

Mini-Course on Physics Education Research and Research-Based Innovations in Physics Instruction

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I. Physics Education Research: Laying the Basis for Improved Physics Instruction

Over the past 20 years, systematic investigations have helped to clarify the dynamics of students' thinking during the process of learning physics. This research has revealed students' learning difficulties, as well as aiding in the development of more effective instructional strategies. I will describe the principal goals and methods of Physics Education Research, and discuss some of the methodological issues related to this work. With examples drawn from investigations we have carried out at Iowa State University, I will illustrate this research process and show how it can lead to improved curricula and instructional methods.

II. Developing Improved Curricula and Instructional Methods based on Physics Education Research

In many research-based curricula, physics students are guided to work their way through carefully designed and tested sequences of questions, exercises, and/or laboratory activities. Utilizing these materials, and interacting frequently during class with instructors and with each other, students have often achieved significant gains in understanding when compared with instruction based on lecture alone. In this presentation I will describe in some detail the process of developing these research-based curricula, as carried out by our group at Iowa State over the past several years. I will show how our research into students' reasoning in thermodynamics is helping guide the development of improved curricular materials. Similarly, investigations of the pedagogical role played by diverse representational modes (mathematical, verbal, diagrammatic, etc.) are also helping us lay the basis for developing more effective instructional methods.

III. Research-Based Active-Learning Instructional Methods in Large-Enrollment Physics Classes

A long-standing challenge has been to incorporate active-learning instructional methods in large-enrollment physics classes traditionally taught in a lecture format. I will describe the methods we have introduced to develop a "fully interactive physics lecture," and discuss the curricular materials that we have created to support this form of instruction. This involves both carefully designed sequences of multiple-choice conceptual questions, and free-response worksheets designed to be used by students working in collaborative groups.