Linköping Studies in Science and Technology Dissertation No. 1038

Engineering problem solving – The case of the Laplace transform as a difficulty in learning in electric circuits and as a tool to solve real world problems

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Akademisk avhandling

som för avläggande av teknologie doktorsexamen vid Linköpings universitet och för avläggande av Doctorat en Didàctica de les Ciències Experimentals i de la Matemàtica vid Universitat de Barcelona kommer offentligt att försvaras i sal K3, Kåkenhus, Linköpings universitet, Campus Norrköping, måndagen den 4 september 2006 kl 10:15. Fakultetsopponent är professor Caroline Baillie, Queens University.

Tesis Doctoral

que, d'acord als requisits de l'examen de teknologie doktor a la Linköpings universitet i als requisits del programa de doctorat en Didàctica de les Ciències Experimentals i de la Matemàtica de la Universitat de Barcelona, es defensarà públicament el dilluns 4 de Setembre del 2006, a les 10:15, a la sala K3, Kåkenhus, Linköpings universitet, Campus Norrköping, Suècia. En aquesta sessió, la Professora Caroline Baillie, Queens University, actuarà com a professor oponent.

Abstract

For engineers it is important to be able to use the ’skill’ of for example handling novel situations in powerful ways and to develop and design. They are expected to be able to understand theories and models and their connection to objects and events in the physical world and being able to apply these models and theories. Engineering knowledge starts with the skill solving and identifying problems and leads to the skill of innovation and design. However, in engineering education, it is easy to confuse ’skill’ and ’knowledge’. A large body of research shows that engineering students can manage complex concepts in mathematical calculations and obtaining correct numerical answers but are not able in many cases to interpret the meaning of results. In the discipline of engineering it is especially important that knowledge is used to produce something new for the society, because the problems planted are focused in to change, improve or impact the level life.

This thesis takes engineering students understanding of electric circuit theory as a starting point for investigation. In the first part the problems that become the motivation to start the research conducted for this thesis will be described. Investigations into students’ difficulties with important concepts and topics in electric circuit for engineering students will be presented in this part. Our conclusion is that engineering students have similar problems with more advanced circuits and concepts as those reported from studies with elementary and secondary school students. We also can conclude that the Laplace transform is one of the

most difficult topics for learning engineering electric circuit theory.

The second part focus on the difficulties that was discovered in the studies presented in the first part of the thesis: the difficulties the engineering students showed in their understanding of the Laplace transform. Two studies were performed in this part, one with university teachers and one with engineering students from three different countries. The objective was to find the reason behind the difficulties mentioned in the first part.

In the third part of the thesis two models that was developed as a conclusion to the studies described in the first and second part of the thesis. In this context we will introduce the "modeling" as the way to link and connect the abstract thinking with the material aspect. We will also introduce a model called the "Techné Pyramid" related to the engineering education context, with three levels whose 'bases' is considered the first, going through an 'analysis' level to reach the 'design' level on the top of the pyramid. In the first level the elements are like different "islands" of concepts, skills and knowledge. These elements are not necessarily managed in a deep way. However, they are an important educational background for engineering students. These "islands" of elements are not necessarily linked to each other. In the second level, called "analysis", the student works with the complexity and develops links between different "islands". Previous concepts help to understand a new complex concept. In the third level, called "design", knowledge and skills from the previous levels are used for producing and designing something new.

The Techné Pyramid model will also be related to the studies of engineering students and their teachers in the context of learning electric circuits and the application of the Laplace transform as discussed in the first two parts of the thesis. To learn is a process and from our analysis of our empirical data we propose that many difficulties arise because the different 'levels' of skills and knowledge, illustrated by our pyramid model, are not understood in the educational process. We propose that every level has a specific objective in education and this thesis will try to explain the implications for engineering education.

The thesis is available from Ingenjörsvetenskapens didaktik, Institutionen för Naturvetenskap och Teknik, Linköpings universitet, SE-601 74 Norrköping, Sweden and is also available in electronic form at http://www.didaktik.itn.liu.se/thesis/gonzalez.html

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