Powerful Ideas in Physical Science

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Introduction

This course differs radically from the traditional introductory physics and physical science courses. For instance the format, the content, the approach, the materials, and the evaluation methods will be unfamiliar to many readers. Even the central philosophy strikes out along a new path that narrows the gap between current research and teaching practices. While we have seen isolated pockets of success in reforming college courses for pre-service elementary teachers, our aim seeks a more expansive and deeper transformation that will span the science field nationwide. With this course we are putting the recent discoveries in cognitive science research into teaching practice. *Powerful Ideas in Physical Science* expects to play an important part in changing the future relationship between student and teacher and how instructors view the entire learning process.

Underlying *Powerful Ideas in Physical Science* is a **less is more** philosophy. Within a single semester, or even a year of study, it is impossible to cover all the ideas of physical science in a meaningful way. Therefore we aim to achieve a well-grounded understanding of **selected fundamental concepts** as well as the **process and thinking skills** that enable and encourage independent thinking.

The actual "seeing" and "observing" of everyday phenomena forms a deeply provocative thought process in students. Through observable events created with the use of everyday or simple objects we propose a precisely structured questioning pattern that is easily learned, accountable, and adaptable to individual teaching styles. Learning does not occur entirely in the abstract realm; therefore, this approach forms the groundwork for the eventual theoretical realizations that will follow. Students are given opportunities to observe and reflect before reaching the point of ideological confrontation and the transformation of their former entrenched, naive ideas.

Course content focuses selectively on providing students with a substantial understanding of those physical science concepts which are initially introduced in elementary science curricula. Specific content for the course was selected by carefully analyzing recently developed curriculum frameworks for grades K-8 and determining the concepts and ideas that elementary teachers must develop before they can effectively teach the physical science contained within these frameworks. Instructors can select materials in a manner that allows prospective elementary teachers to assimilate and understand underlying principles and concepts, and instruction addresses those underpinnings to the physical sciences that are traditionally overlooked and which create barriers to further student learning.

Powerful Ideas in Physical Science develops a strong conceptual understanding of physical science through examination of everyday phenomena, rather than through the utilization of more common theoretical approaches. Throughout the course, emphasis is on the **search for and use of evidence** to provide the basis for drawing scientific

conclusions. Students are encouraged to verbalize not only what they know, but just as importantly, describe "**how they know**." The end result is that students achieve an operative, rather than simply a declarative, knowledge of physical science subject matter.

Special attention is given to addressing the everyday ideas which exist about physical science concepts and phenomena by adopting an approach to teaching which:

- elicits students' existing notions about physical science phenomena,
- presents "disequilibrating experiences" that prompt students to reexamine and reevaluate their previously expressed notions in light of new evidence and,
- engages students in carefully designed collaborative activities to encounter new ideas and information for the construction of mental models leading to an improved conceptual understanding of physical science phenomena.

This approach has proven effective in encouraging students to abandon firmly held notions about the physical world to construct other ideas, explanations, and models.

Instead of traditionally separate lecture and laboratory periods, the model integrates a single hands-on, inquiry-based course which models the way science should be taught to students of all ages. In other words, the prospective elementary teachers participate in the same kinds of learning experiences that they will subsequently offer students in their own classrooms.

Math has not been avoided in the proposed course, but its presentation and use vary substantially from more traditional courses. Math—primarily algebraic expressions, equations, and graphs—is approached as a way of representing ideas symbolically. Mathematical representations are introduced and developed only after the ideas which they represent and illuminate have been conceptualized and expressed in the verbal language of the learner. Once developed, mathematical representations are used by the students as tools for reasoning and investigation to explore ideas within new contexts and in greater depth.

The course is intentionally flexible to allow its application within the existing academic structure of colleges and universities nationwide. It may be used in either a physics or physical science course, as a component of a science methods course, or as a combined methods and content course. The course, however, is primarily designed for use by faculty in the physical sciences who are charged with teaching an introductory science course taken by prospective elementary teachers.

Finally, the course predominantly uses **everyday materials** that are readily accessible to elementary teachers. This use of familiar materials helps to diminish the fear of the physical sciences prevalent among elementary teachers, heightens the relevance of the learning process, and increases prospective teachers' levels in "doing science" once they return to their own classrooms.

Powerful Ideas in Physical Science has been designed and developed by a sixteen-person Development Group under the auspices of the American Institute of Physics (Donald F. Kirwan, Project Director) and the American Association of Physics Teachers (Bernard V. Khoury, Project Director) with partial support from the National Science Foundation Grants #DUE-9496330 and #DUE-9554625.

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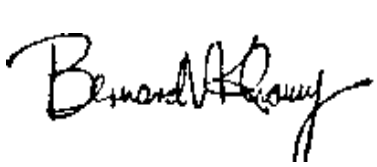
The instructional model represented in *Powerful Ideas in Physical Science* has a tremendous potential for significant and widespread impact, not only in improving the physical science learning of pre-service elementary teachers, but also in improving the teaching practices employed in science courses in all disciplines and at all levels of the university curriculum. Your help in the dissemination of this course model is greatly appreciated.



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