware of the threshold concepts in finance and their (dis)positions in relation the type of knowledge dimension of the curriculum model. In combination, these three original findings can inform learning and teaching in finance in terms of what to teach, what to make more explicit and how to differentiate the curriculum and curriculum delivery based on the needs and dispositions of students.

In addition, the thesis contributes to threshold concept literature in relation to the methodological approach, particularly in the design of the questionnaire used to verify the

proposed threshold concepts. The research also contributes to threshold concept theory in relation to the relevance of the transformative, integrative, irreversible and troublesome characteristics as well as the value of threshold concepts in learning and teaching (finance) as reported by finance academics.

Chapter 2 – Paper 1 – Threshold concepts in finance and the role of mathematics

Introduction

This paper offers unique and original insights into the finance curriculum and learning and teaching in finance in several ways. It is the first research proposing threshold concepts for finance, rather than specific areas or types of finance such as quantitative finance (Diamond & Smith, 2011) or business statistics (Diamond, 2011). It is also the first research to investigate threshold concepts in (any type of) finance based on primary research with participation by finance academics. In addition, the data collected indicate considerable complexity in relation to mathematics in finance, leading to both the distinction between finance concepts and statistics (as a type of mathematics) in mapping the threshold concepts proposed, as well as a systematic, thematic analysis of the discursive data related to mathematics and (learning and teaching) finance.

As stated in chapter 1, this paper reports on the initial stage of the research: a focus group and interviews with Macquarie University finance academics, undertaken to identify threshold concepts in finance. This was relatively unproblematic in that the nominations for threshold concepts could be easily identified in the transcripts. In addition, in the focus group discussion, specific proposals for threshold concepts were not contested by the different participants, rather when a participant made a suggestion other participants agreed or expanded on the suggestion. This indicates that the proposals for threshold concepts in finance are relatively uncontroversial, at least within the group of academics at the focus group. An example of this agreement and expansion is shown in the extract below.

Participant 1: *Well I think risk measurement, definitions of risk and statistical concepts of distribution and means variances [skewiness] and ways to affect your risk by transferring part of it in insurance, reinsurance. Finance derivatives are really just risk transfer.*
Participant 2: *So I guess the concept of hedging in general.*
Participant 1**:** *Hedging in general, yes.*

In contrast, the discussion in the focus group about mathematics in finance was much more problematic, as the extracts below demonstrate.

Participant: *I think it's not fair to say all students can't understand, there are some students who do think mathematically and they [unclear] to it and they're really good at it and they just swim through the course. So there's - you know you don't, you just want to*

design the course to suit the particular people that you're dealing with, and some of them, the mathematical, they're coping. There are some students who...

Participant: *At the risk of sounding like a broken record here, we're saying, look, our students aren't mathematically strong, let's throw a maths course at them. Or, how about this for an alternative, if our students aren't mathematically strong, let's teach them the key financial concepts through actually going through and model building, using Excel™ […] learning the key concepts, such as arbitrage, efficient markets, short-selling...*

These extracts are just two examples of disagreement during the discussion about mathematics in finance. In addition, despite the fact that the purpose of the focus group was to identify specific threshold concepts in finance, the discussion frequently returned to the topic of mathematics in finance more generally. These two factors indicate that mathematics in finance is problematic. Thus, the paper addresses two research questions "What do finance academics consider to be fundamental to grasping their discipline?" and also "What is the role of mathematics in finance?"

Previous research relevant to mathematics in finance finds that better mathematics skills is associated with higher achievement in quantitative business subjects (Alcock, Cockcroft & Finn, 2008) and interest in or aptitude for finance subjects (Balachandran et al., 2006). However, there is limited discussion of the problematic nature of mathematics in finance, particularly from the point of view of teaching finance. This is in contrast to other disciplines, such as engineering, medical and life sciences, where the implications of limited skills or interest in mathematics and the impact this has on learning and teaching are discussed, such that mathematics is identified as a threshold (concept) in itself (Pettersson, 2008; Scheja & Pettersson, 2010; Galligan et al., 2010; Wandel, 2010; Worsley, 2011). Thus, the examination of mathematics in finance in this paper addresses a significant gap in the literature on learning and teaching finance.

In order to conduct a holistic and systematic analysis of the discussion of mathematics in the focus group, the transcript was divided into 28 sections (elements) based on content (primarily change of topic) and structural indicators – such as change of speaker (turn-taking), questioning (change of speech function), discourse markers (comment adjuncts and cohesive conjunctions) (Halliday & Hasan, 1976; Matthiessen, 2004). Fourteen of these 28 sections are identified as being principally concerned with mathematics (including statistics) in finance. Of the other 14 sections, six are principally about proposals for threshold concepts, four are about various generic skills, two are about the structures of

postgraduate programs or subjects, and the remaining two are the opening and closing sections. The fact that mathematics was the principal concern in half the sections indicates the extent to which the discussion in the focus group was dominated by mathematics.

Further analysis of the 14 sections of the discussion identified five key themes, and further, the extent to which there was agreement or disagreement in relation to these themes. Overall, whilst there seemed to be consensus that it is easier to teach finance if students have higher or advance level (secondary) mathematics skills, there was also consensus that there is wide variation in the mathematics skills of finance students. In contrast, there were widely divergent views on how to respond to the variation of mathematics skills of students; the extent to which (learning and) teaching in finance should be mathematical; and the mathematics skills required to work in finance.

These findings lead to the conclusion that there is scope to clarify the role of mathematics in finance and, indeed, the paper does this by identifying and distinguishing the statistics concepts that are potentially threshold concepts in finance. In addition, these findings also indicate that there is a need to differentiate the delivery of the finance curriculum to suit the differing needs and preferences of the students. At the same time, such differentiation is likely to lead to better learning outcomes for all students because teaching the same concepts and other content in different ways develops deeper understanding.

Paper 1: Threshold concepts in finance and the role of mathematics

Susan Hoadley, Leigh N. Wood, Tim Kyng, Leonie Tickle
Macquarie University

Submitted to: *International Journal of Research in Undergraduate Mathematics Education.*

Abstract

In recent years, the curricula of finance degrees, like many other disciplines, have become overcrowded. At the same time, graduates with well-developed capabilities in finance are in increasing demand. The aim of our research is to identify the threshold concepts that are fundamental to a grasp of finance and so underpin these capabilities in order to improve student outcomes. Based on a focus group and interviews conducted with finance academics, we make proposals for specific threshold concepts in finance, a significant proportion of which are statistics concepts. In addition, we explore the extent to which mathematics more generally is perceived as fundamental to a grasp of finance. We conclude that the role of mathematics in finance can be clarified using a threshold concept approach to curriculum design and pedagogical practices. Previous research on the role of mathematics in finance, particularly from the point of view of teaching finance, is limited, and hence this paper offers new insights in this area.

Keywords: finance; statistics; threshold concepts; education

Introduction

Finance degrees, like so many other degrees offered in Australia and around the world, have to meet the needs of a diverse student cohort (Wood 2001) and increasingly rigorous and multifaceted accreditation requirements (for example Australian Securities and Investments Commission Regulatory Guide 146, Chartered Financial Analyst Institute, Australian Qualifications Framework). The tendency to add more and more material, in part to address these needs, has resulted in an overcrowded curriculum. The aim of our research is to investigate the threshold concepts (Meyer and Land 2003) that are central to the mastery (Cousin 2006) of finance in order to inform curriculum design and pedagogical practices and to improve student outcomes. The context for this research is a degree program in which international finance is taught to international and domestic students, and so the results are relevant to an international audience.

Finance is interdisciplinary, drawing on areas of economics, accounting, mathematics and statistics. The significance of mathematics in finance is evident from the fact that the financial services sector is a major employer of mathematics graduates (Bourner, Greener and Rospigliosi 2009). And indeed, the proposed threshold concepts in finance arising from our research include a significant proportion of statistical concepts as well as (mathematical) modelling. At the same time, our findings explore the role of mathematics in the finance curriculum, under the more general themes of how much mathematics to include and how to develop mathematics capabilities in students.

Following Cousin's (2009) identification of the benefits of bringing together discipline specialists to identify threshold concepts, focus groups were selected as an effective way to identify threshold concepts in finance. We report on the outcomes of a focus group with staff from the finance department at our institution. In addition, supplementary interviews were conducted with three key finance staff.

Threshold concept theory was first developed by Meyer and Land in relation to economics in 2003. Since then, it has been rapidly taken up and widely used in other disciplines, as evidenced by Flanagan's online bibliography (http://www.ee.ucl.ac.uk/~mflanaga/thresholds.html), as a way to research and inform curriculum design, pedagogical practices and professional development of teaching staff. Threshold concept research allows academics to discuss and identify what is fundamental to their disciplines, explores the difficulties students have in grasping threshold concepts and identifies curriculum design interventions (Cousin 2009).

Threshold concept theory proposes that there are a number of concepts that are central to the mastery of any discipline (Cousin 2006) and, as originally described by Meyer and Land, these concepts have five key characteristics (2003):

(1) Transformative – occasions a shift in the perception of the subject
(2) Integrative – exposes the previously hidden interrelatedness of something
(3) Irreversible – unlikely to be forgotten, or will only be unlearned by considerable effort
(4) Troublesome – conceptually difficult and/or counter-intuitive
(5) Bounded – serves as boundary-markers for the conceptual spaces that make up the disciplinary terrain.

In the following sections we review previous research on threshold concepts in the fields of finance, mathematics and statistics as it relates to our focus, describe the methodology for this research activity, make proposals for threshold concepts in finance, explore the role and teaching of mathematics in finance more generally and present our conclusions.

Threshold Concepts Research

Despite the rapid take-up of threshold concept theory, research on threshold concepts in finance is limited to the work of Diamond and Smith in relation to quantitative finance (Diamond 2014; Diamond and Smith 2011) and business statistics (Diamond 2011). However, more work has been done in the area of threshold concepts in mathematics and statistics. These studies have the potential to inform our own research in relation to proposals for specific threshold concepts in finance, more general conceptions of threshold concepts in mathematics, and mathematics and statistics threshold concepts in other disciplines, which are discussed in turn below.

Proposals for specific threshold concepts

Previous research on threshold concepts in quantitative finance, business statistics, mathematics and statistics contains proposals for specific threshold concepts. Generally, this research focuses on key threshold concepts or gives examples of threshold concepts, rather than proposing exhaustive lists. The proposals are summarised in Table 1.

Table 1. Threshold concepts in quantitative finance, business statistics, mathematics and statistics

Quantitative finance	- change of measure, incomplete markets, Ito's lemma and risk neutrality (Diamond and Smith 2011) - cointegration analysis (Diamond 2013)
Business statistics	- basic - central tendency and dispersion, mean vs. median, standard deviation, probability - discipline - probability distribution, continuous vs. discrete, hypothesis testing, significance, correlation, regression, time series data, index - procedural - essential mathematical notation (summation with indexes), operation with equations, polynomials, operations with percentages, meaning of Greek letters, normal distribution tables, ability to visualise distribution and modelling procedures that enable the construction of discipline-specific models, arguments and ways of practising (Diamond 2011)
Statistics	- confidence intervals, the concept of significance testing (p values), hypothesis testing, analysis of variance and knowing how and when to apply statistical tests and formulae (Bulmer, O'Brien and Price 2007) - notion of patterns of spread or variation, randomness, sampling, the central limit theorem, linear regression, and introductions to Bayes' theorem - hypothesis testing difficult albeit not threshold (Dunne, Low and Ardington 2003)
Statistics - in medicine	- uncertainty (MacDougall 2010) - sampling theory, normal distribution, statistical significance and the concept of effect size (Thompson 2008) as threshold concepts in medical statistics.
Statistics - in science	- hypothesis testing and statistical significance (Quinnell and Thompson 2010)
Mathematics	- function, limit, derivative, integral and complex numbers (Pettersson 2011) - function (Breen and O'Shea 2012) - linearity, complex numbers and limit (Bloom et al. 2011) - proof (Easdown 2007; Jooganah 2009) - secondary to tertiary - fractions, division and algebraic manipulation - professional/metacognitive - set theory and number theory (Easdown and Wood 2014)
Mathematics - in engineering	- functions as a symbolic representation of relationship (Galligan, Wandel and Hartle 2010)

The specific proposals for threshold concepts in quantitative finance, business statistics and statistics are considered in section 4 in relation to the specific proposals arising from our research

Conceptualisations of threshold concepts in mathematics

In some of the literature more general conceptualisations of threshold concepts in mathematics are explored. Worsley, Bulmer and O'Brien (2012) research conceptual understandings versus procedural knowledge. Easdown (2009; 2011) discusses syntactic versus semantic reasoning in mathematics, and argues that examining syntactic reasoning errors can reveal the deeper semantic reasoning and underlying threshold concepts. Other researchers emphasise the role and use of mathematical discourse in developing the transformed understanding that is implicit in a threshold concept (Jooganah 2009; Pettersson, Stadler and Tambour 2013). In addition, Pettersson (2012) describes a process of extending contextualisation, linked to concrete everyday life examples, gradually enriched to include a more abstract mathematical understanding through which students develop highly personalised understandings.

Mathematics and statistics threshold concepts in other disciplines

Of particular relevance to this paper is research that focuses on threshold concepts for mathematics and statistics in other disciplines such as engineering, medicine and life sciences. Similar to Pettersson above (2012), the link between developing understanding of mathematics and contextualisation is relevant for engineering students (Galligan, Wandel and Hartle 2010; Pettersson 2008; Scheja and Pettersson 2010) and Wandel (2010) emphasises the importance of making connections between the threshold mathematics concepts in foundation subjects and engineering concepts in later subjects. In other work related to mathematics for engineering students, Worsley (2011) seeks to identify threshold concepts and students' progression through concept image to concept definition and concept usage; in addition, interviews with academics reveal different emphases on content and/or concepts versus being able to think like a mathematician or critically. Thinking is also identified as a more general threshold concept for engineering students by Galligan, Wandel and Hartle (2010). Masouros and Alpay (2010) specify identifying and developing resources to teach mathematics threshold concepts as a key aspect of developing the mathematics skills of engineering students. Quinnell and Thompson (2010) argue that unpacking numerical concepts to underlying non-numerical concepts and improving students' confidence in their numeracy skills reduces medical and life sciences students' resistance towards, and anxiety about, mathematics.

Methodology

Cousin (2009) identifies researching threshold concepts as a methodology for researching learning in higher education, involving collaboration with and/or participation by discipline specialists, educational specialist and learners. The primary question that

threshold concept research is designed to explore is “What do academics consider to be fundamental to a grasp of their discipline?” Cousin advocates focus groups with academics as a research activity to answer this question.

The research activities reported on here consist of a focus group with nine academics from a finance department of an Australian university. In addition, we conducted three individual interviews with senior academics from the same department. The participants have a diverse range of experience both in teaching finance and working in the finance industry.

At the start of the focus group, as a result of experience from another project and influenced by Appleby and Barton (2012), a brief introduction to threshold concepts was given. The introduction made reference to the five characteristics identified above and included three clear examples of threshold concepts from three different non-finance disciplines. The group was then asked to propose potential finance threshold concepts. The subsequent discussion, which lasted just under 45 minutes, was recorded, transcribed and all personal identifiers were removed from the transcription.

The interviews were based on a semi-structured approach and covered both the identification of finance threshold concepts and how these concepts are embedded in the curriculum. Following Cousin (2009), a visual prompt was used to introduce and explain threshold concepts using the five characteristics mentioned previously. Two of the interviews were recorded, transcribed and all personal identifiers were removed from the transcription. For the other interview, the interviewee provided a written summary of essential finance concepts.

All transcripts were initially reviewed by one researcher to identify proposals for potential threshold concepts in finance. The concepts identified were provided to the three other researchers along with the de-identified transcripts for verification. The researchers then met to review the proposed list and refine it to remove duplication, that is, the same concept expressed in different ways or concepts subsumed by a higher level concept. The refined list of proposed threshold concepts was then organised using the framework developed by Davies and Mangan (2007), and considered in relation to proposals from previous research for threshold concepts in quantitative finance, business statistics and statistics.

In addition, prompted by the extent to which the discussion during the focus group focussed on and/or returned to the role and teaching of mathematics in finance more

generally, despite the efforts of the facilitator to return the discussion to specific threshold concepts, the transcript was reviewed by a researcher whose disciplinary background is linguistics and divided into 28 sections based on the content and structural indicators. 14 sections of these 28 sections were identified as being principally concerned with the role and teaching of mathematics in finance more generally, with the other 14 sections being concerned with specific proposals for threshold concepts in finance. The 14 sections of the discussion concerned with the role and teaching of mathematics in finance generally were given a descriptive title and the key points of each section were identified. This analysis was provided to the three other researchers along with the de-identified transcript for verification.

Results and analysis

Finance threshold concepts

As a result of our research, 25 concepts are identified and proposed as threshold concepts in finance. Of these 25 concepts, eight are statistical concepts. Our research has not identified any other specific mathematical concepts as potential threshold concepts in finance, although modelling, which is arguably a mathematical procedure, is identified as a threshold concept. The proposed threshold concepts are shown in Table 2 using the framework developed by Davies and Mangan (2007).

Table 2. Proposed threshold concepts in finance.

Type of conceptual change – transformation and integration (Davies and Mangan 2007)	**Finance**	**Statistics**
Basic - Understanding of everyday experience transformed through integration of personal experience with ideas from discipline.	Information asymmetry Leverage/gearing Market structure(s) Pricing Risk versus return Trade offs	Probability/randomness Expected value Regression to the mean Standard deviation Time series
Discipline - Understanding of other subject discipline ideas integrated and transformed through acquisition of theoretical perspective.	Arbitrage Cashflows Diversification Hedging Market efficiency Opportunity cost Risk Short selling Time value of money Utility/risk preference	Central limit theorem and normal distribution Correlation Statistical significance and hypothesis testing
Procedural - Ability to construct discipline-specific narratives and arguments transformed through acquisition of ways of practising.	Modelling – building, critiquing, implementing, discipline-specific models eg pricing models	

From Table 2 it can be seen that, of the 17 finance threshold concepts proposed, six are categorised as bringing about basic conceptual change, that is, concepts in which common-sense understandings based on everyday experience are replaced by ways of thinking in the discipline (Davies and Mangan 2007). For example, the trade off between risk and return is a concept that is generally understood in terms of risk aversion (fear of making a loss) and desire for a high return (greed). Many people intuitively understand this in the gambling context where a bet may have a high probability of failure but a high payoff in the event of success (eg betting odds). The concept of a trade off between risk and return is given deeper and more specific meaning and context in the study of finance and the trade off is conceived of and modelled in various different ways as is the concept of risk.

Ten concepts are categorised as bringing about discipline conceptual change, that is, interrelated finance concepts that are required for/result in a theoretical perspective. For example, hedging is a way to manage risk and derivative instruments are commonly used

for hedging, thus the concepts of hedging, risk and derivatives inform and transform one another. In combination, they represent an important theoretical perspective in finance.

Finally, modelling is categorised as bringing about procedural conceptual change, being the primary way in which arguments are made in finance, as per Davies and Mangan (2007) in relation to modelling in economics and Diamond (2011) in relation to modelling in business statistics. Modelling enables a more complete understanding of the discipline concepts (Davies and Mangan 2007) through defining and/or quantifying such concepts. That is, in relation to the previous example, modelling enables the calculation and therefore understanding of the amount at risk, the extent to which the risk will be hedged by a particular derivative and the cost of the derivative. The degree of overlap between the finance concepts and the examples of quantitative finance threshold concepts from Diamond and Smith (2011) and Diamond (2014) is limited due to the more specialised nature of quantitative finance.

Of the eight statistical concepts that are proposed as threshold concepts in finance, five are categorised as basic and three as discipline. All of these concepts are identified by Diamond (2011) as threshold concepts in business statistics and our categorisation is consistent with theirs, with the exception of regression to the mean and time series which we categorise as basic rather than discipline. The additional threshold concepts in business statistics identified by Diamond (2011) reflect a more specific focus, that is, business statistics as opposed to finance. In comparison with previous proposals for statistics threshold concepts more generally, four of the statistical concepts we propose – probability/randomness, regression (to the mean), the central limit theorem and normal distribution, and statistical significance and hypothesis testing – are put forward as statistical threshold concepts in other research (Bulmer, O'Brien and Price 2007; Dunne, Low and Ardington 2003; Quinnell and Thompson 2010; Thompson 2008).

Mathematics in finance

The linguistic review of the transcript of the focus group discussion based on content and structural indicators identified 28 distinct sections in the discussion. Half of these sections are primarily about the role and teaching of mathematics in finance more generally; only one of these sections (section 8) is concerned specifically with statistics. The descriptive titles of these sections and their key points are shown in Table 3.

Table 3. Focus group discussion sections relating to mathematics with key points.

Section	Key points
3. The role of mathematics in finance and mathematics skills	Finance should be *"more mathematical"* because some arguments are *"inherently better presented mathematically".* There was general agreement "*at department meetings recently*" that it would be better if students were *"more mathematically adept"* than they are.
7. Importance of mathematical background	Students without a good level of secondary mathematics struggle in finance.
8. Role of statistics (and mathematics)	A recent program review has recommended a different statistics subject for the finance degree, which will have the twofold effect of making advanced secondary mathematics a prerequisite and developing higher level statistics/mathematics skills.
10. Proposal to develop mathematics skills 1	Existing or new tailored subjects could be used as bridging courses to develop mathematics skills.
13. Proposal to develop mathematics skills 2	Returns to the idea of a specific mathematics subject to develop mathematics skills.
14. Thinking mathematically and working in finance	Mathematics bridging courses will not teach students *"to think how mathematics teaches you to think"* and you have to *"think mathematically"* to work in finance. Students who say they are *"not really that mathematical"* are doing finance programs because there are jobs in finance.
15. Mathematics and university entry requirements	Some finance programs have a lower entry requirement so students are less likely to have done higher level secondary school mathematics, thus some finance students are more likely to find the mathematics difficult.
17. Thinking mathematically 1	Returns to the theme of *"thinking mathematically"* and argues that people who do not think mathematically *"rote learn"* to compensate.
18. Prospective jobs and mathematics skills	Students may want / will end up in jobs that do not require *"high level mathematics skills".*
19. Skills required for working in finance	Mathematics skills are not the most important skills for working in finance.
20. Only seeing the mathematics	Students with mathematics skills may be able to do the mathematics but not understand the financial concepts.
21. Counter proposal to developing mathematics skills	Instead of trying to get students who are weak in mathematics to do more mathematics, *"teach the key financial concepts"* in a contextualised way through *"model building using Excel™"* or similar software.
22. Thinking mathematically 2	Some students *"do think mathematically"* and get through finance easily, but the program needs to be designed to suit all the students.
23. Counter proposal to developing mathematics skills continued	Returns to the idea of using Excel™ to teach finance concepts.

Five key interrelated themes are evident in the discussion:

(1) Variation in mathematics skills of finance students (sections 3, 14, 15, 22)
(2) Variation in (mathematics) skills required for finance jobs (sections 14, 18, 19)
(3) How much mathematics should be in finance (sections 3, 20, 21, 22, 23)
(4) The importance of mathematics skills for studying finance (sections 3, 7, 17, 20, 21, 22, 23)
(5) Responses to the variation in the mathematics skills of students (sections 8, 10, 13, 21, 22, 23).

These five themes and their implications are discussed in detail in the following section.

Discussion

The aim of our research is to identify the concepts that are fundamental to a grasp of finance. As with previous research into threshold concepts, our results are both specific and general in nature. That is, they include proposals for specific threshold concepts in finance and also explore concerns about the role and development of mathematics skills more generally in finance. Importantly, whilst there was no dissent in the focus group's discussion in relation to the proposals for specific threshold concepts – such proposals were typically supported by several members of the group – the extent to which mathematics more generally is fundamental to a grasp of finance was subject to debate. We discuss these specific and general results in turn below.

The 25 specific concepts that we have identified as potential threshold concepts in finance are divided into two categories: finance concepts, albeit given the interdisciplinary nature of finance a number of these are recognisably from other disciplines; and statistics concepts. Statistics concepts make up a significant proportion (just under one third) of the proposed threshold concepts in finance, indicating the key role of statistics in finance, and hence the importance of the learning and teaching of statistics in the finance curriculum. Most of the statistics concepts identified are supported by previous research relating to threshold concepts in both business statistics and statistics more generally. The rapid pace of the focus group's discussion, as well as the focus on the general role of mathematics in finance, meant that the specific concepts proposed were not discussed in relation to, and thus not tested against, the five characteristics of threshold concepts. Thus, we anticipate further research to test and refine this list.

As stated previously, approximately half of the sections of the group discussion focus on the role and teaching of mathematics in finance more generally. Fig. 1 shows the five key

interrelated themes of the discussion in relation to one another. The themes of variation in mathematics skills of finance students and variation in (mathematics) skills required for finance jobs are the entry and exit points of the program respectively. The other three themes are impacted by the variation at entry and exit point, but also affect one another.

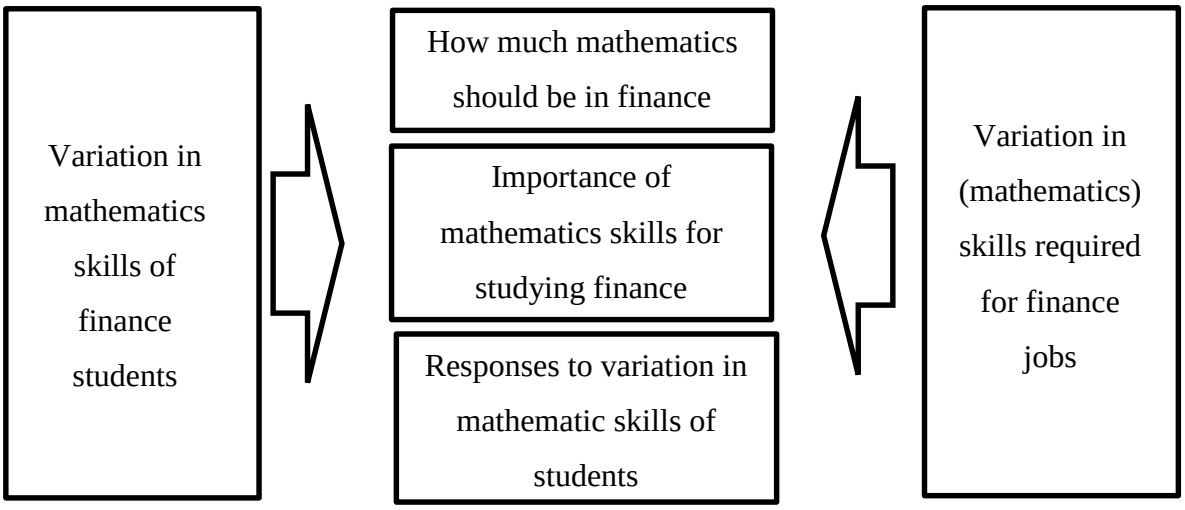


Fig. 1. Key themes of the focus group discussion of mathematics in finance

There is general agreement over the course of the discussion that the mathematics skills of students entering the program vary significantly (sections 3, 14, 15, 22). Although higher level secondary mathematics is assumed knowledge for the finance programs, students can and do enter the programs having done a lower level of mathematics (section 15). According to Quinnell, Thompson and LeBard (2013) based on two Australian studies "students are reducing the level of mathematics they are taking at secondary school".

In contrast, views as to the mathematics skills required to work in finance seem more divergent. At one extreme, it is argued that it is essential to "think" mathematically to work in finance (section 14). However, it is also argued that, whilst some graduates go on to quantitative finance roles which require high level mathematics skills, other graduates work in more general roles that do not need such high level mathematics skills (section 18). Even for specific finance roles it is argued that mathematical skills are not always the most important skills required (section 19). The idea that the mathematics skills required to work in finance roles varies is supported by other research (Wood, Petocz and Reid 2012).

In line with the lack of agreement about the mathematics skills required to work in finance, the discussion reflects debate about the extent to which finance should be more or less mathematical. At the beginning of the discussion a participant suggests that there should be more mathematics in finance programs (section 3), whereas later in the discussion this is

argued against in favour of focusing on teaching finance concepts, using Excel™ for example (sections 21 and 23). The identification of specific threshold concepts in finance offers a way of defining the extent to which finance needs to be mathematical, and indeed the identification of the eight statistics concepts as threshold concepts in finance is a first step in doing this. However, the variation in mathematics skills of students entering the program and the mathematics skills required by graduating students creates uncertainty and pressure to go beyond the scope of this definition.

The research of Alcock, Cockcroft and Finn (2008) shows higher and advanced secondary mathematics improves grade outcomes for quantitative business subjects and it is generally acknowledged in the focus group discussion that mathematics skills are beneficial to students studying finance (sections 3, 7 and 22). However, the variation in the mathematics skills of students coming into the program means that academics cannot rely on students having these skills, or an interest in developing them (Quinnell and Thompson 2010). Identifying the threshold concepts in finance, as well as identifying essential mathematics concepts, will lead to a more explicit understanding of how these concepts relate to the finance concepts. In this way, the role and relevance of mathematics in/to finance can be made explicit to (potential) students, as emphasised by Wandel (2010) in relation to mathematics for engineering students and Quinnell, Thompson and LeBard (2013) in relation to mathematics for science students.

In relation to possible responses to variation in the mathematic skills of students, one focus of the discussion is reducing the variation in the mathematics skills of the students by assuring/developing mathematics skills through a combination of prerequisites/bridging courses/additional mathematic subjects (sections 8, 10 and 13). Faced with similar variation in the mathematics skills of engineering students, universities respond by introducing stricter entry criteria to assure the mathematics skills of students coming into the program and/or by providing more remedial mathematics (Masouros and Alpay 2010). However, the former involves changes at an institutional and policy level that are unlikely to occur and the latter involves trying to get students with weaker mathematics skills to do more mathematics (section 21). According to Quinnell and Thompson (2010), students studying other disciplines may be resistant towards mathematics, regardless of their level of mathematics skills. Furthermore, separate mathematics subjects position mathematics as separate to and removed from finance, as a barrier or a hurdle to be overcome before students "get to" finance rather than as integral to finance. In their most recent work, Quinnell, Thompson and LeBard (2013) emphasise the importance of stopping science

students from seeing scientific tasks that require mathematics or statistics skills as separate and as mathematics or statistics rather than science.

An alternative response to the variation in mathematics skills of the students proposed in the discussion is to focus on teaching the finance concepts in a contexualised way that is less dependent on (high level) mathematics skills (sections 21 and 23). The importance of contextualisation in developing mathematics threshold concepts is emphasised in other research. Galligan, Wandel and Hartle (2010) identify teaching mathematics in (engineering) contexts as a powerful way to develop students' understanding of mathematics. Further, Pettersson (2008) and Scheja and Pettersson (2010) argue that students' ability to contextualise mathematical concepts represents transformative conceptual development in the understanding of the concepts.

Conclusions

Our research supports threshold concepts research as an effective technique to investigate curricula (Cousin 2009). Our focus group was well attended and the discussion lively, and academics were very willing to participate in the research and continue to express an interest in the progress of the project.

Notwithstanding definite proposals for specific threshold concepts in finance, approximately one third of which are statistics concepts, the extent to which mathematics is central to a grasp of finance is subject to debate in terms of how much to teach and how to teach it. This debate arises, in part, because the curriculum of finance programs is expected to prepare students with varying skills in mathematics for a wide variety of finance roles which in turn require varying levels of mathematics skills. Whilst institutional responses could reduce the variation in the mathematics skills of the students coming into finance programs and the variation in the jobs the program aims to prepare students for, such responses need institutional support; take time to implement and have an effect; tend to be mitigated by other factors such as the perceptions of students and the job market; and may be unnecessarily limiting.

Given the previous point, this research indicates the value of using threshold concept theory to gain a better understanding of the finance curriculum and the role of mathematics in finance, making the role of mathematics, especially statistics in finance, explicit to students and developing learning and teaching strategies to meet the needs of students who might reasonably be expected to be primarily interested in finance rather than mathematics.

Our future research will focus on refining and/or validating the potential threshold concepts in finance identified in this paper, using the characteristics of threshold concepts identified by Meyer and Land (2003), and defining the mathematics skills implied in these concepts. In addition, we will investigate students' perceptions of threshold concepts in finance, with particular attention to the role of mathematics, and consider curriculum models that will explicitly focus on the learning of these key concepts.

Acknowledgement

This work was supported by the Macquarie University Competitive Grants Scheme under Grant 9201200424.

References

Alcock, J., S. Cockcroft and F. Finn. 2008. Quantifying the advantage of secondary mathematics study for accounting and finance undergraduates. *Accounting & Finance* 48(5):697–718.

Appleby, Y. and A. Barton. 2012. Case study : Engaging conceptual learning about threshold concepts with pots and pans. *Journal of Learning Development in Higher Education* 4 (March), http://www.aldinhe.ac.uk/ojs/index.php?journal=jldhe&page=article&op=view&path[]=137&path[]=101 (accessed October 8, 2013).

Bourner, T., S. Greener and A. Rospigliosi. 2009. Mathematics students' next steps after graduation. *International Journal of Mathematical Education in Science and Technology* 40(6): 777–793.

Bulmer, M., M. O'Brien and S. Price. 2007. Troublesome concepts in statistics: A student perspective on what they are and how to learn them. In *Assessment in Science Teaching and Learning Symposium, University of Sydney, September 28-29*. Sydney, Australia, pp. 139–144, http://openjournals.library.usyd.edu.au/index.php/IISME/article/view/6337 (accessed October 16, 2013).

Cousin, G. 2006. An introduction to threshold concepts. *Planet* 17:4–5.

Cousin, G. 2009. *Strategies for researching in higher education: An introduction to contemporary methods and approaches*. New York and London: Routledge.

Davies, P. and J. Mangan. 2007. Threshold concepts and the integration of understanding in economics. *Studies in Higher Education* 32(6):711–726.

Diamond, R.V. 2011. *Analysis of assessment data from statistics courses: Grade distributions, surface learning and threshold concepts*, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1890833 (accessed October 8, 2013).

Diamond, R.V. 2014. *Learning and trusting cointegration in statistical arbitrage*, http://ssrn.com/abstract=2220092 (accessed October 8, 2013).

Diamond, R.V. and H.J. Smith. 2011. *Threshold concepts: A disciplinary enquiry in quantitative finance*, http://ssrn.com/abstract=1890837 (accessed October 8, 2013).

Dunne, T., T. Low and C. Ardington. 2003. Exploring threshold concepts in basic statistics, using the internet. In *The International Association for Statistical Education, Statistics & the Internet.* Berlin, Germany. Available at: http://iase-web.org/documents/papers/sat2003/Dunne.pdf (accessed June 26, 2014).

Easdown, D. 2009. Syntactic and semantic reasoning in mathematics teaching and learning. *International Journal of Mathematical Education in Science and Technology* 40(7): 941–949.

Easdown, D. 2011. Excursions to and from semantic oblivion. In *35th Conference of the International Group for the Psychology of Mathematics Education*. Ankara, Turkey, http://talus.maths.usyd.edu.au/u/pubs/publist/preprints/2011/easdown-2.pdf (accessed October 16, 2013).

Easdown, D. and L.N. Wood. 2014. Novel Threshold Concepts in the Mathematical Sciences. *In National Academy's Sixth Annual Conference and the Fourth Biennial Threshold Concepts Conference.* Dublin, Ireland, pp. 44–50, http://www.nairtl.ie/documents/EPub_2012Proceedings.pdf#page=54

Galligan, L., A.P. Wandel and R.T. Hartle. 2010. Scaffolding distance learning in mathematics for engineering: Identifying key troublesome knowledge. In *STEM in Education Conference, 26 & 27 November 2010 - Queensland University of Technology*. Brisbane, Australia, http://eprints.usq.edu.au/19325/2/Galligan_Wandel_Hartle_STEM_2010_AV.pdf (accessed October 16, 2013).

Jooganah, K. 2009. *Proof as a threshold concept for university mathematics: An exploration of student identity and transition*, http://www.education.manchester.ac.uk/research/centres/lta/ltaresearch/transmaths/into-he/papers/ (accessed October 16, 2013).

Masouros, S.D. and E. Alpay. 2010. Mathematics and online learning experiences: A gateway site. *European Journal of Engineering Education* 35(1):59–78.

Meyer, J.H.F. and Land, R. 2003. Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising, In *Improving student learning - theory and practice ten years on*, ed. C. Rust, 412-424. Oxford: Oxford Centre for Staff and Learning Development (OCSLD).

Pettersson, K., 2008. *Algoritmiska, intuitiva och formella aspekter av matematiken i dynamiskt samspel (Algorithmic, intuitive and formal aspects of mathematics in dynamic interplay: A study of students' use of their conceptions in calculus)*. Chalmers Tekniska Högskola och Göteborgs Universitet, http://kurser.math.su.se/file.php/532/Kerstin_Pettersson.pdf (accessed October 16, 2013).

Pettersson, K. 2012. *The threshold concept of a function – a case study of a student's development of her understanding*, Umeå, Sweden. http://www.mai.liu.se/SMDF/madif8/Pettersson.pdf (accessed October 16, 2013).

Pettersson, K., E. Stadler and T. Tambour. 2013. *Development of students' understanding of the threshold concept of function*, http://cerme8.metu.edu.tr/wgpapers/WG14/WG14_Pettersson.pdf (accessed October 16, 2013).

Quinnell, R. and R. Thompson. 2010. Conceptual intersections: Re-viewing academic numeracy in the tertiary education sector as a threshold concept. In *Threshold concepts and transformational learning*, eds. R. Land, J.H.F. Meyer and C. Baillie, 147–164. Rotterdam, Holland: Sense Publishers.

Quinnell, R., R. Thompson and R.J. LeBard. 2013. It's not maths; it's science: Exploring thinking dispositions, learning thresholds and mindfulness in science learning. *International Journal of Mathematical Education in Science and Technology* 44(6): 808–816.

Scheja, M. and K. Pettersson. 2010. Transformation and contextualisation: Conceptualising students' conceptual understandings of threshold concepts in calculus. *Higher Education* 59(2): 221–241.

Thompson, R. 2008. Sexing up stats: Dealing with numeracy issues and threshold concepts in an online medical statistics course. In *Australian and New Zealand Association for Medical Education*, http://www.unsworks.unsw.edu.au/primo_library/libweb/action/dlDisplay.do?vid=UNSWORKS&docId=unsworks_7053&fromSitemap=1&afterPDS=true (accessed October 16, 2013).

Wandel, A.P. 2010. Linkages between courses: A holistic approach to programmes. In *21st Annual Austalasian Association for Engineering Education (AaeE) Conference: Past, Present, Future - the "keys" to engineering education research and practice, 5-8 December 2010, University of Technology*. Sydney, Australia, pp. 177–180, http://eprints.usq.edu.au/9198 (accessed October 16, 2013).

Wood, L.N. 2001. The secondary-tertiary interface. In *Teaching and Learning of Mathematics at University Level: An ICMI Study*, ed. D. Holton, 87–98. Dordrecht: Kluwer.

Wood, L.N., P. Petocz and A. Reid. 2012. *Becoming a mathematician: An international perspective*, Dordrecht: Springer Netherlands.

Worsley, S.R., 2011. The big ideas in two large first level courses of undergraduate mathematics. In *Mathematics: Traditions and [New] Practices, AAMT23/MERGA34,*. Alice Springs, Australia, pp. 839–845, http://www.merga.net.au/documents/RP_WORSLEY_MERGA34-AAMT.pdf (accessed October 8, 2013).

Worsley, S.R., M. Bulmer and M. O'Brien. 2012. Threshold concepts and troublesome knowledge in a second-level mathematics course. In *Assessment in Science Teaching and Learning Symposium, University of Sydney, September 28-29*. Sydney, Australia, pp. 139–144, http://openjournals.library.usyd.edu.au/index.php/IISME/article/view/6256 (accessed October 16, 2013).

Chapter 3 – Paper 2 – Threshold concepts in finance: conceptualising the curriculum

Introduction

This paper makes an original research contribution in its findings in relation to specific threshold concepts in finance as well as their relationship to the finance curriculum more generally and the value of threshold concepts to learning and teaching in finance. In addition, it takes a unique approach to threshold concept research in that the approach is primarily quantitative, responding to a preference within the finance discipline for quantitative evidence.

The main purpose of the research reported on in this paper was to verify the proposals for specific threshold concepts in finance arising from the first part of the research, in which participation was limited to finance academics at one institution. In order to do this, an online questionnaire was sent to finance academics at multiple universities in Australia, Canada, New Zealand, South Africa and the United Kingdom. In addition, the questionnaire gave the respondents the chance to nominate important concepts in finance independently, in advance of seeing the 25 threshold concepts in finance previously proposed, and analyse all the concepts (up to 30) using the threshold concepts framework.

After an introduction to threshold concept theory using opportunity cost as an example (Meyer & Land, 2003; Davies & Mangan, 2007), the five concepts nominated by the respondents and the 25 threshold concepts previously proposed were combined into a single list. The respondents were asked to indicate whether each of the concepts satisfies the transformative, integrative, irreversible and troublesome characteristics and whether it is a threshold concept. The respondent could select from "yes", "no" or "unsure". In order to limit the demands of an already demanding questionnaire, the bounded characteristic was omitted and respondents were not forced to respond to every item.

The responses were scored +1 for "yes", 0 for "unsure" and -1 for "no". Where a concept nominated by a respondent was the same as a concept in the list or a concept nominated by another respondent the scores were combined. (The finance experts in the research team used judgement to determine if different wording reflected the same underlying concept. For example, "efficient market theory", "efficient markets", "efficient market hypothesis", "efficiency" and "market qualities (perfect information etc.)" were all included in the "market efficiency" concept.)

The output of this process was numerical scores for whether or not a concept is a threshold concept and whether it satisfies the four characteristics. The score for whether or not a concept is a threshold concept was used to rank the 25 proposed threshold concepts in finance. Primarily based on this score, but with reference to the score for the transformative, integrative and irreversible characteristics as well as the extent to which a concept was independently nominated, 10 of the 25 concepts are considered to be clearly endorsed as threshold concepts in finance, with three concepts considered to be clearly rejected as threshold concepts in finance. For the remaining 12 concepts the results were considered to be unclear. In addition, the process resulted in an additional seven concepts that were independently nominated by respondents but not on the original list being proposed as threshold concepts in finance. As these concepts were nominated during the course of the survey, only the respondents who nominated them (N = 2-14) were able to indicate that the concepts are threshold concepts and whether the four characteristics apply. Thus, these seven concepts have not been proposed and subsequently verified in the same way as the 25 original proposed concepts.

In addition, by comparing the scores for the characteristics with the threshold score, this approach also provides quantitative evidence on the relationship between a concept satisfying a characteristic and being a threshold concept. Despite the fact that the four characteristics: transformative, integrative, irreversible and troublesome were used to introduce and explain threshold concepts, the respondents did not necessarily perceive these characteristics as defining characteristics. Although, there was found to be a clear relationship between the transformative, integrative and irreversible characteristics and a concept being a threshold concept, but no clear relationship was found between a concept being considered troublesome and being threshold. This finding is in contrast to other threshold concept research which emphasises and focuses on the troublesome characteristic (Barradell, 2013). However, it has been argued that the troublesome-ness may be a result of significant (conceptual and ontological) change brought about rather than an inherent feature of the concept itself (Land et al., 2014). Therefore, finance academics who have mastered finance and gone through the conceptual and ontological change may find it difficult to recognise this characteristic. There may also be other sources of troublesome-ness such as the way the concept is taught or the cultural context (Quinlan et al., 2013), so not everything that is troublesome is a threshold concept, which also explains the finding.

As well as refining the proposed list of concepts, the data collected and the results of the research prompted consideration of where threshold concepts are located within the

conceptual space (Shinners-Kennedy & Fincher, 2013) of the finance curriculum. The model of the curriculum developed uses types of knowledge (Wood et al. 2012, Baillie et al., 2012) as a dimension, where threshold concepts are central to and underpin applied, professional and contextual knowledge. The procedural threshold concept, modelling is conceptualised as extending to applied, professional and contextual knowledge, being the way arguments and narratives are constructed in the practice, as well as the discipline of finance. For example, modelling as professional knowledge is "financial analysis" informed by contextual knowledge such as "economic conditions" and "regulations", which themselves are both informed by and inform modelling. Topics that traditionally form the basis for the way the finance curriculum is described and organised can be located and understood in relation to the model proposed. In providing a model of the finance curriculum as a whole, the paper differs from previous research on the finance curriculum which focuses on a particular stage (eg introductory finance – Balachandran et al., 2006; Krishnan et al., 1999) or more on a specific profession (eg financial planners – Jackling & Sullivan, 2007; accountants or chief financial officers – Lakshmi, 2013; entrepreneurs – Roth, Envick and Anderson, 2002).

Finally, in relation to threshold concepts and learning and teaching finance more generally, the research investigates finance academics' views as to the value of threshold concepts. This is a unique aspect of this paper as the value of threshold concepts is usually regarded as a given in threshold concepts research. Based on responses using the Likert scale, the research provides quantitative evidence that finance academics who responded to the survey consider that threshold concepts can assist with curriculum design and learning and teaching in finance. This is supported and elaborated by the analysis of the responses to an open question about the value of threshold concepts to learning and teaching finance.

Paper 2: Threshold concepts in finance: conceptualising the curriculum

Susan Hoadley, Leonie Tickle, Leigh N. Wood, Tim Kyng
Macquarie University

Published in: *International Journal of Mathematical Education in Science and Technology.* (2015) http://dx.doi.org/10.1080/0020739X.2015.1011244

Abstract

Graduates with well-developed capabilities in finance are invaluable to our society and in increasing demand. Universities face the challenge of designing finance programs to develop these capabilities and the essential knowledge that underpins them. Our research responds to this challenge by identifying threshold concepts that are central to the mastery of finance and by exploring their potential for informing curriculum design and pedagogical practices to improve student outcomes. In this paper, we report the results of an online survey of finance academics at multiple institutions in Australia, Canada, New Zealand, South Africa and the United Kingdom. The outcomes of our research are recommendations for threshold concepts in finance endorsed by quantitative evidence, as well as a model of the finance curriculum incorporating finance, modelling and statistics threshold concepts. In addition, we draw conclusions about the application of threshold concept theory supported by both quantitative and qualitative evidence. Our methodology and findings have general relevance to the application of threshold concept theory as a means to investigate and inform curriculum design and delivery in higher education.

Keywords: finance; statistics; threshold concepts; learning and teaching

1. Introduction

Graduates with well-developed finance skills are invaluable to our society. For example, wealth management – which relies on financial expertise – is predicted to be one of Australia's five most important industry sectors in the near future. [1] Universities face the challenge of providing finance programs to develop these essential skills, at the same time meeting the needs of a diverse student cohort. Our research responds to this challenge by identifying the threshold concepts [2] that are central to the mastery [3] of finance and their potential for informing curriculum design and pedagogical practices, to improve student outcomes. The context for our research is the two undergraduate finance programs offered at our institution. These programs have a strong focus on international finance and a large student cohort (2,400 plus) of international and domestic students. In addition, we extend our research to include finance academics from five countries, including Australia, as participants. Thus, our research and the results are relevant to both domestic and international audiences.

Our project involves a combination of focus groups, interviews and surveys to investigate university staff and student perceptions of threshold concepts in finance. In this paper, we report on the results of an online questionnaire sent to finance academics to gain feedback on the finance threshold concepts proposed as a result of our previous research activities. Whereas our prior research was limited to staff from our institution, the online questionnaire was sent to finance academics at multiple institutions in Australia, Canada, New Zealand, South Africa and the United Kingdom. As well as requesting feedback on the proposed finance threshold concepts – using key characteristics of threshold concepts described below – the questionnaire also asks respondents to nominate important concepts in finance independently and apply the identified characteristics to these concepts. Finally, the survey includes questions relating to the value of threshold concept theory to the learning and teaching of finance more generally.

Student focus groups and surveys are currently being undertaken to investigate student perceptions (following [4, 5]) of threshold concepts in finance. The results of these, particularly in comparison to the perceptions of finance academics, will be reported separately.

Threshold concept theory was initially developed by Meyer and Land in relation to economics in 2003 and has been rapidly and widely applied to other disciplines – as demonstrated by the bibliography collated by Flanagan [6] – in order to research and

inform curriculum design, pedagogical practices and professional development of teaching staff. Threshold concept research allows academics to discuss and identify the concepts that are fundamental to their discipline; explores the difficulties students have in grasping these concepts; and identifies curriculum design interventions to facilitate their learning and teaching. [7] Threshold concepts have five key characteristics: [2]

(1) Transformative – occasions a shift in the perception of the subject
(2) Integrative – exposes the previously hidden interrelatedness of something
(3) Irreversible – unlikely to be forgotten, or will only be unlearned by considerable effort
(4) Troublesome – conceptually difficult and/or counter-intuitive
(5) Bounded – serves as boundary markers for the conceptual spaces that make up the disciplinary terrain.

In the following sections we review previous research on threshold concepts in the fields of finance, mathematics and statistics as it relates to our focus, describe the methodology for our research activity, present, analyse and discuss our results, and draw some overall conclusions.

2. Threshold concepts research

Previous research on threshold concepts in finance consists of working papers by Richard Diamond and a conference presentation by Richard Diamond and Holly Smith in relation to quantitative finance and business statistics. [8] Our research attempts to identify the threshold concepts for a general finance program at undergraduate level, and thus, whilst informed by the work of Diamond and Smith, has a broader focus. As a result of previous research activities with finance staff at our institution, we developed a list of 25 potential threshold concepts in finance. These 25 concepts are shown in Table 1 using the framework developed by Davies and Mangan [9] in relation to economics and further divided into ‘finance’ and ‘statistics’ concepts.

Table 1. Proposed threshold concepts in finance

Type of conceptual change – transformation and integration	Finance	Statistics
Basic - Understanding of everyday experience transformed through integration of personal experience with ideas from discipline.	Information asymmetry Leverage/gearing Market structure(s) Pricing Risk versus return Trade offs	Probability/randomness Expected value Regression to the mean Standard deviation Time series
Discipline - Understanding of other subject discipline ideas integrated and transformed through acquisition of theoretical perspective.	Arbitrage Cashflows Diversification Hedging Market efficiency Opportunity cost Risk Short selling Time value of money Utility/risk preference	Central limit theorem and normal distribution Correlation Statistical significance and hypothesis testing
Procedural - Ability to construct discipline-specific narratives and arguments transformed through acquisition of ways of practising.	Modelling – building, critiquing, implementing, discipline-specific models eg pricing models	

The basic, discipline and procedural categories identified by Davies and Mangan (left column, Table 1) refer to the type and scale of conceptual change implied in the concept. For basic concepts, a common sense understanding is replaced with a discipline-specific way of thinking, thus the conceptual change is profound. [9] Discipline concepts connect with and inform other discipline concepts/ideas leading to the acquisition of organising schemas. [9] Finally, procedural concepts, such as modelling in the case of finance, refer to a whole range of ways to construct narratives and arguments in the discipline through which other concepts are defined and understood. [9]

All of the eight statistics concepts we identified (as shown in table 1) are also identified by Diamond as threshold concepts in business statistics. He identifies additional threshold concepts in business statistics; however, this reflects a different, more specific focus – business statistics as opposed to finance – rather than a contradiction. Four of the statistical concepts we propose as potential threshold concepts in finance – probability/randomness, regression (to the mean), central limit theorem and normal distribution, and statistical

significance and hypothesis testing – are identified as statistical threshold concepts in other research. [10–12]

Our previous research does not identify any other mathematics concepts as potential specific threshold concepts in finance, other than the eight statistical mathematics concepts shown above. However, modelling, which is arguably a mathematical concept, is identified as a threshold concept. Similarly, Diamond identifies modelling as a type of threshold concept in business statistics as do Davies and Mangan [9] in relation to economics.

3. Methods

The online questionnaire was emailed to 753 finance academics at multiple universities in Australia, Canada, New Zealand, South Africa and the United Kingdom identified from information available on university websites. The questionnaire consists of three sections. The first section (Section A) consists of four biographical questions relating to the disciplinary background and experience of the respondents. The second section (Section B) requires respondents to nominate the five concepts they feel are most important in finance, introduces threshold concept theory and asks respondents to indicate whether the transformative, integrative, irreversible and troublesome characteristics apply to each of the concepts they have nominated and the threshold concepts identified in our previous research. For the purposes of managing the length/demands of the questionnaire and given the interdisciplinary nature of finance, the bounded characteristic is not included in the questionnaire. Respondents are also asked whether each concept is a threshold concept. For these questions the respondents select from yes, no and unsure. Finally, the third section of the questionnaire (Section C) uses a Likert scale to assess the respondents' exposure to and/or understanding of threshold concept theory and their opinion in six questions relating to the value of threshold concept theory for learning and teaching finance more generally. Respondents are also given the opportunity to add any other comments.

The responses are analysed using a combination of quantitative techniques for the closed questions and qualitative techniques for the open questions. For the latter, expressions reflecting conceptions of the application of threshold concept theory to learning and teaching in finance are analysed based on similarities, differences and complementarities. [13]

4. Results

We received 44 responses with the biographical section (Section A) plus at least one of the other two sections completed. Of these 44 responses, 43 nominated important concepts in

finance and/or assessed the concepts in terms of the characteristics to some extent. Thus, *N* for Section B ranges from 24–43 depending on the number of responses for each concept/characteristic. Thirty-six responses of the 44 responses contained information in relation to the value of threshold concept theory for learning and teaching finance more generally (Section C). Whilst the low response rate was not entirely unexpected given the method of distribution (email with one follow up email), the relative "newness" of threshold concepts and the fact that the questionnaire is quite long, it potentially increases the margin of error. This has been taken into account in interpreting the results.

4.1 Biographical information (Section A) N = 44

Respondents were asked to indicate their disciplinary background by selecting from a list, with the option to specify a discipline that was not on the list. The majority of respondents (32) selected finance as their disciplinary background, with a further two respondents specifying finance in combination with either accounting or economics. The remaining respondents identified actuarial studies or economics (3 each), accounting (2), or statistics or marketing and business sciences (1 each) as their disciplinary background.

In terms of teaching experience, respondents were asked to indicate how long they had been teaching finance and how long they had been teaching in higher education. They could choose from a range of four options; no teaching experience, up to three years, four to nine years, over 10 years teaching experience. We investigated teaching experience in finance in conjunction with teaching experience in higher education and found that 28 respondents have been teaching in both finance and in higher education for 10 or more years; five respondents for four to nine years; and four for three years of fewer. A further two respondents have been teaching in higher education for over 10 years but have less experience in teaching finance. The remaining five respondents indicated no teaching experience in finance, but two of these have over 10 years of teaching experience in higher education. Thus, 32 of the respondents have 10 or more years teaching experience in higher education.

They were also asked to indicate their main role in teaching undergraduate finance by selecting from tutor, lecturer, subject coordinator and degree/program coordinator, with the option to specify a role that was not on the list. Three respondents selected tutor, 12 selected lecturer, 15 selected subject coordinator and 10 selected degree/program coordinator. Of the remaining four respondents, three indicated that they taught at other levels than undergraduate and one stated they are in a research only position.

4.2 Finance concepts (Section B) N = 24–43

Table 2 shows the list of 25 proposed concepts together with results as to whether each concept was: independently suggested; regarded as threshold; and seen to satisfy the four characteristics: transformative, integrative, irreversible and troublesome. The first column indicates the proportion of respondents who independently suggested the concept when asked to name the five most important finance concepts: this question was asked prior to providing respondents with the list of potential concepts. The authors have used judgement to determine if different wording reflects the same underlying concept as one of the 25 proposed concepts. For example, 'efficient market theory', 'efficient markets', 'efficient market hypothesis', 'efficiency' and 'market qualities (perfect information etc.)' were all included in the 'market efficiency' concept. The remaining columns show the mean rating of whether the concept is threshold and satisfies the threshold characteristics, where -1 indicates 'no', 0 indicates 'unsure' and +1 indicates 'yes'. The concepts have been sorted from highest to lowest rating of whether the concept is regarded as threshold.

Table 2. Suggested concepts, and mean assessment of whether given concepts are threshold and satisfy threshold characteristics (-1 = no, 1= yes)

Concept	Independently suggested (% of respondents)	Mean rating of whether the concept is threshold and satisfies characteristics				
		Threshold	Transform-ative	Integrative	Irreversible	Troublesome
Time value of money	74%	0.86	0.90	0.64	0.80	0.25
Arbitrage	30%	0.79	0.71	0.73	0.46	0.77
Risk versus return	42%	0.63	0.62	0.85	0.92	-0.08
Opportunity cost	5%	0.57	0.54	0.62	0.54	0.77
Diversification	26%	0.55	0.66	0.77	0.64	0.08
Expected value	9%	0.50	0.18	0.46	0.32	0.15
Risk	21%	0.46	0.37	0.60	0.40	0.12
Market efficiency	23%	0.44	0.62	0.48	0.33	0.44
Hedging	5%	0.32	0.24	0.40	0.16	0.34
Information asymmetry	0%	0.28	0.42	0.50	0.13	0.38
Utility / risk preference	0%	0.11	0.15	0.36	0.08	0.69
Correlation	0%	0.07	0.07	0.38	0.33	0.08
Leverage / gearing	0%	0.04	0.12	0.24	0.24	-0.36
Cashflows	7%	0.00	0.07	0.54	0.44	-0.32
Central limit theorem and normal distribution	0%	0.00	0.00	0.07	0.19	0.60
Pricing	0%	0.00	-0.07	0.21	-0.08	-0.08
Trade offs	0%	0.00	0.12	0.46	0.29	-0.11
Market structure(s)	0%	-0.03	-0.04	0.04	-0.15	-0.20
Modelling*	5%	-0.11	0.08	0.48	-0.08	0.20
Statistical significance and hypothesis testing	0%	-0.11	-0.08	0.00	-0.50	0.82
Probability / randomness	5%	-0.12	0.12	0.54	0.16	0.41
Time series	0%	-0.14	-0.26	-0.16	-0.20	0.31
Standard deviation	0%	-0.25	-0.19	-0.08	0.08	-0.04
Short selling	0%	-0.27	-0.27	-0.08	0.00	0.41
Regression to the mean	0%	-0.41	-0.15	-0.20	-0.21	0.30
Average mean		**0.17**	**0.20**	**0.35**	**0.21**	**0.24**

***** The modelling concept is fully stated as 'Modelling – concept of, building, critiquing, implementing, discipline-specific models eg pricing models'.

Note: The proportion of respondents answering each question varies from N=24 to N=43. Averaging is over the number of respondents answering the particular question of interest.

The ratings of whether concepts are threshold show a fairly clear 'yes' response for 10 concepts listed in the table (all of which score ≥ 0.25 – shown as not shaded), an unclear conclusion for the following 12 (all of which score between -0.25 and 0.25 – shown with light shading) and a clear 'no' response for the final three concepts (≤ -0.25 – shown with heavy shading). Almost all of the 10 fairly clear 'yes' concepts were also independently suggested by at least one person and usually many more: for example, three-quarters of the sample independently named the 'time value of money' as one of the most important finance concepts. In contrast, only three of the other 15 concepts were independently

suggested and even then only by one or two respondents. Statistical concepts were rarely independently suggested and were also less often rated as threshold. Despite this, it does not appear that statistical concepts as a whole have been rejected as threshold on the basis of not falling within the finance discipline, because 'expected value' does receive clear endorsement as a threshold concept.

All of the 10 concepts clearly endorsed as threshold (≥ 0.25) are also endorsed as integrative and most are endorsed as transformative and/or irreversible. However, many of the concepts endorsed as threshold are only weakly rated or not rated at all as troublesome. There is also consistency between the three concepts clearly not endorsed as threshold concepts (≤ -0.25) and ratings for the transformative, integrative and irreversible characteristics, but again there is a lack of consistency with the troublesome characteristic. Most of the concepts falling into the uncertain category in terms of being threshold concepts have weak or variable ratings according to the threshold characteristics.

Across all of the concepts, the most frequently endorsed characteristic is the integrative characteristic, with an average mean rating of 0.35 relative to ratings of 0.20 to 0.24 for the other three characteristics, as shown in Table 3. As noted previously and further illustrated in Table 3, there is a clear relationship between endorsement as threshold and endorsement of the transformative, integrative and irreversible characteristics. However, there is no clear relationship for the troublesome characteristic, overall or for either sub-group.

Table 3. Mean assessment of whether given concepts are threshold and satisfy threshold characteristics (-1 = no, 1= yes) by categorisation of whether threshold, and finance and statistical concepts

		Average mean rating of whether the concept is threshold and satisfies characteristics				
		Threshold	**Transform-ative**	**Integrative**	**Irreversible**	**Troublesome**
All concepts	**Clear threshold**	0.54	0.53	0.60	0.47	0.32
	Uncertain	-0.02	0.02	0.26	0.06	0.17
	Not threshold	-0.31	-0.20	-0.12	-0.04	0.22
	All	**0.17**	**0.20**	**0.35**	**0.21**	**0.24**
Finance concepts	**Clear threshold**	0.55	0.56	0.62	0.49	0.34
	Uncertain	0.00	0.06	0.33	0.11	-0.03
	Not threshold	-0.27	-0.27	-0.08	0.00	0.41
	All	**0.27**	**0.31**	**0.46**	**0.30**	**0.19**
Statistical concepts	**Clear threshold**	0.50	0.18	0.46	0.32	0.15
	Uncertain	-0.06	-0.03	0.17	0.00	0.44
	Not threshold	-0.33	-0.17	-0.14	-0.06	0.13
	All	**-0.06**	**-0.04**	**0.13**	**0.02**	**0.33**

Respondents independently put forward a number of concepts that were not on our existing list of 25 potential concepts, or that had some but incomplete overlap with the existing concepts. These additional concepts are listed in Table 4, which also shows the percentage of respondents suggesting these concepts and mean ratings of whether the concept is regarded as threshold and is seen to satisfy the four characteristics.

Table 4. New suggested concepts, and mean assessment of whether given concepts are threshold and satisfy threshold characteristics (-1 = no, 1= yes)

Concept	Independently suggested (% of respondents)	Mean rating of whether the concept is threshold and satisfies characteristics				
		Threshold	Transform-ative	Integrative	Irreversible	Troublesome
Valuation	33%	0.67	0.71	1.00	-0.20	0.20
Capital structure	33%	0.64	0.60	0.83	0.20	0.09
Behavioural finance	19%	1.00	1.00	1.00	1.00	0.33
Portfolio theory	19%	0.60	0.40	1.00	-0.75	1.00
Derivatives	14%	0.50	0.60	0.00	-0.20	1.00
Capital budgeting	14%	-	-	-	-	-
Return	12%	-	-	-	-	-
Dividends	9%	-	-	-	-	-
Principal-agent problem	7%	-	-	-	-	-
Liquidity	5%	-	-	-	-	-
Marginal costs	2%	-	-	-	-	-

Note: Averaging is over the number of respondents rating the particular concept of interest, which ranges from a maximum (not all respondents rated all criteria) of 14 (33% of sample) for Valuation and Capital structure, to 1 (2%) for Marginal costs. Mean ratings have been omitted for 4 respondents or fewer, indicated by -.

4.3 Threshold concepts, curriculum design and learning and teaching (Section C)N = 36

In the first question in Section C, respondents were asked to indicate their familiarity with the idea of threshold concepts, by selecting from the five options shown in Table 5. As can be seen from this table, a majority of the respondents had no (12) or limited (9) exposure to the idea of threshold concepts prior to the questionnaire.

Table 5. Exposure to and/or understanding of threshold concepts

	Number	Percentage
No exposure to the concept apart from this questionnaire	12	33
Some limited exposure to the concept	9	25
Some understanding of the concept	6	17
Solid understanding of the concept	4	11
Strong understanding of the concept	4	11
No response	1	4
	36	**100**

Respondents were then asked to indicate their reaction to six statements about threshold concepts and curriculum design and/or learning and teaching using a Likert scale as shown in Table 6. For all statements a majority of the respondents either agreed or strongly agreed. This indicates that despite a relatively low level of familiarity with the idea of threshold concepts, respondents are positive about their potential.

Table 6. Threshold concepts and curriculum design/learning and teaching (SA = 5, SD = 1)

	SA	A	N	D	SD	Don't Know	Mean
1. Threshold concept research can help academics focus on key ideas in our subject or discipline.	10	21	2	1	1	1	4.09
2. Threshold concept research can help me focus on the difficulties in student learning in my teaching area.	9	16	6	1	2	2	3.85
3. Threshold concept research is helpful for curriculum design.	10	19	4	1	1	1	4.03
4. The identification of threshold concepts can help me develop better learning and teaching activities.	12	13	6	1	2	2	3.94
5. The identification of threshold concepts can help me develop better assessment.	10	16	5	1	2	2	3.91
6. Threshold concepts are a useful way to link subjects/courses/modules into a coherent (degree) program.	12	17	3	0	2	2	4.09

We calculated the mean for the responses to the six statements for each respondent, as an indication of the extent to which they valued the idea of threshold concepts overall. In Table 7, we show the average of these means in relation to each category of exposure to and/or understanding of the idea of threshold concepts. The average for the value of threshold concepts increases as familiarity with the idea of threshold concepts increases.

However, similar to above, the high averages for respondents with little or no exposure indicate that respondents were quick to perceive the potential of threshold concept theory despite it being new to them.

Table 7. Exposure to and/or understanding of threshold concepts and value

	Number	Average
No exposure to the concept apart from this questionnaire	12	3.71
Some limited exposure to the concept	9	3.86
Some understanding of the concept	6	4.09
Solid understanding of the concept	4	4.46
Strong understanding of the concept	4	4.46
No response	1	3.17
	36	

We also calculated the average of the means for each category of years teaching in higher education, years teaching in finance and role in teaching undergraduate finance; however, no pattern was evident for any of these categories.

Section C also included the optional question: 'Do you think the threshold concept idea and in particular, the four characteristics (transformative, integrative, irreversible, troublesome) can help you in your teaching and/or your students' learning? Please explain your answer'. In Tables 8 to 12, we show the 27 responses to the question for each category of familiarity with threshold concepts (from no exposure to strong understanding) and also the mean for the Likert scale questions for each respondent. We broadly categorised the comments as positive (no shading), negative (heavy shading), or somewhere in between (light shading).

Table 8. No exposure to the concept apart from this questionnaire

Id	Response to question	Mean
43	Yes – important.	5.00
46	Yes, an awareness of threshold concepts will help me recognise when students reach important milestones.	5.00
23	The use of the four categories clarifies my thinking about the order of introducing the concepts in my teaching of finance.	4.33
20	Yes, gives a good starting point for how to structure a finance program.	4.00
52	Probably. Intro courses tend to focus on techniques, and key concept identification may be useful. For example, two of my five critical concepts seemed less important when compared to other concepts.	4.00
1	Possibly - not sure yet.	3.67
11	No, we don't need fancy new labels to know about these things. Anyone who has been teaching for a few years will implicitly understand these characteristics, regardless of whether they are formalised.	1.33
13	Not sure I understand what a threshold concept actually is.	-

Thus in the 'no exposure' to threshold concepts category, five comments are positive, in line with the means for the value of threshold concept theory of 4 to 5. These comments indicate that the respondents feel that threshold concepts are useful for curriculum design both in terms of order (20 and 23) and focus (52), and for monitoring student progress (46). One of the comments (23) highlights the use of the characteristics to inform order in the curriculum.

Table 9. Some limited exposure to the concept

Id	Response to question	Mean
41	Yes, if I knew the point that students understood the concepts, it will give me [an] idea of how fast I should be teaching the material.	4.67
8	I like the idea of a threshold concept although I am not entirely sure the characteristics would help me with my teaching. It may be useful to understand how students view the concepts in terms of the characteristics however while I quite like the first 3 I do not see how the last is helpful.	4.00
19	Yes. You can see that there are some concepts they must 'get'. And that they need to have the eureka moment, particularly with the non-intuitive aspects.	4.00
16	To an extent. It is hard to judge the difficulty of a concept when it is being lectured as students may either find the concept difficult or the lecturer's explanations insufficient.	3.80
40	Not specifically, as facilitators we learn from student groups not categorisation of concepts.	3.67
6	Requires me to rethink what is at the core of the discipline, and so yes it can improve teaching/learning - what concepts can link the various parts we teach.	3.33
44	Well it may help in teaching but not likely to be received well by students as students don't relate theory of learning with actual learning. These kind of theoretical interpretations may be good for research work and publishing papers but not for learning by students.	3.33

Most of the comments in the 'limited exposure' category are positive or neutral, with only one negative comment. The means for the value of threshold concepts are all above 3. The three positive comments present threshold comments as a way to re-think and integrate the curriculum (6) or as essential milestones (19 and 41), informing delivery. The three more neutral comments support the idea of threshold concepts, but raise concerns related to students' conceptualisations of threshold concepts (44, 16 and 8).

Table 10. Some understanding of the concept

Id	Response to question	Mean
24	Yes, the threshold concepts can help as it identifies the main characteristics of each of the concepts and how student learning is likely to respond to understanding the concepts.	5.00
45	It can help as it assists to identify the key concepts and therefore scaffold learning. It can impact on curriculum, assessment and the design of programs.	5.00
14	There are a number of different ways of getting to the same education outcome. The threshold concept has some benefit but it depends on your teaching style and the learning style of the student that really matters.	4.00
35	Provides a focus for establishing key understandings within both courses (subjects) and programs (courses), and benchmarks against which to evaluate the learning outcomes and ability to engage in lifelong learning of students.	3.83
10	Somewhat helps but must avoid superficial and vague concepts which appear in some institutions' understanding of threshold concepts, also some of these concepts are so broad as to have no real relevance to the unit/subject and are politically driven to not appear to alienate ethnic groups which begs the question in the latter case as to question the academic and educational value of these concepts.	3.40

All of the five comments in the 'some understanding' category (Table 10) are positive or neutral, with means ranging from 3.4 to 5. The three positive comments express the benefits of threshold concepts in terms of curriculum design (35 and 45) and delivery, in scaffolding learning (45), using characteristics to understand student responses to learning (24) and assessment (45).

Table 11. Solid understanding of the concept

Id	Response to question	Mean
18	Yes, particularly if the students' perspective is explored to determine exactly which concepts they find most difficult and test new ways to explain and explore these concepts. Most well-known text books present the key concepts in exactly the same way, so this research has the potential to try something new if students do not follow these standard text book explanations.	4.83
9	Yes, though of the four characteristics, I'd rank 'troublesome' as the least relevant. A non-threshold concept can also be troublesome. Only in the context of the other characteristics are threshold concepts truly troublesome – eg demonstrating how a threshold concept is 'integrative' may in itself be troublesome even if the underlying concept is not. The extent to which a concept changes thinking (ie is transformative) and its pervasiveness across different branches of [financial] theory are the real measures of a threshold concept. With these two elements a concept becomes 'irreversible'.	4.50
2	Yes, although it is not easy to distinguish between a real and a learnt response – requiring time in assessments that is not always available – and the need to fail students who have not got there. I also think that one needs to follow students over time to identify the threshold concepts.	4.00

All three comments in the 'solid understanding' category (Table 11) are positive in relation to the value of threshold concepts, with means ranging from 4 to 4.83. However, in two cases the positive comments are expanded on with concerns relating to assessment (2) and the four characteristics, in particular the limited value of the troublesome characteristic (9). In contrast, the other comment emphasises the value of the troublesome concept from the students' perspective (18).

Table 12. Strong understanding of the concept

Id	Response to question	Mean
15	Yes, it is very important that (like you do in your research) lecturers have an idea of which topics/aspects are more important than others in Finance.	4.83
21	Yes, it's the basis of setting the curriculum.	4.67
5	The threshold concept idea yes – these are concepts you should make sure a maximum of students have got before moving on. These are the concepts you need to be creative about from a pedagogical point of view. The classification is maybe interesting, but not useful.	4.50

All three of the comments in the 'strong understanding' category (Table 12) are positive about threshold concepts in relation to delivery (5 and 15) and curriculum design (21), with means from 4.5 to 4.83.

5. Discussion

A large majority of the respondents (34) have expertise in finance with the other respondents (10) having expertise in closely related disciplines. In addition, most respondents (40) have significant experience in teaching finance and/or teaching in higher education, and most (37) are either lecturers, subject co-ordinators or degree/program co-ordinators. Overall, whilst we would have liked more responses, we feel that, as a group, the respondents have the expertise and experience to comment on threshold concepts in finance. Furthermore, since only eight of the respondents indicated more than some understanding of the idea of threshold concepts, it is unlikely there is a bias in favour of threshold concepts.

5.1 Finance threshold concepts

In relation to specific threshold concepts in finance, Table 13 shows our original table of proposed threshold concepts in finance (Table 1) updated to incorporate the results of the questionnaire. The 10 threshold concepts we proposed that received clear endorsement are shown in bold: the 12 concepts for which support was less certain are shown in italics; and the three that were rejected as threshold concepts are shown with strikethrough. Of the 11 new suggested concepts, we have added seven (underlined): liquidity, behavioural finance (more than one concept), derivatives, marginal costs, principal-agent problem, return and valuation, which we agree are potentially threshold concepts in finance. We discuss the reasons for rejecting the other four suggested concepts below. Threshold concepts are by definition limited in number in that they are the "jewels in the curriculum" that are central to mastery. [3] We have identified 10 concepts that are clearly endorsed as threshold concepts, with a further 19 concepts (Table 1) subject to further research/testing. Whilst there will be overlap between the threshold concepts identified and the content/topic/concepts of a typical finance curriculum (eg risk, risk versus return, the time value of money), the threshold concepts are the subset of concepts/conceptual understandings that underpin the finance curriculum. [14]

Table 13. Proposed threshold concepts in finance

Type of conceptual change – transformation and integration	Finance	Statistics
Basic - Understanding of everyday experience transformed through integration of personal experience with ideas from discipline.	**Information asymmetry** *Leverage/gearing* *Market structure(s*) Liquidity *Pricing* **Risk versus return** *Trade offs* Valuation (value)	*Probability/randomness* **Expected value** ~~Regression to the mean~~ ~~Standard deviation~~ *Time series*
Discipline - Understanding of other subject discipline ideas integrated and transformed through acquisition of theoretical perspective.	**Arbitrage** Behavioural finance – more than one concept *Cashflows* Derivatives **Diversification** **Hedging** **Market efficiency** **Opportunity cost** Principal-agent problem Marginal costs Return **Risk** ~~Short selling~~ **Time value of money** *Utility/risk preference*	*Central limit theorem and normal distribution* *Correlation* *Statistical significance and hypothesis testing*
Procedural - Ability to construct discipline-specific narratives and arguments transformed through acquisition of ways of practising.	*Modelling – building, critiquing, implementing, discipline-specific models eg pricing models,* valuation	

Most of the concepts that were clearly endorsed are finance concepts in the discipline category of conceptual change. Only two of the six basic finance concepts we proposed were clearly supported as threshold concepts. This perhaps reflects the high level of finance expertise and experience of the respondents. However, we would argue that these basic concepts are central to perceiving the world through the lens of finance. For example, finance can be understood to be largely about managing trade offs – identifying them,

measuring them and responding to them. It is these basic concepts that are most likely to change the way students think and engage them by capturing their imaginations.

The discipline finance concepts which were not fully endorsed were cashflows and utility/risk preference, for which there was only partial support, and short selling, which was rejected as a threshold concept. We are surprised that short selling was rejected as a threshold concept in finance as, once fully understood, the concept of short selling transforms students' understanding of the potential/role/scope of finance and it is difficult to conceive finance without short selling, thus it is transformative, a boundary marker and irreversible. Short selling underpins other finance concepts, such as hedging, and financial instruments, such as options/futures, thus it is integrative.

The procedural concept of modelling, which we identified as a threshold concept, did not receive clear endorsement. However, valuation, the new threshold concept most strongly put forward by the respondents, can be seen as an application of the concept of modelling to the concept of value, which perhaps should be a basic threshold concept. This is indicative of the way modelling is integral to defining finance concepts, such that these concepts and the process of modelling are entwined and therefore it is easy to lose sight of modelling as a separate concept.

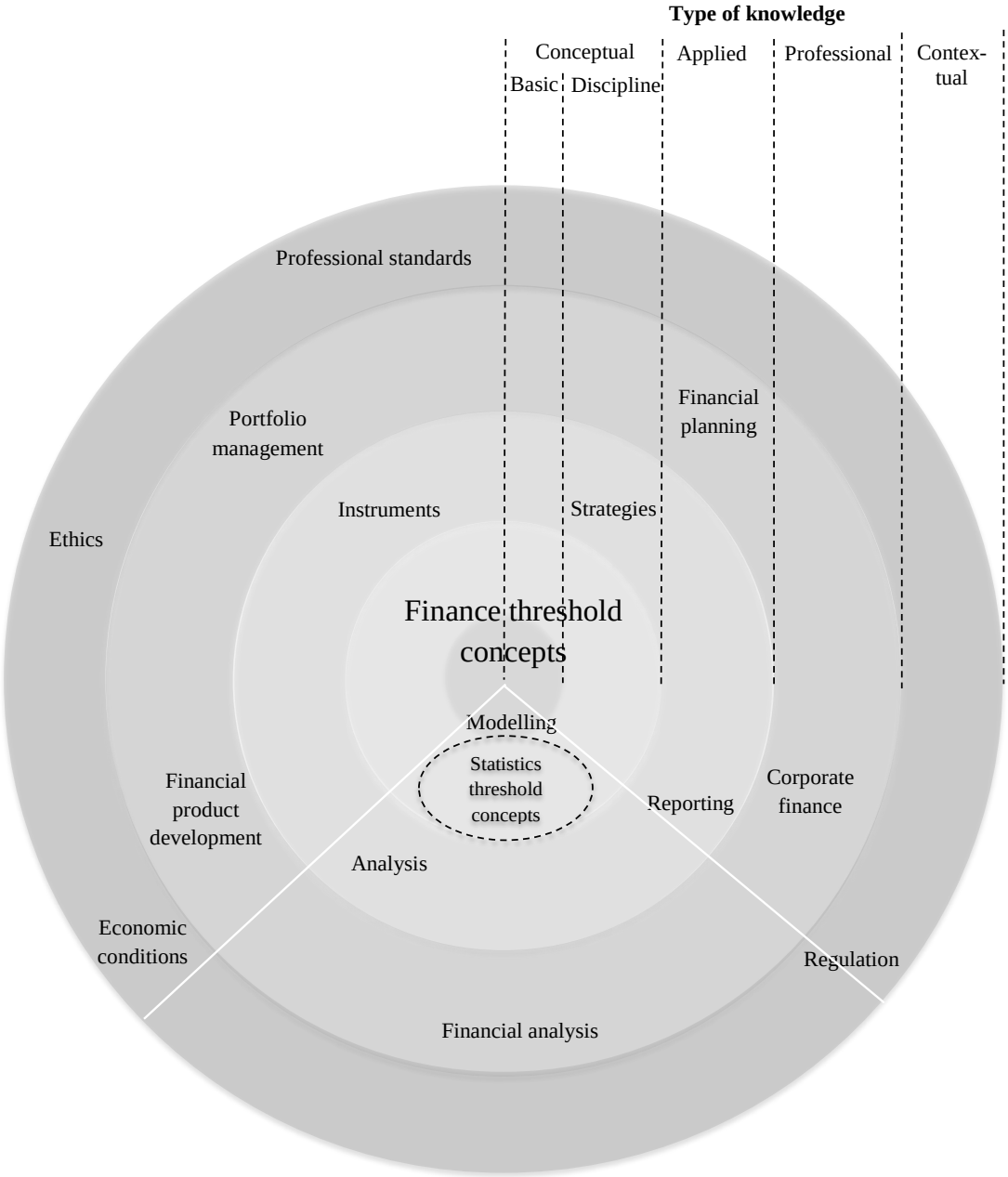
The distinction between a concept and the application of a concept is the reason we have not added four of the 11 new suggested concepts to our set. These four can be seen as applications of other threshold concepts rather than concepts themselves. That is: capital structure is the application of leverage/gearing; portfolio theory is the application of diversification; capital budgeting is the application of several concepts including the time value of money; and dividends is an application of return. Further, it is possible to identify different types of 'application': the negotiation of trade offs eg capital structure; a means to deliver concepts eg dividends as a form of return; and implementation of concepts eg portfolio theory as the implementation of diversification.

Only one of the eight statistics threshold concepts we proposed was clearly endorsed as a threshold concept in finance, despite the fact that they were often identified as troublesome. This led us to consider further the role of these statistics concepts in the finance curriculum. Namely, it may be helpful to conceptualise them as concepts that underpin financial modelling, rather than as stand-alone threshold concepts in finance.

The results as discussed above prompted us to situate more specifically the findings in the conceptual space that is the finance curriculum, following Shinners-Kennedy and Fincher.

[15] As shown in Figure 1, finance can be represented as a transition from abstract/conceptual understanding/knowledge at the centre, through knowing what potentially can be done in finance, to actually doing it informed by professional/contextual knowledge in the outer area. This transition has been informed by a framework proposed by Wood et al. [16] in relation to mathematics which identifies three types of knowledge – conceptual, procedural and professional – but extended here to make the role of contextual knowledge explicit. Thus we show four types of knowledge: conceptual, applied, professional and contextual. A similar transition from conceptual understanding to doing in context is conceptualised by Baillie et al in relation to the threshold concept framework using the Aristotelian notions of episteme – "understanding the concepts themselves", techne – "the capacity to actually accomplish what needs to be done" and phronesis – "the capacity to discern relevant aspect of new situations and make judgements about what needs to be done". [14, p.239]

Figure 1: Threshold concepts and the finance curriculum



The centre circle shows the basic and discipline finance threshold concepts as being central to the mastery of finance. Even at this conceptual level, these concepts are informed, defined and quantified by modelling. The statistics threshold concepts which were generally not endorsed as finance thresholds in this research (with the exception of expected value) underpin modelling but are not finance threshold concepts.

The next circle shows the potential applications of the finance threshold being the financial instruments and strategies used to manage (the effects of) the finance threshold concepts. Modelling here takes the form of analysis.

The next circle represents practising finance. Here the conceptual understanding and the knowledge of instruments, strategies, analysis and reporting from the inner circles are used to manage the finances of individuals and corporations, inform the development of financial products and for financial analysis. These practices are also informed by professional knowledge such as ethics and professional standards and contextual knowledge such as economic conditions and financial regulation, shown in the outer circle.

5.2 Threshold concepts theory and implications for learning and teaching finance

The responses to both the quantitative and qualitative questions concerning the contribution that threshold concepts can make to learning and teaching finance indicated strong support for and appreciation of the theory. The overall mean for the Likert scale responses is 3.96 and 17 of 22 qualitative comments are positive. As anticipated, support for and appreciation of the theory increases as familiarity with the theory increases. However, respondents who were relatively unfamiliar with the theory were also positive about it and its potential.

In the qualitative responses, threshold concept theory was identified as being beneficial for curriculum design and delivery. Threshold concepts were seen as a way to inform the *design* of programs and subjects in relation to what to teach, the order in which to teach and how/how much to focus on concepts. They were perceived as being able to inform *delivery* in terms of what to focus on, making connections with other material, progressing through the material, formative (and summative) assessment, anticipating and dealing with students' reactions to learning and scaffolding learning. In contrast, some responses indicated that a perceived drawback of threshold concept theory is the focus on content rather than student learning. This is perhaps a result of our research focusing on the identification of the threshold concepts in finance. The intention of threshold concept theory/research, as well as allowing academics to discuss and identify what is fundamental to their disciplines, is to explore the difficulties students have in grasping threshold concepts and to identify curriculum design interventions. [7]

Specifically in relation to the four characteristics (transformative, integrative, irreversible, troublesome), some responses indicated they are helpful for reasons outlined above, whilst other responses identified them as less useful. In particular, the troublesome characteristic

was perceived as not helpful or valid by three respondents, but as important by one. This ambivalence about the troublesome characteristic resonates with the results of the quantitative analysis of the responses to specific finance threshold concepts, where this characteristic had the least validity/reliability. Further, 'troublesomeness' may not be an inherent feature of the concept itself but due to the significant (conceptual and ontological) change brought about in the student. [17]

6. Conclusions

With regards to specific finance threshold concepts, this research has clearly endorsed 10 of the 25 concepts proposed as a result of our previous research with finance academics at our own institution. Furthermore, the results of this research have enabled us to develop a model of the finance curriculum incorporating finance, modelling and statistics threshold concepts, using a framework of four different types of knowledge: conceptual, applied, professional and contextual.

In relation to threshold concept theory, both the quantitative and qualitative data indicate a strong appreciation of the value of threshold concepts to inform curriculum design and learning and teaching activities. More specifically, the transformative, integrative and irreversible characteristics have a clear correlation with a concept being identified as a threshold concept. In contrast, the results in relation to the troublesome characteristic are more ambiguous, which is probably a result of the respondents (being finance experts) having already gone through the troublesome conceptual and ontological shift involved.

In general, our study demonstrates the potential for the application of threshold concept theory as a framework for curriculum research. In addition, our results suggest that threshold concept theory is likely to be well received and taken up by higher education academics.

Although this research has enabled us to test the results of our previous more qualitative research using quantitative methods and to investigate the application of threshold concept theory to learning and teaching in finance more generally, its scope, in terms of participants, is limited to academics. As indicated in the introduction, we are also undertaking research with students about their perceptions of threshold concepts in finance which will provide more complete insights.

Acknowledgements

Yongqing (Ree) Chen for constructing the database of academics.

Emily Inglis for transferring the questionnaire to an online format.

Brad Louis for providing feedback on the content of the questionnaire.

This work was supported by the Macquarie University Competitive Grants Scheme under Grant 9201200424.

References

[1] Deloitte. Positioning for prosperity? catching the next wave. News and Research; 2013. Available from: http://www.deloitte.com/view/en_AU/au/news-research/luckycountry/prosperity-next-wave/index.htm.

[2] Meyer JHF, Land R. Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising. In Rust C, editor. Improving student learning - theory and practice ten years on. Oxford: Oxford Centre for Staff and Learning Development (OCSLD); 2003. p. 412-424.

[3] Cousin G. An introduction to threshold concepts. Planet. 2006; 17: 4–5.

[4] Krishnan V, Bathala C, Bhattacharya T, Ritchey R. Teaching the introductory finance course: what can we learn from student perceptions and expectations. Financ. Pract. Educ. 1999; 9: 70–83.

[5] Balachandran B, Skully M, Tant K, Watson J. Australian evidence on student expectations and perceptions of introductory business finance. Account. Financ. 2006; 46: 697-713.

[6] Flanagan M. Undergraduate teaching, postgraduate training and professional development - a short introduction and bibliography. Threshold Concepts; 2015. Available from: http://www.ee.ucl.ac.uk/~mflanaga/thresholds.html.

[7] Cousin G. Strategies for researching in higher education: an introduction to contemporary methods and approaches. New York and London: Routledge; 2009.

[8] Diamond R V., Smith HJ. Threshold Concepts: A Disciplinary Enquiry in Quantitative Finance. Paper presented at: The Sixth International Developments in Economics Education (DEE) Conference [Internet]. London, UK; 2011.

[9] Davies P, Mangan J. Threshold concepts and the integration of understanding in economics. Stud. High. Educ. 2007; 32: 711–726.

[10] Dunne T, Low T, Ardington C. Exploring threshold concepts in basic statistics, using the internet. The International Association for Statistical Education, Statistics & the Internet; 2003. Available from: http://iase-web.org/documents/papers/sat2003/Dunne.pdf.

[11] Bulmer M, O'Brien M, Price S. Troublesome concepts in statistics: a student perspective on what they are and how to learn them. Paper presented at: Assessment in Science Teaching and Learning Symposium; 2007; Sydney, Australia. Available from: http://openjournals.library.usyd.edu.au/index.php/IISME/article/view/6337.

[12] Quinnell R, Thompson R. Conceptual intersections: re-viewing academic numeracy in the tertiary education sector as a threshold concept. In: Land R, Meyer JHF, Baillie C, editors. Threshold concepts and transformational learning. Rotterdam, Holland: Sense Publishers; 2010. p. 147–164.

[13] Marton F, Dall'Alba G, Beaty E. Conceptions of learning. Int. J. Educ. Res. 1993; 19: 277–300.

[14] Baillie C, Bowden JA, Meyer JHF. Threshold capabilities: threshold concepts and knowledge capability linked through variation theory. High. Educ. 2012; 65: 227–246.

[15] Shinners-Kennedy D, Fincher S. Identifying threshold concepts: from dead end to a new direction. Paper presented at: The Ninth Annual International ACM Conference on International Computing Education Research; 2013; New York, USA. Available from: doi:10.1145/2493394.2493396.

[16] Wood LN, Mather G, Petocz P, Reid A, Engelbrecht J, Harding A, Smith GH, Perrett G. University students' views of the role of mathematics in their future. Int. J. Sci. Math. Educ. 2012; 10: 99–119.

[17] Land R, Rattray J, Vivian P. Learning in the liminal space: a semiotic approach to threshold concepts. High. Educ. 2014; 67: 199–217.

Chapter 4 – Paper 3 – Threshold concepts in finance: student perspectives

Introduction

The research reported on in this paper involves the analysis of nominations from finance students for important concepts in finance in relation to the findings of the previous two papers. Thus, it provides a unique insight into the extent to which finance students have a shared understanding of the threshold concepts in finance with academics. It also considers the data from students in relation to type of knowledge (conceptual, applied, professional and contextual) and modelling to ascertain the student dispositions to these aspects of the finance curriculum. As a result, important and original conclusions are drawn in relation to the development of threshold concepts in the context of the finance curriculum as modelled in paper 2. In addition, the approach taken extends previous research on learning and teaching finance.

The approach taken in the research was to ask students in all years of study (ie first, second, third and fourth) from two finance programs (a specialist finance degree and a finance major) to nominate the most important concepts in finance and compare these to the threshold concepts in finance identified by academics. The research provides a snapshot of the perceptions of different students at various stages of the programs rather than following a particular cohort through the program. This approach extends previous research in three ways. Firstly, it investigates the perceptions of students at all stages of the curriculum rather than focusing on a particular stage of the curriculum (Balachandran et al., 2006; Krishnan et al., 1999). Secondly, the concepts are nominated by the students themselves rather than being predetermined by the researchers and simply rated by the students (Balachandran et al., 2006, Lai et al., 2009). Thirdly, the research is the first to use the threshold concept framework to analyse student perceptions of finance, and to compare these with staff perceptions.

Furthermore, the approach taken is original in relation to threshold concept research which tends to lend itself to more qualitative analysis of discursive data from fewer participants. Partially as a result of difficulties encountered in getting discursive data from students, but also in accordance with the focus of the research on identifying threshold concepts in finance, the student questionnaire is deliberately brief – consisting of a few closed or short answer questions. The advantage of this approach is that it allows data from a greater number of students to be collected and analysed. In addition, the data collected lend

themselves to more quantitative methods of analysis. Both of these factors mean the approach is highly appropriate for the disciplinary context of this research.

The original intention in relation to analysing the nominations was to identify the extent to which students nominated the specific threshold concepts proposed in the previous research. However, the nominations made by students are very diverse, and only a relatively modest proportion of the nominations (18%) are the same as or directly equivalent to one of the previously identified concepts. This result is the outcome of asking students to nominate concepts themselves rather than providing them with a predetermined list of concepts to rate or rank. This increases the validity of the results in that students nominated what they perceived as important in finance independently, without being influenced or limited by a predetermined list. Thus, the research is able to comment on the extent to which finance students and academics have a shared understanding of what is essential in finance by comparing separate, independent data. Further, although the wide variation in the nominations made the analysis more complex, it provided the opportunity to analyse the nominations in relation to type of knowledge and modelling.

An initial categorisation system was developed to describe and analyse the nominations, consisting of four categories as follows:

(1) proposed threshold concept (or direct equivalent)
(2) related to a proposed threshold concept
(3) generic skill
(4) too general/unclear to classify.

An additional category of “not related to a proposed threshold concept” was initially conceived, but it soon became clear that this category was not sustainable because so few nominations could be categorised as such. Thus, a great majority of the nominations (78%) are categorised as being a proposed threshold concept (category 1) or related to a proposed threshold concept (category 2) identified in the previous research. This in itself is a key finding as it indicates not only that the threshold concepts proposed in papers one and two constitutes a reasonably comprehensive list of the key conceptual knowledge in the finance curriculum, but also that what students identify as important in finance has a strong overlap with what academics identify as central to the mastery of finance.

A large proportion of the nominations (60%) are classified as related to the proposed threshold concepts. This is because, although students were specifically asked to nominate

the most important **concepts** in finance, many nominations are not conceptual knowledge, but rather "go beyond" conceptual knowledge to applied, professional or contextual knowledge. For example, "interest rate" is an application or applied form of the concept of 'return'. This has two implications. Firstly, it indicates there is scope to teach threshold (and other) conceptual knowledge more explicitly to ensure students are fully aware of and have a deep understanding of the conceptual knowledge that is central to the mastery of finance. Secondly, it supports the idea that students are disposed to different types of knowledge (Wood et al., 2012), and thus, that type of knowledge is a valid way to differentiate curriculum delivery to suit the different needs of students.

Because data were collected from students in two different programs and all years of study, the research is able to investigate and report on the impact of these factors. For example, it was expected that nominations of threshold concepts would increase with year of study and be higher for specialist degree students than major students. The results do show an increasing trend for nominations of threshold concepts with year of study (the exception being a lower result for third year specialist degree students) indicating that the current programs do develop the students' threshold conceptual knowledge to some degree, bearing in mind the relatively low proportions of threshold concept nominations overall. Nominations of threshold concepts are consistently higher for specialist degree students than for major students. Consideration needs to be given as to whether this is appropriate and, if not, how it can be addressed.

The research also investigates the type of knowledge and the role of modelling in finance, and how these vary by program and year of study. Similar to the results for nominations of threshold concepts discussed above, conceptual knowledge is more evident in nominations from specialist degree students than major students, and generally increases over the course of both programs. In addition, the nominations appear to reflect a slightly higher disposition towards applied knowledge. Other clear trends in relation to type of knowledge are limited. Overall, only 25% of the nominations reflect conceptual knowledge, despite the fact than students were specifically asked to nominate concepts, which indicates that students are unable to distinguish between different types of knowledge. This indicates that the different types of knowledge and their role in finance need to be made much more explicit to students. Student responses were also classified according to whether they implied modelling, because the research had previously identified modelling as an important threshold concept spanning and enabling all four types of knowledge. Modelling

is evident in 24% of the nominations and for all types of knowledge, supporting the idea that modelling is relevant throughout the curriculum (as shown in the curriculum model).

In relation to specific concepts, the paper reports on the extent to which the threshold concepts from the previous two papers are evident in the student nominations. This is done for the "threshold concept" and the "related to a threshold concept" nominations (ie categories 1 and 2 above). Taken separately, these categories make the distinction between concepts that students are explicitly aware of and concepts that are related to what students identify as most important in finance. The results for the student nominations are considered in relation to the three groupings arising from our previous research: clearly endorsed threshold concepts, concepts not clearly endorsed as a threshold concept, and new proposed threshold concepts that have not been tested yet. Nine out of the 10 clearly endorsed threshold concepts are identified in the student nominations, and seven out of the 10 are nominated explicitly (category 1) and identified in the related a threshold concept to the nominations (category 2). For the twelve concepts not clearly endorsed as threshold concepts, five are identified in both category 1 and 2 nominations although, with the exception of markets and market structure(s), they are nominated less often than the 10 clearly endorsed concepts. (A significant proportion of the related to a threshold concept nominations (category 2) are identified as relating to markets and market structure(s), covering a diverse range of nominations, for example "stock", "market based theories" "regulation".) For the seven new potential threshold concepts, the same four are identified in category 1 and 2 nominations, with valuation, return and to a lesser extent derivatives being significantly nominated. Overall, there is strong agreement between the student nominations and the threshold concepts clearly endorsed by academics. There is less overlap between the student nominations and not clearly endorsed and yet to be tested concepts in terms of the number of concepts nominated, however there are concepts in both groups that are significant in both the category 1 and category 2 student nominations. The results in relation to specific concepts indicate the extent to which there is scope to focus on particular concepts more, or more explicitly in curriculum delivery.

Paper 3: Threshold concepts in finance: student perspectives

Susan Hoadley, Tim Kyng, Leonie Tickle, Leigh N. Wood

Macquarie University

Submitted to: *International Journal of Mathematical Education in Science and Technology.*

Abstract:

Finance threshold concepts are the essential conceptual knowledge that underpin well-developed financial capabilities and are central to the mastery of finance. In this paper we investigate threshold concepts in finance from the point of view of students, by establishing the extent to which students are aware of threshold concepts identified by finance academics. In addition, we investigate the potential of a framework of different types of knowledge to differentiate the delivery of the finance curriculum and the role of modelling in finance. Our purpose is to identify ways to improve curriculum design and delivery, leading to better student outcomes. Whilst we find that there is significant overlap between what students identify as important in finance and the threshold concepts identified by academics, much of this overlap is expressed by indirect reference to the concepts. Further, whilst different types of knowledge are apparent in the student data, there is evidence that students do not necessarily distinguish conceptual from other types of knowledge. As well as investigating the finance curriculum, the research demonstrates the use of threshold concepts to compare and contrast student and academic perceptions of a discipline and, as such, is of interest to researchers in education and other disciplines.

Keywords: finance; statistics; threshold concepts; education; learning and teaching; curriculum

1. Introduction

In this paper we investigate threshold concepts in finance from the perspective of students. We examine the extent to which students are aware of finance threshold concepts as identified by finance academics in our previous research.[1,2] In addition, we investigate the potential of a framework of different types of knowledge (conceptual, applied, professional and contextual) as a way to differentiate the delivery of the finance curriculum [3] and the role of modelling in finance. We also examine how program type (specialist versus major) and program stage (first, second, third and fourth year) affect the identification of threshold concepts as important concepts in finance, type of knowledge and modelling. The findings of our research can be used to inform finance curriculum design and delivery, through a focus on threshold concepts as central to the mastery [4] of finance, to improve student outcomes.

Whilst our overall project involves a combination of focus groups, interviews and questionnaires investigating both staff and student perceptions of threshold concepts in finance, in this paper we focus on student perceptions of the most important concepts in finance. The participants in this research are international and domestic students from a large cohort completing one of two finance programs (a specialist finance degree and a finance major), which themselves have a strong international focus. In addition, our previous research identifying threshold concepts involved participation by finance academics from five countries (Australia, Canada, New Zealand, South Africa and the United Kingdom). Thus, the research is relevant to finance programs generally, both within Australia and internationally. In addition, the research uses threshold concepts to compare and contrast student and academic perceptions of a discipline and so is relevant to researchers in education and other disciplines.

The two undergraduate finance degree programs offered at our institution are a specialist finance degree named the Bachelor of Applied Finance, and a finance major undertaken as a coherent study within a generic degree, most commonly a Bachelor of Commerce. The specialist degree has double the amount of prescribed content (about 70% of the degree) as the finance major (about 35% of the degree). Historically, there has been considerable overlap between the two programs, with the subjects in the major being more or less a subset of the subjects in the specialist degree. (More recently the major has been revised to focus more on corporate finance, whereas the emphasis of the specialist degree remains on funds and investment management.) The specialist degree has a higher general entry

requirement and recommends that prospective students have studied advanced mathematics. The combined student cohort is currently over 2,430 students.

Using a short questionnaire, we obtained student nominations for important concepts in finance, enabling us to gain significant insight into students' perceptions of what is most important in finance. We consider these perceptions in relation to the findings of our previous research into threshold concepts in finance involving finance academics.[1] Based on these findings and our expectations of student engagement, confidence and development in relation to the program and year of study, we identify and respond to three research questions as follows:

(1) To what extent do students identify the threshold concepts identified by academics as important concepts in finance, and how does this vary by program and year?
(2) To what extent do student nominations reflect the four different types of knowledge (conceptual, applied, professional and contextual), and how does this vary by program and year?
(3) To what extent do student nominations imply modelling, and how does this vary by program and year?

Originally developed by Meyer and Land [5] in relation to economics, the threshold concepts approach has been rapidly and widely applied to other disciplines to research and inform curriculum design, pedagogical practices and professional development of teaching staff.[6,7] In our previous research we explicitly used the threshold concept framework to investigate staff perceptions of threshold concepts in finance, as a form of transactional curriculum inquiry.[8] In contrast, in this research the questionnaire used is deliberately brief in order to maximise the response rate, so students were simply asked for their opinions as to the (three) most important concepts in finance. Thus, whilst we have used the threshold concept framework to analyse the responses, it was not made explicit to students in collecting the data. In the following sections we review the previous research on threshold concepts in finance, describe the methodology for this research activity, present, analyse and discuss our results and draw some overall conclusions.

2. Threshold concepts research

Previous research into threshold concepts in finance consists of the work of Diamond and Smith in relation to quantitative finance [9,10] and business statistics [11]. In comparison to the work of Diamond and Smith, our research attempts to identify the threshold concepts

for a general finance program and therefore has a broader focus. Our research is also informed by research into statistics threshold concepts. [12,13,14]

As a result of our initial research activities involving finance academics at our institution, we identified 25 potential threshold concepts in finance, which were mapped using the framework developed by Davies and Mangan [15]. A key finding of the research was the distinction between finance concepts and statistics concepts. In a subsequent research activity, we sought feedback on our findings by means of an online survey of finance academics at universities in five different countries. The results of this research are shown in table 1, where:

concepts (10) that received clear endorsement as finance threshold concepts are shown in bold
concepts (12) not clearly endorsed are shown in italics
concepts (3) rejected as threshold concepts are shown with strikethrough
concepts (7) that are new potential finance threshold concepts arising from the survey are shown underlined.

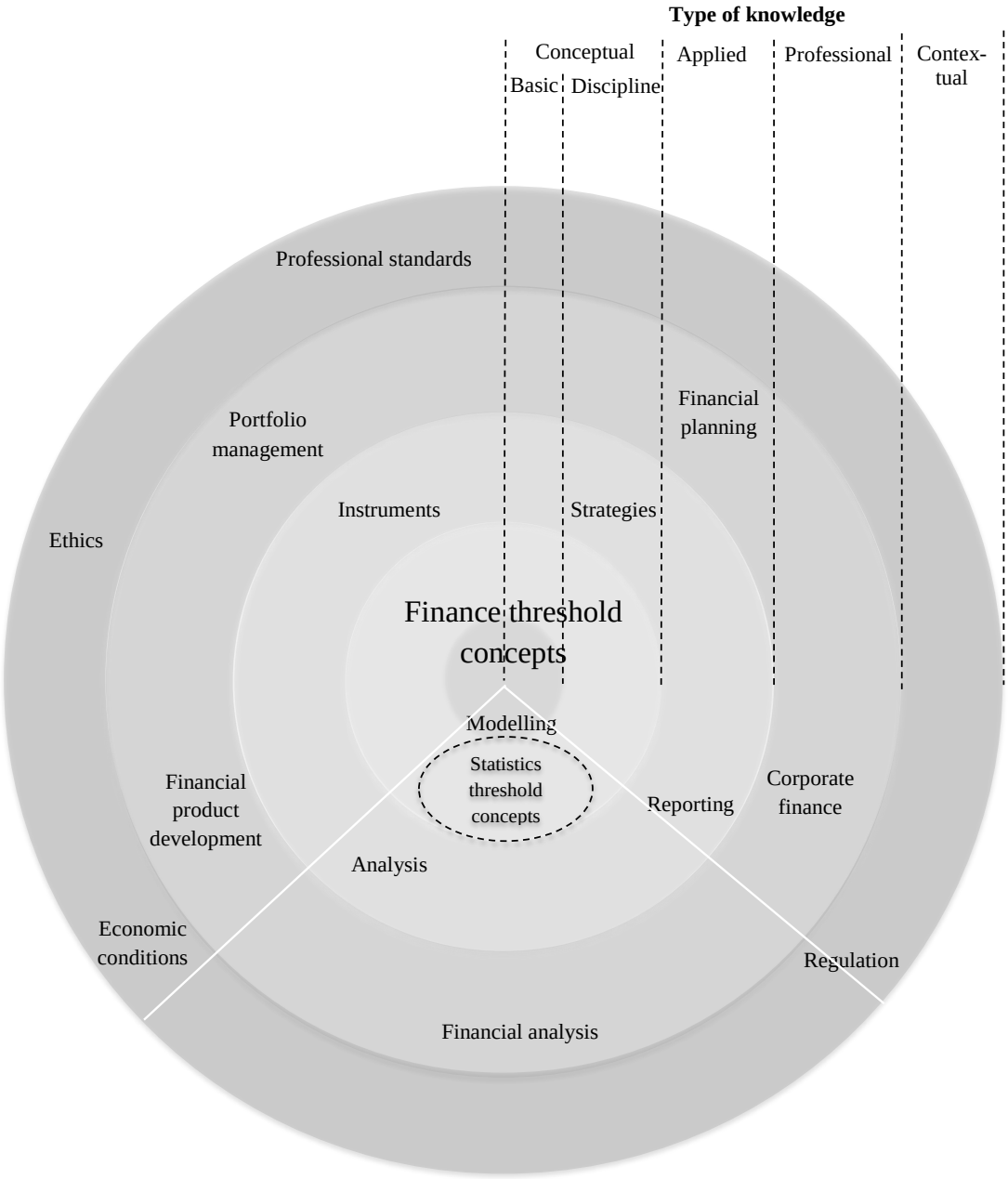
Table 1. Threshold concepts in finance.[1]

Type of conceptual change – transformation and integration (Davies & Mangan 2007)	**Finance**	**Statistics**
Basic - Understanding of everyday experience transformed through integration of personal experience with ideas from discipline.	**Information asymmetry** **Risk versus return** *Leverage/gearing* *Markets and market structure(s)* *Pricing* *Trade offs* Liquidity Valuation (value)	**Expected value** *Probability/randomness* *Time series* ~~Regression to the mean~~ ~~Standard deviation~~
Discipline - Understanding of other subject discipline ideas integrated and transformed through acquisition of theoretical perspective.	**Arbitrage** **Diversification** **Hedging** **Market efficiency** **Opportunity cost** **Risk** **Time value of money** *Cashflows* *Utility/risk preference* Behavioural finance - more than one concept Derivatives Principal-agent problem Marginal costs Return ~~Short selling~~	*Central limit theorem and normal distribution* *Correlation* *Statistical significance and hypothesis testing*
Procedural - Ability to construct discipline-specific narratives and arguments transformed through acquisition of ways of practising.	*Modelling* – building, critiquing, implementing, discipline-specific models eg pricing models, valuation*	

In interpreting these results we located our findings in the finance curriculum as a conceptual space.[16] As shown in figure 1, following a framework proposed by Wood et al. [3] in relation to mathematics, we conceptualise the finance threshold concepts positioned as conceptual knowledge at the centre of the curriculum with outer areas of applied, professional and contextual knowledge. The procedural nature of modelling means that it is present in various forms throughout the curriculum. However, in the conceptual area, modelling is so integral to defining concepts that it may not be perceived as a separate concept, which would explain why modelling is not clearly endorsed as a threshold concept. In addition, statistics concepts underpin modelling rather than being

threshold concepts in finance. This framework represents a way of understanding and mapping the finance curriculum which can be used to inform delivery, in particular, to respond to student's dispositions towards the four types of knowledge. Further, the capacity to act in professional roles involves the development and integration of different types of knowledge.[17]

Figure 1. Threshold concepts and the finance curriculum



3. Methodology

Our research methodology is to investigate threshold concepts as a form of transactional curriculum inquiry as described by Cousin [8], involving collaboration with, or participation by, discipline specialists, educational specialists and learners. In accordance with this methodology, as mentioned previously, we have successfully used focus groups and interviews with academics to identify potential threshold concepts in finance, which were then tested via an online survey of academics. However, we found it difficult to get students to participate in the research by attending focus groups. We scheduled 10 focus groups (providing lunch or refreshments) at a variety of times when students would be on campus to attend scheduled classes for compulsory subjects in the finance programs. The focus groups were publicised frequently using multiple channels. Despite this, only five students came to the focus groups – one student for two "groups" and three students for another group.

Given our lack of success in getting students to attend focus groups to discuss threshold concepts in finance, we decided to use a questionnaire to investigate what students perceive as fundamental to a grasp of finance. To this end we designed a questionnaire seeking students' opinions as to the most important concepts in finance. In order to maximise the number of responses the questionnaire is very brief, consisting of only four questions as follows:

(1) What degree/major are you completing?
(2) What year of your degree are you in?
(3) In your opinion, what are the 3 most important concepts in finance?
(4) What other comments would you like to make about your finance degree/major?

The questionnaire was distributed electronically to all students enrolled in either the specialist finance degree or the finance major via SMS and email and also manually in lectures for selected compulsory finance subjects. The questionnaire was administered at the end of the teaching session with the aim of contacting students when they are most likely to be reflecting on their learning. Completion of the questionnaire was voluntary and responses were anonymous. Over 250 responses were received and, since students were asked for the three most important concepts in finance, resulted in 750 nominations.

Because the 750 nominations are in response to an open question, there is a great deal of variation in the data. Although this could have been avoided by asking students to select

from or rank a list of concepts we wanted to collect completely independent data. We spent some time reviewing the data to come up with the following four broad categories:

(1) threshold concept (or direct equivalent)
(2) related to a threshold concept
(3) generic skill
(4) too general/unclear.

In relation to categories 1 and 2, a 'threshold concept' is one of the 29 concepts shown in table 1 (the three concepts rejected as threshold concepts were ignored). Initially, we had an additional category, 'not related to a threshold concept' however so few of the nominations fell into this category we decided it was not a sustainable category. The generic skill category covers skills such as communication and decision making, but also extends to more technical generic skills such as mathematics. The too general/unclear category covers nominations that are too broad or vague to reasonably relate them to any single concept (eg 'apply what you have learnt', 'elements', 'global economy' or 'understanding business').

For category 1 nominations we noted the number of times each concept in table 1 was nominated. However, since only 18% of the nominations are in category 1, we also identified the most relevant threshold concept for nominations in category 2.

In addition, the nominations were assessed to identify the type of knowledge (conceptual, applied, professional or contextual) they most seem to reflect and whether or not they imply modelling. Where the type of knowledge or implications of modelling could not be determined the nominations were categorised as too general/unclear.

The researchers used judgement to categorise the nominations, with extensive discussion to reach agreement where nominations were difficult to categorise. Quantitative techniques were used to summarise and interpret the results of the categorisation and to investigate potential correlations with the program the students are undertaking and year of study.

4. Results and analysis

4.1 Program and year of study

We received responses from over 250 students. However, as not all responses include three nominations, the total number of nominations for analysis is 750. As shown in table 2, more nominations are from students enrolled in the specialist degree (66%) than students doing the finance major (34%). The majority of nominations (76%) are from second and

third year students, both in total and for each program, although there are more nominations from third year than from second year students in the specialist degree (13% difference) but more nominations from second year than from third year students in the major (7% difference). Less than 10% of the nominations are from first year students, again both in total and for each program. A relatively low proportion of the nominations are from fourth year students, 15% in total. The majority of these are from fourth year specialist degree students (94) rather than fourth year major students (16).

Table 2. Nominations by program and year of study.

Year of study	1st	2nd	3rd	4th	Total
Specialist degree students	48	144	206	94	492
Major students	21	120	101	16	258
Total	**69**	**264**	**307**	**110**	**750**

4.2 Initial categorisation

The initial categorisation of the nominations is shown in table 3. Whilst the majority of nominations (78%) are categorised as either a threshold or related to a threshold concept (categories 1 and 2), only 18% are in the first category. In total 21% of the nominations are either too general/unclear (category 4 - 16%) or a generic skill (category 3 - 5%). The same overall pattern of distribution applies to the totals for both the specialist degree and the major, however a higher proportion (7% difference) of nominations are categorised as a threshold concept (or direct equivalent) for the specialist degree than the major whilst a lower proportion of nominations are categorised as a related to a threshold concept.

Table 3. Initial categorisation of responses.

Year of study		1st	2nd	3rd	4th	Total
All students	**1. threshold concept (or direct equivalent)**	9	50	51	28	138
	2. related to a threshold concept	51	158	180	62	451
	3. generic skill	3	14	18	6	41
	4. too general/unclear	6	42	58	14	120
		69	**264**	**307**	**110**	**750**
Specialist degree students	1. threshold concept (or direct equivalent)	7	34	36	25	102
	2. related to a threshold concept	34	79	114	53	280
	3. generic skill	3	7	12	4	26
	4. too general/unclear	4	24	44	12	84
		48	**144**	**206**	**94**	**492**
Major students	1. threshold concept (or direct equivalent)	2	16	15	3	36
	2. related to a threshold concept	17	79	66	9	171
	3. generic skill	0	7	6	2	15
	4. too general/unclear	2	18	14	2	36
		21	**120**	**101**	**16**	**258**

In relation to year of study, the total proportion of nominations falling into the threshold concept or related to a threshold concept categories (categories 1 and 2) is 87%, 79%, 75% and 82% for years 1, 2, 3 and 4 respectively. The decrease from year 1 in subsequent years which occurs for both programs appears significant, but may be the result of the relatively small number of nominations from first year students. The lower result for year 3 driven by nominations from specialist degree students is notable. Otherwise, the proportion of nominations falling into the threshold concept category (category 1) shows an increasing trend with year of study, both in total (13% to 25%) and for the two programs separately (specialist degree 15% to 27%, major 10% to 19%). The proportion of nominations categorised as a generic skill or too general/unclear (categories 3 and 4) is lower for year 1 than later years; the significantly lower proportion of nominations from fourth year specialist degree students categorised as too general/unclear is notable.

4.3 Specific concepts

In Table 4 we show the results of relating the student nominations to the specific threshold concepts proposed in our previous research (table 1). The left side of the table shows the explicit nominations of threshold concepts by students (category 1), whereas the right-hand side shows the threshold concept that seems most closely related to the students' category 2 nominations as determined by us. Thus, the left-hand side of the table shows the extent to which students directly nominated specific threshold concepts, whereas the right-hand side of the table shows our assessment of the relevance of threshold concepts to students' category 2 nominations. The concepts are ranked by the number of nominations. The font style shows the results of our previous research with finance academics, where bold indicates a clearly endorsed threshold concept, italics indicates a concept that has not been clearly endorsed as a threshold concept, and underlined indicates a new potential threshold concept that has not been tested yet.

Table 4. Threshold concepts ranked by number of nominations.

1. threshold concept (or direct equivalent)			2. related to a threshold concept		
Rank	**Concept**	**Nomin-ations**	**Rank**	**Concept**	**Nomin-ations**
1	**Risk**	21	1	Markets and market structure(s)	96
	Time value of money	21	2	Return	59
3	Valuation	19	3	Valuation	54
4	**Risk versus return**	18	4	**Risk versus return**	50
5	**Hedging**	9	5	**Risk**	33
	Return	9	6	**Time value of money**	31
7	**Arbitrage**	7	7	Leverage/gearing	24
	Derivatives	7	8	**Diversification**	23
9	Modelling	6	9	Derivatives	18
10	**Market efficiency**	5	10	Pricing	14
11	Markets and market structure(s)	4	11	Modelling	13
12	Leverage/gearing	3	12	Cashflows	11
13	Behavioural finance (more than one concept)	2	13	**Arbitrage**	9
	Cashflows	2	14	**Hedging**	5
	Diversification	2	15	Time series	4
	Opportunity cost	2	16	**Information asymmetry**	3
17	Time series	1	17	Behavioural finance (more than one concept)	1
				Opportunity cost	1
				Probability/randomness	1
				Statistical significance and hypothesis testing	1
		138			**451**

For the 138 nominations that are a threshold concept (category 1), 17 of the concepts from table 1 are nominated at least once. Of these concepts, eight are concepts that were clearly endorsed as threshold concepts in our previous research (bold), four are concepts that were not clearly endorsed as threshold concepts in our previous research (italic), and three are new potential threshold concept arising from our previous research (underlined). Risk, time value of money, valuation and risk versus return are most significantly nominated, with 57% of the nominations relatively equally distributed between them. Of these, valuation is

a new potential threshold concept whereas the other three were clearly endorsed in our previous research. The remaining 42% of the nominations are distributed across the other 13 concepts with no obvious significance or pattern.

For the 451 nominations categorised as related to a threshold concept, 20 of the concepts from table 1 are considered to be related to the nominations. Eight of these are concepts that were clearly endorsed as threshold concepts in our previous research (bold), eight were not clearly endorsed as threshold concepts in our previous research (italic), and four are new potential threshold concepts arising from our previous research (underlined). The four new potential threshold concepts identified are the same as those nominated by students explicitly in category 1 nominations; return, valuation, derivatives and behavioural finance. Markets and market structure(s) is the concept most often identified as the related threshold concept, with 22% of the related to a threshold concept nominations (21%). Return, valuation and risk versus return are also significant with over 10% of the nominations each, accounting for 36% of the nominations in total. Risk and time value of money have about 7% of the nominations each, accounting for a further 14% in total. The remaining 29% of the nominations are distributed across the other 14 concepts with no obvious significance or pattern.

4.4 Type of knowledge

Table 5 shows the student nominations categorised according to the four types of knowledge: conceptual, applied, professional and contextual (as per figure 1). The conceptual knowledge category includes the 138 explicit threshold concept nominations (category 1), also shown separately in italics.

In total, most of the nominations (86%) are categorised as applied, professional or conceptual knowledge in that order, with relatively few (8%) categorised as contextual knowledge and a smaller proportion (6%) too general/unclear to categorise. Applied knowledge is similarly highest for both programs (33%). The proportions of conceptual and professional knowledge are not that dissimilar overall (25% and 28% respectively); however, at a program level there is a significant difference. For major degree students, conceptual knowledge nominations are 12% lower than professional knowledge nominations. In contrast, for the specialist degree the proportions of conceptual and professional knowledge nominations are very similar, only 2% difference, although conceptual knowledge is higher than professional knowledge. Contextual knowledge

nominations are slightly higher from major students than specialist degree students (10% versus 7%) and too general/unclear nominations slightly lower (5% versus 7%).

Table 5. Type of knowledge.

Year of study		**1st**	**2nd**	**3rd**	**4th**	**Total**
All students	**Conceptual**	14	65	78	33	190
		9	50	51	28	138
	Applied	28	77	98	43	246
	Professional	16	77	94	23	210
	Contextual	8	24	20	7	59
	Too general/unclear	3	21	17	4	45
		69	**264**	**307**	**110**	**750**
Specialist degree students	Conceptual	11	41	57	29	138
		7	34	36	25	102
	Applied	22	36	66	36	160
	Professional	10	41	57	20	128
	Contextual	3	14	12	5	34
	Too general/unclear	2	12	14	4	32
		48	**144**	**206**	**94**	**492**
Major students	Conceptual	3	24	21	4	52
		2	16	15	3	36
	Applied	6	41	32	7	86
	Professional	6	36	37	3	82
	Contextual	5	10	8	2	25
	Too general/unclear	1	9	3	0	13
		21	**120**	**101**	**16**	**258**

In relation to year of study, it is difficult to identify strong trends, particularly taking into account the relatively limited number of nominations from first and fourth year major students (21 and 16 respectively) and to a lesser extent first year specialist degree students (48). Generally, the proportion of conceptual knowledge nominations increases with year of study. However, the proportion of explicit nominations of threshold concepts by third year specialist degree students is significantly low at 17%. For the specialist degree program, the proportionate increase in conceptual knowledge nominations (8%) is matched

by a decrease in applied knowledge in the same proportion. Applied knowledge represents the highest or joint highest proportion of nominations in every year for both programs combined, and for six out of the eight individual groupings.

4.5 Modelling in finance

In order to explore the role of modelling throughout the finance curriculum, we considered whether the nominations imply modelling, and how this varies with program, year of study and type of knowledge. The results of this analysis are shown in table 6. The 45 nominations previously categorised as too general/unclear in relation to the type of knowledge are also categorised as too general/unclear to determine whether or not they imply modelling.

Table 6. Role of modelling.

Year of study		**1st**	**2nd**	**3rd**	**4th**	**Total**
All students	**Conceptual**	2/14	5/65	13/78	7/33	27/190
		0/9	3/50	3/51	1/28	7/138
	Applied	2/28	25/77	47/98	26/43	100/246
	Professional	4/16	15/77	25/94	5/23	49/210
	Contextual	1/8	2/24	0/20	0/7	3/59
	Too general/unclear	3	21	17	4	45
		9/69	**47/264**	**85/307**	**38/110**	**179/750**
Specialist degree students	Conceptual	2/11	3/41	12/57	7/29	24/138
		0/7	3/34	3/36	1/25	7/102
	Applied	2/22	13/36	34/66	22/36	71/160
	Professional	4/10	10/41	11/57	4/20	29/128
	Contextual	1/3	0/14	0/12	0/5	1/34
	Too general/unclear	2	12	14	4	32
		9/48	**26/144**	**57/206**	**33/94**	**125/492**
Major students	Conceptual	0/3	2/24	1/21	0/4	3/52
		0/2	0/16	0/15	0/3	0/36
	Applied	0/6	12/41	13/32	4/7	29/86
	Professional	0/6	5/36	14/37	1/3	20/82
	Contextual	0/5	2/10	0/8	0/2	2/25
	Too general/unclear	1	9	3	0	13
		0/21	**21/120**	**28/101**	**5/16**	**54/258**

Overall, just under a quarter (24%) of the nominations imply modelling, with a higher proportion for specialist degree students (25%) than for major students (21%). For both programs the proportion of nominations that imply modelling clearly increases with year of study and the increase is perhaps more significant for the major than the specialist degree, notwithstanding the previous observation about relatively low numbers of nominations in some categories.

In total, modelling is most frequently implied in applied knowledge nominations (41%), followed by professional knowledge nominations (23%) and conceptual knowledge (14%), with only 5% of contextual knowledge nominations implying modelling. The same overall pattern applies to both programs, however a higher proportion of applied and conceptual nominations in the specialist degree (44% and 17% respectively) imply modelling than in the major (34% and 6% respectively). A relatively low proportion of explicit threshold concept nominations (category 1) imply modelling; 5% overall, 7% for the specialist degree students and 0% for major degree students.

5. Discussion

5.1 Program and year of study

The higher number of nominations from specialist degree students (66%) than from major students (34%) is not unexpected given the higher number of students enrolled in the specialist degree, and the fact that we would expect these students to be more engaged with and confident about finance concepts and content. The number of nominations from first year students in both programs is low, suggesting that first year students lack confidence or are less engaged with finance concepts and content. Further, the limited number of nominations from first year students, particularly for the major, has been taken into account in interpreting the results, particularly in relation to the identification of trends associated with year of study.

5.2 Initial categorisation

Most of the nominations (78%) are the same as or related to a threshold concept (categories 1 and 2) from our list developed by academics shown in table 1. Furthermore, a category for nominations not related to a threshold concept was not sustainable due to insignificant numbers. This indicates that what students identify as important in finance has a good overlap with the concepts that academics identify as central to the mastery of finance.

However, the low proportion (18%) of nominations that are threshold concepts (category 1) as well as the high proportion (60%) of nominations categorised as related to a threshold concept indicate that students cannot identify or articulate the threshold concepts explicitly. For example, for the concept 'risk', there are 21 nominations which are the actual threshold concept (category 1) and 33 nominations that relate to the threshold concept 'risk' (category 2). Most of the 21 category 1 responses (17) simply consist of the word 'risk', with the others including some reference to understanding or defining the concept (eg 'understanding of risk' or 'financial risk'). Of the 33 category 2 nominations, most include the word 'risk' but go beyond the basic concept, most commonly to some form of managing risk (eg 'risk management', 'controlling the risk' or 'contingent payments') and to a lesser extent measuring, assessing or evaluating risk (eg 'risk analysis', 'value at risk' or 'risk assessment on investment'). From these nominations, it is not clear whether the student is identifying the concept of risk or the process, activity, or instrument of risk management as the important "concept". These results indicate that there is the potential to teach the central concepts underlying the processes, activities and instruments in finance more explicitly.

The significant number (21%) of the nominations in the other two categories, particularly those in the too general/unclear category (16%), notwithstanding the limitations of the brevity of the questionnaire design, is further evidence that students are either unclear about what a concept is or unable to articulate important concepts in finance. Again, this indicates the potential to teach important concepts in finance more explicitly.

The proportion of direct articulations of threshold concepts (category 1) generally increases in relation to the year of study and is higher for specialist degree students due to the higher entry level and more intense program. However, only 17% of nominations from third year specialist degree students are threshold concepts (category 1), compared with 24% in year 2 and 27% in year 4. While the difference may be random fluctuation, it is also possible that clarity about the central concepts in finance decreases during the third year for specialist degree students. This may be due to both the higher volume of finance material as a result of the increase in finance subjects taken, and more advanced and specialised finance knowledge that does not reiterate or make explicit links to the threshold concepts.

5.3 Specific concepts

By relating the nominations to the specific concepts in table 1 we are able to be more specific about the overlap between the students' nominations of what is important in finance and the threshold concepts proposed by academics. In relation to the 10 concepts clearly endorsed as a finance threshold by academics in our previous research, seven are identified in both the threshold concept and the related to a threshold concept nominations (categories 1 and 2). Of these seven, risk, time value of money and risk versus return are significantly nominated in both categories and diversification is significant in category 2. Expected value is the only clearly endorsed threshold concept not to appear in either category, and interestingly, it is a statistics concept. Market efficiency is identified in the category 1 nominations but not the category 2 nominations. Information asymmetry is identified in the category 2 nominations but not the category 1 nominations. The extent to which clearly endorsed threshold concepts are identified both directly and indirectly in the student nominations indicates a strong relationship between what students identify as important in finance and what academics see as central to the mastery of finance.

In relation to the 12 concepts not previously clearly endorsed as threshold concepts in finance, five are identified both directly (category 1) and as related to a threshold concept (category 2): cashflows, leverage/gearing, markets and market structure(s), modelling and time series. With the exception of markets and market structure(s) none of these concepts are particularly significantly nominated. Markets and market structure(s) is identified as the related threshold concept for 21% of the related to a threshold concept nominations (category 2).These markets and market structure(s) nominations include a diverse range of responses (eg 'stock', 'market based theories', 'regulation') but with a high proportion of financial instruments (applied knowledge – around 50%) and contextual factors (contextual knowledge – around 25%). This indicates that the concept needs more refined definition, as it can be interpreted too broadly. Also, an emphasis in the responses on financial instruments and other elements of financial markets, rather than the concepts that underpin them, reflects an overly narrow view of finance, as suggested by Wood, Petocz and Reid [18], where teaching focuses on the tools and techniques of a discipline, rather than the underlying conceptual understanding and making connections to professional roles.

In relation to new potential threshold concepts, four of the seven from our previous research are identified in the student nominations. The same four (behavioural finance, derivatives, return and valuation) are identified both directly (category 1) and in the related

to a threshold concept nominations (category 2). Valuation occurs significantly in both categories and return occurs significantly in category 2 and to a lesser extent in category 1. These results support the inclusion of valuation, return and, to a lesser extent, derivatives as threshold concepts. In addition, the emerging area of behavioural finance and associated concepts needs to be considered.

5.4 Type of knowledge

Although we specifically asked students to nominate 'important concepts' only a quarter of the nominations (25%) are conceptual knowledge. Whilst this indicates that students may not be able to distinguish conceptual knowledge, it also provides the opportunity to analyse the nominations in relation to the type of knowledge dimension in our model of the finance curriculum (figure 1).

Based on our model we anticipated that all four types of knowledge would be evident in the nominations and were surprised by the relatively low proportion (8%) of contextual knowledge nominations. However, it was difficult to categorise some nominations as professional or contextual as they articulated "doing" in context and therefore elements of both (eg 'Understanding/interpreting what is happening in the market'). In these cases we categorised the response as professional knowledge, potentially resulting in understating contextual knowledge versus professional knowledge. Thus, whilst we feel that contextual knowledge is an important element of finance it is often integrated with professional knowledge. In accordance with the result for the nominations of threshold concepts (category 1) discussed previously, a greater proportion (8% difference) of nominations from specialist degree students are conceptual knowledge than from major students, indicating that specialist degree students are better able to identify or are more familiar with conceptual knowledge. Conversely, a higher proportion of major student nominations are professional and contextual knowledge (6% and 3% differences) than for specialist student nominations, indicating that major students are more disposed to these types of knowledge. There appears to be a slightly higher disposition to applied knowledge, which is more significant for specialist degree students than for major students where applied and professional knowledge are about the same at 33% and 32% respectively.

Notwithstanding the limitations of the first and fourth year data discussed previously, overall the proportion of conceptual knowledge increases over the course of the programs, indicating that the programs do develop students' conceptual knowledge and their ability to identify it. For specialist degree student nominations there is an associated shift away from

applied knowledge whereas for major students the associated shift is away from contextual knowledge.

5.5 Role of modelling

In our proposed model (figure 1), modelling is present throughout the curriculum as a procedural threshold concept, being the way arguments are made in finance. Only just under a quarter (24%) of the nominations imply modelling, however this is not surprising as we did not ask the students to identify modelling in the questionnaire. Although modelling is implied in nominations relating to all four types of knowledge, supporting the idea it is present throughout the curriculum, it is more frequently implied in applied knowledge nominations (41%).

Specialist degree student nominations imply modelling more than major students, however the difference is only 4%. Nominations implying modelling increase with year of study, with the increase perhaps being more significant for major students. This is evidence that, whilst specialist degree students have a greater disposition to and awareness of modelling than major students at the outset of the program (possibly due to having studied mathematics at a higher level at secondary school) both programs develop the modelling abilities of the students.

6. Conclusions

Notwithstanding the reliance on the categorisation of responses by the research team, when compiled and analysed by program and year of study the results lead to a number of interesting findings. In particular, the significant overlap between important concepts identified in the student nominations and threshold concepts identified by finance academic validates our previous research and indicates a reasonable amount of shared understanding between what students perceive as important in finance and what academics consider central to the mastery of finance.

Our first research question is the extent to which students identify the threshold concepts identified by academics as important concepts in finance, and whether this varies by program and year. In fact the extent to which students explicitly nominated threshold concepts is limited (18%). However, the majority of the student nominations (60%) can be related to threshold concepts in finance, indicating that what students identify as important is related to the threshold concepts identified by academics. Explicit nominations of threshold concepts are higher for specialist degree students than for major students and increase over the program. Thus, whilst the current programs do lead to an increase in

explicit awareness of finance threshold concepts, there is scope to make threshold concepts much more explicit, identifying them and distinguishing them from other types of knowledge, and at the same time making their role in finance clear by explaining their relevance to and manifestations as other types of knowledge.

Also in relation to the first research question, the results for explicit nominations of specific threshold concepts (category 1) give some indication (considering there are 168 nominations over 17 concepts) of the concepts that students consider important in finance and are explicitly aware of. The results for specific concepts based on the category 2 nominations indicates the extent to which particular threshold concepts are related to what students identify as most important in finance. Both of these results can be used to inform curriculum delivery in relation to which concepts need to be taught more, or more explicitly.

In relation to the second research question, the student nominations reflect all four types of knowledge: conceptual, applied, professional and contextual. This, together with the fact that such a limited proportion of responses are conceptual knowledge (despite students being specifically asked for concepts in the questionnaire), supports the explicit use of type of knowledge as a way to organise and deliver the finance curriculum. The type of knowledge reflected in the nominations does vary by program and year, however this variation needs to be considered and managed to ensure all four types of knowledge are developed so as to meet the program goals of preparing students to act in professional roles.[17]

The third research question relates to the role of modelling in finance. Modelling is evident in the student nominations for all types of knowledge, although more highly evident in applied knowledge nominations. Modelling is slightly more evident in specialist degree student nominations and there is some evidence that it increases with year of study. These results support our proposed model of the curriculum which shows modelling as present in various forms throughout the curriculum. However, combined with the fact that modelling was not clearly endorsed as threshold concept by academics, the results also indicate that there is scope to clarify the role of modelling in finance and also the aims of finance programs in relation to modelling.

This research generally supports our proposed model of the finance curriculum which incorporates threshold concept theory and the framework developed by Wood et al. [3] in relation to type of knowledge. This model has the potential to inform curriculum design

and delivery, by making threshold concepts and the type of knowledge explicit, and the basis of organisation and development throughout the curriculum more transparent.

As mentioned in the introduction, our research involves the participation of international and domestic finance students and academics, and thus the findings incorporate the views and perceptions of students and academics from a number of different countries. This, combined with the relatively universal nature of finance, means that the findings of the research are applicable to finance programs globally.

Acknowledgements

Emily Inglis for transferring the questionnaire to an online format.

Sue Carter for distributing the link to the questionnaire.

References:

[1] Hoadley S, Tickle L, Wood LN, Kyng T. Threshold concepts in finance: conceptualising the curriculum. Int J Math Educ Sci Technol [Internet]. Available from: http://dx.doi.org/10.1080/0020739X.2015.1011244

[2] Hoadley S, Wood LN, Kyng T, Tickle L. Threshold concepts in finance and the role of mathematics. 2015.

[3] Wood LN, Mather G, Petocz P, Reid A, Engelbrecht J, Harding A, et al. University students' views of the role of mathematics in their future. Int J Sci Math Educ [Internet]. 2012 [cited 2013 Oct 16];10(1):99–119. Available from: http://link.springer.com/article/10.1007/s10763-011-9279-y

[4] Cousin G. An introduction to threshold concepts. Planet [Internet]. 2006 Dec [cited 2013 Oct 8];(17):4–5. Available from: http://journals.heacademy.ac.uk/doi/abs/10.11120/plan.2006.00170004

[5] Meyer JHF, Land R. Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising within the disciplines. In: Rust C, editor. Improving student learning - theory and practice ten years on [Internet]. Oxford: Oxford Centre for Staff and Learning Development (OCSLD); 2003. p. 412–24. Available from: http://www.etl.tla.ed.ac.uk/docs/ETLreport4.pdf

[6] Flanagan M. Threshold concepts: Undergraduate teaching, postgraduate training and professional development - A short introduction and bibliography [Internet]. 2015. Available from: http://www.ee.ucl.ac.uk/~mflanaga/thresholds.html

[7] Land R, Rattray J, Vivian P. Learning in the liminal space: a semiotic approach to threshold concepts. High Educ [Internet]. 2014 Jan 5 [cited 2014 Feb 19];67(2):199–217. Available from: http://link.springer.com/10.1007/s10734-013-9705-x

[8] Cousin G. Strategies for researching in higher education: an introduction to contemporary methods and approaches. New York and London: Routledge; 2009.

[9] Diamond R V. Learning and Trusting Cointegration in Statistical Arbitrage [Internet]. Social Science Research Network. 2014 Aug. Available from: http://ssrn.com/abstract=2220092

[10] Diamond R V., Smith HJ. Threshold Concepts: A Disciplinary Enquiry in Quantitative Finance [Internet]. Social Science Research Network. 2011 Jul. Available from: http://ssrn.com/abstract=1890837

[11] Diamond R V. Analysis of assessment data from statistics courses: grade distributions , surface learning and threshold concepts [Internet]. Social Science Research Network (SSRN). 2011. Available from: http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1890833

[12] Bulmer M, O'Brien M, Price S. Troublesome concepts in statistics: a student perspective on what they are and how to learn them. Assessment in Science Teaching and Learning Symposium, University of Sydney, September 28-29 [Internet]. Sydney, Australia; 2007 [cited 2013 Oct 16]. p. 139–44. Available from: http://openjournals.library.usyd.edu.au/index.php/IISME/article/view/6337

[13] Dunne T, Low T, Ardington C. Exploring threshold concepts in basic statistics, using the internet [Internet]. The International Association for Statistical Education, Statistics & the Internet (IASE/ISI Satellite, 2003). Berlin, Germany; 2003. Available from: http://iase-web.org/documents/papers/sat2003/Dunne.pdf

[14] Quinnell R, Thompson R. Conceptual intersections: re-viewing academic numeracy in the tertiary education sector as a threshold concept. In: Land R, Meyer JHF, Baillie C, editors. Threshold concepts and transformational learning. Rotterdam, Holland: Sense Publishers; 2010. p. 147–64.

[15] Davies P, Mangan J. Threshold concepts and the integration of understanding in economics. Stud High Educ [Internet]. 2007 Dec [cited 2013 Oct 16];32(6):711–26. Available from: http://www.tandfonline.com/doi/abs/10.1080/03075070701685148

[16] Shinners-Kennedy D, Fincher S. Identifying threshold concepts: from dead end to a new direction. Ninth annual international ACM conference on international computing education research [Internet]. 2013 [cited 2013 Oct 21]. p. 9–17. Available from: http://dl.acm.org/citation.cfm?id=2493396

[17] Baillie C, Bowden JA, Meyer JHF. Threshold capabilities: threshold concepts and knowledge capability linked through variation theory. High Educ [Internet]. 2012 Jun 5 [cited 2014 Mar 7];65(2):227–46. Available from: http://link.springer.com/10.1007/s10734-012-9540-5

[18] Wood LN, Petocz P, Reid A. Becoming a Mathematician [Internet]. Dordrecht: Springer Netherlands; 2012 [cited 2014 Nov 5]. Available from: http://link.springer.com/10.1007/978-94-007-2984-1

Chapter 5 – Conclusions

The research as presented and discussed in the previous chapters enables significant original conclusions to be drawn in relation to the finance curriculum in terms of specific threshold concepts and types of knowledge, and their implications for learning and teaching finance. In addition, conclusions can be drawn in relation to threshold concepts both as a theoretical framework and a methodological approach. Areas for further research are identified and discussed at the end of this chapter.

Specific threshold concepts in finance

A key outcome of this study is the proposals for specific threshold concepts in finance that finance educators can use to inform the design and delivery of finance subjects and programs (Table 1). In addition, the proposals for threshold concepts have been analysed in four interrelated ways that further inform learning and teaching in finance. Firstly, the concepts have been mapped using the framework developed by Davies and Mangan (2007), enabling the distinction between basic, discipline and procedural concepts. Secondly, the distinction has been made between finance and statistics concepts, allowing the role of mathematics and statistics in finance to be more precisely described. Thirdly, the original proposals for threshold concepts by academics from a single institution have been verified by other academics from a number of institutions in different communities. This has enabled the identification of three categories of concepts for consideration by finance educators; 10 clearly endorsed threshold concepts, 12 concepts not clearly endorsed and an additional seven concepts that have yet to be tested with finance academics. Finally, the concepts have been related to student nominations for important concepts in finance, allowing the extent to which student understandings of what is important in finance overlap with the threshold concepts to be identified. Table 1 shows the threshold concepts. The numbers in brackets after each concept indicates the extent to which they are evident in the student nominations for important concepts in finance, where normal font indicates the number of explicit nominations and italics indicates the number of times the concept was identified as related to a student nomination.

For finance educators the 10 clearly endorsed threshold concepts provide an important starting point for curriculum design around essential conceptual knowledge. In addition, finance educators can also consider the 12 concepts not clearly endorsed – particularly the basic concepts which are possibly overlooked by finance academics due to their experience

and expertise, and the untested concepts – particularly valuation (value) and return, which are strongly evident in the student data, and to a lesser extent, derivatives.

Table 1. Threshold concepts in finance

Type of conceptual change (Davies and Mangan, 2007)	Finance	Statistics
Clearly endorsed		
Basic	Information asymmetry (0, *3*) Risk versus return (18, *50*)	Expected value
Discipline	Arbitrage (7, *9*) Diversification (2, *23*) Hedging (9, *5*) Market efficiency (3, *0*) Opportunity cost (2, *1*) Risk (21, *33*) Time value of money (21, *31*)	
Not clearly endorsed		
Basic	Leverage/gearing (3, *24*) Markets and market structure(s) (4, *96*) Pricing (0, *14*) Trade offs	Probability/ randomness (0, *1*) Time series (1, *4*)
Discipline	Cashflows (2, *11*) Utility/risk preference	Central limit theorem and normal distribution Correlation Statistical significance and hypothesis testing (0, *1*)
Procedural	Modelling* (6, *13*)	
Yet to be tested with academics		
Basic	Liquidity Valuation (value) (19, *54*)	
Discipline	Behavioural finance**(2, *1*) Derivatives (7, *18*) Principal-agent problem Marginal costs Return (9, *59*)	

*building, critiquing, implementing, discipline-specific models eg pricing models, valuation
**more than one concept

This research found that the extent to which students are aware of finance threshold concepts is limited, with only 18% of the student nominations for important concepts in finance being threshold concepts. Both the extent to which students are explicitly aware of concepts and the extent to which the student nominations are related to concepts can inform curriculum design. Where the research indicates students are not aware of a threshold concept or are only aware of content related to a threshold concept, there is

potential to put more emphasis on the concept and teach it more explicitly and in different ways to develop student awareness and understanding.

Importantly, statistics concepts, with the exception of expected value, tended not to be clearly endorsed as threshold concepts by academics and not to be evident in student nominations. This, together with the ambivalence about mathematics as reported in paper one, indicates the need for less emphasis on quantitative methods in favour of teaching finance threshold concepts.

Modelling plays an integral role in finance in defining concepts and the procedural knowledge (Wood et al., 2012) to construct discipline-specific narratives and arguments (Davies & Mangan, 2007). Despite this, and despite being implied in other concepts such as the time value of money, pricing and valuation, modelling is not clearly endorsed as a threshold concept in finance. At the same time, modelling is more evident in data from the specialist degree students (who are likely to have advanced mathematics skills) and is increased with year of study. These factors, together with the ambivalence about mathematics as reported in paper one, argue for the role of modelling in finance to be made more explicit, and for modelling to be taught in ways that are not highly dependent on mathematics skills such as via Microsoft Excel™, as advocated in the original focus groups and supported by the research of Kyng, Tickle and Wood (2011).

The threshold concepts identified in this study are entirely focused on discipline content knowledge, and furthermore reflect a bias towards a neoclassical (quantitative, normative and rational) view of finance with only minimal reference to behavioural finance. As such, it is possible that the threshold concepts identified represent a rather traditional, narrow view of finance and exclude more broad, fundamental or general learning thresholds that students face, as well as developments in finance. This is partly due to the focus of threshold concepts on underlying conceptual knowledge. However, as discussed in the introduction, whilst identifying specific threshold concepts is often the focus of research into threshold concepts, other research has taken a broader view and identified more general or generic learning thresholds, for example subjectivity, uncertainty, contextualised meaning in accounting (Lucas & Mladenovic, 2006, 2007) and thinking like a mathematician or critically in engineering (Galligan et al., 2010; Worsley, 2011). More general and generic thresholds did arise in this research (mathematics and other more generic skills identified in the original focus group with academics and the student data)

but, because they were not the focus of this study, they were not further explored as thresholds in finance.

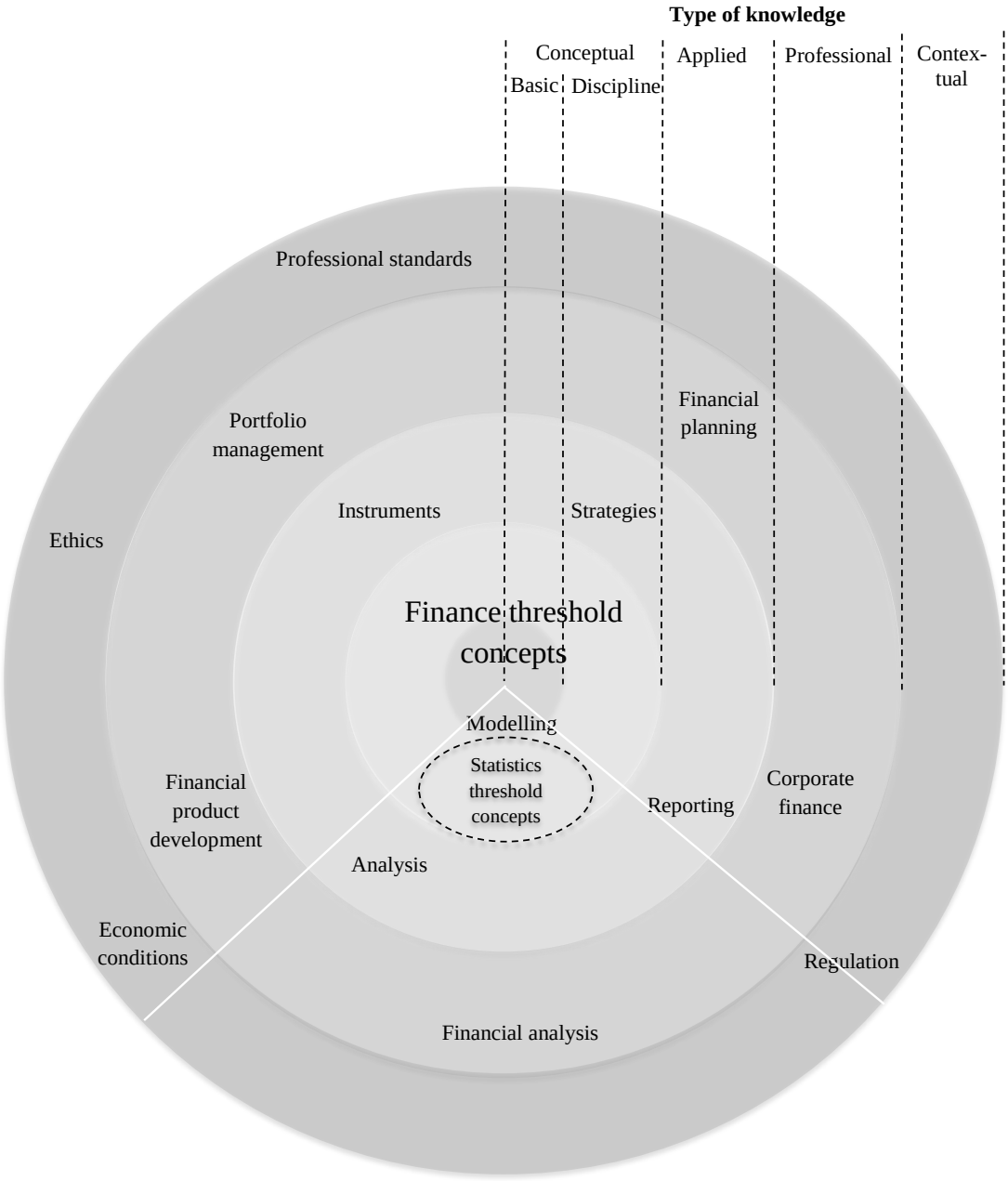
The limited reference to behavioural finance in the threshold concepts identified is not surprising given Coleman's (2013) argument that the neoclassical approach has been the basis of finance teaching. However, it may indicate that the concepts identified are based on what has been taught rather than what should be taught. And indeed, there is very little in table 1 that is entirely new or unrelated to the finance topics and concepts identified in research in the 1980s and 1990s shown in table 1 of chapter 1. Notwithstanding this, this study attempts to identify the threshold concepts that underpin theories and approaches rather than the theories and approaches themselves, and as such there is scope to refresh the finance curriculum by considering and teaching the threshold concepts from a behavioural perspective (Shiller, 2006). For example, the neoclassical view of market efficiency is that markets are efficient (the price of a stock is equal to its fundamental value) and cannot be beaten, but the behavioural finance view is that markets are not efficient – although they may be difficult to beat, notwithstanding that the assumption of efficiency is a useful heuristic to focus the analysis of pricing on other factors (Statman, 2008).

The inclusion of more generic skills and more qualitative behavioural finance perspectives in the finance curriculum/learning and teaching finance is essential to prepare students for roles as finance practitioners. The failure of higher education programs to adequately prepare students for professional roles, particular in relation to generic skills, is a common complaint of industry (Freeman et al., 2008). The importance of more generic skills, as opposed to discipline-specific knowledge, is reflected in graduate learning standards such as the Academic Learning Standards for Finance in the Australian Higher Education Context (Finance Learning Standards Working Party Australian Business Deans Council, 2014) which list application, judgement, communication, teamwork and reflection alongside knowledge. Furthermore, finance practitioners criticise the neoclassical finance theory which is the focus of finance programs as being of limited use in practice because the data required are not available, it does not work and it ignores more valuable qualitative data that is available (Coleman, 2013).

Conceptualising the finance curriculum

The second key outcome of the research is the model of the finance curriculum which uses type of knowledge as a dimension to map threshold concepts and in relation to other (types of) knowledge as shown in figure 1. As stated in chapter 1, previous research into the finance curriculum has focused on topics rather than concepts. However, there is slippage and overlap between what is meant by the two terms. Similarly, despite the explicit focus on identifying threshold concepts in this study, many of the responses from students and to a lesser extent academics were not conceptual knowledge, but rather other types of knowledge. Thus, as identified by Wood et al. (2012) and supported in this research, data from students reflect different types of knowledge. However, students are not aware of the different types of knowledge and cannot distinguish between them. This indicates the importance of incorporating type of knowledge as a dimension in the model of the finance curriculum to make the types of knowledge explicit in finance learning and teaching, as well as to more precisely map and better understand the curriculum.

Figure 1. Finance curriculum model



Most obviously the type of knowledge dimension allows the explicit distinction between (threshold) conceptual knowledge and other types of knowledge, leading to more explicit teaching, and thus student awareness and understanding, of (threshold) concepts and their relationship to other curriculum content and types of knowledge. Further, in addition to teaching concepts (in abstract) the other types of knowledge offer different perspectives on and ways to teach the concepts. That is, without implying any order, how does a threshold concept manifest in finance applications (applied knowledge), professional practice (professional knowledge) and the context (contextual knowledge)? In this way, the types of knowledge become the contexts in which the threshold concepts are taught.

The model makes the role of modelling explicit by showing it as conceptual knowledge (statistics concepts are shown as underpinning modelling) but also fanning out and being used in conjunction with all types of knowledge. This is supported by the findings of paper 3 in which modelling is evident in nominations reflecting all knowledge types. The fact that there is a need to make the role of modelling throughout the curriculum explicit in curriculum delivery is supported by the lack of clear trends in relation to modelling, type of knowledge and year of study in paper 3, together with the fact that modelling was not clearly endorsed as threshold concept by academics.

The finance curriculum model (Figure 1) should be used to communicate the finance curriculum to students, providing a view of the curriculum that makes different types of knowledge, the role of threshold concepts and the location of content explicit. Further, this model should be constantly referred to in delivering the curriculum to locate what is being taught and learnt and track student progression through the curriculum.

Following Baillie et al. (2012), the goal of the finance curriculum is to equip students to act effectively in future professional roles which involves the identification, understanding and integration of epistemic or conceptual knowledge, techne or technical skills (shown in the model as applied knowledge), and phronesis being judgements and decisions about what to do in particular circumstances (divided into professional and contextual knowledge in the model). As discussed in paper 3, although it seems clear that conceptual knowledge is increased over the course of both programs, clear trends in relation to the balance between the different types of knowledge each year are difficult to identify. The differences between the two programs in relation to type of knowledge, whilst not unexpected, are not necessarily appropriate. For example, do specialist degree students need less professional or contextual knowledge than major students? Conversely, do finance major students need less conceptual knowledge than specialist degree students? Overall, this indicates the need for a much more explicitly motivated and planned approach to the development of the different types of knowledge as appropriate to the goals of the program.

Threshold concepts as a theoretical framework

This research both supports and informs threshold concepts as a theoretical framework to inform learning and teaching (in finance) and the transformative, integrative, irreversible and troublesome characteristics. Motivated by the relative newness of threshold concepts and the limited research into threshold concepts in finance particularly, the research sought the views of finance academics as to the potential of threshold concepts to inform learning and teaching in finance. As reported in paper 2, the majority of finance academics

surveyed rated the potential of threshold concepts to inform curriculum design and learning and teaching in finance highly, even if they have no or limited exposure to the idea prior to being surveyed. Thus, the research provides evidence in support of the appeal (Barradell, 2013) and acceptance (Baillie et al., 2012) of threshold concepts. More specifically, finance academics perceived threshold concepts as a way to inform the design of programs and subjects in relation to what to teach and the order in which to teach; pedagogical practices in relation to making connections to other material; progressing through the material; assessment; anticipating and dealing with students' reactions to learning; and scaffolding learning.

This research uses the transformative, integrative, irreversible and troublesome characteristics as a way to analyse and verify the proposed threshold concepts. At the same time, this approach has a reciprocal effect, in that it provides evidence as to the extent to which each of the four characteristics is associated with a concept being a threshold concept. The characteristic most strongly associated with a concept being a threshold concept is the integrative characteristic, followed by the transformative and irreversible characteristics. This finding in relation to the integrative characteristic is particularly relevant for relatively new disciplines that have evolved from other disciplines, such as finance, where the discipline boundaries might be unclear. This is because, according to Davies and Mangan (2007), integration is associated with the definition of the boundaries of a discipline, such that the higher the integration, the clearer the discipline boundaries are. Thus, threshold concept theory through the integrative characteristic provides a way to define and delineate a discipline. Overall, this research supports Davies and Mangan (2007) in that the transformative, integrative and irreversible characteristics are the "primary" characteristics of threshold concepts.

Interestingly, the troublesome characteristic seems to have no clear relationship with a concept being threshold. Similarly, perceptions of the value of the troublesome characteristic are somewhat varied in the quantitative data. There appear to be three concerns with the troublesome characteristic. Firstly, a concept may be troublesome but not necessarily a threshold concept (Barradell, 2013) as per the statistics concepts in this research. Secondly, the "troublesomeness" may be due to other factors (Quinlan et al., 2013), as one of the participants in this research wrote:

"It is hard to judge the difficulty of a concept when it is being lectured as students may either find the concept difficult or the lecturer's explanations insufficient."

Thirdly, the "troublesomeness" may not be due to the difficulty of the concept, but rather due to the significant (conceptual and ontological) change brought about in the student (Land et al., 2014). Thus, academics, having gone through and reconciled themselves to this change, may have lost sight of troublesomeness. Similarly, academics tended not to endorse basic concepts as threshold concepts in this study, despite the fact that it is these concepts that are most likely to be transformative for students. This is perhaps because, having gone through the ontological shift, academics lose sight of the significance of such basic concepts and possibly even the concept itself.

Finally, by focusing on the conceptual knowledge that underpins mastery in a discipline, as discussed above specifically in relation to finance, threshold concept theory perhaps focuses on what is most static and constant in a discipline at the expense of innovation and the future needs of the discipline. Thus overall, whilst this study provides evidence in support of threshold concept theory and its use in curriculum design and learning and teaching, its focus on essential conceptual discipline knowledge and the subjectivity involved in the perception of the characteristics are factors which need to be taken into account when using threshold concept theory to investigate and inform curricula.

Threshold concepts as research methodology

Following Cousin's (2009) description of threshold concept research, the study was originally conceived as primarily qualitative, with data collected in focus groups and semi-structured interviews with finance academics and students. However, this approach does not take into account the fact that although qualitative research is well established and accepted in education, other disciplines, of which finance is one, value quantitative research more highly. As the study progressed, the need to take into account the preferred research approach in finance, in part led to the adoption of more quantitative methods to validate the results of the qualitative research. This shift in approach was compounded by difficulties in getting sufficient discursive data from students.

In addition, two key outcomes of the project are the identification of threshold concepts in finance and the extent to which threshold concept theory is of value to learning and teaching in finance. Both of these outcomes are a function of the extremely limited research into threshold concepts in finance. That is, it was necessary to satisfy finance academics on these points in the first instance.

Thus, the collaboration between discipline specialists, educational researchers and students that is a feature of threshold concepts research (Cousin, 2009) may require the research methodology to be adapted and extended, and may affect the outcomes of research. However, these adjustments and outcomes can inform and develop threshold concepts research methodology, as well as adding rigour to the theory by testing it in new ways.

Threshold concepts research is described by Cousin (2009) as a form of transactional *curriculum* inquiry, and hence the focus is on the concepts, that academics identify as fundamental to the discipline, how students perceive these concepts and what curriculum design interventions are required to teach the concepts. However, this approach does not involve reference to industry practitioners, which is a significant omission for a vocational degree such as finance. Some finance industry practitioners are critical of the predominately neoclassical finance theory taught at universities (Coleman, 2013), and their involvement in threshold concept research would be a way to investigate and address the disjunction between what academics teach and the needs of the industry. This study therefore supports the argument of Barradell (2013) that transactional curriculum inquiry needs to be extended to include the professional community. Furthermore, locating the threshold concepts within a broader framework, incorporating type of knowledge as in this study, to explain their role in equipping graduates to be effective in professional roles (Baillie et al., 2012) will further facilitate discussion with industry.

Threshold concepts methodology emphasises the role of discipline specialists in exploring the threshold concepts that are fundamental to a grasp of their own discipline (Cousin, 2009). However, when the discipline being researched involves enabling disciplines, such as mathematics in finance, the research should also involve academics from the enabling discipline. This would ensure that the contribution the enabling discipline makes to the threshold conceptual knowledge of the discipline being researched is more explicitly and comprehensively investigated. Whilst this study has explored and added clarity to the role of mathematics in finance and the extent to which mathematics concepts are threshold concepts in finance, it has only done so from the point of view of finance educators and would have benefited from the expertise of mathematics educators, particularly in relation to defining and developing mathematics skills in other disciplines. Furthermore, being involved in threshold concepts research would provide academics from enabling disciplines with additional insights into the perspectives of academics and students in relation to developing skills in the enabling discipline.

According to Cousin (2009) a key aspect of threshold concepts research is that curriculum inquiry and (re)design is done at the same time, rather than sequentially. However, implementing the curriculum changes and pedagogical practices to embed and develop threshold concepts at a discipline or program level needs to be driven by the institution, generally at a department level, not least because of the time and resources required. And indeed, much threshold concept research is conducted within large (cross) institutional projects (for example Åkerlind, Mckenzie & Lupton, 2011; Parker & McGill, 2014; Quinlan et al., 2013). Despite this, this study makes a valuable contribution by identifying threshold concepts; considering their implications for curriculum design and delivery; as well as demonstrating and critiquing threshold concept research.

In summary, as a result of using the threshold concepts research methodology, this study has identified threshold concepts in finance and considered these in relation to other conceptual knowledge in finance, as well as other types of knowledge to conceptualise the finance curriculum. The research also provides convincing quantitative evidence that threshold concept theory is a valid theoretical framework, particularly the transformative, integrative and irreversible characteristics, perceived by finance academics as being helpful to learning and teaching in finance. However, due to the focus on identifying threshold concepts and the type of data collected, the study is limited in its findings in relation to pedagogical practices required to embed and develop threshold concepts in finance and in relation to the bounded, discursive, reconstitutive and liminal aspects of the threshold concepts framework. Further, without the involvement of industry the outcomes of threshold concept research may identify what is required to complete educational programs successfully, rather than what is required to act effectively in professional roles. In addition, the outcomes and impact that threshold concept research can have are limited unless there is significant institutional commitment to the process and subsequent implementation.

Future research

This study investigates an under researched area, the finance curriculum and learning and teaching in finance, and uses a relatively new theory, threshold concepts, as both a framework and research methodology to do so. Thus, whilst the outcomes of the study are significant, it also provides a valuable starting point for further research.

In relation to specific threshold concepts (table 1), there is the potential to further test these concepts with academics, but perhaps more importantly with students and finance industry

practitioners. The extent to which students experience the concepts identified here, and other finance concepts, as threshold concepts could be further investigated using the threshold concepts framework more explicitly and collecting discursive data. As well as testing specific concepts, this would provide a different perspective on characteristics associated with threshold concepts, particularly the troublesome and transformative characteristics which may be understated by academics. However, the difficulties in conducting research with students experienced in this study indicates that such further research might be best undertaken as action research (Cousin, 2009) embedded in pedagogical practices as discussed below. The threshold concepts identified in this study provide the starting point for discussion and debate between industry practitioners and academics about the essential conceptual content of finance programs. The aim of this research would be to ensure that finance programs are robust in their conceptual basis and also meet the needs of the finance industry and society more generally.

In addition, there is the potential to extend the research beyond highly content specific concepts to more general or generic ones, and, perhaps more significant, learning thresholds. For example, a third year finance student reported that realising that everything can (and perhaps has to be) considered in financial terms, and also that financial implications are relative (that is, good for some, bad for others) has transformed her understanding of the world, as well as her understanding of (the role of) finance. The focus of this research on highly content specific threshold concepts has limited the identification and exploration of highly transformative thresholds such as this.

Further research into the model of the finance curriculum proposed (figure 1) is required to test its effectiveness in conceptualising, mapping and communicating the content of specific finance programs. Such research would need to involve collaborative participation by finance academics, students and industry practitioners. The implications of the model need to be considered and investigated. For example, how does the type of knowledge dimension inform program design in terms of progression through the curriculum; and how should this be reflected in learning outcomes, which generally reflect a different taxonomy of knowledge such as Bloom's (Anderson & Krathwohl, 2001)?

In addition to curriculum design, further research is required to develop and evaluate pedagogical practices to embed and teach threshold concepts in finance. Shinners-Kennedy and Fincher (2013) suggest that threshold concepts are expressed and made apparent to students in "pedagogical content knowledge" (PCK). Therefore a content representation (CoRe) grid, originally conceived to develop PCK, is a way to both document and analyse

threshold concepts and to articulate ways to "teach" them. The threshold concepts identified in this research are an important starting point for future research into learning and teaching finance using a CoRe grid. In addition, the CoRe grid can be further informed by the results of this research. In table 2 below, I have supplemented the CoRe grid with additional questions (shown in bold) that prompt explicit consideration of the integrative, transformative and, by implication, irreversible characteristics and the type of knowledge, found in this research to be relevant to learning and teaching in finance. In addition, a separate additional question has been added to inform assessment task design, incorporating the assessment and feedback cycle developed by Wood (2012).

Table 2. CoRe grid threshold concepts in finance with additional questions

	Finance Threshold Concepts		
	Concept 1	Concept 2	Concept N
1.What do you intend students to know about this concept?			
2.Why is it important for students to know this? **(How does the concept manifest as contextual/professional/applied knowledge? How does this concept integrate with other concepts?)**			
3. What else do you know about this concept (that you don't intend students to know yet)?			
4. Difficulties/limitations connected with teaching this concept.			
5. Knowledge about students' thinking that influences your teaching of this concept. **(How does the concept transform the way students think?)**			
6. Other factors that influence your teaching of this concept.			
7. Teaching procedures (and particular reasons for using these to engage with this concept). **(How can the concept be taught as contextual, professional as well as applied and conceptual knowledge?)**			
8. Specific ways of ascertaining students' understanding or confusion around this concept. **(How can the concept be probed as contextual, professional and applied as well as conceptual knowledge?)**			
9. How can the concept (and type of knowledge) be made explicit in the assessment task design (task, standards, marking, feedback and reflection)?			

(Adapted from Loughran, Mulhall and Berry, 2004)

Completion of the CoRe grid will result in the identification of specific pedagogical practices to embed and develop threshold concepts in finance. The effectiveness of such practices needs to be investigated and it is suggested that this take the form of action research (Cousin, 2009), where the academics research the effect of their practice(s) with students. At the same time as mentioned above, students' perceptions of threshold concepts in finance could be further investigated, particularly in relation to the troublesome, transformative, discursive, reconstitutive and liminal characteristics, by analysing students' responses to the pedagogical practices. Since the pedagogical practices are learning and teaching activities for students, this approach avoids the problem (ethical and practical) of trying to get students to give up their time to participate in research which they perceive, quite correctly, has little benefit to themselves.

As discussed previously, finance is a relatively new discipline and very interdisciplinary, in that it is still regarded by many as a branch or sub-field of economics, involving knowledge of accounting and, traditionally, mathematics and statistics (Finance Learning Standards Working Party Australian Business Deans Council, 2014). As such, it might be anticipated that the discipline boundaries of finance are rather unclear, which in turn is partly why the bounded characteristic is not pursued in this research. However, an unexpected finding of the research was the extent to which finance threshold concepts are associated with the integrative characteristic, which according to Davies and Mangan (2007) indicates clear discipline boundaries. Thus, further research into the integration of threshold concepts in finance, for example using concepts maps as discussed in Quinlan et al. (2013), offers a way to define, describe and distinguish finance as a discipline. In addition, the research was able to significantly clarify the role of interdisciplinary knowledge, primarily mathematics and statistics in finance.

The future research activities identified here involve a qualitative approach to research that is more commonly used and readily accepted in education research than in finance research. The preference for quantitative research is a feature of finance research discourse which, by expecting it to conform to accepted practices and conventions (Fairclough, 1992), has the potential to influence future research in finance education (Evans & Cable, 2011). My experience during this study has taught me that, in order to maximise the outcomes and impact of research, it is important to analyse the expectations of the research discourses of the all disciplines involved in the research, and to respond to these expectations strategically in the planning and design of the research. At the same time,

Fairclough (1992) also describes discourse as creative as well as conventional, and it is hoped this study has paved the way for more research that pushes the boundaries and contributes to greater acceptance of qualitative research in finance education.

Although this thesis is focused on finance, it informs future research in other areas. In particular, it shows the potential of threshold concepts to define and describe a discipline in terms of its boundaries and the role of key interdisciplinary knowledge, such as mathematics and statistics. The thesis also demonstrates the value of a curriculum model which both distinguishes and integrates different types of knowledge, ways of understanding the discipline (for example concepts versus topics) and particular aspects of the discipline (for example the role of modelling in finance). And just as importantly, it highlights the need to develop and share this model with both academic staff and students. Finally, the thesis demonstrates that threshold concepts research itself is interdisciplinary, and that whilst conducting threshold concepts research may require accommodating different research paradigms this likely to result in original and novel approaches and outcomes.

Full Reference List

Åkerlind, G., McKenzie, J., & Lupton, M. (2011). *A threshold concepts focus to curriculum design: Supporting student learning through application of variation theory*. Final Report, Australian Learning & Teaching Council. Retrieved from http://www.thresholdvariation.edu.au/sites/default/files/pp8-885_anu_akerlind_final_report_v1.0_.pdf

Alcock, J., Cockcroft, S., & Finn, F. (2008). Quantifying the advantage of secondary mathematics study for accounting and finance undergraduates. *Accounting and Finance, 48*(5), 697–718. doi:10.1111/j.1467-629X.2008.00261.x

American Finance Association. (2012). The American Finance Association. Retrieved from http://www.afajof.org

Anderson, L. W., & Krathwohl, D. (Eds.). (2001). *A taxonomy for learning, teaching and assessing: A revision of Bloom's taxonomy of educational objectives*. New York: Longman.

Appleby, Y., & Barton, A. (2012). Case study: Engaging conceptual learning about threshold concepts with pots and pans. *Journal of Learning Development in Higher Education*, (4). Retrieved from http://www.aldinhe.ac.uk/ojs/index.php?journal=jldhe&page=article&op=view&path%5B%5D=137&path%5B%5D=101

Baillie, C., Bowden, J. A., & Meyer, J. H. F. (2012). Threshold capabilities: Threshold concepts and knowledge capability linked through variation theory. *Higher Education, 65*(2), 227–246. doi:10.1007/s10734-012-9540-5

Balachandran, B., Skully, M., Tant, K., & Watson, J. (2006). Australian evidence on student expectations and perceptions of introductory business finance. *Accounting & Finance, 46*, 697–713. doi:10.1111/j.1467-629X.2006.00193.x

Barradell, S. (2013). The identification of threshold concepts: A review of theoretical complexities and methodological challenges. *Higher Education, 65*(2), 265–276. doi:10.1007/s10734-012-9542-3

Berry, T. D., & Farragher, E. J. (1987). Survey of introductory financial management courses. *Journal of Financial Education, 16,* 65–72. Retrieved from http://www.jstor.org/discover/10.2307/41948111?uid=3737536&uid=2134&uid=2&uid=70&uid=4&sid=21104404361821

Bloom, W., Bower, M., Brown, N., Donovan, D., Joshi, N., Loch, B., Skalicky, J, & Wood, L. N. (2011). Threshold concepts. *AMS Gazette*, 72–74. Retrieved from http://www.austms.org.au/Publ/Gazette/2011/May11/ClassNotes.pdf

Bourner, T., Greener, S., & Rospigliosi, A. (2009). Mathematics students' next steps after graduation. *International Journal of Mathematical Education in Science and Technology, 40*(6), 777–793. doi:10.1080/00207390902971965

Breen, S., & O'Shea, A. (2012). *Designing tasks to aid understanding of mathematical functions*. Retrieved from http://staff.spd.dcu.ie/breens/documents/BreenOShea_FunctionThresholdConcept.pdf

Bulmer, M., O'Brien, M., & Price, S. (2007). Troublesome concepts in statistics: A student perspective on what they are and how to learn them. Proceedings from *Assessment in Science Teaching and Learning Symposium, University of Sydney, September 28-29* (pp. 139–144). Sydney, Australia. Retrieved from http://openjournals.library.usyd.edu.au/index.php/IISME/article/view/6337

CFA Institute. (2014). CFA Intitute. Retrieved from http://www.cfainstitute.org/programs/cfaprogram/courseofstudy/Pages/cbok.aspx?PageName=searchresults&ResultsPage=1

Coleman, L. (2013). Why finance theory fails to survive contact with the real world: A fund manager perspective. *Critical Perspectives on Accounting*, *25*(3), 226–236. doi:10.1016/j.cpa.2013.02.001

Cooley, P., & Heck, J. (1996). Establishing benchmarks for teaching the undergraduate introductory course in financial management. *Journal of Financial Education, 22,* 1–10. Retrieved from http://www.jstor.org/discover/10.2307/41948218?uid=3737536&uid=2&uid=4&sid=21104401021731

Cousin, G. (2006). An introduction to threshold concepts. *Planet*, (17), 4–5. doi:10.11120/plan.2006.00170004

Cousin, G. (2009). *Strategies for researching in higher education: an introduction to contemporary methods and approaches*. New York and London: Routledge.

Davies, P., & Mangan, J. (2005). Recognising threshold concepts: An exploration of different approaches. Proceedings from *European Association in Learning and Instruction Conference (EARLI) August 23 – 37th 2005*, (Vol. 44, pp. 1–18). Nicosia, Cyprus.

Davies, P., & Mangan, J. (2007). Threshold concepts and the integration of understanding in economics. *Studies in Higher Education*, *32*(6), 711–726. doi:10.1080/03075070701685148

Davies, P., & Mangan, J. (2008). Embedding threshold concepts: From theory to pedagogical principles to learning activities. In R. Land, J. H. F. Meyer, & J. Smith (Eds.), *Threshold concepts within the disciplines. …* (pp. 37–50). Rotterdam: Sense.

Deloitte. (2013). *Positioning for prosperity? Catching the next wave*. *News and Research*. Retrieved from http://www.deloitte.com/view/en_AU/au/news-research/luckycountry/prosperity-next-wave/index.htm

Diamond, R. V. (2011). *Analysis of assessment data from statistics courses: Grade distributions , surface learning and threshold concepts*. *Social Science Research Network*. Retrieved from http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1890833

Diamond, R. V. (2014). *Learning and Trusting Cointegration in Statistical Arbitrage*. *Social Science Research Network*. Retrieved from http://ssrn.com/abstract=2220092

Diamond, R. V., & Smith, H. J. (2011). Threshold concepts: A disciplinary enquiry in quantitative finance. *The Sixth International Developments in Economics Education (DEE) Conference*. London, UK. Retrieved from http://ssrn.com/abstract=1890837

Dunne, T., Low, T., & Ardington, C. (2003). *Exploring threshold concepts in basic statistics, using the internet*. *The International Association for Statistical Education, Statistics & the Internet (IASE/ISI Satellite, 2003)*. Berlin, Germany. Retrieved from http://iase-web.org/documents/papers/sat2003/Dunne.pdf

Easdown, D. (2007). The role of proof in mathematics teaching and the plateau principle. Proceedings from *Assessment in Science Teaching and Learning Symposium, University of Sydney, September 28-29* (pp. 28–33). Sydney, Australia. Retrieved from http://science.uniserve.edu.au/pubs/procs/2007/09.pdf

Easdown, D. (2009). Syntactic and semantic reasoning in mathematics teaching and learning. *International Journal of Mathematical Education in Science and Technology*, *40*(7), 941–949. doi:10.1080/00207390903205488

Easdown, D. (2011). Excursions to and from semantic oblivion. *35th Conference of the International Group for the Psychology of Mathematics Education*. Ankara, Turkey. Retrieved from http://talus.maths.usyd.edu.au/u/pubs/publist/preprints/2011/easdown-2.pdf

Easdown, D., & Wood, L. N. (2014). Novel threshold concepts in the mathematical sciences. C. O'Mahony, A. Buchanan, M. O'Rourke, & B. Higgs (Eds.), Proceedings from *National Academy's Sixth Annual Conference and the Fourth Biennial Threshold Concepts Conference* (pp. 44–50). Dublin, Ireland. Retrieved from http://www.nairtl.ie/documents/EPub_2012Proceedings.pdf#page=54

Entwistle, N., & Nisbet, J. (2013). The nature and experience of academic understanding. *The Psychology of Education Review*, *37*(1), 5–14. Retrieved from http://web.b.ebscohost.com.simsrad.net.ocs.mq.edu.au/ehost/pdfviewer/pdfviewer?sid=829d99ac-1919-495e-86a5-f7608c5f4359@sessionmgr114&vid=3&hid=101

Evans, E., & Cable, D. (2011). Evidence of improvement in accounting students' communication skills. *International Journal of Educational Management*, *25*(4), 311–327. doi:10.1108/09513541111136612

Fairclough, N. (1992). *Discourse and social change*. Cambridge: Polity Press.

Finance Learning Standards Working Party Australian Business Deans Council. (2014). *Academic learning standards for finance in the Australian higher education context*. Deakin, Australia.

Flanagan, M. (2015). Threshold concepts: Undergraduate teaching, postgraduate training and professional development - A short introduction and bibliography. Retrieved from http://www.ee.ucl.ac.uk/~mflanaga/thresholds.html

Freeman, M., Hancock, P., Simpson, L., Sykes, C., Petocz, P., Densten, I., & Gibson, K. (2008). *Business as usual: A collaborative and inclusive investigation of existing resources, strengths, gaps and challenges to be addressed for sustainability in teaching and learning in Australian university business faculties*. Sydney, Australia. Retrieved from file:///D:/Users-Data/mq20021280/Downloads/Grants_DBI_ABDC-Freeman-Business-Final-Report_March27_2008 (5).pdf

Galligan, L., Wandel, A. P., & Hartle, R. T. (2010). Scaffolding distance learning in mathematics for engineering: Identifying key troublesome knowledge. *STEM in Education Conference, 26 & 27 November 2010 - Queensland University of Technology, Brisbane, Australia.* Retrieved from http://eprints.usq.edu.au/19325/2/Galligan_Wandel_Hartle_STEM_2010_AV.pdf

Gup, B. (1994). The five most important finance concepts: A summary. *Financial Practice and Education*, 106–110. Retrieved from http://jpkc.hust.edu.cn/gscwgl/data/uploadfile/20090605104429329.pdf

Halliday, M. A. K., & Hasan, R. (1976). *Cohesion in English*. London: Longman.

Halliday, M. A. K., & Matthiessen, C. M. I. M. (1999). *Construing experiance through meaning: A language-based approach to cognition*. London: Cassell.

Hoadley, S., Tickle, L., Kyng, T., & Wood, L. N. (2015). Threshold concepts in finance: conceptualising the curriculum. *International Journal of Mathematical Education in Science and Technology*. doi:10.1080/0020739X.2015.1011244

Jackling, B., & Sullivan, C. (2007). Financial planners in Australia: An evaluation of gaps in technical and behavioral skills. *Financial Services Review*, *16*(3), 211–228.

Johnson, R. B., & Onwuegbuzie, A. J. (2004). Mixed methods research: A research paradigm whose time has come. *Educational Researcher*, *33*(7), 14–26. doi:10.3102/0013189X033007014

Jooganah, K. (2009). *Proof as a threshold concept for university mathematics: An exploration of student identity and transition*. Retrieved from http://www.education.manchester.ac.uk/research/centres/lta/ltaresearch/transmaths/into-he/papers/

Krishnan, V. S., Bathala, C. T., Bhattacharya, T., & Ritchey, R. (1999). Teaching the introductory finance course: What can we learn from student perceptions and expectations. *Financial Practice and …*, 70–83. Retrieved from http://elibrary.ru/item.asp?id=3470366

Kyng, T., Tickle, L., & Wood, L. N. (2011). Graduates' use of technical software in financial services. In M. Lau & S. Sugden (Eds.), *Applications of spreadsheets in education the amazing power of a simple tool* (pp. 241–260). Hilversum, The Netherlands: Bentham Science Publishers. doi:10.2174/978160805276911101010241

Lai, M. M., Kwan, J. H., Kadir, H. A., Abdullah, M., & Yap, V. C. (2009). Effectiveness, teaching, and assessments: Survey evidence from finance courses. *Journal of Education for Business*, *85*(1), 21–29. doi:10.1080/08832320903217556

Lakshmi, G. (2013). An exploratory study on cognitive skills and topics focused in learning objectives of finance modules: A UK perspective. *Accounting Education*, *22*(3), 233–247. doi:10.1080/09639284.2013.788830

Land, R., Rattray, J., & Vivian, P. (2014). Learning in the liminal space: A semiotic approach to threshold concepts. *Higher Education*, *67*(2), 199–217. doi:10.1007/s10734-013-9705-x

Loughran, J., Mulhall, P., & Berry, A. (2004). In search of pedagogical content knowledge in science: Developing ways of articulating and documenting professional practice. *Journal of Research in Science Teaching*, *41*(4), 370–391. doi:10.1002/tea.20007

Lucas, U., & Mladenovic, R. (2006). Developing new world views: Threshold concepts in introductory accounting. In J. H. F. Meyer & R. Land (Eds.), *Overcoming barriers to student understanding: Yhreshold concepts and troublesome knowledge* (pp. 100–114). London and New York: Routledge - Taylor Francis Group.

Lucas, U., & Mladenovic, R. (2007). The potential of threshold concepts: An emerging framework for educational research and practice. *London Review of Education*, *5*(3), 237–248. doi:10.1080/14748460701661294

MacDougall, M. (2010). Threshold concepts in statistics and online discussion as a basis for curriculum innovation in undergraduate medicine. *MSOR Connections*, *10*(3), 21–41. doi:10.11120/msor.2010.10030021

Macquarie University. (2012). *Review of the Bachelor of Applied Finance*. Sydney, Australia.

Macquarie University. (2015). Macquarie University Applied Finance Centre. Retrieved February 10, 2015, from http://www.mafc.mq.edu.au/

Magdziarz, S., Myers, P., & Bellamy, S. (2012). The integrative nature of threshold concepts in financial accounting - An exploration of the interdisciplinarity of one threshold concept. *Fourth Bienniel Conference on Threshold Concepts: From Personal Practice to Communities of Practice, Trinity College, Dublin, 28-29 June 2012*. Dublin, Ireland.

Marton, F., Dall'Alba, G., & Beaty, E. (1993). Conceptions of learning. *International Journal of Educational Research, 19*(3), 277–300.

Masouros, S. D., & Alpay, E. (2010). Mathematics and online learning experiences: A gateway site. *European Journal of Engineering Education*, *35*(1), 59–78. doi:10.1080/03043790903428729

Matthiessen, C. M. I. M. (2004). *The semantic system of RELATIONAL EXPANSION: Rhetorical structure theory Revised*. Sydney, Australia.

McGuigan, N., & Kern, T. (2010). Leaping over the perceptual threshold in accounting courses. *Australian Technology Network (ATN) Assessment Conference, University of Technology, Sydney, 18-19 November 2010*. Sydney, Australia. Retrieved from https://www.uts.edu.au/sites/default/files/McGUIGAN.pdf

McGuigan, N., & Weil, S. (2011). Transforming student preconceptions of introductory accounting: Galloping over the biggest threshold of them all! Proceedings from *Seventh International Critical Management Studies Conference (CMS7 2011), Faculty of Economics, University of Naples Federico II, Naples, July 11-13, 2011 and Doctoral Consortium, Villa Orlandi, Capri, July 14-16, 2011, 22 pages*. Naples, Capri, Italy. Retrieved from http://mams.rmit.edu.au/1aokmvm2ymw2.pdf

McWilliams, V., & Pantalone, C. (1994). Structuring the finance curriculum: A survey. *Financial Practice and Education*, 37–47. Retrieved from http://connection.ebscohost.com/c/articles/9607300522/structuring-finance-curriculum-survey

Meyer, J. H. F., & Land, R. (2003). Threshold concepts and troublesome knowledge: linkages to ways of thinking and practising within the disciplines. In C. Rust (Ed.), *Improving student learning - theory and practice ten years on* (pp. 412–424). Oxford: Oxford Centre for Staff and Learning Development (OCSLD). Retrieved from http://www.etl.tla.ed.ac.uk/docs/ETLreport4.pdf

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*(3), 373–388. doi:10.1007/s10734-004-6779-5

Parker, T., & McGill, D. (2014). Modularisation of learning outcomes in terms of threshold concepts. *Waikato Journal of Education (Te Hautaka Mātauranga O Waikato), Special Edition: Emergent Learning and Threshold Concepts in Tertiary Education*, *19*(2), 105–114. Retrieved from http://www.wje.org.nz/index.php/WJE/article/view/102

Partington, G. (2014). Finance. Retrieved from http://sydney.edu.au/business/finance

Pettersson, K. (2008). *Algoritmiska, intuitiva och formella aspekter av matematiken i dynamiskt samspel (Algorithmic, intuitive and formal aspects of mathematics in dynamic interplay: A study of students' use of their conceptions in calculus)*. Chalmers Tekniska Högskola och Göteborgs Universitet. Retrieved from http://kurser.math.su.se/file.php/532/Kerstin_Pettersson.pdf

Pettersson, K. (2011). Threshold concepts: A framework for research in university mathematics education. *The Seventh Congress of the European Society for Research in Mathematics Education (Cerme 7), University of Rzesów, Poland, 9th and 13th February 2011*. Retrieved from https://www.cerme7.univ.rzeszow.pl/WG/14/CERME7-WG14-Paper---Petterson-REVISED-Dec2010.pdf

Pettersson, K. (2012). The threshold concept of a function – A case study of a student 's development of her understanding. *Madif 8: The Eighth Swedish Mathematics Education Research Seminar, Umeå, Sweden, January 24-25,*. Retrieved from http://www.mai.liu.se/SMDF/madif8/Pettersson.pdf

Pettersson, K., Stadler, E., & Tambour, T. (2013). Development of students' understanding of the threshold concept of function. *The Eighth Congress of European Research in Mathematics Education (CERME 8), Manavgat-Side, Antalya, Turkey, 6-10 February 2013*. Retrieved from http://cerme8.metu.edu.tr/wgpapers/WG14/WG14_Pettersson.pdf

Philippon, T., & Reshef, A. (2012). Wages and human capital in the US financial industry: 1909-2006. *Quarterly Journal of Economics*, *127*(November), 1551–1609. doi:10.1093/qje/qjs030.Advance

Quality Assurance Agency for Higher Education. (2007). *Subject benchmark in finance*. Gloucester, UK. Retrieved from http://www.qaa.ac.uk/Publications/InformationAndGuidance/Documents/Finance.pdf

Quinlan, K. M., Male, S., Baillie, C., Stamboulis, A., Fill, J., & Jaffer, Z. (2013). Methodological challenges in researching threshold concepts: A comparative analysis of three projects. *Higher Education*, *66*(5), 585–601. doi:10.1007/s10734-013-9623-y

Quinnell, R., & Thompson, R. (2010). Conceptual intersections: Re-viewing academic numeracy in the tertiary education sector as a threshold concept. In R. Land, J. H. F. Meyer, & C. Baillie (Eds.), *Threshold concepts and transformational learning* (pp. 147–164). Rotterdam, Holland: Sense Publishers.

Quinnell, R., Thompson, R., & LeBard, R. J. (2013). It's not maths; it's science: exploring thinking dispositions, learning thresholds and mindfulness in science learning. *International Journal of Mathematical Education in Science and Technology*, *44*(6), 808–816. doi:10.1080/0020739X.2013.800598

Roth, G., Envick, B. R., & Anderson, R. (2002). The most important finance skills for entrepreneurs: Differing views among finance professionals. *The Entrepreneurial Executive*, *7*, 35–37.

Rowbottom, D. P. (2007). Demystifying Threshold Concepts. *Journal of Philosophy of Education*, *41*(2), 263–270. doi:10.1111/j.1467-9752.2007.00554.x

Scheja, M., & Pettersson, K. (2010). Transformation and contextualisation: conceptualising students' conceptual understandings of threshold concepts in calculus. *Higher Education*, *59*(2), 221–241. doi:10.1007/s10734-009-9244-7

Shiller, R. J. (2006). Tools for financial innovation : Neoclassical versus behavioral finance. *The Financial Review*, *41*(1), 1–8. doi:10.1111/j.1540-6288.2006.00129.x

Shinners-Kennedy, D., & Fincher, S. (2013). Identifying threshold concepts: From dead end to a new direction. Proceedings from *Ninth annual international ACM conference on international computing education research (ICER '13)* (pp. 9–18). New York, NY, USA: ACM. Retrieved from http://dl.acm.org/citation.cfm?id=2493396

Statman, M. (2008). What is behavioral finance? In F. J. Fabozzi (Ed.), *Handbook of finance* (Vol. II, pp. 79–84). Hoboken, NJ: John Wiley & Sons.

Stoner, G., & Milner, M. (2010). Embedding generic employability skills in an accounting degree: Development and impediments. *Accounting Education*, *19*(1-2), 123–138. doi:10.1080/09639280902888229

Thompson, R. (2008). *Sexing up stats: dealing with numeracy issues and threshold concepts in an online medical statistics course*. *Australasian and New Zealand Association for Medical …*. Retrieved from http://www.unsworks.unsw.edu.au/primo_library/libweb/action/dlDisplay.do?vid=UNSWORKS&docId=unsworks_7053&fromSitemap=1&afterPDS=true

Walker, C. F., Meltzer, A. H., Peske, E., Howard, B. B., Shelton, J. P., & Naess, R. D. (1966). Developments in the curriculum and teaching of finance: Discussion. *The Journal of Finance, Papers and Proceedings of the Twenty-Fourth Annual Meeting of the American Finance Association*, *21*(2), 423–434. Retrieved from http://www.jstor.org/stable/2977889

Wandel, A. P. (2010). Linkages between courses: A holistic approach to programmes. Proceedings from *21st Annual Australasian Association for Engineering Education (AaeE) Conference: Past, Present, Future - the "keys" to engineering education research and practice, 5-8 December 2010, University of Technology* (pp. 177–180). Sydney, Australia. Retrieved from http://eprints.usq.edu.au/9198

Weil, S., & McGuigan, N. (2010). Threshold concepts in the bank reconciliation section of an introductory accounting course: Creating an ontological shift for students. In R. Land, J. H. F. Meyer, & C. Baillie (Eds.), *Threshold concepts and transformational learning* (pp. 333–345). Rotterdam, The Netherlands: Sense Publishers.

Wood, L. N. (2001). The secondary-tertiary interface. In D. Holton (Ed.), *Teaching and learning of mathematics at university level: An ICMI study* (pp. 87–98). Dordrecht, The Netherlands: Kluwer.

Wood, L. N. (2012). How to align assessment: Learning through a program approach. Sydney, Australia: Macquarie University.

Wood, L. N., Mather, G., Petocz, P., Reid, A., Engelbrecht, J., Harding, A., Houston, K., Smith, G. H., & Perrett, G. (2012). University students' views of the role of mathematics in their future. *International Journal of Science and Mathematics Education, 10*(1), 99–119. doi:10.1007/s10763-011-9279-y

Wood, L. N., Petocz, P., & Reid, A. (2012). *Becoming a mathematician*. Dordrecht, The Netherlands: Springer. doi:10.1007/978-94-007-2984-1

Worsley, S. R. (2011). The big ideas in two large first level courses of undergraduate mathematics. Proceedings from *Mathematics: Traditions and [New] Practices, AAMT23/MERGA34,* (pp. 839–845). Alice Springs, Australia. Retrieved from http://www.merga.net.au/documents/RP_WORSLEY_MERGA34-AAMT.pdf

Worsley, S. R., Bulmer, M., & O'Brien, M. (2012). Threshold concepts and troublesome knowledge in a second-level mathematics course. Proceedings from *Assessment in Science Teaching and Learning Symposium, University of Sydney, September 28-29* (pp. 139–144). Sydney, Australia. Retrieved from http://openjournals.library.usyd.edu.au/index.php/IISME/article/view/6256

Appendices

Appendix 1. Ethics approvals

On 16 May 2012 10:15, Mrs Yanru Ouyang <yanru.ouyang@mq.edu.au> wrote:
Dear A/Prof. Leigh Wood

Re: project title: Threshold Concepts in Finance, Reference No: "5201200284"

Thank you for your recent correspondence. Your response has addressed the issues raised by the Faculty of Business & Economics Human Research Ethics Sub Committee, and you may now commence your research.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:
http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf.

The following personnel are authorised to conduct this research:
Chief Investigator: Leigh Wood
Other Personnel: Leonie Tickle, Tim Kyng

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL EMAIL TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:
1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).
2. Approval will be for a period of five (5) years subject to the provision of annual reports.
Progress Report 1 Due: 16 May 2013
Progress Report 2 Due: 16 May 2014
Progress Report 3 Due: 16 May 2015
Progress Report 4 Due: 16 May 2016
Final Report Due: 16 May 2017

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.
Progress reports and Final Reports are available at the following website:
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/

human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:
http://www.mq.edu.au/policy/
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have final approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of Final Approval to an external organisation as evidence that you have Final Approval, please do not hesitate to contact the FBE Ethics Committee Secretariat,Yanru Ouyang, via yanrun.ouyang@mq.edu.au or 9850 4826.

Please retain a copy of this email as this is your official notification of final ethics approval.

Yours sincerely
Alan Kilgore
Chair, Faculty of Business and Economics Ethics Sub-Committee

From: **Mrs Yanru.Ouyang** <yanru.ouyang@mq.edu.au>
Date: Wed, Jun 19, 2013 at 4:18 PM
Subject: Amendment Jun13 Approved - 5201200284
To: A/Prof Leigh Wood <leigh.wood@mq.edu.au>
Cc: A/Prof Leonie Tickle <leonie.tickle@mq.edu.au>, Mr Timothy Kyng <timothy.kyng@mq.edu.au>, Ms Susan Marie Hoadley <susan.hoadley@students.mq.edu.au>

Dear A/Prof Wood,

Re: Project entitled: 'Threshold Concepts in Finance.'
Reference No.: 5201200284

Thank you for your recent correspondence. The following amendments have been approved:

1. The research will be submitted by a student in a doctorate degree.
2. Add Ms Susan Hoadley as the new investigator.
3. Additional information and consent form for data collected previously and revised information and consent forms for future data collection.

If you have any questions or concerns please contact the FBE Ethics Secretariat on 9850 4826 or at the following email fbe-ethics@mq.edu.au.

Yours sincerely,

Parmod Chand
Chair, Faculty of Business and Economics Ethics Sub-Committee
Faculty of Business and Economics
Level 7, E4A Building
Macquarie University
NSW 2109 Australia
T: +61 2 9850 4826
F: +61 2 9850 6140
www.businessandeconomics.mq.edu.au/

From: **Mrs Yanru Ouyang** <yanru.ouyang@mq.edu.au>
Date: Thu, Jul 4, 2013 at 9:37 AM
Subject: Approved - 5201300475
To: A/Prof Leigh Wood <leigh.wood@mq.edu.au>
Cc: A/Prof Leonie Tickle <leonie.tickle@mq.edu.au>, Mr Timothy Kyng <timothy.kyng@mq.edu.au>, Ms Susan Marie Hoadley <susan.hoadley@students.mq.edu.au>

Dear A/Prof Wood,

RE: 'Threshold Concepts in Finance (Part 2) ' (Ref: 5201300475)

The above application was reviewed by the Faculty of Business & Economics Human Research Ethics Sub Committee. Approval of the above application is granted, effective "4/07/2013". This email constitutes ethical approval only.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf.

The following personnel are authorised to conduct this research:

A/Prof Leigh Wood
A/Prof Leonie Tickle
Mr Timothy Kyng
Ms Susan Marie Hoadley

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL EMAIL TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 4th Jul. 2014
Progress Report 2 Due: 4th Jul. 2015
Progress Report 3 Due: 4th Jul. 2016
Progress Report 4 Due: 4th Jul. 2017
Final Report Due: 4th Jul. 2018

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final

Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

http://www.mq.edu.au/policy/
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of approval to an external organisation as evidence that you have approval, please do not hesitate to contact the FBE Ethics Committee Secretariat, via fbe-ethics@mq.edu.au or 9850 4826.

Please retain a copy of this email as this is your official notification of ethics approval.

Yours sincerely,

Parmod Chand
Chair, Faculty of Business and Economics Ethics Sub-Committee
Faculty of Business and Economics
Level 7, E4A Building
Macquarie University
NSW 2109 Australia
T: +61 2 9850 4826
F: +61 2 9850 6140
www.businessandeconomics.mq.edu.au/

19 November 2013 Mrs Yanru Ouyang yanru.ouyang@mq.edu.au

Dear A/Prof Wood,

Re: 'Threshold concepts in finance (Part 3).'

Reference No.: 5201300793

Thank you for your recent correspondence. Your response has addressed the issues raised by the Faculty of Business & Economics Human Research Ethics Sub Committee. Approval of the above application is granted, effective "19/11/2013". This email constitutes ethical approval only.

This research meets the requirements of the National Statement on Ethical Conduct in Human Research (2007). The National Statement is available at the following web site:

http://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/e72.pdf.

The following personnel are authorised to conduct this research:

A/Prof Leigh Wood
A/Prof Leonie Tickle
Mr Timothy Kyng
Ms Susan Marie Hoadley

NB. STUDENTS: IT IS YOUR RESPONSIBILITY TO KEEP A COPY OF THIS APPROVAL EMAIL TO SUBMIT WITH YOUR THESIS.

Please note the following standard requirements of approval:

1. The approval of this project is conditional upon your continuing compliance with the National Statement on Ethical Conduct in Human Research (2007).

2. Approval will be for a period of five (5) years subject to the provision of annual reports.

Progress Report 1 Due: 19th Nov. 2014
Progress Report 2 Due: 19th Nov. 2015
Progress Report 3 Due: 19th Nov. 2016
Progress Report 4 Due: 19th Nov. 2017
Final Report Due: 19th Nov. 2018

NB. If you complete the work earlier than you had planned you must submit a Final Report as soon as the work is completed. If the project has been discontinued or not commenced for any reason, you are also required to submit a Final Report for the project.

Progress reports and Final Reports are available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

3. If the project has run for more than five (5) years you cannot renew approval for the project. You will need to complete and submit a Final Report and submit a new application for the project. (The five year limit on renewal of approvals allows the Committee to fully re-review research in an environment where legislation, guidelines and requirements are continually changing, for example, new child protection and privacy laws).

4. All amendments to the project must be reviewed and approved by the Committee before implementation. Please complete and submit a Request for Amendment Form available at the following website:

http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/forms

5. Please notify the Committee immediately in the event of any adverse effects on participants or of any unforeseen events that affect the continued ethical acceptability of the project.

6. At all times you are responsible for the ethical conduct of your research in accordance with the guidelines established by the University. This information is available at the following websites:

http://www.mq.edu.au/policy/
http://www.research.mq.edu.au/for/researchers/how_to_obtain_ethics_approval/human_research_ethics/policy

If you will be applying for or have applied for internal or external funding for the above project it is your responsibility to provide the Macquarie University's Research Grants Management Assistant with a copy of this email as soon as possible. Internal and External funding agencies will not be informed that you have approval for your project and funds will not be released until the Research Grants Management Assistant has received a copy of this email.

If you need to provide a hard copy letter of approval to an external organisation as evidence that you have approval, please do not hesitate to contact the FBE Ethics Committee Secretariat, via fbe-ethics@mq.edu.au or 9850 4826.

Please retain a copy of this email as this is your official notification of ethics approval.

Yours sincerely,

Parmod Chand
Chair, Faculty of Business and Economics Ethics Sub-Committee
Faculty of Business and Economics
Level 7, E4A Building
Macquarie University
NSW 2109 Australia
T: +61 2 9850 4826
F: +61 2 9850 6140
www.businessandeconomics.mq.edu.au/

1 October 2014 Mrs Yanru Ouyang yanru.ouyang@mq.edu.au

Dear A/Prof Wood,

Re: Project entitled: 'Threshold concepts in finance (Part 3).'
Reference No.: 5201300793

Thank you for your recent correspondence. The following amendments have been approved:

* Recruit participants/administer the questionnaire face-to-face in tutorials in order to supplement data collected online.

* Amendments to the Questionnaire

* Identified Finance Units to seek participation are: AFIN100, AFIN252, AFIN253 and AFIN310, and

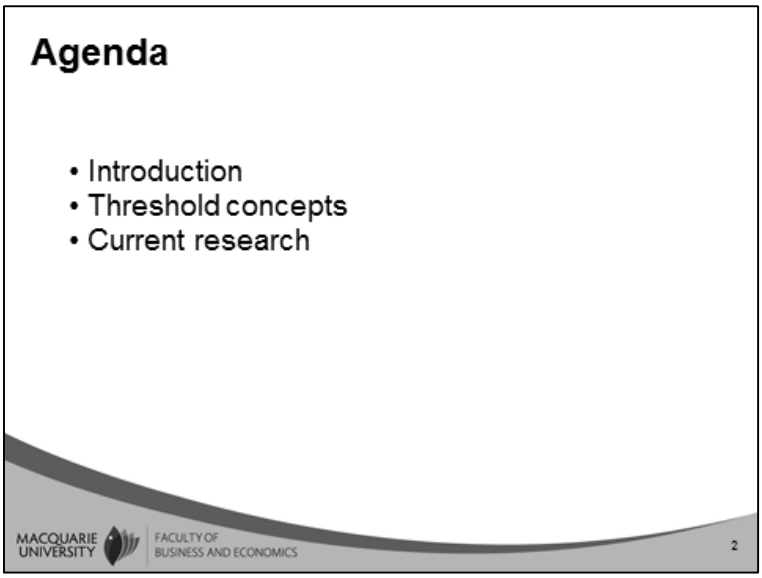
* Completed questionnaires will be stored in loceked cabinet, with responses converted/transfered to an electronic format, and password protected.

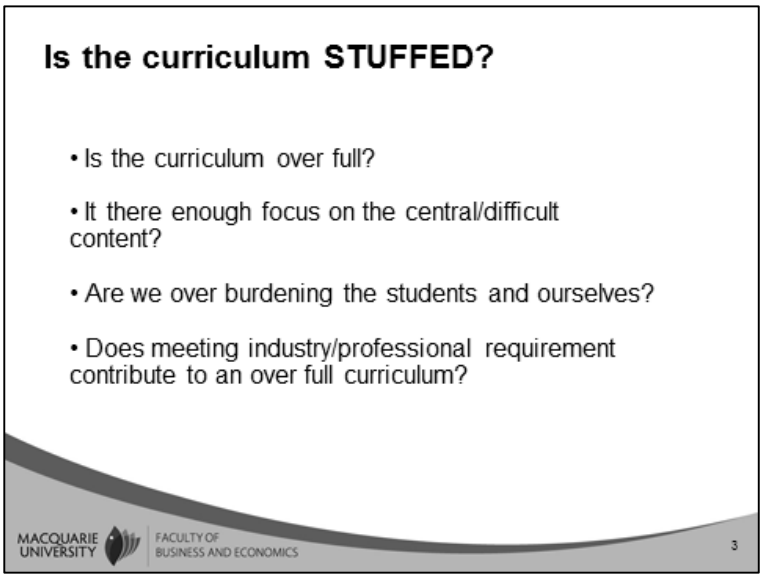
If you have any questions or concerns please contact the FBE Ethics Secretariat on 9850 4826 or at the following email fbe-ethics@mq.edu.au.

Yours sincerely,

Parmod Chand
Chair, Faculty of Business and Economics Ethics Sub-Committee
Faculty of Business and Economics
Level 7, E4A Building
Macquarie University
NSW 2109 Australia
T: +61 2 9850 4826
F: +61 2 9850 6140
www.businessandeconomics.mq.edu.au/

Appendix 2. Introduction to threshold concepts slides for academic focus group





"Threshold concepts"

"A threshold concept … represents a transformed way of understanding, or interpreting, or viewing something without which the learner cannot progress."

Threshold Concepts and Troublesome Knowledge: Linkages to Ways of Thinking and Practising within the Disciplines, Meyer and Land 2003

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS

4

"Statement of neutral position"

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS

5

Properties of threshold concepts

Transformative

Integrative

Irreversible

Difficult/Counter intuitive

Boundary markers

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS

6

Examples of threshold concepts

- **Statistics**
- **Linguistics**
- **Economics**

Statistics

Linguistics

Economics

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS

10

Possible implications of identifying key concepts

- Curriculum design
  - sequencing
  - critical points
  - connections
  - volume

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS

11

Current research – Questions

Identifying core/threshold concepts in finance

- What are the core and threshold concepts in finance?
- To what extent are these concepts covered in different units in the finance degree program?

Implications for teaching

- What are the practical benefits of threshold concepts for teaching?

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS

12

Next steps

- Questionnaires
- Wiki - https://wiki.mq.edu.au/display/ThresholdConceptsinFinance/Welcome
- Students

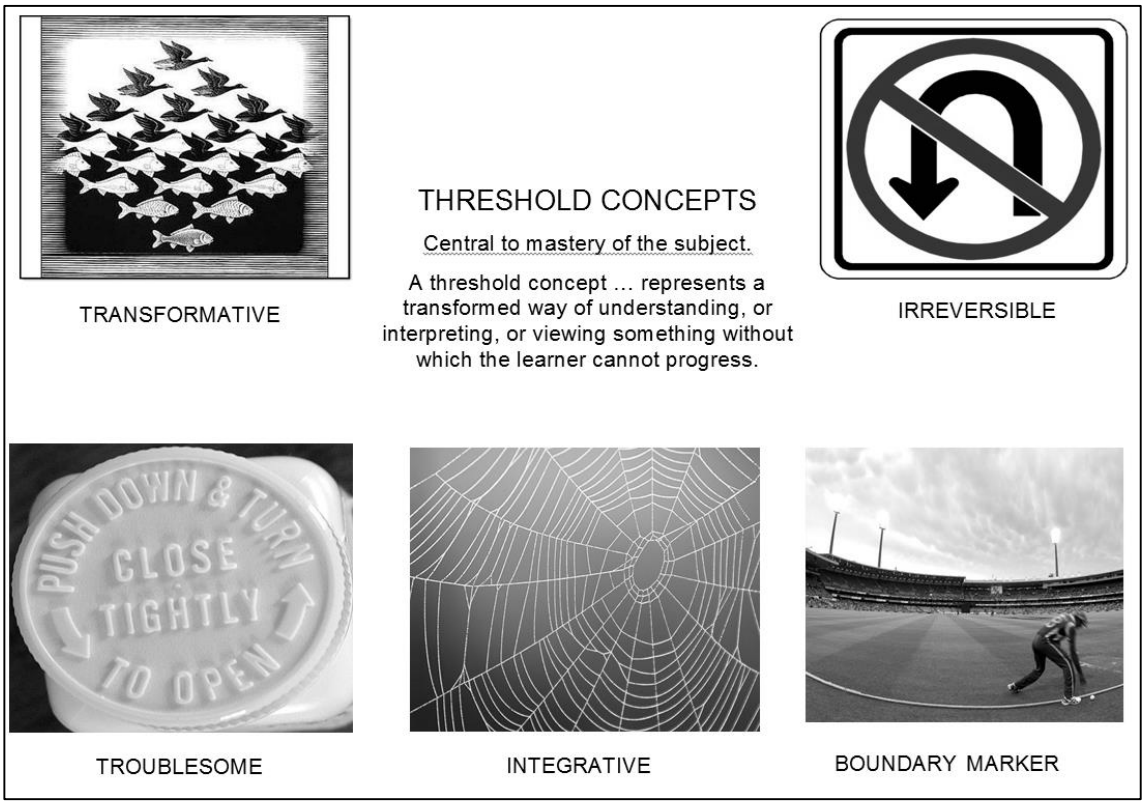
MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS 13

References

- Boustedt et al 2007
- Cousin 2006
- Davies and Mangan 2005
- Meyer and Land 2003

MACQUARIE UNIVERSITY | FACULTY OF BUSINESS AND ECONOMICS 14

Appendix 3. Visual stimulus for academic interviews and student focus groups



Appendix 4. Academic questionnaire

Section A: Biographical information

Q1. What is your disciplinary background?

- ❍ accounting
- ❍ actuarial studies
- ❍ economics
- ❍ finance
- ❍ mathematics
- ❍ statistics
- ❍ other (please specify)

Q2. For how many years have you been teaching in higher education?

- ❍ I have not taught in higher education
- ❍ 3 or fewer
- ❍ 4-9
- ❍ 10 or more

Q3. For how many years have you taught finance?

- ❍ I have not taught finance
- ❍ 3 or fewer
- ❍ 4-9
- ❍ 10 or more

Q4. Which of the following best describes your main role in teaching undergraduate finance?

- ❍ tutor
- ❍ lecturer
- ❍ subject coordinator
- ❍ degree/program coordinator
- ❍ other (please specify)

Section B: Finance concepts

Q5. In your opinion, what are the 5 most important concepts in finance?

1.
2.
3.
4.
5.

Q6 Threshold concept theory proposes that each discipline has a number of concepts that are central to the mastery of the discipline (Cousin, 2006). These threshold concepts have the following characteristics:

- Transformative – change the way a person thinks about the topic
- Integrative – tie other concepts together/expose previously hidden inter-relatedness
- Irreversible – unlikely to be forgotten/difficult to unlearn
- Troublesome – conceptually difficult and/or counterintuitive, particularly for students (Meyer and Land, 2010)

For example, a proposed threshold concept in economics is opportunity cost, which is considered central to what it means to think like an economist (Meyer and Land, 2003). Understanding opportunity cost will fundamentally change the way a student thinks about choices, including their own (Meyer and Land, 2003). Opportunity cost can be understood in relation to other concepts such as sunk costs, and in this way can be seen as integrative (Davies and Mangan, 2007). It might be a troublesome concept for students because, despite being introduced to the concept, students do not always apply it fully to solve economics problems (Davies and Mangan, 2007). Arguably, these three characteristics also mean that, once fully understood by a student, opportunity cost is unlikely to be forgotten/difficult to unlearn.

Please complete the table below to indicate whether, in your opinion:

- the characteristics of threshold concepts apply to the concepts you identified in question 5
- the characteristics of threshold concepts apply to the other finance concepts listed
- each concept is a threshold concept or not.

	Transformative			Integrative			Irreversible			Troublesome			Is this a threshold concept?		
	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure	Yes	No	Unsure
(1)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
(2)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
(3)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
(4)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
(5)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Arbitrage	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Cashflows	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Central limit theorem and normal distribution	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Correlation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Diversification	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Expected value	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Hedging	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Information asymmetry	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Leverage / gearing	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Market efficiency	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Market structure(s)	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Modelling - concept of, building, critiquing, implementing, discipline specific models eg pricing models	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Opportunity cost	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Pricing	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Probability / randomness	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Regression to the mean	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Risk	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Risk versus return	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Short selling	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Standard deviation	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Statistical significance and hypothesis testing	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Time series	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Time value of money	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Trade offs	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○
Utility / risk preference	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○

Section C: Threshold concepts, curriculum design and learning and teaching

Q7. How would you describe your exposure to and/or understanding of the idea of threshold concepts?

- ❍ No exposure to the concept apart from this questionnaire
- ❍ Some limited exposure to the concept
- ❍ Some understanding of the concept
- ❍ Solid understanding of the concept
- ❍ Strong understanding of the concept

Q8. Do you think the threshold concept idea and in particular, the 4 characteristics (transformative, integrative, irreversible, troublesome) can help you in your teaching and/or your students' learning? Please explain your answer. (optional)

Q9. Please indicate the extent to which you agree or disagree with the following statements

	Strongly Agree (1)	Agree (2)	Neither Agree nor Disagree (3)	Disagree (4)	Strongly Disagree (5)	Don't Know (6)
Threshold concept research can help academics focus on key ideas in our subject or discipline.	❍	❍	❍	❍	❍	❍
Threshold concept research can help me focus on the difficulties in student learning in my teaching area.	❍	❍	❍	❍	❍	❍
Threshold concept research is helpful for	❍	❍	❍	❍	❍	❍

curriculum design.						
The identification of threshold concepts can help me develop better learning and teaching activities.	❍	❍	❍	❍	❍	❍
The identification of threshold concepts can help me develop better assessment.	❍	❍	❍	❍	❍	❍
Threshold concepts are a useful way to link subjects/courses/modules into a coherent (degree) program.	❍	❍	❍	❍	❍	❍

Q10 Any comments regarding Question 9. (optional)

Appendix 5. Student questionnaire

Q1 What degree/major are you completing?

- ☐ Bachelor of Applied Finance - as a single degree or part of a double degree
- ☐ Bachelor of Commerce with a major in finance - as a single degree/major or part of a double degree/major
- ☐ Other (end questionnaire)

Q2 What year of your degree are you in?

- ☐ First year
- ☐ Second year
- ☐ Third year
- ☐ Fourth year

Q3 In your opinion, what are the 3 most important concepts in finance?

1 _____

2 _____

3 _____

Q4 What other comments, if any, would you like to make about your finance degree/major?