

Aspects of establishing threshold concepts and identifying threshold concepts

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Overview

- Who are we?
- Background of this contribution
- Introduction with the two core questions
- Threshold Concept Framework
- Educational context, Methods, Analysis of our TC investigations
- Results
- A closer look at the two core questions
- Staff/teachers and students determine a TC
- Reflections on TCF, its characteristics, and the students
- Conclusions: our answers to the two core questions, recommendations

Who are we?



- Paquita Perez: Professor in Education and Science, and Learning for Sustainability; teacher/examiner of the course Physics for Environmental Sciences, Faculty of Science of the Open Universiteit
- Gé Nielissen: member of the Quality Team of the Open Universiteit
- Bert Zwaneveld: emeritus Professor in the professionalization of teachers in mathematics and computer science, guest researcher of the Faculty of Science of the Open Universiteit



Background of this contribution

We have for several years experience with research of threshold concepts in different science disciplines:

- Zwaneveld, Perrenet, and Bloo: TCs in BSc Computer Science (Durham, 2014)
- Zwaneveld and Sterk: TCs in BSc Mathematics (Halifax, 2016)
- Zwaneveld and Sterk: TCF or didactical theories (Ohio, 2018)
- Zwaneveld, Perrenet, and Sterk: mathematical proving as a TC in first year of BSc Applied Mathematics (London, 2021)
- Perez, Zwaneveld, and Nielissen: TCs in the course Physics for Environmental Sciences (London, 2021)
- Perez, Zwaneveld, and Nielissen: (under construction) TCs in the course Logic and Set theory
- After about ten years: time for REFLECTION

Introduction with the two core questions

- On what do we reflect and why?
- Short answer: Threshold Concepts Framework
- Long and better answer: we reflect on the following questions:
 - What are the essential elements of the Threshold Concepts Framework
 - What is the role of the characteristics and their interdependent relationships
 - What is the role of the staff and/or teacher, and what is or should be the role of students in identifying threshold concepts?
 - What is the relationship between threshold concepts and core concepts?
- The two core questions:
 - *Who* decides if a concept is a threshold?
 - *How* does someone establish if a concept is a threshold to students?

Threshold Concept Framework

- *TCF* (Meyer and Land, 2003, 2005, 2006): those concepts in bachelor's programmes or courses where students have to master concepts to become a (beginning) member of the discipline; think of going through a portal and then viewing a complete different landscape
- Examples of *TCs* in earlier mentioned investigations: the concept of limit in mathematics (Zwaneveld & Sterk, 2020), mathematical proving (to be published), radiation enforcement and the Carnot Cycle (Perez, Zwaneveld, Nielissen, to be published), object-oriented programming in computer science (Zwaneveld, Perrenet & Bloo, 2016)
- Thresholds have *characteristics*: transformative, irreversible, integrative, troublesome/counterintuitive, bounding, discursive and reconstitutive of which transformative and troublesome might be the most important; in our research we used the five first mentioned and about mathematical proving and logic we added discursive
- Mostly, staff/teachers establish *TCs* by analyzing what students say/write what they have to learn, especially what they find difficult or troublesome

Educational context, Method, Analysis of our TC investigations

Our investigations to TCs was done in two different educational contexts:

- Distance teaching at the Open Universiteit (Ounl): Physics for Environmental Sciences, Logic
- Traditional teaching at Eindhoven University of Technology (TU/e): Computer Science, Mathematics including mathematical proving
- Method in both institutions: online, almost the same questionnaire, mostly closed questions, some open questions so students could give explanations; students assimilated it in a reflection report
- Analysis: mostly counting the answers of the closed questions and interpreting the answers of the open questions

Results

	BSc Computer Science	BSc Mathematics	Physics	Mathematical proving
#participants	59	60	32	132
# TCs	108	78	76	-
# different TCs	53	37	48	-
Average # TCs per student	1.8	1.3	2.3	-
Highest scoring TCs	Object oriented programming	Limit, 16 x Complex number, 8 x	Carnot Cycle, 9x	-
% Characteristics				
Transformative	88	96	23	73
Irreversible	72	72	19	51
Integrative	64	63	24	66
Counter-intuitive	78	82	17	52
Bounding	55	59	18	27
Discursive	-	-	-	59
Pattern: few high scoring TCs, many low scoring TCs	Pattern: yes	Pattern: yes	Pattern: yes	-

% Characteristics:
Percentage of
number
characteristics
students thought
applicable

A closer look at the two core questions

The two core questions are:

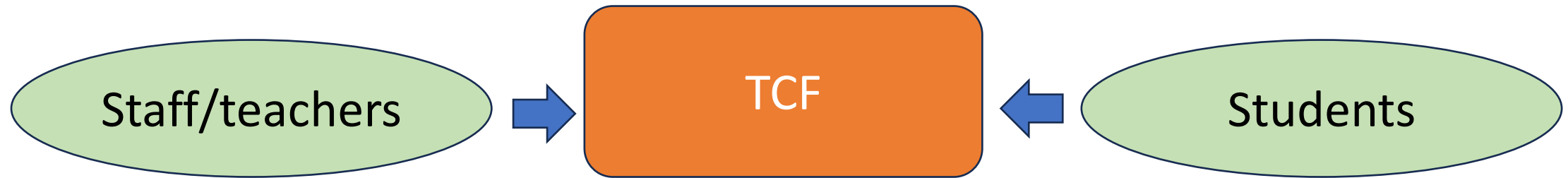
- *Who* decides if a concept is a TC? Staff/teachers, students or both?
- *How* is that decided? Prior to the (re-)design, after?
- The description of TCs consists in the two aspects:
 - Threshold concepts are disciplinarily necessary; staff or teachers establish the core concepts, including those that turn out to be or have previously been established as TC in the process of (re-)designing the curriculum or a course
 - Mastering threshold concepts is for many students a troublesome process and threshold concepts give the student who mastered them a new view on the discipline or parts of it

This leads to the following questions:

- What is the difference between a core concept and a TC?
- Are transformative, counter-intuitive and mastering necessary conditions?

Staff/teachers and students determine a TC

- Every educational framework or theory in a discipline owes comes into existence thanks to staff/teachers and students; this also holds for TCF

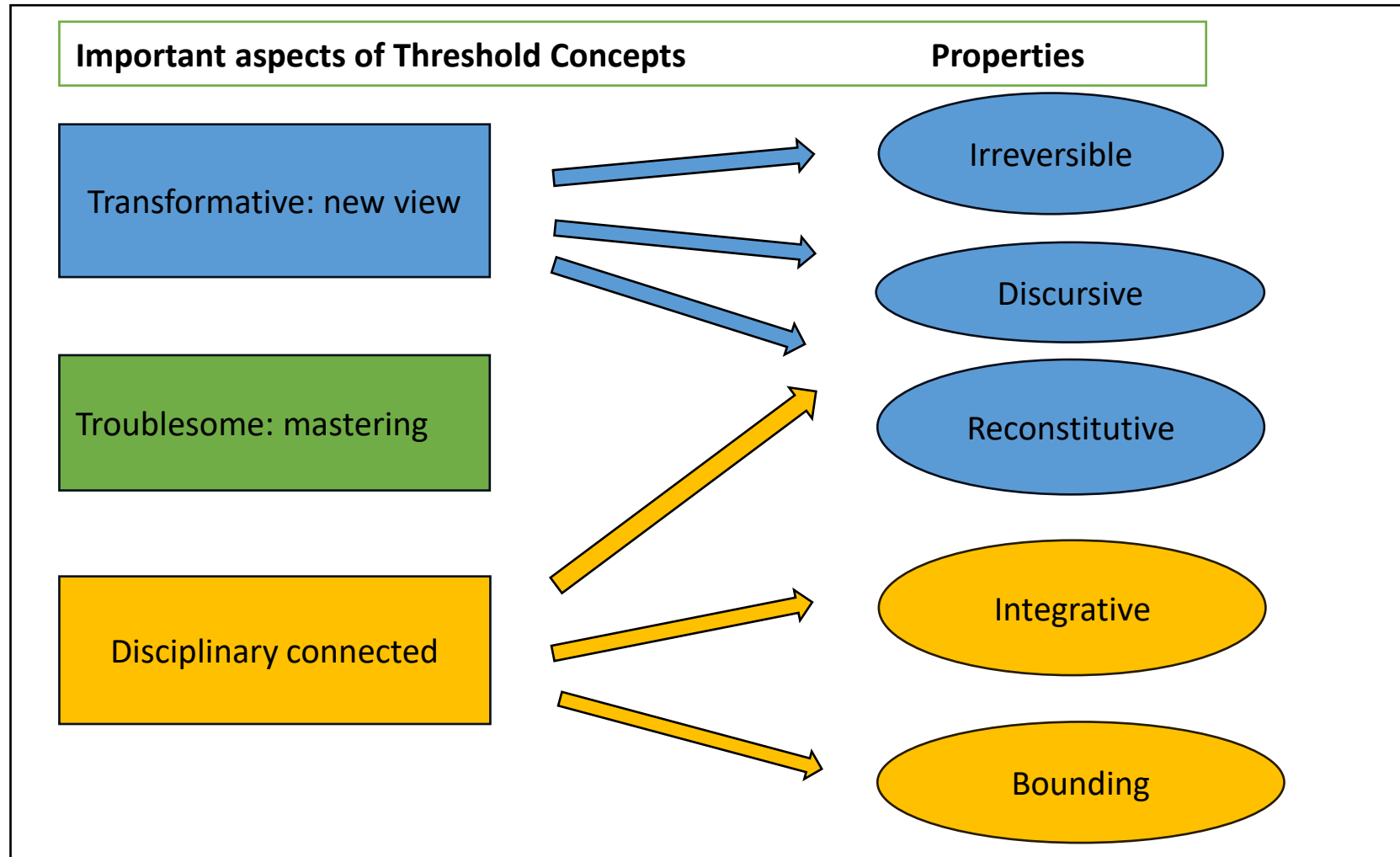


- The role of the two groups:
 - Establishing disciplinary concepts (staff/teacher)
 - Mastering these concepts (students)
- Leading to the questions:
 - What is the difference between a disciplinary core concept and a threshold concept?
 - Is 'mastering' a troublesome, as one of the TC characteristics, process to every student?

Reflection on TCF and its characteristics

- Answer to the latter question: no, students differ, every experienced teacher knows
- Answer to the former question: every threshold concept is a core concept, but not the other way around; one example from physics: uniform velocity is a core concept but not a TC
- Transformative: new view on (parts of) the discipline
- Troublesome or even counterintuitive: difficulty of mastering
- Integrative and bounding: properties of transformative
- Irreversible, discursive and reconstitutive: also properties of transformative, while discursive is also a property of discipline

A picture of the relations between the characteristics

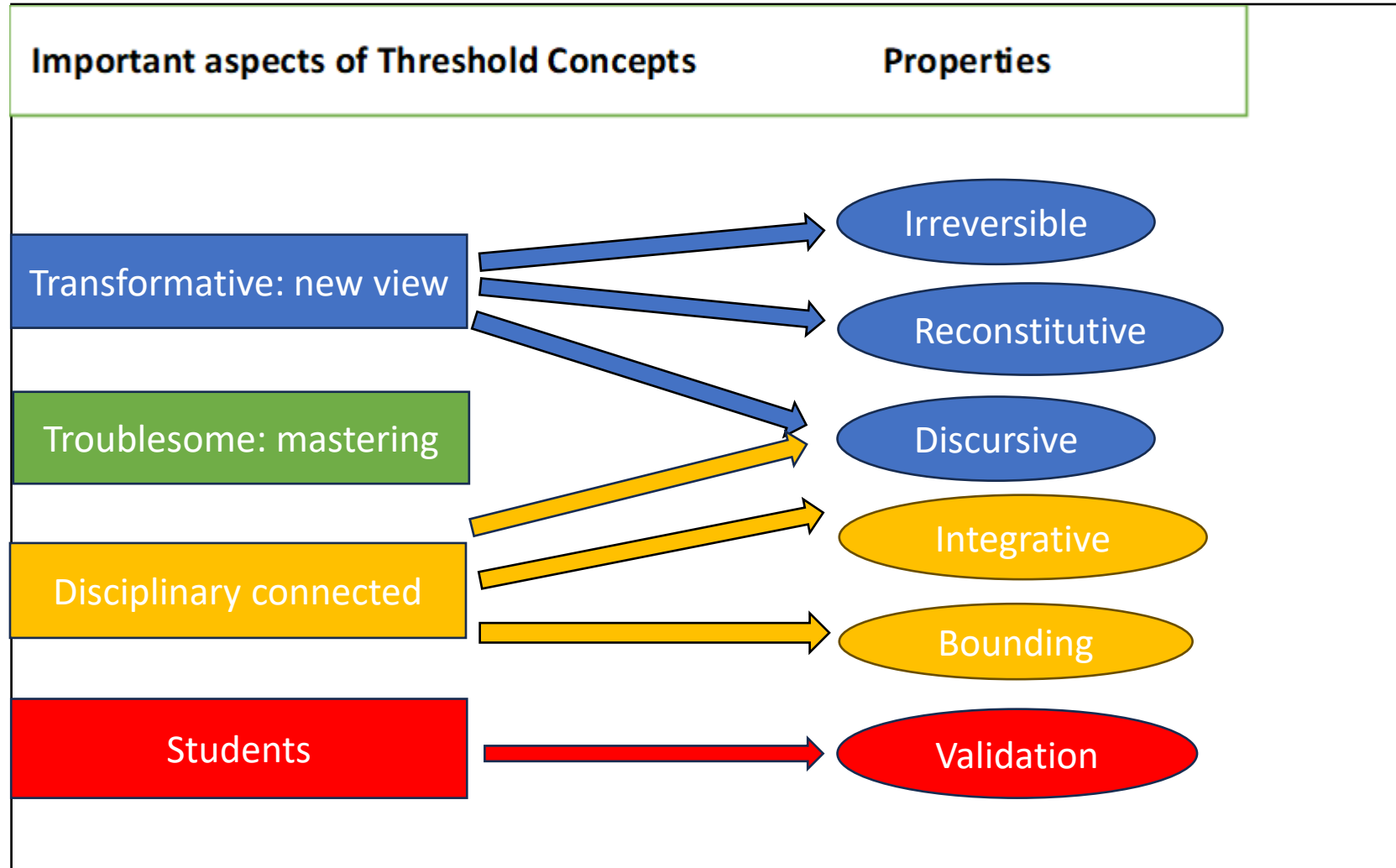


Remark linguistically: A is a characteristic of B means A and B are equivalent; if B is a property of A then A is not necessarily a property of B

A closer look at the role of the students

- Students are different, also in understanding concepts due to e.g. prior knowledge, their position towards a discipline or parts of it
- As a consequence: not all students will experience the same concepts as threshold concepts and assign the same characteristics, also not the two defining ones: transformative and troublesome
- So, these two are not necessary conditions for a concept to be a threshold concept
- As 'solution' to these remarks we suggest an adaptation of the former figure with an important role for the students
- By making the students' role in the Threshold Concepts Framework explicit, the TCF becomes an empirical underpinned educational framework
- A TC has, as a coin, two sides: (1) the discipline (2) the validation by the students

A picture of the aspects of TC with a distinct place for the students



Conclusions: our answers to the two core questions; Recommendations

- The two mentioned core questions were:
 1. *Who* decides if a concept is a threshold?
 2. *How* does someone establish if a concept is a threshold to students?
- 1. Staff/ teachers, although not always explicitly
- 2. Asking the students and possibly also by asking the staff/teachers
- Call a concept only really a TC when students give it a high score, TCs with low scores are ‘individual’, troublesome core concepts
- Use the students’ results in the (re-)designing process of a curriculum or course with respect to *content* and *didactics*