**THRESHOLD CONCEPTS – THEIR IDENTIFICATION AND USE IN OPERATIONS**

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## **Introduction**

Threshold concepts (TCs) have been identified as a crucial aspect of student learning which when mastered can open up new and previously inaccessible ways of thinking. Moreover they have been very well received by the academic community (e.g. McLean, 2009). While a wide range of disciplines including history, economics and maths (eg Meyer and Land, 2003: and Cronin, 2016) have been examined the author could find no work on operations. Furthermore, most extant empirical work is resource intensive (eg Barradell and Peseta, 2012) and as TCs can vary from student to student ([Shanahan](https://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsS.html#shanahan), [Foster](https://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsF.html#foster) and [Meyer](https://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsM.html#emeyer), 2016) this inhibits regular research. Consequently, this paper seeks to address these issues by carrying out work to identify TCs in operations using pre existing module data.

The literature review will examine the literature and set out areas for further work; research methods will examine current methods and propose a time efficient method to collect data to address the gaps identified, finally the results will be presented and discussed and a conclusion will highlight the significance of the work and prose future work.

### **Literature review**

Since Land and Meyer’s seminal paper (2003) TCs have attracted a significant amount of attention and while there are conceptual and methodical issues which will be addressed later it is worth noting the level of adoption within HE. TCs offer significant opportunities in terms of reviewing the learning of students both through the curriculum, with a focus on key areas, how material is delivered, and how students learn (see Barradell and Peseta, 2014; and Mclean, 2009). Moreover, there have been high levels of interested in academics in TCs suggesting a strong take up in the concept, not only in initial interest but also on sustained interest global in wide range of disciplines (McLean, 2009).

Lund and Meyer’ seminal work (2003) identified threshold concepts as having five characteristics. *Transformative*being ‘akin to a portal, opening up a new and previously inaccessible way of thinking about something . . . it represents a transformed way of understanding, or interpreting, or viewing . . . without which the learner cannot progress’ where learner starts to think like a professional. (Meyer and Land, 2003; p.53). *Troublesome* were learning might be counter-intuitive, alien, tacit, ritualised, inert, conceptually difficult, super complex or a require a major change in ways of thinking (Perkins 2006, Land, Cousin, Meyer & Davies 2005, Land, Meyer & Baillie, 2010). *Irreversible*– difficult to unlearn, and *integrative* – combine several aspects. Finally, *bounded*, the delineation of a conceptual space with a specific purpose (Smith, 2006) which may have a different meaning from everyday usage. Further evolution has resulted from an attempt to differentiate TCs from educational concepts including core or key concepts, which has led to three additional characteristics being suggested (e.g. [Baillie](https://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsB.html#baillie), [Bowden](https://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsB.html#bowden) and [Meyer](https://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsM.html#emeyer), 2013). *Liminality* ie partial understanding (Land, Meyer and Baille, 2010) perhaps part way between a child and an adult (Cousin, 2006), *reconstitution* ie reconfiguring learning by discarding earlier concepts and *discourse* with discipline specific language (Baillie, Bowden, & Meyer, 2013; Meyer & Land, 2005; Nicola-Richmond, Pépin, Larkin and Taylor; 2018).

However, there has been confusion as to whether all characteristics have to be met, in an effort to clarify, it has been argued that TCs should be liminal and transformative and are likely to have many of the other characteristics (e.g., Lund and Meyer, 2005 and Rowbottom, 2007) though confusingly the exact number is not specified. As an alternative, it has been suggested that troublesomeness is the most important TC (Barradell, 2012). However if taken by itself any learning which is troubling could then become a TC (Barradell, 2012), additionally it could become a filter with other criteria used to confirm (see Rodger and Turpin (2011). In short, identification has with conceptual challenges that remain unresolved for researchers (Barradell and Peseta, 2014), the characteristics can be considered subjective (O’Donnell, 2010; and Rowbottom, 2007), which leads into issues around the empirical research (Rowbottom, 2007).

Given such issues the empirical researcher is left with two alternatives, firstly, either not carry out or hold back research in the hope that such difficulties will be resolved. Or secondly, acknowledge that there are conceptual issues and argue that although not a perfect situation this should not stop research in such an important pedagogic issue and carry out research with the main of contributing knowledge though acknowledging the conceptual weakness. Not unsurprisingly the author has adopted the second view, hence this paper.

TCs can vary by discipline, Meyer and Land’s (2003) initial work was in economics where they identified opportunity cost a threshold concept, in maths they used Artigue’s (2001) suggestion of limits, similarly precedence in law and for history the issue of subjectivity (Cronin, 2014) have been identified. In short differences in the practice and thinking of disciplines and their teaching makes it unlikely that ‘one size fits all’ (Barradell, 2012). Consequently, work needs to be carried out by discipline (McLean, 2009).

Furthermore, TCs can also vary from student to student (O’Donnell, 2010: Rowbottom, 2007), for example, Shanahan et al. (2006) found that disciplines studied previously and type of previous education had a greater impact on outcomes than university class or tutorial attendance. At this stage, it is worth noting that there have been significant changes in UK secondary education since 2010, which have affected the assessment and structure of the key qualifications, taken at both 16 and 18/19. Consequently, TCs can vary not only by discipline but also by student cohort.

Moreover while there is work in many business disciplines e.g. marketing, e.g. ([von der Heidt](http://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsV.html#tvonderheidt), 2014) and accountancy ([Gronow](http://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsG.html%22%20%5Cl%20%22egronow), and [Morrison](http://www.ee.ucl.ac.uk/~mflanaga/thresholds_authorsM.html#amorrison), 2017) the author could find non examining operations either in it is widely accepted academic function in general business degrees or as part of a narrower specialism e.g. operations and supply chain management.

## **Research methods**

While there are a limited number of empirical papers (Walker, 2013) a wide variety of methods have been adopted to measure TCs. These include interviews, case studies, reflection, framing exercises(see Quinlan et al., 2013; Lucas and Mladenovic, 2007; Barradell and Peseta, 2014; Davies and Mangan 2008) and questionnaires, surveys, short answer problems and review of old examination papers (Davies and Mangan, 2005) and the involvement of other stakeholders such as professional bodies (Barradell, 2012).

Pertinently and making data collection more complex lecturers do not always agree amongst themselves as to threshold concepts in their discipline and only a small number of TCs identified had all of Meyer and Land’s original five characteristics (Lucas and Mladenovic, 2007) let alone the three additional ones. Moreover, research involving students which focuses on the area of learning they find difficult may take them in areas they find emotional (Lucas and Mladenovic, 2009)

To conclude a wide variety of methods including multiple methods have been used which can include students, academic and other stakeholders eg professional bodies. While this is laudable in terms of the methods used and resources deployed if TCs can vary depending on the student intake I submit that there is also a role for resource lite approach which could be carried out relatively quickly on annual basis. Furthermore, as there is no widely identified professional body which confers a licence to practice in operations it was relatively easy to eliminate any professional body. As TCs focus on the student perspective, and as lecturers can disagree on them (Lucas and Mladenovic, 2009) it was decided to follow (Quinlan et al., 2013) and that students should be the sole source of data. Given the aim of limiting resources it was decided to use data which was already going to be collected with a slight adjustment.

Consequently, student feedback forms were used. It was decided not to use TC characteristics on the grounds that they can be confusing and the more time spent on this the fewer the number of students were likely to complete the questionnaire. Instead form were modified and students were asked what they had found the most difficult and why with the aim of using this to identify areas of difficulty and from this TCs.

The second piece of data came from reflections on an individual portfolio piece of work which covered two main but interlinked topics – quality through a consideration of the applicability of Statistical Process Control (SPC) to service and a case study applying quality and Slack, Brandon-Jones and Johnston’s (2016) four other POs. Students were asked to identify their most difficult aspect of each piece of work, why it was difficult and how they tacked this difficulty, again the what gave the aspect of operations, the why might indicate whether it was at TC or not and how it was tackled was more for module development than strictly tied to TCs. On the reflective work, the aim was to gain information on the areas which were troublesome from the first question with details on why from the second (to assist in assessing whether they met the characteristics of TCs). The final question was more for module assessment purposes but included in the data collected and analysed as it may give some indication as to the teaching and learning on the module may be developed.

The module chosen for this study was one the author leads and is the sole teachers, it is a final year module of 75 students in operations management. Students are enrolled on the module from a variety of educational backgrounds including direct entry student from the UK FE providers with Foundation Degrees, overseas students and students who have completed a placement year alongside students from the UK in their third year of uninterrupted study.

The data was analysed using thematic analysis where data is coded data for themes and facilitates presenting order in an orderly and logical manner (e.g. Saunders, Lewis, Thornhill; 2016: and Easterby-Smith, Thorpe, and Jackson, 2008).

## **State problems or challenge**

Firstly, TCs is a well established pedagogic concept, while there has been research identifying TCs in variety of disciplines including some in Business, the author could find no work on Operations. Secondly, TCs can vary not only by discipline but also and significantly by type of previous education, with recent changes in UK secondary schooling it would seem sensible to review TCs on a regular basis. Thirdly, extant research on TCs tends to be time consuming often involving multiple stakeholders, methods and data sources this requires significant resources and would mitigate against regular reviews of TCs. Consequently, this research seeks to identify TCs in operations using pre existing data sources.

## **Data presentation and discussion**

### **Portfolio Reflection**

It should be noted that while SPC and service and five POs are, in the sense of being aspects of quality and performance measurement, typically small parts of an operations module, and therefore it might be questioned if they are threshold concepts. They can also be part of a more in depth module or even programmes e.g. in quality or operations strategy.

The results for portfolio reflection are divided into generic and topic specific. The generic issues raised as the most difficult were how to be critical ’evaluating critically’, applying theory to practice, structure, word count - usually deemed as tight e.g. ‘low word count’, and gathering data ‘difficult to find organisational sources’. At this stage these were discarded as the purpose of the paper is to examine operations specific TCs.

The topic specific were for SPC: understanding SPC as a concept, with specific concerns about the complexity of statistics ‘the mathematics of SPC’, control charts how to apply SPC to service ‘how SPC works in services’ especially on the data aspect.

For the POs the exact definitions of POS ’the definitions of the performance objectives’ including perceived overlap ‘overlaps in the definitions of the terms’ and trade offs between them ‘interactions among the five performance objectives’.

Unfortunately, the comments on why a topic was difficult were of limited assistance as they were more likely to provide extra detail on the difficulty than the underlying reason why it was difficult. For example, what was difficult when identified as SPC statistics was typically accompanied by a why which covered issues with maths.

Taking each of the original five TCs in turn. *Transformative*where the learner starts to think like a professional (Meyer and Land, 2003) examples of this were deemed to be the integration of the performance objectives, a balancing act faced by professional operations managers and the understanding of SPC itself and with reference to service which could be a crucial part of assessing quality for an operations manager. *Troublesome* in one sense all aspects, however, if applying counter-intuitive, alien, tacit, ritualised, inert, conceptually difficult, super complex or a require a major change in ways of thinking (Perkins 2006, Land, Cousin, Meyer & Davies 2005, Land, Meyer & Baillie, 2010) it becomes difficult without more data given the brevity of the answers to why. *Irreversible* from anecdotal evidence of post exam discussion vary from those who appear to have very short term memories and those who make more use of long-term memories. *Integrative*this could be integrating five performance aspect and understanding SPC especially in relation to service.

*Bounded* - delineate a conceptual space with a specific purpose (Smith, 2006) may have a different meaning from everyday usage. This appeared to be quality where for example McDonalds (a case which could be used) has high conformance to quality but might be considered in general terms to provide low quality food.

Turning now to the three additional characteristics. *Discursive* with discipline specific language – here concepts in bounded might well apply. *Reconstitutive*reconfigure learning discarding earlier concepts, there is a second year operations module which covers SPC and service and integrating POs so this characteristic can be expected to be present. *Liminality* partial understanding (Land, Meyer and Baille, 2010) adolescent – part way between a child and an adult (Cousin, 2006), here some students clearly from their marks partially understood SPC, SPC as applied to service and integrated the five performance objectives.

All items mentioned were troublesome in the general meaning of the word, which Rowbottom (2007) appears to use. However, when applying the other characteristics tests other than irreversible, SPC, SPC and service and integration of the 5PoS appear to meet the other criteria for TCs. As this is the first piece of literature which looks at operations, there is no other literature to discuss. It confirms perhaps not unsurprisingly that TCs can be applied to another discipline though this is subjective (e.g. Rowbottom, 2007) and it is difficult to find a possible TC which meets all characteristics.

### **Module Feedback Questionnaire**

There was a surprisingly low response with only 13 out of 45 who completed the feedback form completing this section, perhaps as was added at the end and this was at the start of a well attended revision session which was going to include guidance on what to study for the exam which might explain this. The results were 46% could identify why a topic was difficult 54% could not. Most difficult topic sin order were SPC 23%, Six Sigma and the assignment (a portfolio covering SPC and 5 performance objectives) (15%), and bottlenecks, calculations, JIT, service products, ‘a lot of academic info’, and transfer knowledge to case study (8%). Whys included ‘complex business environment’, distinguishing between conceptual and application especially in service industry, ‘It’s hard to analyse numbers’, ‘choosing a relative theory and making it applicable’, ‘lack of practice’ and ‘hard to get head around’. Overall, due to a lack of detail, it is very difficult to see how these can be used other than screening device.

Both methods raised aspects of operations which might be TCs with more detail in the reflective pieces. However, the resource ‘lite’ approach while producing some useful data has its limitations, and it would befit from more data.

## **Conclusion**

This paper set out to mitigate two gaps one being the lack of work on TCs in operations and secondly to trail the identification of TCs solely from pre existing data in this case module feedback and assignment reflection.

The work on operations has identified three possible TCs the integration of the POs, the concept of SPC (especially the mathematics) and the application of SPC to service.

In terms of contribution to the literature, work has now started on new discipline with some tentative TCs identified. A ‘lite’ approach which facilitates data collections has had some success though follow up interviews with a smaller group of students, together with a readjustment of the module feedback form to give the questions more prominence is expected to increase response rates.

The reflection provides useful information on troublesome aspects of operations; this is however restricted by the area of the assessment and the conceptual issues with the identification of TCs. It would also be useful to follow up some of the key issues with a small number of interviews from a structured sample, though as this is final semester module, this might be difficult to achieve given pressure on student time, but may be more realistic with another module.

As the goal is to strive student learning, perhaps it is more important to gain an insight into student difficulties and their commonality and with an insight into their degree of difficulty than to precisely and confidently state whether they are TCs or perhaps core concepts etc.

Looking forward I contend that more work is needed on TCs in operations and gathering lite annual data alongside a more extensive exercise which might be better suited to a first semester module.

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