# TEXTBOOKS AND THEIR AUTHORS: ANOTHER PERSPECTIVE ON THE DIFFICULTIES OF TEACHING AND LEARNING ELECTRICITY

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ABSTRACT

Despite extensive research, our understanding of the teaching and learning of direct current (DC) electricity remains poor. As part of a larger project focused on learning outcomes and analogies/models/metaphors appropriate at different levels of electricity learning, in this study we investigated the detailed forms of explanations and analogies/models/metaphors used in senior high school textbooks in Victoria, Australia, and the understandings of the writers of these textbooks. All 3 authors had inadequate understandings of models and analogies, there was great variation in author understanding of voltage (with one author having clearly inadequate understanding), and the approaches authors used in their books reflected these inadequacies. We suggest that this serious issue is not specific to the state of Victoria.

## 1. INTRODUCTION

Many studies of students' conceptions in the last 25 years have focused on introductory direct current (DC) electricity. These have involved young children (e.g. Cosgrove *et al.*, 1985), high school physics students (e.g. Koumaras *et al.*, 1997), university physics students (e.g. Viennot & Rainson, 1992), and science/physics teachers (e.g. Pordhan, & Bano, 2001). Recently we argued two reasons for this strong research concentration (Mulhall *et al.*, 2001), [Edit: shifted reference slightly.] reasons initially stated in 1985 (Duit *et al.* 1985, p. 10) and still valid today. The first is that electricity in some form is seen as central in physics/science curricula at all levels of education. The second, central to the project from which this paper derives, is that the concepts of electricity are particularly difficult – these concepts are abstract and complex in ways that make their understanding both centrally dependent on analogies and metaphors and frequently problematic.

Despite much research, on both student conceptions and approaches intended to change conceptions, our understandings of ways to develop concepts such as 'voltage' remain disappointingly poor. Two significant aspects of this poor progress



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are a lack of agreement about both detailed learning outcomes appropriate for different student ages/levels, and analogies/models/metaphors appropriate for different ages/levels – a stark contrast with another highly abstract area of science, particle theory (Mulhall *et al.*, 2001, p. 583). We are currently seeking to establish informed consensus about appropriate different forms of learning outcomes and analogies/models/metaphors for different levels of students studying DC electricity.

However, fundamental to such informed consensus is that those from whom the consensus is sought have good understandings of the concepts about which they are giving opinions. We have argued in some detail (Mulhall *et al.*, 2001) the considerable difficulty of DC concepts *per se*. Physics textbooks (and their authors) have considerable influence here – these books shape the ways many students and teachers conceptualize these ideas. Preliminary analysis of some popular textbooks has revealed conceptual inadequacies (Mulhall *et al.*, 2001). The purpose of the present study was to explore author and textbook understandings in greater detail. The research question underpinning the study is:

> How are the central concepts of direct current (DC) electricity understood by authors of senior high school physics textbooks and represented by these textbooks?

## 2. THE CONTEXT OF THE STUDY

Our sample of books and authors is from the context in which we work, the Australian state of Victoria. Here the final years of school (Years 11 and 12) include a specialist physics course, with DC electricity in Year 11, as shown in Figure 1. This electricity content is not unusual for such a course.

*CENTRAL IDEAS*

The use of electricity underpins much of the structure of our lives. Safe and effective use of electricity is important for individuals and the community generally. Much of our present use can be explained by basic DC circuit theory.

The area of study should include:

- current, charge, voltage, energy and power in series and parallel circuits *(including $Q=It$, $W=VIt$, $P=VI$);*
- Ohm's law and resistance in series and parallel circuits *(V-I graphs for ohmic conductors; $R_T=R_1+R_2$ etc.*
- non-ohmic devices *(awareness of their existence; examples of some V-I graphs);*
- cells, batteries and power supplies *(including e.m.f. and internal resistance);*
- electric shocks *(descriptive treatment of effects on humans, awareness of approximate dangerous quantities.*

*Figure 1: The DC electricity component of the curriculum in the context of the research*