Physics By Inquiry In Diverse Populations: Addressing Student Learning and Attitude

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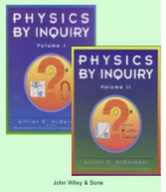
INTRODUCTION

The results of Physics Education Research and research-based instructional materials have been disseminated from traditional research universities to a wide variety of colleges and universities. Nevertheless, the ways in which different institutions implement these materials depend on their students and the institutional context. Even with the widespread use of these curriculums, the research documenting the effectiveness of these materials with different student populations is scarce. This poster:

- Describes the challenges associated with implementing *Physics by Inquiry* at California State Polytechnic University Pomona.
- Confirms its effectiveness in promoting student conceptual knowledge of physics.
- Suggests that the students did not appreciate the self-discovery aspect of the inquiry approach and characterized the learning process as difficult and unpleasant.

COURSE & STUDENT POPULATIONS

Science 210: Special Courses for future K-9 teachers



- Textbook: *Physic by Inquiry*
- *Properties of Matter* and *Heat & Temperature*
- There were fifteen students in the class
- Mostly, female, liberal art majors with an interest in an elementary school teaching career
- Little or no physics or physical science background
- No formal inquiry-based learning experience prior to this course

The original physical science course design had separate lecture and laboratory components. To implement the inquiry approach, the lecture and laboratory were combined; students met twice a week for a total of six hours.

Reasoning Level Assessed	% correct
Conservation of weight	90%
Conservation of displaced volume	90%
Proportional reasoning	30%
control of variables	15%
Hypothetico-deductive reasoning	7%

Table 1. Lawson's Classroom Reasoning Test results

DATA

- Research-based pre/post-test
- Lawson's classroom reasoning test
- Mid-quarter student evaluations

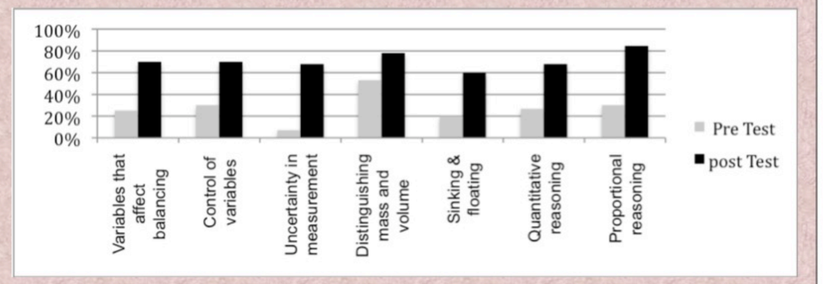


Fig 1. Pre-test post-test data at Cal Poly Pomona on different topics of Properties of Matter

Analysis of the pre-test data confirmed that the students had little background knowledge related to the course. For example:

- 7% had some understanding of measurement uncertainty
- 20% were somewhat familiar with the principles of sinking & floating

In pre-test data students often lacked consistent and logical thought patterns that enabled them to propose relationships between observed phenomena.

Topics of Properties of Matter	Pre-test	Post-test	Normalized Gain
Variables that affect balancing	25%	75%	67%
Control of variables	30%	75%	64%
Uncertainty in measurement	7%	60%	57%
Distinguishing mass and volume	53%	90%	79%
Sinking & floating	20%	60%	50%
Quantitative reasoning	27%	75%	66%
Proportional reasoning	30%	80%	71%

Table 2. Normalized gain for students in different topics of Properties of Matter

The learning gain in the content knowledge for each topic was measured by calculating a normalized gain score. The observed gain across all topics was reasonably high (more than 50%), considering that student typical gain in traditional lecture-based mechanics courses is only about 30%.

STUDENT FEEDBACK

A three-item mid-quarter assessment tool was administered:

- What is helping you learn the material in this class?
- What makes learning hard in this class?
- What other suggestions do you have?

Although students seem to value the group work and the hands on approach, they generally seemed to dislike the self-discovery aspect of the course:

> *"I think that <u>not</u> all of the class should be learning by inquiry and that we need a good portion of lecture. People learn in different ways and I need some lecture and teacher explanation, not my blind ides going into a exercise."*
>
> *"Not lecturing before we start the experiments makes it hard to understand what it is we are supposed to be finding."*
>
> *"The things make learning hard is that the teacher doesn't lecture, also if the concepts of what we are learning is not demonstrated to me prior to doing the section, it is a lot harder."*

DISCUSSION

The students' attitudes and expectations conflict with observed learning gains. The results describe the reluctance of students to develop an appreciation for the self-discovery process inherent in the inquiry approach.

- Many students did not have experience with inquiry-based teaching models in their high school and college courses; therefore, their unfamiliarity created an obstacle that impeded their ability to appreciate their own learning
- Their generally weak science background and lack of formal reasoning skills made the process very difficult for some students
- Demanding facts and principles in a lecture suggest a lack of comfort and their unwillingness to construct their own knowledge

What innovative methods can improve student engagement with the self-discovery process and promote their motivation and curiosity?

In spite of these issues, the evidence suggests that inquiry-based models of learning are viable and should be part of the science teacher's repertoire. Implementation of inquiry-based teaching and learning needs to account for factors such as the student's reasoning ability, background, curiosity, attitudes, and level of motivation.