Threshold Concepts in Disciplinary Settings: Problem Solving in Electronic Engineering

Brian Foley

Electronic Engineering
Trinity College Dublin

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Introduction

- **Achieving a threshold concept opens up a distinctive way of thinking and practice**
- **For many disciplines, there is much more than concepts and principles; *knowing how* leads to threshold functions or threshold experiences**
- **Aim: reflect on engineering problem solving as such a threshold function**

Overview

- **Background : ways of thinking and practice**
- **Electronic engineering and problem solving**
- **Investigation and results**
- **Discussion and conclusions**

Disciplinary thinking

Meyer & Land (2003) suggested

"Such a transformed view or landscape may represent how people 'think' in a particular discipline, or how they perceive, apprehend, or experience particular phenomena within the discipline."

Transformed discourse

Meyer & Land (2006) suggested

"The acquisition of transformative concepts … brings with it new and empowering forms of expression that in many instances characterise distinctive ways of disciplinary thinking"

WTP Definition

"the richness, depth and breadth of what students might learn through engagement with a given subject area in a specific context. This might include, for example, coming to terms with particular understandings, forms of discourse, values or ways of acting which are regarded as central to a graduate-level mastery of a discipline or subject area."

[McCune & Hounsell 2005]

Threshold function

Meyer & Land (2003) posited

" …… within areas where there is not such a clearly identified body of knowledge it might still be the case that what the ETL project team have come to encapsulate in the term ways of thinking and practising also constitutes a crucial threshold function in leading to a transformed understanding"

Issues in Electronic Engineering

- **Important for high-tech/smart economy**
- **Student numbers falling**
- **Perception of being difficult / abstract**
- **Falling standard; grade inflation**

Need for improvement in teaching-learning approaches

Sub-Disciplines of Electronic Engineering

- Electromagnetism
- Materials
- Integrated circuit technology
- Electronic circuits
- Computer hardware
- Signal processing
- Telecommunications

ETL Project

- **Identified a number of WTP in Electronic Circuits and examined how they might enhance teaching & learning:**
  - **Appreciating the function of a circuit**
  - **Recognising salient groups of components**
  - **Thinking logically about the circuit analysis**

[ETL Project 2006]

- **Limitations:**
  - **Problem solving aspects incomplete**
  - **Connection with Threshold Concepts**

Engineering Problems

- Evaluate new designs
- Analyse given systems or scenarios
- Range of problem types:
  - Putting data into formulae
  - Extending textbook principles
  - Addressing model limitations
  - Dealing with multiple solutions
- Two layers
  - The underpinning principles
  - Methods and approaches

The Study

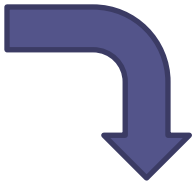
- **A phenomenographic investigation into**
  - **Threshold concepts**
  - **Ways of thinking and practising**

- **Foundation module in electronic circuits involving about half the cohort of 175 students**

Results (i): Characteristic WTP

- From a supplied list
  - Problem-oriented
  - Logical
  - Mathematical

- Also mentioned
  - Spatial reasoning
  - Visual reasoning



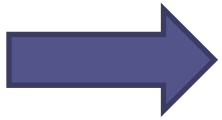
May be connected with extensive use of graphs

Results (ii): Comfortable WTP

- **Handling electrical quantities**
- **Characterising signals**
- **Carrying out circuit analysis**
  ie the mathematics

Results (iii): Troublesome WTP

- **Deciding an approach to analysing a circuit**
- **Constructing a circuit representation from a statement**
- **Incorporating a model into a circuit analysis**



Very much elements of problem solving

Elaborations on "Approach to analysing …"

- *"There seems to be a few ways to solve problems."*
- *"There's so many ways to do things its hard to know where to start but once its started its OK."*
- *"Just find that deciding on an approach to a question is often the most difficult part."*

Elaborations on "Constructing circuit representation"

- *"Awkward to see what the circuit does in total but in parts make sense"*
- *"Difficult to picture problem unless it is drawn out"*

Elaboration on "Incorporating a model …"

- *"They aren't very intuitive"*
- *"Recognising the function of added complexities to a normal amplifier circuit"*

One further recurring theme:

- *"I personally haven't done enough"*
- *"Haven't done enough probs"*
- *"more practice"*

Complexities of Modelling

- **(In engineering) a model is typically a mathematical encapsulation or representation of some physical system and involving simplifying assumptions.**

- **Two types:**
  - **Physical — based on laws of physics**
  - **Empirical — based on measurement data**

- **Always require experimental validation**

Technology evolves and

- **Physical systems get smaller(/bigger)**
  - ➡ **Assumptions no longer entirely valid**
  - ➡ **Model has to be adjusted**

- **Should the adjustment be**

  Physical — model can get mathematically very complex

  or

  Empirical — model lacks physical explanation

- **Choice of model is indeed problematic**

Discussion

- **Some disciplines are Threshold Concept intensive**

  eg physics, mathematics

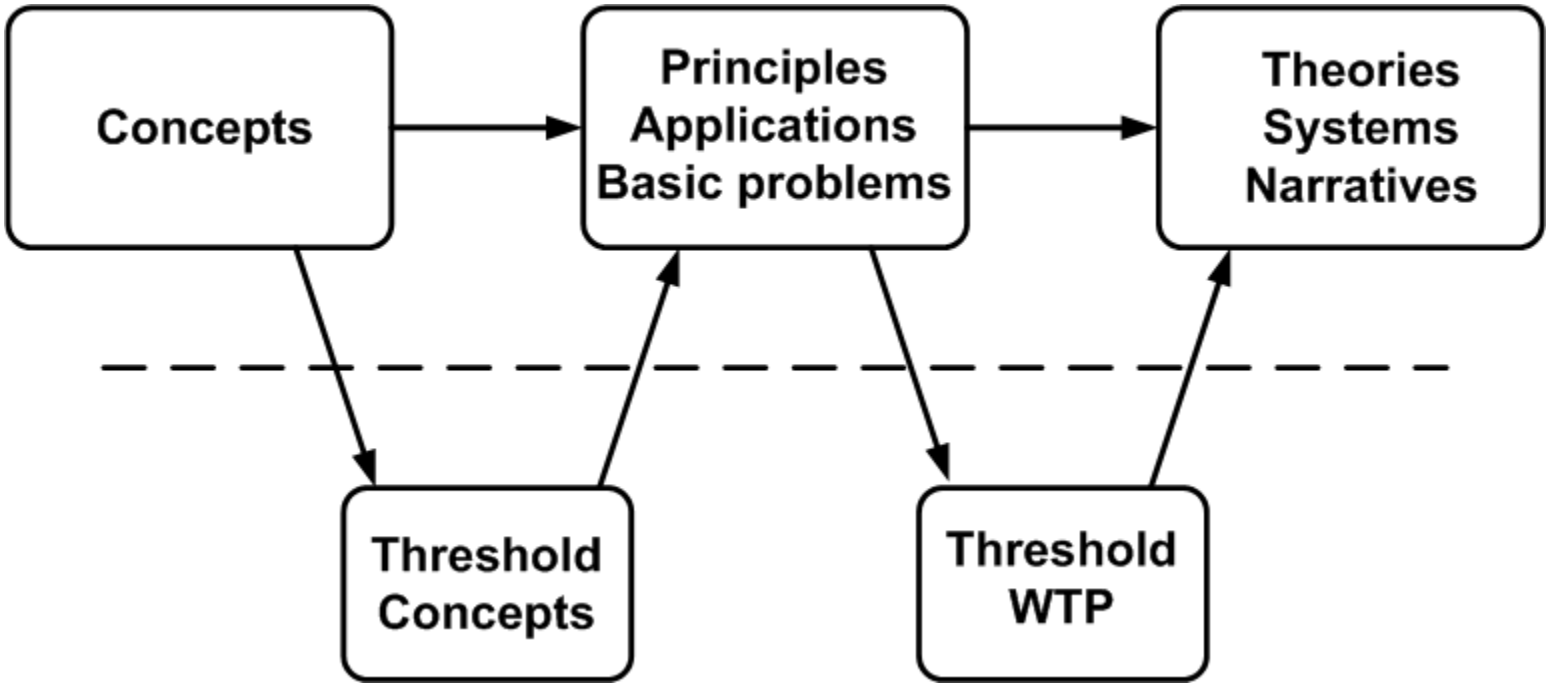
- **Some disciplines are WTP focussed**

  eg history, literature

- **Some disciplines need both**

  eg economics, engineering

Discipline Model



WTP as Thresholds?

Threshold Concepts	WTP
• Transformative	• Yes
• Irreversible	• ?
• Integrative	• Yes
• Bounded	• No
• Troublesome	• Definitely yes

Threshold features of WTP: transformative

Empowerment

"The acquisition of transformative concepts … brings with it new and empowering forms of expression that in many instances characterise distinctive ways of disciplinary thinking"

[Meyer & Land 2006]

Might typically have mastered the ability to solve a class of problem that previously was a mystery.

Threshold features of WTP: troublesome

(i) Tacit knowledge

"includes all the implicit relations, tacit conventions, subtle cues, untold rules of thumb, recognizable intuitions, …., embodied understandings, underlying assumptions, and shared world view"

[Wenger 1998]

(ii) Time/practice factor

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