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The Iowa Physics Project: Past, Present, and Future

Timothy M. Cooney
University of Northern Iowa

Roy D. Unruh
University of Northern Iowa

THE IOWA PHYSICS PROJECT: PAST, PRESENT, AND FUTURE

Timothy M. Cooney
Associate Professor of Teaching and Science Education
Malcolm Price Laboratory School
University of Northern Iowa
Cedar Falls, Iowa 50613

Roy D. Unruh
Associate Professor of Physics and Science Education
University of Northern Iowa
Cedar Falls, Iowa 50614

Iowa, along with many other states, has been faced with a loss of qualified physics teachers to the private sector for better salaries. This has created a shortage of people qualified to teach physics. A study by Howe and Gerlovich (1983) indicated that the majority of states in the United States are experiencing serious shortages of "qualified" science and math teachers. Science consultants from each state were asked to rate the supply of science and mathematics teachers on a Likert Scale ranging from one to five (1 = surplus and 5 = critical shortage) in the years from 1980 to 1982. The summary in Table 1 shows the degree of shortage of physics, chemistry and mathematics teachers and permits a comparison of physics with chemistry and mathematic teachers.

Table I
COMPARISON OF SHORTAGE OF CHEMISTRY, PHYSICS AND MATHEMATICS TEACHERS

Subject	1980	1982
Chemistry	3.71	4.16
Physics	4.15	4.43
Mathematics	3.92	4.37

(1 = surplus, 5 = critical shortage)

Need for the Iowa Physics Project

The authors conducted a survey of Iowa high school physics teachers in early 1983. One hundred seventy-two teachers (45% of all physics teachers in Iowa) responded to the questionnaire. Their responses give a profile of the academic qualifications of people teaching physics in Iowa. Only fifteen percent had majors in physics, and nearly one-third of those teaching physics had twelve or fewer semester credit hours of physics. Twenty-five percent of the physics teachers had less than five years of experience and over half had less than ten years of experience. These physics teachers were asked to cite their greatest problem in teaching physics. They responded as follows:

- — Twenty-nine percent mentioned their lack of background preparation.
- — Sixteen percent indicated they had too many teaching preparations and a lack of preparation time.
- — Thirty-seven percent cited the need for laboratory activities that are more interesting and motivating to students.

The Iowa Department of Public Instruction created a task force to address the problems associated with the shortage of trained physics teachers. The task force is composed of six high school physics teachers, five of whom have been selected as annual Outstanding-Iowa-Physics-Teacher awardees by the Iowa Academy of Science; three science-education professors from two of the Iowa regents universities; an Area-Education-Agency science consultant; and the science consultant from the Iowa Department of Public Instruction who is also currently president of the Council of State Science Supervisors. The members of the Iowa Physics Task Force are:

Dr. Timothy M. Cooney
Chair of Science
Malcolm Price Laboratory School
University of Northern Iowa
Cedar Falls, Iowa

Rollan Freel
Physics Teacher
Marshalltown Senior High School
Marshalltown, Iowa

Dr. Jack Gerlovich
Consultant, Science Education
Department of Public Instruction
Des Moines, Iowa

Ken Hartman
Science Department Chair
Ames Senior High School
Ames, Iowa

Dr. Vincent Lunetta
Professor of Science Education
Science Education Center
University of Iowa
Iowa City, Iowa

Dr. George Magrane
Science Consultant
Southern Prairie AEA
Ottumwa, Iowa

Dan McGrail
Physics/Chemistry Teacher
Carlisle High School
Carlisle, Iowa

Kennon Schaefer
Science Department Chair
Mason City Community Schools
Mason City, Iowa

Peggy Steffen
Teacher of Contemporary Science
Ottumwa High School
Ottumwa, Iowa

Dr. Roy D. Unruh
Project Director, PRISMS
Physics Department
University of Northern Iowa
Cedar Falls, Iowa

Robert J. Wilson
Physics/Chemistry Teacher
Belmond High School
Belmond, Iowa

During the first six months of the project, the task force members donated their time and received no compensation other than mileage to scheduled meetings. This task force met with superintendents and teachers from a number of school systems in Iowa. As a result of this exposure and further study, the following needs in secondary school physics were identified.

1. Many physics teachers need additional coursework in physics in order to be fully endorsed and have the proper background for teaching the subject.
2. Applications of the physics principles need to be modified to include phenomena common to high school student experiences such as sporting events, automobiles, carnival rides, etc., instead of the type seen in college laboratories.
3. The methods and strategies of teaching physics need to have a theoretical base built on learning theory research.
4. The teaching/learning activities need to make use of current technology such as computers, videotapes, videodiscs interfaced with microcomputers, etc.
5. A cost effective in-service model is needed to provide teachers with support during the implementation period without releasing them from class for long periods of time.

PRISMS Teaching Material

To meet these needs, a major effort of the Physics Task Force has been the development of a teacher's guide that incorporates: (a) teaching strategies designed to cultivate laboratory problem-solving skills, (b) the use of laboratory interfacing with computers, (c) the use of computer software as part of an instructional strategy for the course, (d) the development of student instructional materials to enhance the integration of selected software with the course objectives, (e) the development of two video tapes for the physics course, (f) impact activities that relate physics to societal issues, and (g) suggestions to evaluate student-laboratory skills. This guide is not intended to replace textbooks but rather to supplement them. The guide contains content outlines for the teacher and expected behavioral objectives for the student. More than 100 teachers of physics have participated in the three years of field testing of these materials.

The teaching strategies in the guide, *Physics Resources and Instruction Strategies for Motivating Students* (PRISMS), are based on a learning theory derived from Jean Piaget's work. Numerous studies have shown that high school students, including those taking physics, have not developed mental structures normally associated with formal reasoning. (Lawson and Renner, 1983) The *PRISMS* materials utilize the learning cycle as described and advocated in the *Science Teaching and the Development of Reasoning: Physics,* workshop materials developed at the Lawrence Hall of Science, Berkeley, California. The learning cycle blends exploratory activities, concept development and application activities to stimulate problem-solving skills as well as understanding major concepts in physics.

Current technology is integrated into many of the learning activities as well as utilized in teachers in-service programs. The teaching strategies of this project employ the learning cycle approach. This approach is compatible to the nature of physics, a process of determining relationships or connections between variables in physical phenomena. The learning cycle incorporates the three stages of *exploration, concept introduction* and *application.* Other science curricula also use the learning cycle format. Perhaps the most widely known is the Science Curriculum Improvement Study, an elementary science project directed by Dr. Robert Karplus, Lawrence Hall of Science. Workshop materials, *Science Teaching and the Development of Reasoning* for the separate disciplines in science, were also produced at the Lawrence Hall of Science (Karplus, 1981) with support from the National Science Foundation. Two of the task force members have conducted workshops using these materials in several states.

Exploration activities encourage students to observe relationships, identify variables and develop tentative explanations of phenomena. Some students may even be able to design experiments that will lead to formulating models. Students who propose incorrect conclusions are not penalized, but instead are encouraged to continue to search for explanations.

Concept introduction involves the development of the concept based on the experiences in the exploration phase of the learning cycle. Mental stimulation is provided through social interaction between student and student, or student and teacher. The concept introduction may be aided by the teacher, texts, computers, films or other media. Students are more receptive to a concept if they have taken part in an experience that created in their minds a need for further understanding (disequilibration).

In the application phase of the learning cycle, students test the generalization which appeared to bring observations and explanations back into mental equilibrium. The emphasis now is not to discover or verify, but to use the concept. The ideal application activity would allow students to analyze a phenomenon by using the simple models formulated during the exploratory activity and clarified during the concept development. As the application activity concludes the learning cycle students should be able to reach conclusions in agreement with established concepts in physics.

The task force has created or rewritten approximately 125 activities that are included in the PRISMS guide. The write-ups contain sheets that can be duplicated and distributed to the students as instructions. The teacher notes give instructional strategies, sample observations/calculations, a summary of the concept or outcome of the activity, and a planning key that indicates the difficulty of calculations, reliability of results, student interest level for the activity and time needed to conduct the activity.

In addition to these materials, computer software files containing over 1200 multiple-choice questions are now available. Teachers use the files to generate quizzes and tests to evaluate student progress. The questions have been tested for validity and reliability. They also have been keyed to concepts identified in *PRISMS* and appropriate levels of Bloom's taxonomy.

Various types of laboratory interfacing for microcomputers were evaluated and used by the more than 100 schools participating in the project. One of the most popular types utilizes four photo transistors attached to the game-paddle port of the Apple computer. It graphs light intensity vs time on the screen so that when an object, such as a toy car, interrupts the beam, the display shows a dip on the intensity curve. Hence the time of the event can be measured. The four photo transistors can be used to measure the velocity of the toy car at four position points along its route, or they can be used to measure the acceleration of gravity as an object falls past them. Students and teachers found additional ways to use this popular interfacing. It can also be used to measure the light intensity of a light source at various distances. This allows the determination of the efficiency of the light source and the study of the inverse square law.

Another type of interfacing used in several activities is the heat thermistors. These can be placed in liquids to measure temperatures for various heat activities. Several solar energy activities use these thermistors. The indoor and outdoor temperatures of a cardboard model greenhouse can be monitored throughout an entire day and a record kept on the screen of the computer or printed out for student analysis.

Numerous computer programs were reviewed for appropriateness to a high school physics course. These programs were then referenced in the guide to show where and how they could best be utilized. With so many computer programs of questionable value available, the teachers appreciated having such recommendations. State monies were available to the project to purchase up to six software programs and one interface unit for each of the first year schools. In the second year of the project, these programs were bought at a considerable savings to the schools because of volume purchasing.

Two video tapes have been completed to date and have been used by the pilot schools. "Collage of Motion" is a collection of common scenes including carnival rides at the state fair, a football game, car races, and a dance group. The video tape is designed to be used as an exploratory activity introducing motion. Students are subsequently asked to develop their own system of classifying motion. The video tape "Potential and Kinetic Energy" is introduced by archery and skiing scenes. The purpose of this tape is to allow measurements of the potential energy transferred to a rubberband across an air track simulating the archer's bow and to compare this with the kinetic energy of the glider released by the drawn rubberband. All the measurements for the analysis of this motion can be taken from the video tape and can be completed by the students after viewing the tape.

Financial Investments in the Prisms Project

The description of support that the Iowa Physics Project has received to date is as follows:

Summer, 1982, Iowa Department of Public Instruction Develop activities for a sample unit and test with 7 volunteer school systems.	$ 6,500
7/1/83 - 6/30/84, Iowa State Legislature Develop materials for one semester, purchase software, telephones and amplifiers for teleconferences	40,000
9/1/83 - 12/31/83, University of Northern Iowa Professional Development Leave for director of project	16,800
11/83 Unsolicited gift from donor	18,800
1/1/84 - 12/31/84, U.S. Department of Education	132,000
10/84, University of Northern Iowa Foundation	1,300
1/1/85 - 12/31/85, U.S. Department of Education	70,000
Total to 1/1/86	285,400

Dissemination Activities

Roy Unruh and Timothy Cooney, along with master teachers on the task force and selected teachers at participating schools, have presented PRISMS and conducted workshops at such meetings as the annual National Science Teachers Association conventions in 1984, 1985 and 1986; regional NSTA meetings in 1984 and 1985; AAPT national meeting in Toronto and Flagstaff in 1985 and Atlanta in 1986; as well as making presentations at state and area meetings. The University of Northern Iowa Alumni Foundation and PRISMS project have paid the exhibitor's fee for display booths at the regional and national conventions of NSTA in 1985 and 1986.

Requests for the PRISMS guide have been received from teachers and administrators all over the United States.

The Future

The Iowa Department of Public Instruction has committed $10,000 of block grant funds for the spring of 1986 toward further evaluation of the project. This will permit the building of an evaluation data bank to be used in the validation studies for acceptance by the National Diffusion Network (NDN). The project has been nominated for inclusion in the NDN and an attempt will be made to collect the appropriate validation data within the next two years.

In March of this year, the National Science Foundation awarded the University of Northern Iowa a $178,250.00 grant to provide training in the PRISMS materials to 60 teachers of physics from a nine-state mid-west area. Workshops will be held during summer 1986 with follow-up activities during the 1986-87 academic year.

Readers wishing to purchase a PRISMS guide, interested in receiving training to use the materials, or needing further information about the Iowa Physics Project, should contact Roy Unruh or Timothy Cooney.

References

Howe, T.B. and Jack Gerlovich. 1983. Where the Jobs Are! *The Science Teacher* 50(3):56-60.

Lawson, Anton E. and John W. Renner. 1983. Relationships to Science Subject Matter and Developmental Levels of Learners. *Journal of Research in Science Teaching* 90(3):117-118.

Karplus, Robert *et al.* 1981. *Science Teaching and the Development of Reasoning.* Lawrence Hall of Science, University of California, Berkeley, CA.