

## Threshold Concepts and Key Concepts in Electrical Engineering Education

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### Abstract

Research in science education has for a long time dealt with students' views of single concepts, although one of the common objectives in physics and engineering education is "to learn relationships". The research on threshold concepts is dealing with concepts that are related, and is thus opening up a new dimension of the research on understanding. In our own research we have been investigating what we call complex concepts, i. e. concepts that make up a holistic system of "single" interrelated concepts.

In the field of electrical circuits, there has been extensive research on student understanding of direct current (DC) circuits among pre-university students, but hardly any research on alternating current (AC) circuits and engineering students understanding. Confusion of concepts such as current, voltage, power and energy and local and sequential reasoning is reported. One possible reason for these concepts to be troublesome could be that they are highly interdependent, and can thus possibly not be understood one by one, but have to form an integrated whole.

What then constitutes a threshold concept? How can we find them? And how can we possibly find a way to teach so that thresholds are crossed?

Our proposal in this paper is to distinguish between ways to identify *threshold concepts* and ways to identify what needs to be addressed in order to open up learning spaces. We propose the term "*key concepts*" for those concepts that open up the "portal". We try to explore how a threshold concept may become identified, how we by studying video recordings from labwork could propose a way to see what is particularly troublesome within the concept, how the use of variation theory can open up new dimensions in the learning space, thus finding keys to open up the "portal", and how, again by analyzing video transcripts, we can evaluate the new learning sequence.

In our paper we will also briefly describe how we have designed labwork in an electrical circuit course, for engineering students, taking the ideas behind *threshold concepts* and *key concepts* into account. Key elements in our design is the conscious use of mediating technology and the application of the theory of variation developed by Marton and coworkers.