ACTIVE LEARNING PROCESSES AND CLASSROOM PEDAGOGY: THOSE THAT ENCOURAGE STUDENT SELF-EMPOWERMENT AND THOSE THAT FOSTER ASSIMILATION OF PHYSICS CONCEPTS

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INTRODUCTION

This workshop was intended for instructors, administrators who train faculty and teaching assistants, and anyone interested in the education of engineering students. Participants had the opportunity to experientially "sample" the classroom pedagogy and active learning processes that encourage self-empowerment and comprehension. In this workshop, we (1) defined "student self-empowerment" and explained why in this model it is primarily social,[3] (2) reviewed the conceptual foundation for the empowerment process and for suggested instructional strategies, and (3) discussed potential effects of classroom social structure[6,7,8,9] on student self-empowerment and comprehension.

THE WORKSHOP

In this workshop, we examined two pedagogy approaches that encourage self-empowerment by students in their educational experiences in science and engineering colleges. The long-term goal of such self-empowerment is persistence and ultimate successful completion of science and engineering undergraduate degree requirements.[14] In the workshop, we demonstrated and contrasted the approaches such that educators could select the most appropriate approach for the educational goals they have for their students. The two pedagogy approaches potentially differ in underlying processes, curricular content, and the type of academic curricular or student social behavior outcomes.[1,2,5] While a number of student outcomes are possible, we discussed student self-empowerment in academic physics performance and self-empowerment of social behaviors commonly associated with self-confidence and persistence in non-traditional areas.[23]

The academic self-empowerment approach was demonstrated with examples from physics activities developed by Julie Schuck at Cornell University. The student self-empowerment of social behaviors associated with persistence and self-confidence were demonstrated with social science content activities developed by Jan Carpenter, while at Penn State, in conjunction with approximately 240 student participant research subjects from 1992 to 1996. Both of these pedagogy techniques use active learning methods and include encouragement of class participation, hands-on-activities, and cooperative learning. But as we illustrated via the experiential hands-on-activities in the workshop, active learning pedagogy that potentially increases student assertive self-confident behavior, as well as their independent analysis of their own experiences about a social issue,[10,12] does not make them more competent to do physics. Likewise, active learning pedagogy that increases physics knowledge makes students potentially more self-confident about physics but may not increase their sense of self-confidence,[16,20] for example, to be one of three female students among 40 male physics students.

In the physics part of the workshop, we modeled a problem-solving session where participants split into groups of three or four to work on physics problems. Each group was also assigned a participant-observer who recorded observations on the group dynamics but did not contribute to solving the problems. The participants were given twelve problems (too many for the allotted time) which illustrated different approaches: (1) problems requiring manipulation of visual aids, (2) problems requiring reading from graphs, (3) calculable problems (strict number-crunching), (4) problems requiring written explanations, (5) problems requiring short factual responses (1-2 words), and (6) problems based on earlier reading material (in the workshop, some information on light and diffraction was distributed to read prior to the problem set).

From the physics exercise in the workshop, we made the following observations. All workshop participants were women with a variety of different backgrounds: for example, engineering, computer science, math, and English writing.

(1) Groups consumed a large amount of time introducing themselves and figuring out how to work as a group while solving the first problem.
(2) Initially participants were inclined to make excuses for their lack of knowledge and/or inability to contribute. However, the observers noted that these same people offered extremely useful suggestions for the problem solving. Individuals' excuses lessen as other participants began to affirm their contributions to the group's discussion.
(3) Participants were driven to completion. Even though they were told it was OK not to finish all the problems, they wanted to complete the entire set. They were frustrated to leave something unfinished. When a five to ten minute wrap-up warning was given, participants turned toward individual work to try to finish the problems.
(4) Participants filled out a questionnaire after the problem-solving session. Responses were relatively evenly distributed among preferences for the different types of

approaches to problem solving though many favored the questions with visual aids available and those that required short factual responses.
(5) Participants found working with people of different skill levels challenging. They noticed that others' apparent attitudes affected the group process and motivation.

In the social behavior active learning activity we demonstrated one example of the topics addressed in similar fashion in the semester long Carpenter empowerment/retention class. The example illustrated in the WEPAN workshop, for class use as an "empowerment" activity, was set in a context of required readings and other class projects. This explanation of the context is offered, since the social behavior activity might appear as a "fluff-feeling" exercise, but for class use, it was grounded in a larger framework.

In the social behavior active learning exercise we focused on the interpretation, and potential proscriptive power given to the term "feminist", from the perspective of a first year S & E female. The underlying goal was to help females identify potentially inaccurate perceptions or beliefs about being labeled "feminist" by classmates that might influence the student's perceived likelihood of success as a S & E female. Female self-confidence in non-traditional careers may be linked to their perceptions of potentially harmful consequences, whether academic or personal. For example, perceiving the likelihood of success in physics as a female might be related both, to one's ability in physics and to one's belief that being successful in physics as a female will not be uncomfortable or appear to generate social teasing or disdain by peers. We illustrated, with administrator and faculty responses from the WEPAN workshop, how the class processes examined possible harmful underlying belief systems via the social behavior activity.

Following the physics task, workshop participants began the social behavior task. We modeled the pedagogy and content focus as it was used by Carpenter in the empowerment class. WEPAN participants were given some simple interaction instructions to help them "break" from the physics exercise. Then we regrouped as an informal discussion circle. A series of worksheets were passed out, with instructions to complete the answers as honestly as possible but to omit identifying information or names. The worksheets were collected, shuffled, then re-distributed. As a group we processed the now-anonymous answers to examine the perspectives or stereotypes "voiced" by members of the group such that individual views did not expose a particular group member. First participants gave, from the perspective of a first year S & E female, a definition of "feminist". Care was taken to explain that we were interested in societal stereotypes of the term, not whether a person was, or was not, a feminist. Definitions given by workshop participants, for the term feminist, were both positive and negative, but the majority of the labels were negative. Next, participants described circumstances under which this hypothetical first year female might be labeled as a "feminist" by S & E classmates. In contrast to the negative stereotypes of "feminist", the student behaviors that might "earn" such a label by classmates were positive and competent behaviors such as "talk in class, know the answer, appear smart, be assertive, etc."

We modeled the role that either a workshop leader, or an empowerment class instructor, could use to guide group discussion of the definitions and perceived consequences. The leader also guided discussion of ways to help female students disconnect the link between the two with the intent of disrupting the perception that competent physics behaviors (knowing the answers, talking in class, doing well on tests) might result in potential aversive social consequences, such as being labeled "feminist" by their classmates and thought of in potentially negative ways. The goal of the task was not to reinforce the negative societal stereotypes but to bring them to awareness, to discuss and deconstruct, and then to reconstruct a more realistic interpretation of likely outcomes.[4]

A brief description of the underlying theory and examples from the authors' research base are presented in this paper to provide background.

BACKGROUND ON RESEARCH

The "Physics Anxiety" Project

From 1994 to 1998, the Women's Programs in Engineering Office at Cornell University conducted a research study to identify factors contributing to the under-representation of women in physics-based engineering fields.[21] The study began after recognizing that the percentage of undergraduate women in fields such as electrical and mechanical engineering has remained well under 20 percent while the percentage of women in chemical and industrial engineering has grown to almost 40 percent. For this study, we surveyed 499 undergraduate women at eight U.S. universities about their decisions to major in engineering. The observed differences among women in engineering majors suggested factors which could have contributed to the under-representation of women in physics-based engineering fields: (1) absence of mechanical activities prior to college, (2) absence of engineering role models, and (3) poor perceptions of physics. Some women purposely choose majors such as chemical or industrial engineering to avoid additional physics courses. Their frustration with physics stemmed primarily from the inability to grasp physics concepts in introductory courses. (Note, however, many expressed confidences in their comprehension when they saw the material again in other courses.) Our findings suggest that women who chose to avoid physics-based majors were either missing preparation (i.e., insufficient math skills and/or no or poor high school physics courses) or had received instruction in a manner incompatible with their learning preferences. To generate teaching strategies that would develop students' confidence and comprehension in physics, we combined data collected from the study with instructors' experiences in physics courses and results from other research in the area of physics education. The strategies focus on (1) creating multiple representations, (2) encouraging active participation,[17,19] (3) including hands-on activities, (4) addressing perceived relevance, and (5) promoting cooperative learning.[11,13,15] This workshop demonstrated three of these strategy areas (2, 3, & 5) which promote active learning. The recommended teaching strategies are meant to transform class time into time spent learning as opposed to time spent recording information that will be digested later. To accomplish this, students must arrive prepared to think about the presented material and to participate in exercises; students should have opportunities for hands-on activities; and students should be able to discuss ideas and questions with their peers and/or instructors.

Carpenter's "Female Empowerment/Retention Class"

The empowerment/retention research on which was based the social behavior portion of this workshop, was initiated and conducted by Jan Carpenter from 1992 to 1996. The instructor's salary, for the course taught six semesters in the College of Liberal Arts, was funded by David Wormley, Ph.D., Dean of the College of Engineering, Penn State. Concurrent with this special section for first-year females from the four S & E colleges, were regular Introduction to Women's Studies sections and Women in Science courses (for example, with syllabi similar to the Women's Studies based class offered at Washington State University), and the first-year orientation classes taught in the S & E colleges (for example, "Success 101" in the College of Engineering and many others).[18,22] The "empowerment" activities were unique to the Carpenter-taught-class since they were the Independent Variable components contrasted between the Experimental and Control groups. An hourly undergraduate teaching assistant for the class was funded by the National Science Foundation ECSEL Coalition. Using the small sample of Experimental and Control group subjects, an institution-wide naturalistic evaluation experiment was conducted since equal proportions of the E and C groups were distributed among the four S & E Colleges at Penn State. As an Institutional Review Board approved research project, subjects for both the Experimental group and a matched Control group were recruited from College admit lists, by positive recruitment letter, with assistance from the Deans and advisors in the four S & E Colleges. A mostly female cluster group for the class was established by use of course holds and advance enrollment restrictions. Each semester a few males enrolled and earned credit for the class, which was advertised as having a concentration focus on women in society but in science and engineering fields. A summary of the "Empowerment" retention procedures, methods, and results are available from Carpenter.

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