Chapter 18
Research-Based Strategies in an Electric Circuits Lab: Tutorials and RealTime Physics Approaches

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ABSTRACT
This study reports the outcomes of comparing three methods to carry out a physics laboratory with active learning strategies: Tutorials in Introductory Physics (Tutorials) and RealTime Physics (RTP). A sample of 476 students was divided into three groups, about one third of the students used Tutorials, another third used RTP, and the last third used RTP with graphing calculators and probes. A multiple choice test was used to find that the three groups had statistically-significant differences on conceptual understanding of current concepts. Additionally, it was found differences in gains among the three groups using a multiple-choice pretest and posttest. With an analysis of misconceptions it was found that an important portion of students still holding misconceptions. The change of instruction seems to affect conceptual understanding when students have to analyze difficult circuits. Besides, it was found that students still holding misconceptions, they continue using terms like current and voltage interchangeably.

INTRODUCTION
The use of educational technologies in university physics has increased dramatically in the last few years. Over the past few decades, mostly in the United States, Physics Education Research (PER) has provided deep insight into how students learn physics at all educational levels (Fraser, Timan, Miller, Dowd, Tucker & Mazur, 2014). A subject of interest in PER is electricity and magnetism. Electricity is a scientific and basic topic with relevance to everyday life (Bilal & Erol, 2009). Research on students’
understanding of electric circuit concepts (Cohen, Eylon & Ganiel, 1983; Engelhardt & Beichner, 2004; Hewitt, 2007; Shipstone, 1988; Zavala & Velarde, 2009) has shown that students still have basic misconceptions regarding current and voltage concepts. The related literature has proved that, with circuits in series and parallel, the current and voltage behavior are difficult concepts for students (McDermott, 1992; Peşman & Eryılmaz, 2010; Engelhardt & Beichner, 2004).

In the last two decades, different research-based instructional strategies have been designed encouraging interactive engagement among students and to improve student’s conceptual learning (Hake, 1998; Fraser et al., 2014), such as Tutorials in Introductory Physics (McDermott, Shaffer & PERG-WU, 2001) and RealTime Physics worksheets (Sokoloff, Thornton, & Laws, 2004). Furthermore, use of technology is reported in literature as a successful tool that contributes to interaction, discussion and involvement from students, mainly talking about computers (Beichner & Abbott, 1999; Dancy & Beichner, 2006; Tarekegn, 2009; Zavala & Velarde, 2009). In the same way, the use of graphing calculator has taken relevance as an educational tool (Bos, 2007; Cavanagh, 2003; Doerr & Zangor, 2000; Jones, 2005; Robutti, 2009), since the evolution of technology allows graphing calculator to be used as a computer. The advantages of using a calculator are that it is less expensive and portable compared to computers.

This research proposes to compare two active learning strategies, Tutorials in Introductory Physics and RealTime Physics, through a conceptual learning analysis (Hake, 1998), that allows us to see the outlook of pros and cons of changing the instruction, such as the use of calculators instead of the use of computer in a research-based strategy.

The main goal is to compare the students’ conceptual learning when they perform the laboratory session in three different manners:

1. Using RealTime Physics with a graphing calculator and probes
2. Using RealTime Physics with a computer and probes
3. Using Tutorials in Introductory Physics

The active learning approach helps student’s conceptual understanding and promote long-term retention of knowledge (Wattanakasiwich, Khamcharean, Taleab, & Sharma, 2012). The use of electronic devices (or lack thereof) gave rise to conduct this research. It is our interest to evaluate the efficacy of the use of a calculator as a substitute for a computer. These two options were also compared (RTP plus computer and RTP plus calculator) to Tutorials in Introductory Physics, a very useful strategy reported in the literature.

LITERATURE REVIEW

In the last decades, Physics Education Research has developed research-based instructional strategies which are specific pedagogical approaches that have shown effectiveness through empirical measurements (Fraser et al., 2014). Active learning instruction engages students in their own learning more deeply and more intensely than does traditional instruction. This study is focused on two active learning strategies: Tutorials in Introductory Physics (McDermott et al., 2001) and RealTime Physics (Sokoloff et al., 2007). On the next section these strategies are described.