

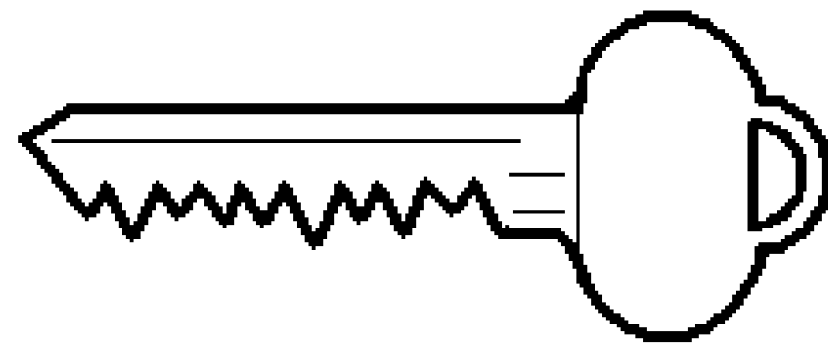
Potentials for learning or Problems in students' understanding

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Key concepts' - concepts that open up the 'portal' of understanding.



As the title - Potentials for Learning or Problems in Students Understanding - suggests, we propose two distinguished analytical categories in research in education within the disciplines. We suggest that a clearer differentiation between 'problems' and 'potentials for learning' is made. Otherwise there is a risk that studies end when the problems are found.

For many years research into science education has dealt with misconceptions about single concepts, even though one of the common objectives in physics is to develop an understanding of the relationships. Research into 'threshold concepts' examines related ideas, and is thus opening up a new dimension of our understanding. In our own research we have been examining what we call 'complex concepts', i.e. concepts that make up a holistic system of 'single' interrelated concepts (See Fig. 1).

The idea behind our model, of a complex concept, is that knowledge is built both by learning of the pieces, the islands, and by learning the whole by making explicit links. The more links that are made, the more complete the knowledge becomes. The most difficult links to make are those that go between the two 'worlds', object/event and theory/model world, thus to identify those and to explore possibilities for learning is to identify as well the 'problems' as the 'potentials'.

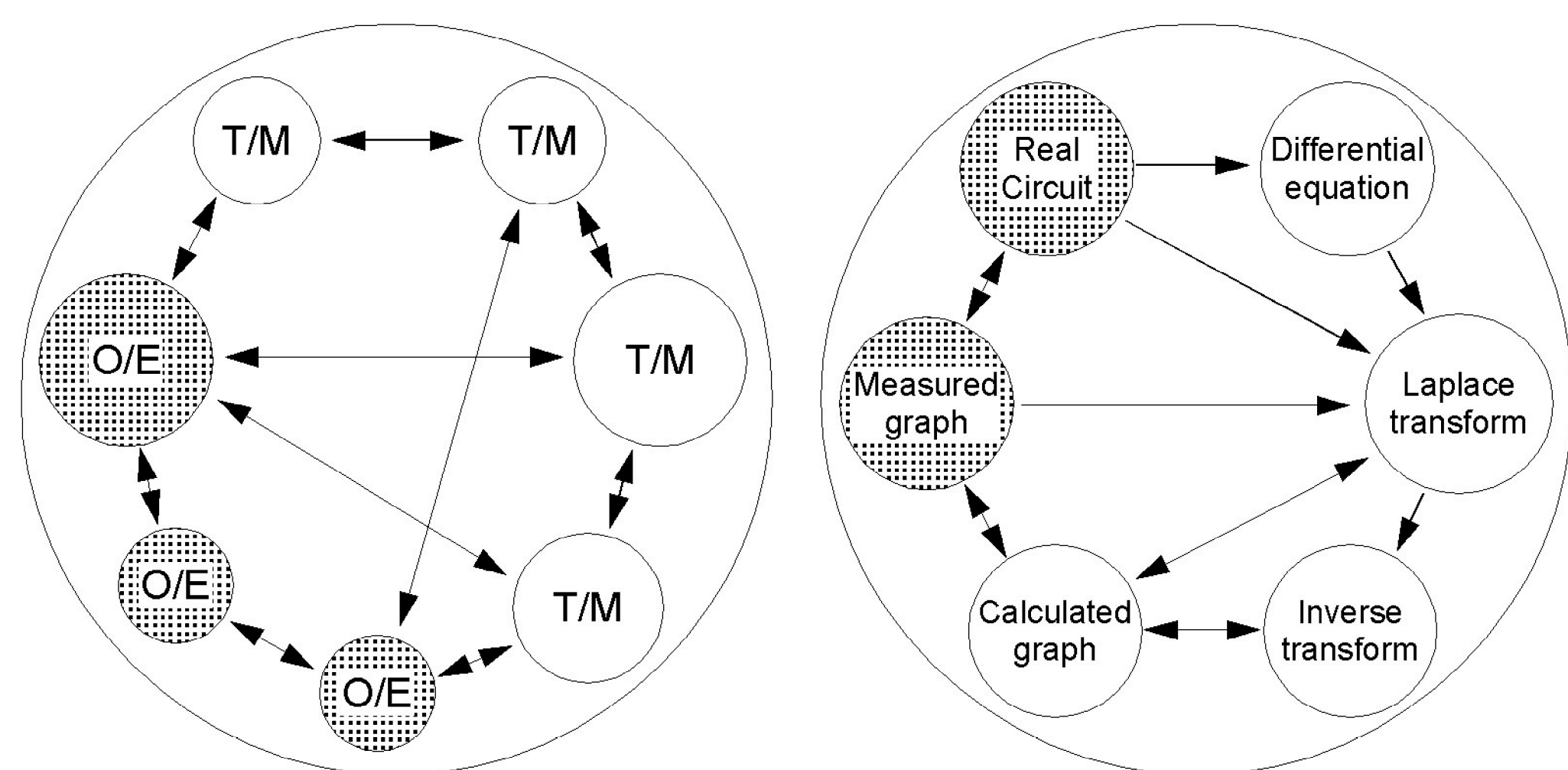


Figure 1. Our model - Learning of complex concepts - and translated into the example of the Transient Lab. The shaded circles are analytically attributed to the object/event 'world' and the unshaded circles represent the theory/model 'world'.

In the field of electrical circuits there has been a great deal of research on the understanding of direct current (DC) circuits among pre-university students, but hardly any research on alternating current (AC) circuits. Confusion between concepts such as current, voltage, power and energy has been reported. One possible reason that these are troublesome is that they are highly interdependent, so perhaps they cannot be learned one by one, but have to form an integrated whole.

Using digital camcorders we have studied students' courses of action in labwork carried out in a first year university course on electric circuit theory for engineering students.

Our focus in this study has been the lab concerning transients considered by most students to be very difficult since it included complicated mathematics such as Laplace transforms.

The first study was made before the revision of the course and the second after. In the revision of the lab-course problem-solving classes and labs were merged and the problems to solve during the sessions implemented very small but systematic variations inspired by Marton's theory of variation.

Our method to identify what was troublesome was to look for the questions raised during labwork (See Fig. 2 for an example), a method which gives a different insight into what really is troublesome, than commonly used recalled interviews, since the latter only can show what is remembered afterwards, which might not be the same.

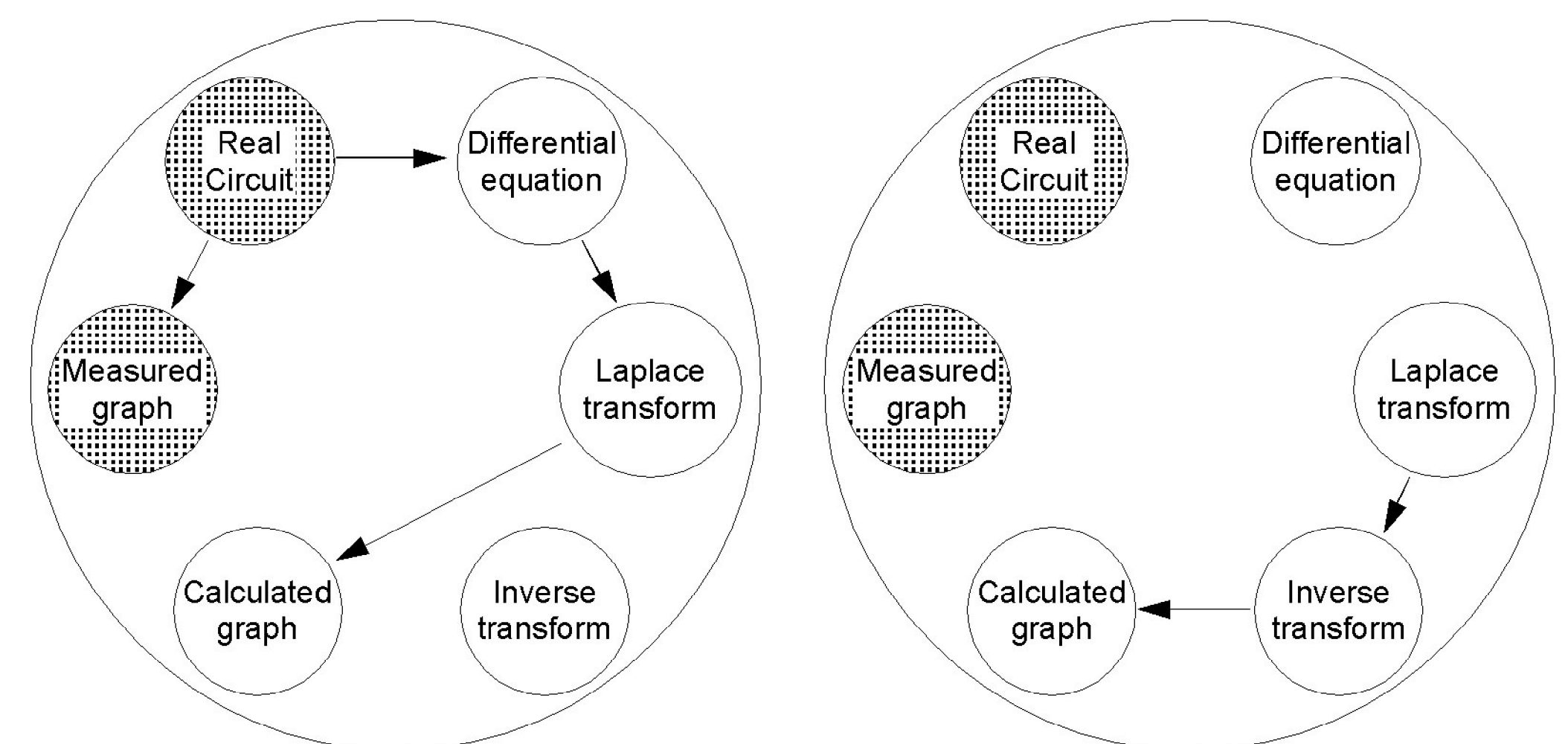


Figure 2. Example of an analysis of learning in the Transient Response lab, using the model for learning a complex concept: a) Student Benny's lived object of learning after the first part of the revised lab: b) Student Tess's lived object of learning at the same time

But rather than to end the study by finding what is thresholds, we used the model that emerged as a result from our first study, to find what is critical in order to learn, i.e. the keys that open up possibilities for learning.

The links are analysed in two ways:

- 1) what links do teachers want the students to make, i.e. how can we find a way to teach a specific link? and
- 2) what links do students actually make during the lab, i.e. what are they doing, or talking about.

The purpose of developing new analytical tools, new models and new concepts in research is to try to describe something better than was previously possible. In our research we have found 'the model of a complex concept', an essential tool for analysing the relationships that are intended and enacted in lab- and problem-solving sessions.

Research into 'threshold concepts' thus seems to include three fundamentally different modes of investigation: How do we recognize a threshold concept? In what ways is it difficult and troublesome? And how do we find the critical aspects, i.e. the 'key' characteristic of the concept that will open up the portal?

A key is not the foundation that a building is constructed upon; it is what you use to open the door. 'Core concepts' are the building blocks, fundamental for building a discourse or syllabus, and the 'key concepts', in our sense, make it possible to enter the building.

Finding critical aspects, i.e. finding the 'keys' that will open up the portal of understanding and search for potentials for learning should be an important mission for education research.