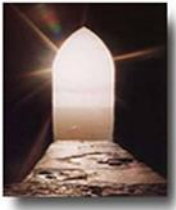


# **Threshold Concepts in the OU course Physics for Environmental Sciences**

*Bert Zwaneveld (MST), Paquita Pérez  
Salgado (MST), Gé Nielissen (ECOP)*



# Threshold Concepts in the OU course Physics for Environmental Sciences

## Overview

### Threshold concepts

### Provisional results

- troublesome concepts and threshold concepts
- threshold concepts
- threshold concepts and characteristics
- crossing a threshold
- ‘effect’ of studying the course (extra)

### Provisional conclusions and discussion

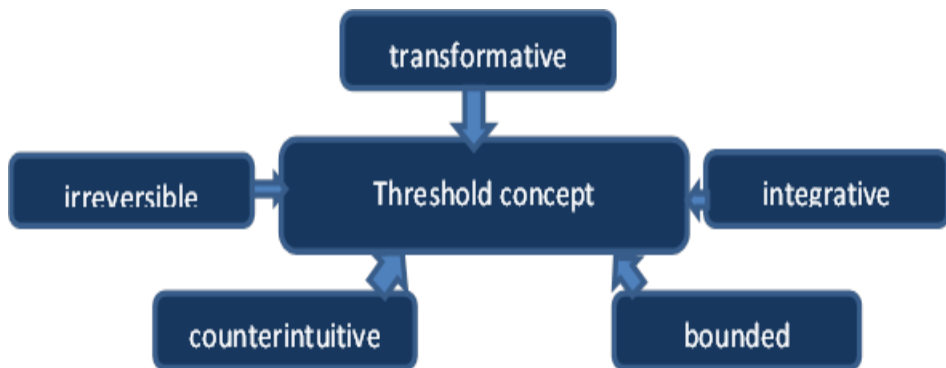


# Threshold Concepts in the OU course Physics for Environmental Sciences

Bert Zwaneveld (MST), Paquita Pérez Salgado (MST), Gé Nielissen (ECOP)

## Threshold concepts

Threshold concepts (TCs) are concepts a student has to master in order to become a (starting) member of a scientific community<sup>1</sup>. This mastering is a troublesome process. If such a concept is mastered the student gets a new view on the discipline he or she is studying. Meyer and Land called TCs a sort of portals to that discipline. They characterized TCs as *transformative*: the student's perception changes completely; *irreversible*: one cannot go back to the earlier, more primitive way of seeing; *integrative*: different parts of the subject become related; *counter-intuitive*: at first sight the concept is strange or even absurd; *bounded*: the concept bounds the discipline clearly from other disciplines. An example in mathematics, mentioned by many authors and students, is the concept 'limit of a function'.



## Design of the research

**1 Main questions for the students** (after an introduction) in an online questionnaire as part of a reflection assignment:

- Which troublesome concepts are thresholds to you?
- Which characteristics are applicable to your thresholds? Why?
- What did you do to cross your thresholds?

**2 We are also interested** if the pattern with very few general thresholds and many individual thresholds, as established among computer science and mathematics bachelor students<sup>2,3</sup>, also occur in the proposed research in physics education.

**3 Expected threshold concepts** electromagnetism, radiation forcing, some special sorts of energy, quantum mechanics, radioactivity. *Remark* given the 'overall' character of the course there are many physical concepts in the course.

**4 Expected ways students used to cross their thresholds** practicing, reflecting.

## References

- <sup>1</sup>Meyer, J.H.F., & Land, R. (Eds.) (2006). *Overcoming Barriers to Student Understanding: Threshold Concepts and Troublesome Knowledge*. New York: Routledge.
- <sup>2</sup>Zwaneveld, B., Perrenet, J., & Bloo, R. (2016). Discussion of Methods for Threshold Research and an Application in Computer Science. In R. Land, J.H.F. Meyer, & M.T. Flanagan (Eds.). *Threshold Concepts in Practice*, 269–284. Rotterdam: Sense Publishers.
- <sup>3</sup>Zwaneveld, B., & Sterk, H. (forthcoming). Threshold Concepts in the Applied Mathematics BSc Programme, a structural comparison with the threshold concepts in the Computer Science BSc Programme. In J. A. Timmermans & R. Land (Eds.), *Threshold concepts on the edge*. Leiden: Brill | Sense.

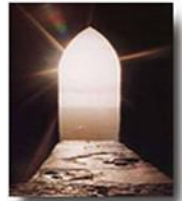


# Threshold Concepts in the OU course Physics for Environmental Sciences



*Provisional results: troublesome and threshold concepts*

- 32 students filled in the online questionnaire
- Answers of 3 students ignored: one about another course, the other two provide hardly any answer.
- 29 answers of students, 17 male and 12 female students.
- 92 times a troublesome concept mentioned of which 76 times a threshold concept, almost 83% of the troublesome concepts.
- 53 *different* troublesome concepts of which 43 threshold.
- On the average, each student mentioned slightly more than 3 troublesome concepts, and slightly more than 2.5 threshold concepts.

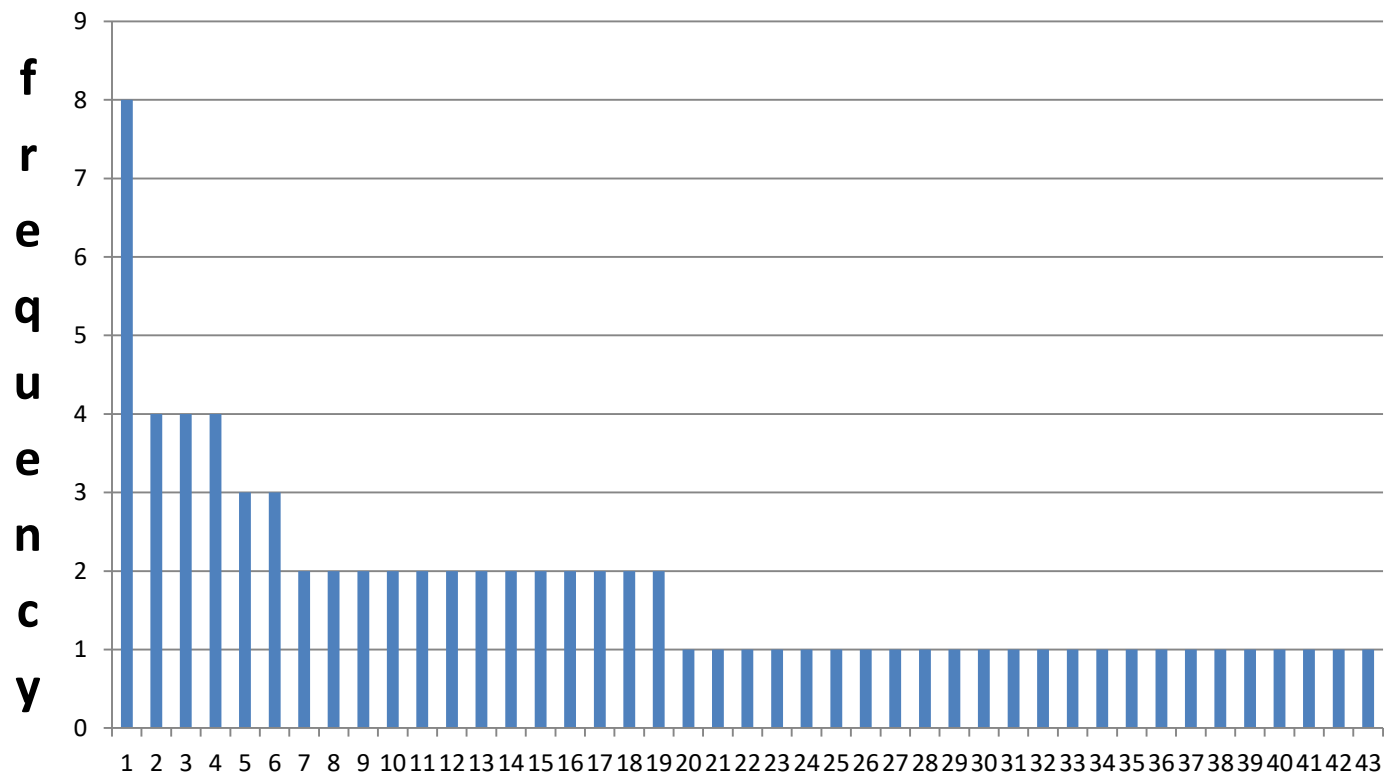


# Threshold Concepts in the OU course Physics for Environmental Sciences

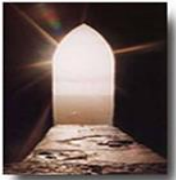


*Provisional results: threshold concepts*

**frequencies of the 43 different threshold concepts**



**1 = Carnot cycle, 2 = electromagnetism, ..., 43 = derivative**



# Threshold Concepts in the OU course Physics for Environmental Sciences

*Provisional results: threshold concepts*

Threshold concepts, in descending frequency, clustered according to (physical) sub-disciplines as used in the course; also the percentages are mentioned

<i>sub-discipline</i>	<i>frequency</i>	<i>percentage</i>
<b>optics, radiation, quantum theory</b>	<b>20</b>	<b>26,3</b>
<b>electromagnetism</b>	<b>17</b>	<b>22,4</b>
<b>thermodynamics</b>	<b>16</b>	<b>21,1</b>
<b>Mechanics, energy</b>	<b>13</b>	<b>17,1</b>
<b>radio-activity</b>	<b>5</b>	<b>6,6</b>
<b>climate</b>	<b>4</b>	<b>5,3</b>
<b>mathematics</b>	<b>1</b>	<b>1,3</b>
<b><i>total</i></b>	<b>76</b>	<b>100</b>

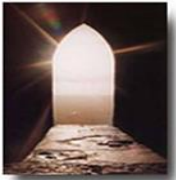


# Threshold Concepts in the OU course Physics for Environmental Sciences

*Provisional results: threshold concepts, characteristics*

Students mentioned 305 times one or more of the 5 characteristics applicable to the 76 threshold concepts. An impression of students' remarks about the applicability

- Student A about black radiation; (s)he declared all the five characteristics applicable to this threshold concept: 'It changes the full view on the subject. Further, it transforms the subject that on first sight seems qualitative. This creates completely new possibilities.'
- Student B about electromagnetism; (s)he also declared all five characteristics applicable to this threshold concept: 'But I do not really understand it. So, I think it will be a threshold concept to me.'



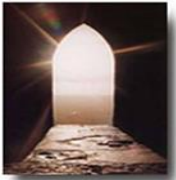
# Threshold Concepts in the OU course Physics for Environmental Sciences

*Provisional results: threshold concepts, characteristics*

Frequencies and percentages of the applicability of the five characteristic to the mentioned threshold concepts

<i>characteristics</i>	<i>frequency</i>	<i>percentage</i>
<b>transformative</b>	<b>69</b>	<b>22.6</b>
<b>irreversible</b>	<b>58</b>	<b>19.0</b>
<b>integrative</b>	<b>72</b>	<b>23.6</b>
<b>counter-intuitive</b>	<b>52</b>	<b>17.0</b>
<b>bounded</b>	<b>54</b>	<b>17.7</b>
<b><i>total</i></b>	<b><i>305</i></b>	<b><i>100</i></b>





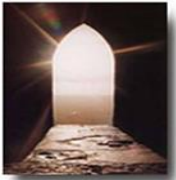
# Threshold Concepts in the OU course Physics for Environmental Sciences



*Provisional results: crossing a threshold*

- 203 ways students used to master a troublesome or threshold concept (one or more ways possible)
- Of the originally 20 ways mentioned as ‘otherwise’ we interpreted 15 consulting an external source

<i>ways of mastering a troublesome or threshold concept</i>	<i>frequency</i>	<i>percentage</i>
studying again	58	28.6
practicing	33	16.3
working with or using the concept	40	19.7
self-reflection	52	25.6
consulting external resources, e.g. internet, literature	15	7.4
otherwise	5	2.5
<i>total</i>	<i>203</i>	<i>100</i>



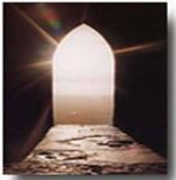
# Threshold Concepts in the OU course Physics for Environmental Sciences

*Provisional results: 'effect' of studying the course*

The last question was: to what extent do you get better insight in environmental topics through studying the physical concepts of the course?

Student C: 'The similarities between the different forms of current and the adhering concepts, formulae, etcetera, provide a deeper, common background to physical phenomena.'

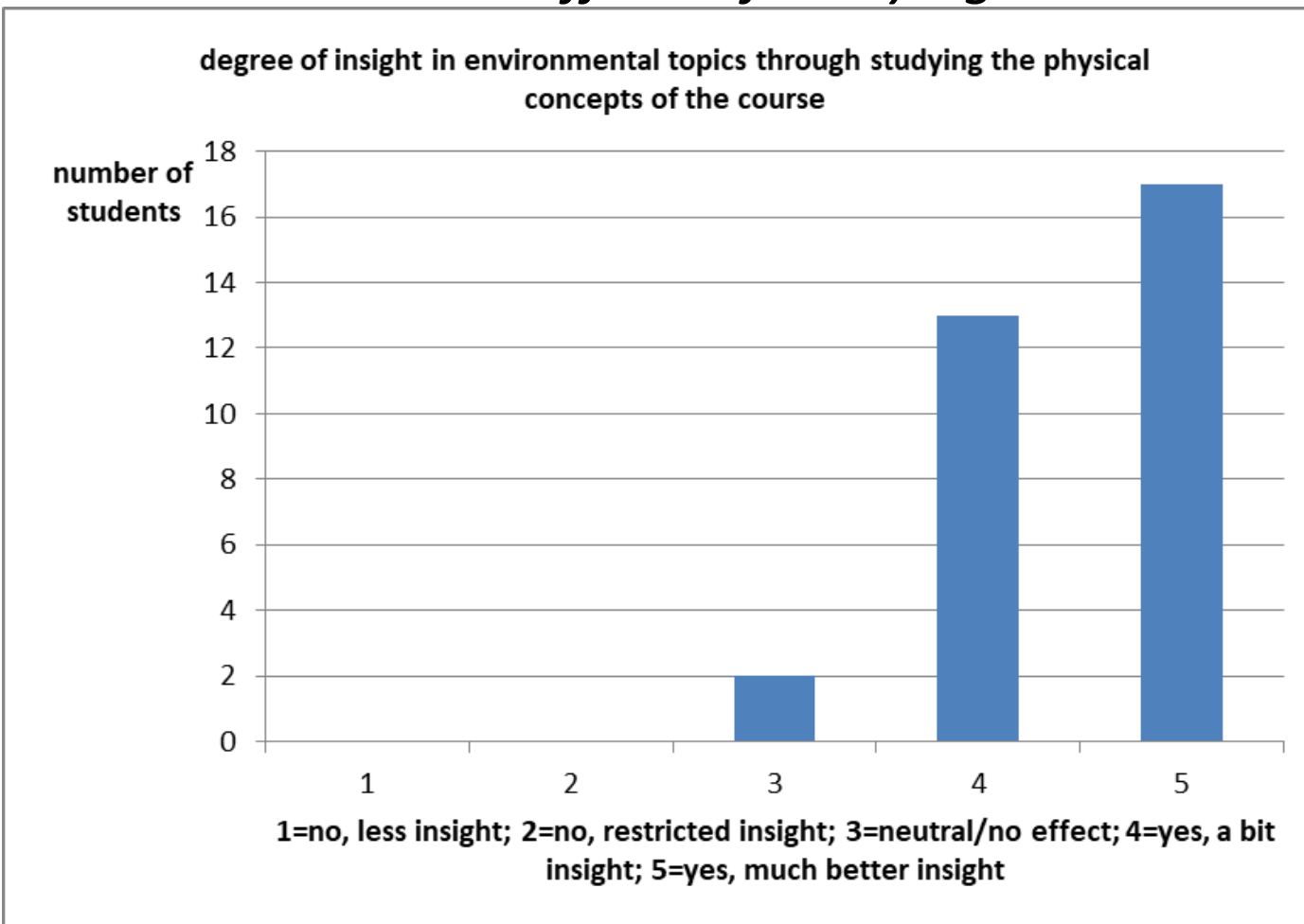
Student D: 'A good example is knowledge of the physical concept radiation in order to understand the greenhouse effect.'



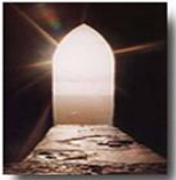
# Threshold Concepts in the OU course Physics for Environmental Sciences



*Provisional results: 'effect' of studying the course*



The average 'effect' was 4.5.

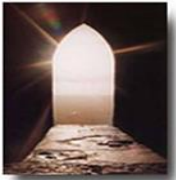


# Threshold Concepts in the OU course Physics for Environmental Sciences



## *Provisional conclusions and discussion*

- Many troublesome concepts, more than 80% also threshold concepts
- But, only one concept (Carnot cycle) gets a relatively high score, indeed, a pattern comparable with what earlier was found in Computer Science and Mathematics
- All 5 characteristics are applicable to the threshold concepts, transformative and integrative get the highest score, about 25%; the threshold concept framework requires transformative to be the highest and at least about 90%; it seems that a threshold concept is more individual than general



# Threshold Concepts in the OU course Physics for Environmental Sciences

## *Provisional conclusions and discussion*

- The mentioned threshold concepts are more or less as we expected, but we did not expect the Carnot cycle to get the highest score
- The results and conclusions of this research are based on a response of 29; so, more research with more students is required; we shall replicate it with next cohorts of the course
- Students mention how they crossed a threshold, but we cannot be sure that they indeed did so
- The course contains a lot of concepts; then, it cannot be amazing that student mention so many concepts as a threshold