

# Surveying prior conceptual understanding of direct current resistive electric circuits of first year students in electrical engineering: an update

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## Abstract

This contribution reports, analyses and reflects on the results of a multiple-choice diagnostic quiz to assess student understanding of basic electrical concepts taken by a number of cohorts of first year, Level 7 and Level 8 engineering students at Dublin Institute of Technology over the past four academic years.

## Introduction

Many aspects of direct current resistive electrical circuits are introduced to students in the junior certificate cycle of second level education. However, many students struggle with the topic, with students' reasoning about basic electrical concepts often differing from accepted explanations. This is an international phenomenon, with Engelhardt and Beichner (2004), for example, reporting that U.S. high school and university students have similar conceptual difficulties, even after instruction in the subject. These authors supply a 29 question multiple-choice quiz, labelled with the acronym DIRECT, to tease out student misconceptions. The author applied this test to four cohorts of students, on the same DIT Level 7 engineering programme, from 2008-12 (n=106), and two cohorts of students, on the same DIT Level 8 engineering programme, from 2010-12 (n=64). The test duration is 30 minutes. The quiz was taken by the students at the start of instruction in the topic.

## Analysis

Table 1: Mean value of correct answers

Student cohort	%	n
Level 7, Year 1, 2008-12	42	106
Level 8, Year 1, 2010-12	42	64
High school students (USA)	41	454

1. For the Level 8 student cohort, there is no statistically significant relationship between subject Semester 1 exam results in the Electrical Systems subject and the results of the DIRECT quiz (n = 54), or between terminal examination performance in the subject and the results of the DIRECT quiz (n = 51).
2. For the Level 7 student cohort, there is a highly statistically significant, weakly positive correlation between the Electrical Principles Semester 1 exam results and the results of the DIRECT quiz (n = 91).
3. For the Level 7 student cohort, there is also a highly statistically significant, weakly positive correlation between the subject terminal exam results and the results of the DIRECT quiz (n = 87) - see plot.
4. Other work performed by the author has shown that there is no statistically significant relationship between an individual's results on the DIRECT test and associated Leaving Certificate Physics or Physics and Chemistry grades (when converted to CAO point scores).

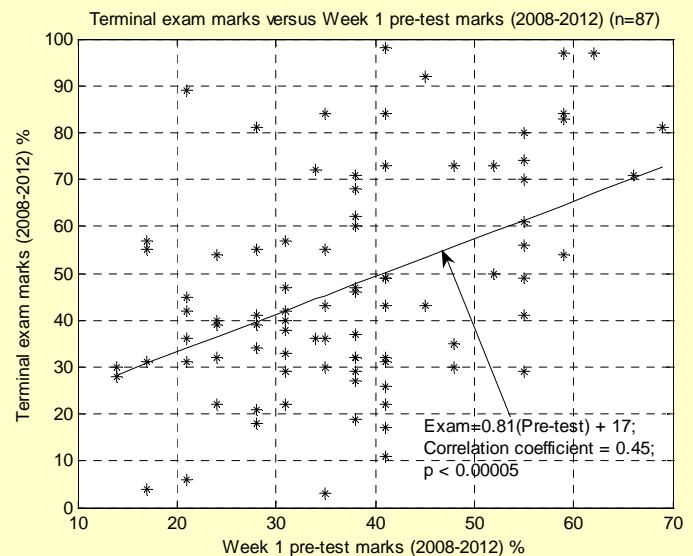


Table 2: Objectives for DIRECT and results

Objective	Question Numbers	Mean % correct
<b>Physical aspects of d.c. electric circuits (1-5)</b>		<b>49 (44)</b>
1. Identify and explain a short circuit	10, 19, 27	45 (44)
2. Understand the two-endedness of elements	9, 18	57 (55)
3. Identify a complete circuit	27	44 (47)
4. Apply the concept of resistance	5, 14, 23	42 (38)
5. Interpret pictures and diagrams of circuits	4, 13, 22	54 (41)
<b>Energy (6-7)</b>		<b>47 (48)</b>
6. Apply the concept of power to circuits	2, 12	47 (59)
7. Apply understanding of energy conservation	3, 21	47 (36)
<b>Current (8-9)</b>		<b>27 (21)</b>
8. Understand, apply conservation of current	8, 17	41 (31)
9. Explain microscopic aspects of current flow	1, 11, 20	19 (14)
<b>Voltage (10-11)</b>		<b>38 (38)</b>
10. Current depends on voltage and resistance	7, 16, 25	62 (63)
11. Apply concept of voltage to circuits	6, 15, 24, 28, 29	26 (36)

Data in brackets: Level 7 students

## Comment

- The concept of current clearly causes difficulties for many students.

## Conclusions

- The test has potential "in evaluating curriculum or instructional methods as well as providing insight into students conceptual understanding of d.c. circuit phenomena" (Engelhardt and Beichner, 2004);
- Identifying misconceptions and difficulties determined by the test allows explicit addressing of these problems in the learning environment.
- The work could be applied more widely to Irish students studying basic electricity in programmes in second level and third level education.
- Overall, the test does not reliably predict students who may be in danger of failing Year 1 examinations in the related subjects taught by the author.

## Reference

Engelhardt, P.V. and Beichner, R.J. (2004). *Am. J. Phys.*, 72(1), 98-115.