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Houston, We Have a Problem: Effects of Technical Frustration on Student Learning in Physics Laboratories

Kayla Kutz
Valparaiso University

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**Abstract**

This study investigates the effect of laboratory work’s typical technical difficulties on student learning in the physical science classroom. Certainly, the educational strategies of text and lecture are sorely lacking. But do laboratories in physical science frustrate students more than they teach them? To investigate this question, the study involved differentiating instruction for three classes of freshmen, sophomore, junior, and senior students enrolled in an introductory physical science course at a local high school. Two classes participated in a physical DC circuits laboratory, while a third class instead participated in a simulation counterpart - that is, an electronic experimental setup that by design cannot have technical difficulties like poor wire connections or faulty bulbs. Results show that the simulation laboratory had a more significant impact on students’ posttest responses, though not always for the better. These results are enlightened by observations of student interaction with each laboratory activity.

**Method**

In order to study the differences in student learning between a physical laboratory setup and a virtual counterpart, two laboratories were written. The concepts and questions posed as a guide in each laboratory were identical. The procedural guidelines were differentiated appropriately for a physical setup versus the simulation, and an effort was made to keep the vocabulary, wording, and conceptual nature of the tasks the same while the actual procedure differed.

The research instrument consisted dually of classroom observations and a portion of The Electric Circuits Concept Evaluation (ECCE) administered to students before and after participation in the laboratory. The ECCE is a multiple choice test, and the questions administered address concepts of current, voltage, and resistance explored in both laboratory setups. Since the study is concerned with student frustration with technical difficulties in the laboratory, the classroom observations were made while students interacted with both laboratories to provide insight.

**Results**

**Classroom Observations of Student Work**

**Physical**

- Faced with faulty connections between batteries and from wires to bulbs, students first responded by asking the teacher for solutions to the issues. If encouraged to solve the problem themselves, seeing that the final “answers” were simple, students sought solutions from other groups.
- All students finished in the allotted time, which is unusual for this group of individuals. Some were left working quickly to keep from falling behind. No technical difficulties as far as the construction procedure were observed.

**Virtual**

- Faced with slow computers, students responded by looking to peers whose computers were working quickly.
- All students finished in the allotted time, though most utilized the computers over the entire period.

**Inside classroom observations**

- Step-by-step instructions which were intended to make the lab as technically fool proof as a typical lab.
- In addition to the same thoughtful lab questions, the virtual procedure required students to move the student from this incorrect response.

**Pretest and Posttest Assessment Results**

**Impact on Students’ Understanding of Current through Bulbs in Parallel (Item 2)**

- Percent of students indicating that current increases through a simple circuit decreases but does not increase when a second bulb is added in parallel.
- Percent of students indicating that current decreases through a simple circuit decreases but does not increase when a second bulb is added in parallel.

**Impact on Students’ Understanding of Current through Bulbs in Series (Item 6)**

- Percent of students indicating that current decreases through a simple circuit decreases but is not increased when a second identical bulb is added in series.
- Percent of students indicating that current increases through a simple circuit increases but is not increased when a second identical bulb is added in series.

**Reinforcement of Misconceptions of Current in Simple Parallel Circuits (Item 3)**

- Percent of students indicating that current decreases through a parallel circuit decreases but is not increased when a second identical bulb is added in parallel.
- Percent of students indicating that current decreases through a parallel circuit decreases but is not decreased when a second identical bulb is added in parallel.

**Contact Information**

Kayla Kutz  
E: Kayla.Kutz@valpo.edu  
P: 414-651-6601  
Del Gillispie, Ph.D.  
E: Del.Gillispie@valpo.edu  
P: 219-464-5078

**Conclusions**

- Students who participated in the simulation showed a more significant difference between pretest and posttest answer choices across all concepts tested.
- Though designed to cut out the technical difficulties of actual batteries and bulbs, the simulation ultimately required more thoughtful student input than the physical laboratory setup.
- Though subject to some more technical difficulties, the physical setup minimized the student mental effort to a fault. Some students even self-identified it as “the easiest lab ever”.
- There appears to be a positive correlation between appropriate levels of mental effort on the part of the student and concept attainment as measured by the assessment.
- Instead of investigating how too much intellectual frustration may hamper student learning, I believe I have inadvertently investigated how not enough intellectual frustration may have the same result.
- These conclusions are significant for teachers in that “easy” labs don’t mean “easy” learning.
- They are also significant for students as they struggle with laboratories, realizing that struggling in a laboratory may provide evidence of critical thought and a foundation for learning.

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