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AUTHOR Novemsky, Lisa  
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ABSTRACT

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Second Teaching: A Study of Small Group Physics Learning  
Lisa Novemsky, Ed.D., Assistant Professor  
Brooklyn College School of Education  
Presented at NARST, 2003 in Philadelphia, PA

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## **Second Teaching: A Study of Small Group Physics Learning**

Lisa Novemsky, Ed.D., Assistant Professor

Brooklyn College School of Education

“Second teaching” (Novemsky, 1994, 1998) is an idea that was developed after a long period of observation of participants in an educational opportunity preparatory program at a public technological university. These students were successful in a small group setting pedagogical format. “Second teaching,” follows the initial presentation of new ideas in lecture and/or text, “first teaching.” The students were learning introductory physics using Alan Van Heuvelen’s Overview, Case Study Method (Van Heuvelen, 1991) which emphasizes conceptual learning and involves small group learning with guided materials with successive approximations and multiple representations.

### **Objectives of the Study**

The discipline of physics has evolved into a culture of relatively homogeneous individuals who have developed their own established practice with characteristic behaviors and language. The nature of physics communication involves a very precise set of lexical items and linguistic structures that are particular to physicists and those in closely related disciplines.

To many students standard English enhanced with physics parlance presents severe difficulties similar to confusion encountered when confronted with a totally foreign language (Lemke, 1990; Orr, 1987). Formal and precise language structures and vocabulary of scientific discourse tend to be distant from non-traditional physics learners and distinct from the natural language of students' peer cultures. An intervening process seems to be important for non-traditional learners to comprehend and thereby gain access

to physics content. An educational experiment at New Jersey Institute of Technology (Gautreau & Novemsky, 1997) provided strong evidence that a reform model of physics education with small group practice or “second teaching” appeared to contribute to significantly greater student success in introductory physics learning than conventional instruction (lecture, lab, and recitation), particularly for non-traditional students who would not have been admitted to the university under time-honored guidelines.

### **Traditional and non-traditional physics students**

Until recently there was a custom in science education in the United States wherein students were labeled according to early identification of unchanging abilities, such as spatial visualization, reasoning, and computation. Students were systematically categorized as fit or unfit to learn physics. Introductory physics courses served as gatekeepers for eliminating or “weeding out” those who did not have these initial skills. Individuals who did not succeed in physics were summarily excluded and went on to other studies that were not so strictly protected.

The general rule seemed to involve identifying a potential physicist and cultivating that individual. Successful candidates tended to be those who were able to create an internal image from a verbal text and lecture. Candidates were expected to be adept at scientific perception and abstract reasoning, as well as advanced language usage skills for reading technically challenging texts with understanding. It was assumed that these prized students would develop the art of question formation and explanation as needed. Implicit problem-solving skills, including problem categorization, approaches, logic, and mathematics were also expected to be fully present as pre-requisites for entering the exclusive gates to the physics classroom.

Many students graduate from high schools and enter colleges with major deficiencies in understanding of the subject of physics, and disconnected from the subject as traditionally presented. Of the many possible causes of widespread failure of success in studies of physics are teachers inability to teach physics; lack of preparation of students from previous courses; poor motivation on the part of students; the subject itself, often seen as boring and bearing no relation to real life; and the difficult math that is involved. In particular persons from minority cultures, women, persons with disabilities, and poorly prepared students were essentially left out of the physics stream, pursuing other studies and careers (Matyas & Malcom, 1991).

Women are among those who are seriously underrepresented in physics, "the coldest science" (Brush, 1991, p. 404; Fehrs & Czujko, 1992). Tobias (1990), who explored exclusionary aspects of introductory physics courses, states that science courses are unnecessarily difficult, distasteful and even dull for many students. The emphasis on problem-solving, competition for grades and lack of community among students, lack of personalization of subject matter, combined with a perceived authoritarian teaching style, has extinguished motivation to learn for many students, particularly women. A sociological theory based on status in small groups versus status in classrooms in the presence of an authority of high status (a teacher) states that small group interaction can facilitate gains in self-esteem and self-efficacy (Meeker, 1981) so desperately needed in certain minority groups, as well as in females involved in physics and math. The underrepresentation of women in physics and physics-related subjects may be a more complex issue than previously described.

## Theoretical Underpinnings

*First teaching* describes initial presentation of new subject matter and/or problem-solving techniques. A lecture, a laboratory experience, or a text reading are possible formats, although in the context observed, a semi-traditional lecture format (lecture with provocative discussion) was preserved.

*Second teaching* is a practice that is based on two of Vygotsky's (1978, 1986) ideas. The first of these ideas involves the relationship of language and visual representations to learning. Rather than considering language and drawing purely as a means of communicating ideas, Vygotsky saw language and drawing as tools and cultural instruments for developing logical and analytic thinking and learning.

The second idea concerns the "zone of proximal development." In a highly complex dynamic relations between developmental and learning processes, Vygotsky argued that learning is converted into individual internal developmental processes in a "zone of proximal development," which is the distance between the actual developmental level of an individual as determined by the person's independent problem solving and the level of potential development as determined through problem solving with guidance or in collaboration with more capable peers. (Vygotsky, 1978, p. 86)

*Second teaching* occurs when the collective wisdom of a collaborative group acts as a mentor to its individual members. . For peer groups in general, this collective wisdom is most likely to fall within the zone of proximal development for most of its individual members. This collective wisdom is created then recreated through group collaboration (Novemsky, 1998).

## A Study

A study was conducted with NJIT's Educational Opportunity Program students in a summer program. Identical pre-and post-tests were administered at the beginning and end of a summer program. Forty four students were asked to give written explanations for each of their chosen answers for five multiple-choice questions. A carefully composed concept test on basic mechanics concepts was administered to the participating students. Each multiple-choice question had space provided for students to explain their thinking. Explanations provided by the students were the focus of this study. Independent random sorts of 440 explanations, (44 for each of 5 questions on each of the two tests) were printed with no identifying information.

Overall, students improved significantly in physics knowledge suggesting that Overview, Case Study methodology, including second teaching, was effective in producing an increase in physics knowledge. Changes in physics knowledge ratings were calculated for each student by subtracting post-test physics knowledge ratings from pre-test physics knowledge ratings. With the exception of one student, all physics knowledge difference ratings were positive. Overall, students' knowledge increased by 2.33 points (on a ten-point scale).

Language clarity ratings were determined for each student's pre- and post-test on a ten-point scale. Difference in average language change was marginally significant at roughly one half point, showing that overall language clarity gains were small.

In addressing the major research question of this study, language clarity change and physics knowledge change were compared. For the overall population, the finding of a significant correlation (correlation coefficient of  $r = 0.34$ ,  $p < 0.05$ .)

### Significance

The findings in this study appear to confirm the hypothesis that one of the cognitive factors that accounts for the success of second teaching in physics learning for non-traditional learners is the development of explanatory language in the context of learning physics. This study also suggests that second teaching serves as a useful form of pedagogy for developing scientific and technical discourse while learning a given domain of science.

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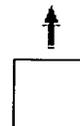
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Signature: Lisa Novemsky

Printed Name/Position/Title:  
Lisa Novemsky, Assistant Professor of Education

Organization/Address:

School of Education  
Brooklyn College  
2900 Bedford Ave  
Brooklyn, NY 11210

Telephone:

718 951-5061

Fax:

718 951-3115

E-mail Address:

novemsky@brooklyn.cuny.edu 2003

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