Fewer than 16% of our high school students take physics (National Center for Education Statistics, 1981). It is possible that this common lack of experience with physics concepts has translated into the low level performance of U.S. students in the International Evaluation of Educational Achievement (Travers, 1985) and in the recent National Assessment of Educational Progress (Mullis & Jenkins, 1988). What can be done to spark interest in physics? One suggestion is teaching with a historical, cultural approach. Brouwer and Singh (1983) report that such an approach produces many positive student outcomes and especially an understanding of the nature of growth and change in scientific knowledge. Swartz and Swartz (1983) believe that physics students need to study history to have an accurate perspective of the nature of science. A second suggestion for increasing interest is to use experimental approaches in teaching physics (Farmer, 1985; Meyer, 1984).

The Bakken is a library and museum of electricity in life founded by Earl Bakken, the inventor of the first wearable cardiac pacemaker. The Bakken's collections comprise approximately 12,000 books, bound journals, and manuscripts and close to 2,000 instruments and machines. In addition to its collection of primary sources dating from the thirteenth century, but with the emphasis on the eighteenth, nineteenth, and early twentieth centuries, the library has a support collection of histories, biographies, and reference works. The library also possesses slides, photographs, portraits, and artworks that depict the subject matter of its print and instrument collections. The goals of the Bakken are to exhibit and interpret historical objects, to promote scholarly research and development, and to foster educational and cultural programs.

The directors of The Bakken advocate combining history and experimentation to allow students to share in the wonder of discovery. Their aim is to facilitate an increase in student experimentation by showing physics teachers how to repeat historically important experiments with simple and inexpensive replicas of historical apparatus, an approach pioneered by Dr. Samuel Devons, Professor Emeritus of Columbia. The Bakken has been providing teacher training in this approach since 1984 through a series of special summer physics courses offered by the University of Minnesota. This study focuses on the program offered during the summer of 1987.

The three-week summer course, supported by a grant from the National Science Foundation (NSF), was devoted to vibrations and waves. Its main objectives were to promote a historical approach and experimentation with an emphasis on student investigations conducted in classrooms or at home. History of science served as a resource. In a way, the course was a blend of history of science and experimental physics.

Participating teachers were involved in various activities between 9 a.m. and 5 p.m. daily. At lectures they studied the historical development of physical concepts. At seminars they shared their experiences in teaching subjects related to the course. At laboratory sessions they conducted open-ended group experiments. Any remaining time was left for them to work on individual projects. Each person's project, presented to his or her peers at the end of the course, reproduced a historical experiment. The project was intended to be integrated into its author's curriculum and was also made available to the other teachers participating in the course.

The following is an example of an open-ended experiment conducted during a group lab. The objective was to test Galileo's law that the period of a mathematical pendulum does not depend on its mass or the amplitude of its vibrations. The materials utilized were simple stands made of particle board, PVC pipes and dowels, and ball bearings, ping pong balls, thread, and masking tape. A point of the assignment was to resolve the dispute between Galileo and Huygens. Galileo discovered experimentally that the vibrations of a pendulum are isochronous for both small and large amplitude, while Huygens deduced theoretically that this is true only for small amplitudes. The participants were asked to determine if Galileo’s conclusion was the result of the low precision of his observations. To answer this question, teachers measured time both by a stopwatch and by counting the pulse beat, as it was done by Galileo.

The teachers were very positive about their experiences at the institute and particularly enjoyed the opportunity with hands-on history. The important question remaining, however, is what happened in their classrooms? Did the teachers' training in open-ended historical experiments allow their high school students to perceive physics in a more favorable light?

Methodology

Because of funding constraints and in order to keep testing to a minimum while obtaining maximum input, the effect of the institute on the participants' classrooms was examined in two ways. First, the way one-half of the participants (experimental group) taught the subjects covered by the institute—light and sound—was compared to the way non-participating physics teachers (control group) taught these topics. Second, the way the second half of the participants (self-
comparison group) taught light and sound was compared to the way in which they taught magnetism and electricity, topics not studied at the institute.

The comparisons were conducted through the use of questionnaires completed by the teachers and opinionnaires completed by the students. Students of teachers in the self-comparison group completed an activity rating form which asked them to rate how often they studied certain things or engaged in particular behaviors during units on light or sound and during units on electricity or magnetism. Half of the students of the experimental and control group teachers completed the activity rating form during light or sound units while the other half of the students completed a questionnaire which asked about their grades, why they chose to study physics, and what they hoped to do in the future.

The control group of physics teachers was selected in the fall of 1987. Schools were selected to be comparable in size, in geographical location, and in public or private orientation to the schools of the participants in the experimental group. Once the control schools were selected, the physics teacher was called and asked to participate in the study. The response rate overall was 67%, and there appeared to be no consistent bias among non-responding teachers.

Comparisons Among Experimental and Control Groups

Teachers

The experimental and control group physics teachers were asked to fill out questionnaires asking how they taught light and sound and about themselves. The experimental group was 71% male, and the control group was 83% male. The average number of years of teaching experience was 13 for both groups, and in both groups all but one person had a major in physics or chemistry. The number of students in the physics classes varied from 5 to 27 for the experimental group (average = 18), and from 14 to 27 for the control group (average = 20). The typical teaching sequence varied for each individual teacher, but in general, all emphasized hands-on approaches. Although there were no overwhelming differences between the teachers in the two groups, the experimental teachers, as might be expected, more often reported discussing biographies and historical details and requiring the students to be involved with and to conduct laboratory activities.

Students

The questionnaire results from 130 experimental and control group students are presented in Table 1 and show that the students in the two groups were quite similar overall. The gender distribution matches national figures with the classes being about two-thirds male. The range of reported grades was somewhat wider than expected, but 56% of the students did report having mostly A's or B's. The data reinforce the perceived college preparatory nature of physics classes with 93% of the students planning to go on to a two-year or four-year college. It was interesting that although a variety of careers was mentioned, a full 46% of the students chose one of three areas: engineering (18%), business (17%), or teaching (11%). The decision to enroll in a physics class appears to have been influenced more by people than experiences (25% vs. 12%) with the most important people being fathers, teachers, school counselors, mothers, and friends, in that order. It is somewhat encouraging in the face of the “video generation” that the most commonly mentioned experience for encouraging students to take physics was watching true scientific shows on television (15%).

Although the students in the two groups were very similar, there were some minor trends within the groups. The students of the institute participants were slightly more likely to be boys, with a broader range of grades and with more experience repairing things contributing to their desire to take physics. The control group students were slightly more likely to be college bound, to want to become teachers, and to be encouraged by others, especially siblings and counselors, to take physics.

The student activity data from 129 experimental and control group students and the results of t-test comparisons are presented in Table 2. Engagement in activities was rated one to five with 1 = almost always and 5 = never. The range of ratings was 2.0 to 4.8 so students did engage in the activities at least some of the time. Although students in both groups reported participating, the ratings show a consistent pattern of more student involvement in activity for the students of the participants. Six of the 15 t-test comparisons showed statistically significant differences. Students of institute participants were significantly more likely to believe studying light and sound was fun, to conduct experiments at home that were not assigned in class, to have their teacher suggest that they build experimental apparatus, to study about famous scientists and their lives, to help plan the procedures for the experiments they did in class, and to study how past scientific discoveries were made.

On the activity opinionnaires the students were also asked to say what they liked best and least about the class. Forty-eight different “best” things were mentioned, but the most popular “best” response was doing experiments; 43% of the participants’ students chose this response compared to 16% of the control teachers’ students. Fifty-one different “worst” things were mentioned. The most popular “worst” response was tests, with students from both groups saying this 8% of the time.

Comparisons Within the Self-Comparison Group

Teachers

Self-comparison group teachers were asked about themselves and about how they taught light, sound, magnetism,