Lillian McDermott

Model, Mentor, and Inspiration

David Meltzer, Arizona State University
Valerie Otero, University of Colorado Boulder

Lillian as a Model

The Long Road to Physics Education Reform

- Physics teaching at the high school and college level in the United States began in the early 1800s

- For more than a hundred years, most efforts at research and reform of physics education were focused on the high school level

- During the 1950s, new ideas and new trends in physics teaching were beginning to spread: it was a time of tremendous ferment in the physics education community

- However, serious and focused efforts to carry out research and reform at the college level would not begin for another 20 years…

Before the Beginning: The Genesis and Development of Lillian McDermott's Physics Education Group

1950s-1960s: Arons; PSSC; Karplus

1950s-1960s: Arons;

During the 1950s, Arnold Arons developed a highly innovative physics course at Amherst College, requiring students to explain their reasoning in great detail, and to design, explain, and carry out experiments to analyze physical systems.

Structure, Methods, and Objectives of the Required Freshman Calculus-Physics Course at Amherst College

A. B. Arons
Amherst College, Amherst, Massachusetts

(Received, February 24, 1959)

A description is given of the Amherst freshman calculus-physics course with specific examples of test questions, term paper assignments, and laboratory instructions. A few quotations are given from student papers, and fairly detailed syllabi of the mathematics and physics work are included.

I. INTRODUCTION

A FRESHMAN calculus-physics course, required of all students, was instituted at Amherst College in 1947 as part of a major postwar curriculum revision.[1]

The objective was a course which would deal with the main stream of physical concepts, laws, and ideas; would examine these matters in some depth, with sophistication and with adequate mathematical tools; would consider logical, epistemological, philosophical, and historical aspects; and would be of such nature in subject matter and content as to be simultaneously a proper introductory course for science majors, a terminal course in physical science for nonscience majors, and a "general education" course for both groups.

In the first few years of operation, the "common experience" aspects were compromised to some extent, and the freshman class was divided into two halves of higher and lower aptitude as indicated by various C.E.E.B. test scores. The lower aptitude group proceeded at a somewhat slower pace in mathematics and received a more descriptive development in physics than did the higher aptitude group. As the experiment progressed and more confidence developed, the separation was eliminated, and for the past few years the entire class has been treated as a single unit, all students taking the same program in calculus and physics.

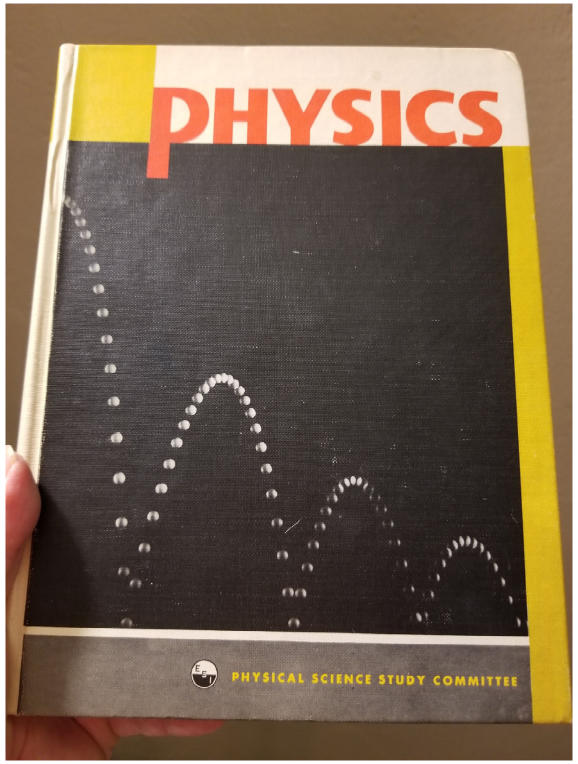
A description of the course in its present state

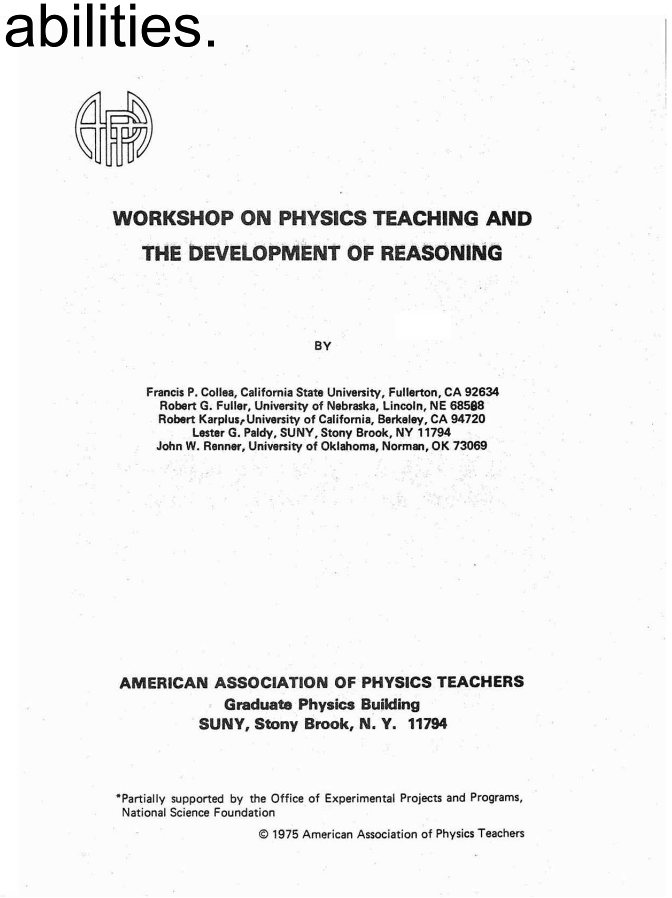
[1] G. Kennedy, *Education at Amherst* (Harper and Brothers, New York, 1955).

Am. J. Phys. 27, 658-666 (1959)

1950s-1960s: PSSC; Karplus

- The Physical Science Study Committee (PSSC) engaged many research physicists in the design and implementation of a new high school physics curriculum;
- Berkeley physicist Robert Karplus developed an elementary science curriculum based on developing students' reasoning abilities.





WORKSHOP ON PHYSICS TEACHING AND
THE DEVELOPMENT OF REASONING

BY

Francis P. Collea, California State University, Fullerton, CA 92634
Robert G. Fuller, University of Nebraska, Lincoln, NE 68588
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SUNY, Stony Brook, N. Y. 11794

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Arons to U. Washington; McDermott joins him

- 1968: After facing persistent resistance from physics curriculum “reformers” who objected to his focus on examining student thinking in detail, Arons joined the faculty at the University of Washington to develop an inquiry-based physics course for elementary school teachers, emphasizing slow-paced Socratic questioning to gradually build students’ conceptual understanding and reasoning skill.

- 1969: Having taught in several universities following her Ph.D. in nuclear physics, Lillian McDermott joined Arons as volunteer instructor in his course. She observed and implemented his instructional methods, already familiar to her from her Greek family background that included Socratic dialogue with her father.

- 1970: Arons and McDermott receive their first NSF grant to create a Summer Institute for elementary teacher education in science.

Interview, November 16, 2019

Beginning of Physics Education Research

- 1970: McDermott becomes part-time Lecturer at UW; creates “combined course” for elementary and secondary teacher education in physics and physical science; begins revising some of Arons’ instructional materials to make them more accessible to less-prepared students.

1970 UW Bulletin

PHYSICS

Chairman
Ronald Geballe
215 Physics Hall

Professors
Arnold B. Arons, Marshall Baker, John S. Blair, David Bodansky, Henry L. Brakel (emeritus), Kenneth C. Clark, J. G. Dash, Hans G. Dehmelt, George W. Farwell, Ronald Geballe, James B. Gerhart, Isaac Halpern, Joseph E. Henderson, Ernest M. Henley, Jere J. Lord, Seth H. Neddermeyer, Fred H. Schmidt, Edward A. Stern, Edwin A. Uehling, Clinton L. Utterback (emeritus), Lawrence Wilets, Robert W. Williams

Associate Professors
David G. Boulware, Lowell S. Brown, Victor Cook, John G. Cramer, E. Norval Fortson, Paul M. Higgs (emeritus), Robert L. Ingalls, Ray W. Kenworthy (emeritus), Henry J. Lubatti, Robert D. Puff, Joseph E. Rothberg, Llewellyn A. Sanderman (emeritus), John F. Streib, Jr.

Assistant Professors
Naren F. Bali, Samuel C. Fain, George Glass, Larry D. Kirkpatrick, Philip C. Peters, Alberto Pignotti, Jesse J. Sabo, Jr., Michael Schick, Oscar E. Vilches, David M. Wolfe (visiting), Kenneth K. Young

Lecturers
Richard J. Davisson, Lillian C. McDermott

1974 article in American Journal of Physics

AJP Volume 42

Combined Physics Course for Future Elementary and Secondary School Teachers*

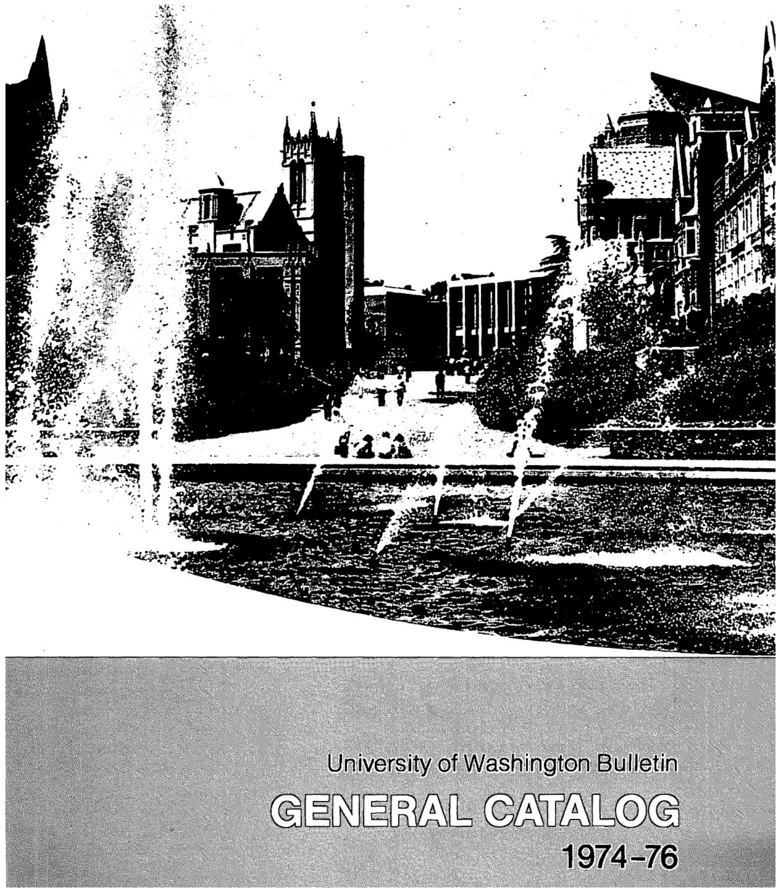
LILLIAN C. McDERMOTT
Department of Physics
University of Washington
Seattle, Washington 98195
(Received 16 October 1973)

In order to improve the preparation of both future elementary school teachers to teach physical science and secondary school teachers to teach physics, a combined physics course which includes both groups of students has been developed. The course content, which emphasizes depth of understanding, is discussed in some detail. A description is given of the techniques used to encourage the development of the skills and attitudes necessary for teaching the new nationally developed, inquiry-oriented science curricula.

A National Science Foundation grant provided support for developing a program which would prepare future elementary school teachers to make effective use of the new elementary science curricula. The program which has evolved rests solidly on a one-year introductory course in physical science (Physics 101–102, 103) intended for general education students as well as for future elementary school teachers.[5] The three-quarter course carries five credits each quarter and is taught in the hands-on, inquiry-oriented manner characteristic of the new curricula. It has been in operation for several years. Beginning in 1971–72, our efforts have been expanded beyond this first-year level to include the development of a continuation course and a closely related practice teaching program for preservice elementary school

Beginning of Physics Education Research

1973: McDermott hired as tenure-track Assistant Professor at UW; begins to guide three *physics* Ph.D. students in systematic research on the teaching and learning of physics, probably the first time this had happened anywhere.



PHYSICS
215 Physics

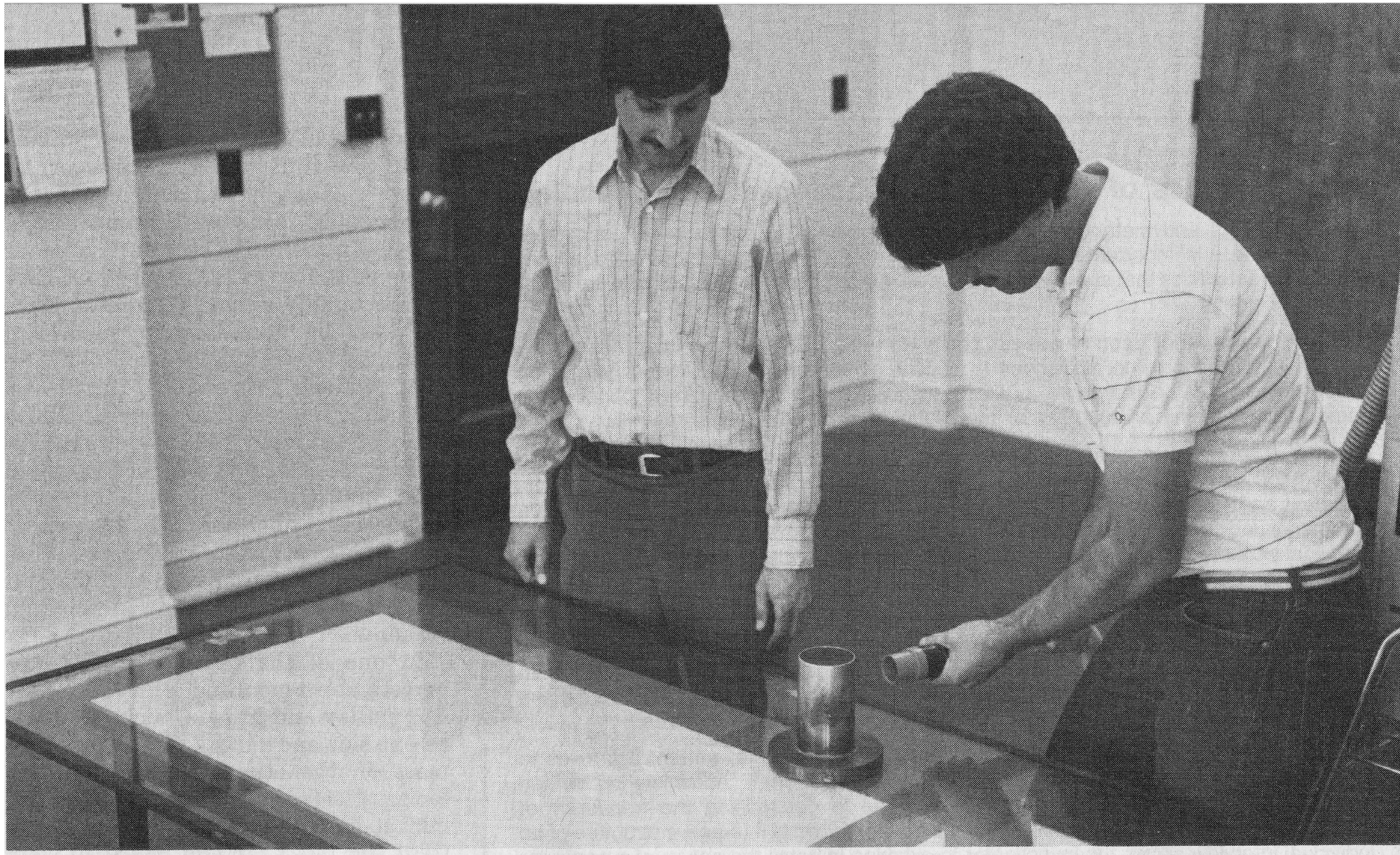
Physics is the study of the fundamental structure of matter and the interactions of its constituents, as well as the basic natural laws governing the behavior of matter.

Faculty

Ernest M. Henley, Chairman; Adelberger, Arons, Baker, Bali, Blair, Bodansky, Boulware, Brakel (emeritus), Brown, Cahn, Clark, Cook, Cramer, Dash, Davisson, Dehmelt, Fain, Farwell, Fortson, Geballe, Gerhart, Halpern, Henderson (emeritus), Henley, Higgs (emeritus), Ingalls, Kenworthy (emeritus), Kirkpatrick, Lee, Lord, Lubatti, L. McDermott, M. McDermott, Moriyasu, Neddermeyer (emeritus), Peters, Puff, Rothberg, Sabo, Sanderman (emeritus), Schick, Schmidt, Stern, Streib, Uehling (emeritus), Vilches, Weis, Weitkamp, Wilets, Williams, Young. D. Boulware, graduate program adviser.

McDermott's Research Program

- Recognize that *research is required* to best decide "the right questions to ask" during Socratic inquiry-based instruction.
- Recognize that students' physics difficulties often stem from a combination of weak conceptual understanding and underdeveloped reasoning skills, requiring that students' reasoning and physics concept understanding be investigated *simultaneously.*
- *Combine* student data from written qualitative problems requiring explanations of reasoning with data from "individual demonstration interviews" [one-on-one question-and-answer sessions with students engaged in interpreting physics experiments].
- Develop curricular materials that are *rigorously and repeatedly tested*, to ensure they help improve students' physics performance *in a manner that would be satisfactory to an ordinary physics instructor.*



Investigating student understanding of force. Ronald Lawson (left) is asking a student to deflect a moving dry-ice puck at a 45° angle to its direction of motion using a blast of air from the hose; the student's reactions and comments will be recorded. In this research project, conducted by the Physics Education Group at the University of Washington, students were asked to perform this and similar tasks in individual demonstration interviews. As in other research conducted by the group, the major criterion used to assess conceptual understanding was the ability to apply concepts learned in class to actual physical systems.

Individual Demonstration Interview from the 1980s

Investigation of student understanding of the concept of velocity in one dimension

David E. Trowbridge[a] and Lillian C. McDermott
Department of Physics, University of Washington, Seattle, Washington 98195
(Received 25 February 1980; accepted 20 May 1980)

This paper describes a systematic investigation of the understanding of the concept of velocity among students enrolled in a wide variety of introductory physics courses at the University of Washington. The criterion selected for assessing understanding of a kinematical concept is the ability to apply it successfully in interpreting simple motions of real objects. The primary data source has been the individual demonstration interview in which students are asked specific questions about simple motions they observe. Results are reported for the success of different student populations in comparing velocities for two simultaneous motions. It appears that virtually every failure to make a proper comparison can be attributed to use of a position criterion to determine relative velocity. Some implications for instruction are briefly discussed.

I. INTRODUCTION

The Physics Education Group at the University of Washington has been engaged for several years in a systematic study of the ways in which students in introductory college physics courses think about motion. The degree of difficulty of the courses ranges from compensatory (for academically disadvantaged students) to calculus based (for physics, engineering, and mathematics majors). This article is the first of two devoted to the kinematical concepts. The present paper reports on the ability of students to apply the concept of velocity in interpreting simple motions of real objects. A subsequent article will discuss student under-

critical to the study of almost all of p
has been research by other investiga
of conceptual understanding of dynar
studies on kinematics have appeare
beginning our investigation with the
we hoped not only to identify speci
have with kinematics but also to g
possible kinematical origins of
namics.

B. Criterion for understanding

An important distinction must

1980

These were among the very first articles to report detailed research on the learning of physics by university students

1981

Investigation of student understanding of the concept of acceleration in one dimension

David E. Trowbridge[a] and Lillian C. McDermott
Department of Physics, University of Washington, Seattle, Washington 98195
(Received 15 April 1980; accepted 23 July 1980)

This paper describes a systematic investigation of the understanding of the concept of acceleration among students enrolled in a variety of introductory physics courses at the University of Washington. The criterion for assessing understanding of a kinematical concept is the ability to apply it successfully in interpreting simple motions of real objects. The main thrust of this study has been the qualitative understanding of acceleration as the ratio $\Delta v/\Delta t$. The primary data source has been the individual demonstration interview in which students are asked specific questions about simple motions they observe. Results are reported for the success of different student populations in comparing accelerations for two simultaneous motions. Failure to make a proper comparison was due to various conceptual difficulties which are identified and described. Some implications for instruction are briefly discussed.

I. INTRODUCTION

The Physics Education Group at the University of Washington has been engaged for several years in a systematic study of the ways in which students in introductory college physics courses think about motion. The degree of difficulty of the courses ranges from compensatory (for academically disadvantaged students) to calculus based (for

angle to the horizontal. The accelerations of the balls can be varied by using channels of different widths as shown in Fig. 1. Thus prior knowledge about the dependence of acceleration on slope yields no clues for making correct comparisons. A mechanism for releasing the balls automatically insures that the motions are reproducible.

The interviews are conducted according to a standard questioning format but at any point the interviewer may

1987

Student understanding of the work-energy and impulse-momentum theorems

Ronald A. Lawson[a] and Lillian C. McDermott
Department of Physics, FM-15, University of Washington, Seattle, Washington 98195

(Received 4 September 1986; accepted for publication 17 November 1986)

Student understanding of the impulse-momentum and work-energy theorems was
performance on tasks requiring the application of these relationships to the analysis
motion. The participants in the study were undergraduates enrolled in either the hon
a calculus-based introductory physics course or in the regular algebra-based course.
were asked to compare the changes in momentum and kinetic energy of two frictio
pucks as they moved rectilinearly under the influence of the same constant force. T
the investigation revealed that most of the students were unable to relate the algebra
learned in class to the simple motion that they observed.

A conceptual approach to teaching kinematics

Mark L. Rosenquist[a] and Lillian C. McDermott
Department of Physics FM-15, University of Washington, Seattle, Washington 98195

(Received 21 February 1986; accepted for publication 21 May 1986)

Results from research on student understanding of velocity and acceleration hav
guide the development of a conceptual approach to teaching kinematics. This paper
instruction based on the observation of actual motions can help students: (1) develo
understanding of velocity as a continuously varying quantity, of instantaneous velo
and of uniform acceleration as the ratio of the change in instantaneous velocity to the elapsed time; (2) distinguish the concepts of position, velocity, change of velocity, and acceleration from one another; and (3) make connections among the various kinematical concepts, their graphical representations, and the motions of real objects. Instructional strategies designed to address specific difficulties identified in the investigation are illustrated by example.

I. INTRODUCTION

The Physics Education Group at the University of

II. UNDERSTANDING INSTANTANEOUS VELOCITY AS A LIMIT

1987

Student difficulties in connecting graphs and physics: Examples from kinematics

Lillian C. McDermott, Mark L. Rosenquist,[a] and Emily H. van Zee
Department of Physics, University of Washington, Seattle, Washington 98195

(Received 21 February 1986; accepted for publication 21 May 1986)

Some common errors exhibited by students in interpreting graphs in physics are illustrated by examples from kinematics. These are taken from the results of a descriptive study extending over a period of several years and involving several hundred university students who were enrolled in a laboratory-based preparatory physics course. Subsequent testing indicated that the graphing errors made by this group of students are not idiosyncratic, but are found in different populations and across different levels of sophistication. This paper examines two categories of difficulty identified in the investigation: difficulty in connecting graphs to physical concepts and difficulty in connecting graphs to the real world. Specific difficulties in each category are discussed in terms of student performance on written problems and laboratory experiments. A few of the instructional strategies that have been designed to address some of these difficulties are described.

I. INTRODUCTION

Many undergraduates taking introductory physics seem to lack the ability to use graphs either for imparting or extracting information. As part of our research on student

that many are a direct consequence of an inability to make connections between a graphical representation and the subject matter it represents. In this paper, we describe two categories of student difficulty that we have investigated: difficulty in connecting graphs to physical concepts and

1986

An investigation of student understanding of the real image formed by a converging lens or concave mirror

Fred M. Goldberg[a] and Lillian C. McDermott
Physics Education Group, Department of Physics FM-15, University of Washington, Seattle, Washington 98195

(Received 18 September 1985; accepted for publication 18 March 1986)

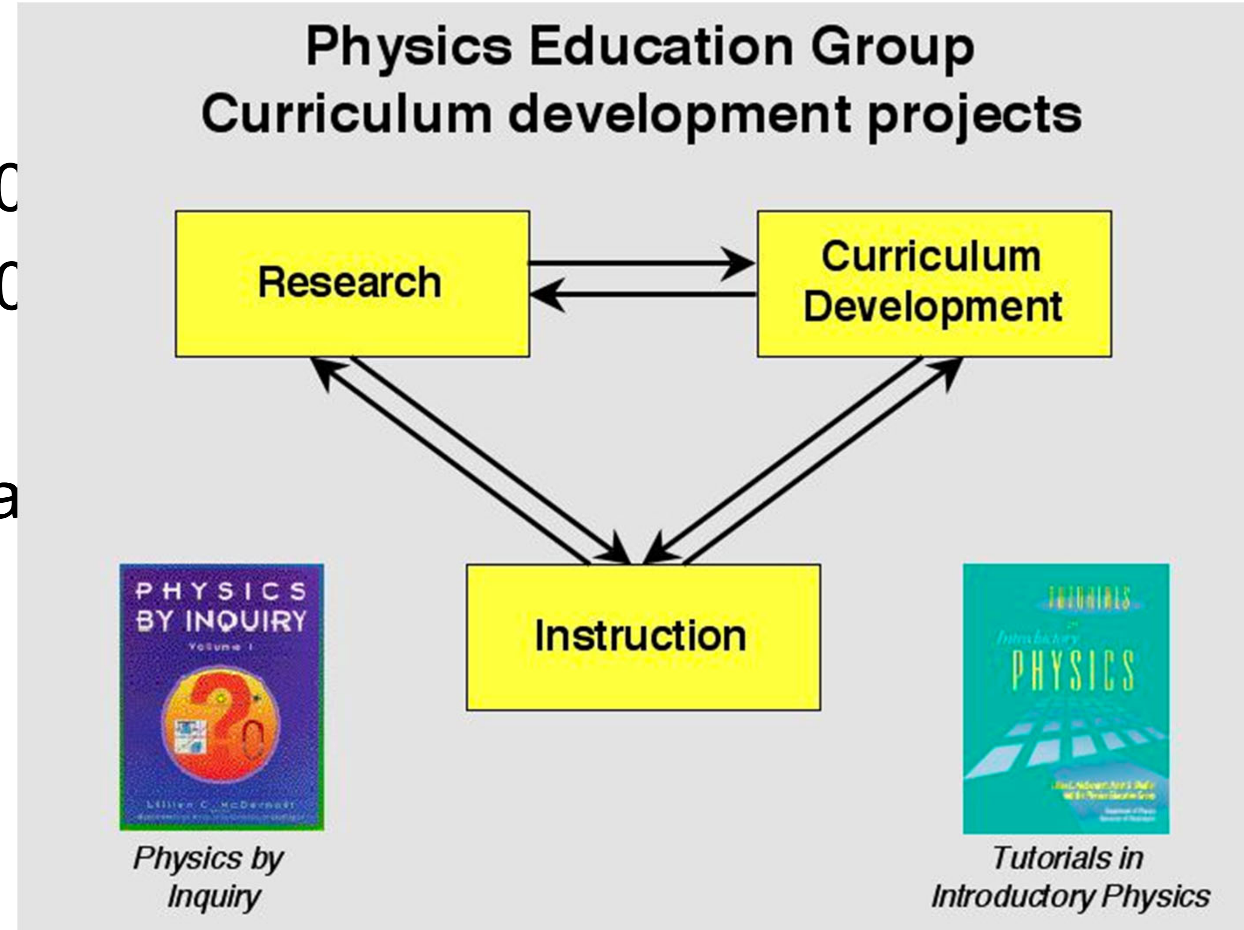
Student understanding of the real images produced by converging lenses and concave mirrors was investigated both before and after instruction in geometrical optics. The primary data were gathered through interviews in which undergraduates taking introductory physics were asked to perform a set of prescribed tasks based on a simple demonstration. The criterion used to assess understanding was the ability to apply appropriate concepts and principles, including ray diagrams, to predict and explain image formation by an actual lens or mirror. Performance on the tasks, especially by students who had not had college instruction in geometrical optics, suggested the presence of certain naive conceptions. Students who had just completed the study of geometrical optics in their physics courses were frequently unable to relate the concepts, principles, and ray-tracing techniques that had been taught in class to an actual physical system consisting of an object, a lens or a mirror, and a screen. Many students did not seem to understand the function of the lens, mirror, or screen, nor the uniqueness of the relationship among the components of the optical system. Difficulties in drawing and interpreting ray diagrams indicated inadequate understanding of the concept of a light ray and its graphical representation.

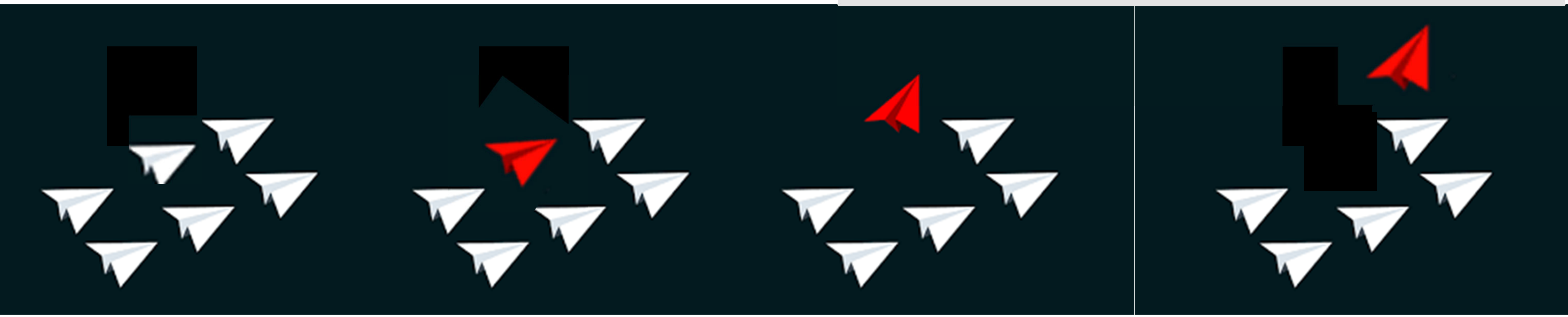
I. INTRODUCTION

This paper reports on an investigation of student understanding of the real image formed by a converging lens or concave mirror. This study, which extended over a period of two years (1982–1984), also included image formation by a plane mirror.[1] Conducted by the Physics Education Group at the University of Washington, this investigation was part of our ongoing effort to identify and address conceptual difficulties encountered by students taking introductory college physics.[2]

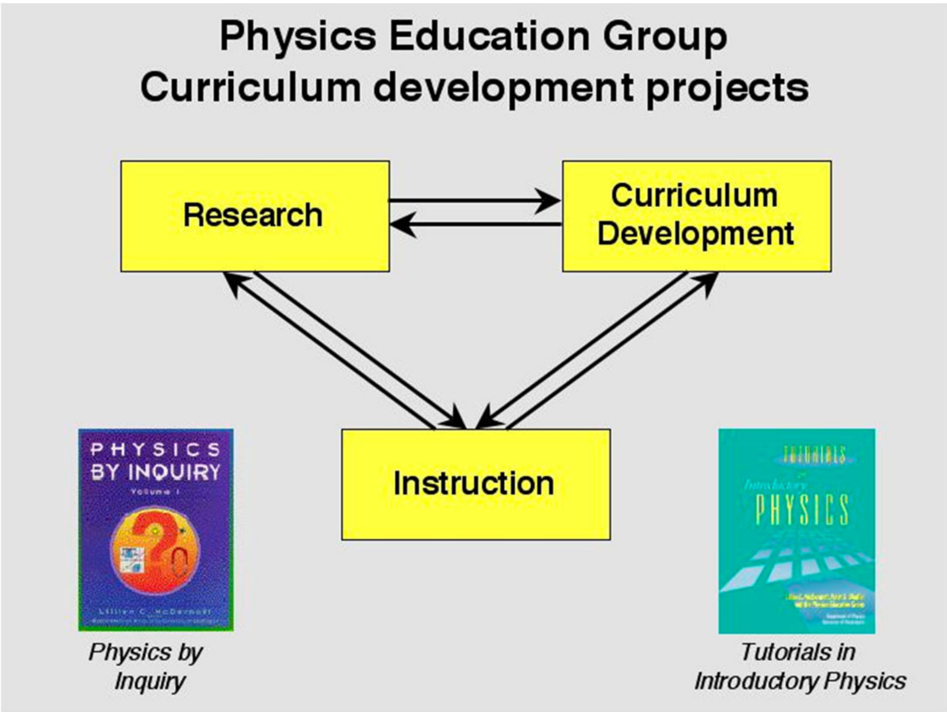
Washington. The rest were in their second semester of algebra-based physics at West Virginia University. All the courses were taught by lecture. About half of the students had not yet studied geometrical optics in college. The other half had recently taken the course examination on that material. Of these, about half were enrolled in the optional accompanying laboratory course and had already completed the experiments in geometrical optics.

- Lillian was a physicist
- Lillian was a woman in physics in the 1960
- Lillian was a woman in physics in the 1970
- and physics teacher preparation
- and committed to rigorous research to eva





As a physicist she understood the concept of system and surroundings

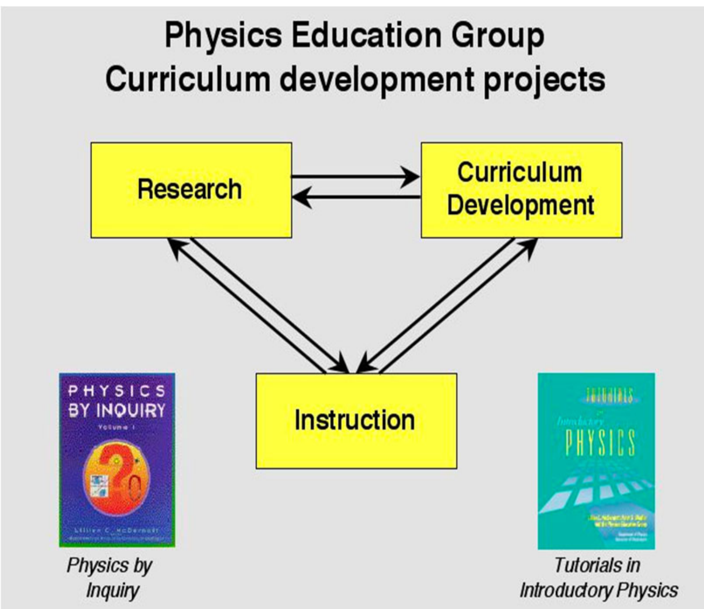


System of PER innovation

People she wanted to influence

Institutional Change

As a physicist she understood the concept of system and surroundings



System of PER innovation

People she wanted to influence

a perpetual cycle of growth and renewal

Theory of Change

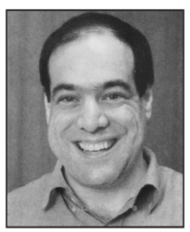
Lillian as a Mentor

1994: After years of studying Lillian’s writings, I finally met her at an NSF PI conference. She promptly invited me to visit her group, which I did in early 1995. It was a transformative experience for me. I observed both Physics by Inquiry classes and Tutorials, learning how she and her group had implemented gently paced, inquiry-based learning in the context of lecture-free physics instruction.

In 1996, Kandiah Manivannan and I published at article in *Physics Teacher* describing our work in transforming large lecture classes along an inquiry-based model. Soon after we met with Lillian at a PEG workshop at an AAPT meeting. She complimented us on the article, and told us, “And now the next step is for you to do research.” This remark helped motivate us to move forward with our work.

Promoting Interactivity in Physics Lecture Classes

By David E. Meltzer and Kandiah Manivannan



David E. Meltzer *is assistant professor of physics in the Department of Chemistry and Physics at Southeastern Louisiana University (Hammond, LA 70402). He received a Ph.D. in theoretical condensed matter physics from SUNY at Stony Brook in 1985 and had postdoctoral research appointments at the Oak Ridge National Laboratory, the University of Tennessee at Knoxville, and the Quantum Theory project at the University of Florida in Gainesville. He started teaching at SLU in 1991, focusing efforts on development of new curricular materials and instructional methods. He has directed an NSF-sponsored project to develop a new elementary physics course and has worked with middle-school and high-school teachers to improve precollege science instruction.*

Several innovative methods directed toward improving physics instruction in the introductory courses (both algebra- and calculus-based) have been developed recently. These include microcomputer-based laboratories,[1] integrated lab/lecture “studio” setups,[2] computerized animations and simulations employed in lectures,[3] and the use of electronic devices for linking students and instructors in the lecture hall.[4] However, the large number of students in introductory physics lecture classes makes it difficult to promote a higher level of student-faculty interaction and active student participation in the learning process during class time. At our institution, faced with limited resources and logistical constraints (e.g., no teaching assistants and little computer hardware), we have been working to develop methods that may be readily applied in the setting of lecture classes with a hundred or more students, and which are not dependent on simultaneous reorganization of the laboratory course. Our techniques are specifically aimed at converting a traditional lecture class, which may have either small or large attendance, into something that is closer in spirit to a seminar or a tutorial. We present here a number of the methods that we have been using and some of the thinking that underlies their development.

The Goal

The traditional lecture format consists of a rapid-fire presentation of ideas with little time or opportunity allowed for students to grapple with and comprehend concepts during class time. The detailed—and rather complex—thought processes that are required to master the key physical concepts tend to be glossed over or overlooked.[5,6] Instead, students become adept at recognizing certain problem types and patterns, and matching the pattern to an appropriate equation that may yield a numerical solution.[7] Studies have documented that, for instance, basic concepts in Newtonian mechanics are not learned very well even by most students who obtain good grades in traditional courses.[8,9]

We aim to *require* students to think about, discuss, work through, and solve problems *during class time* that bear directly on key conceptual issues.[10] (One consequence of this is a reduction in the sheer quantity of topics that may be presented during class.) The instructor plays more the role of a guide who promotes thinking and questioning by leading and focusing the discussion. (Quite similar methods have been pioneered during the past several years by Eric Mazur at Harvard University.[11]) We have in mind the “athletics instruction” paradigm: the “coach” doesn’t just lecture and draw diagrams, but offers instantaneous critiques and feedback as the “player” attempts to perform the desired skill.

Methods Used

We utilize techniques for acquiring immediate feedback from all of the students in the class. Through these methods, the instructor is transformed from a “provider of information” into a tutorial leader who is constantly interacting with students, asking questions, hinting at answers, and helping students to move forward in their

problems, either with each other or in a constant back-and-forth dialogue with the instructor. The central elements of the process are as follows:

I. De-emphasis of Formal Lecture

In our large lecture classes we do not generally deliver a formal lecture in the traditional manner. Instead, we introduce concepts and solve sample problems for several minutes, at which point we pause and present either a question or a problem for the students to work on and discuss with each other. Although we might present an overview lecture in which the major ideas in a chapter are introduced and their interconnections sketched out, we would then return to these concepts one by one for approximately five to 15 minutes each.

II. Group Problem Solving

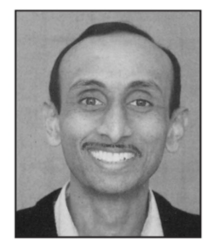
We give students time to work together on problems, typically in groups of two, three, or four neighboring students, and these groups are often encouraged to confer with each other. As the students discuss and work through these problems, the instructor frequently circulates throughout the room examining students’ work when they indicate that they have a result and offering assistance to those who request it. Periodically, the instructor may go to the board and offer hints and partial solutions to the whole class as they continue to work. Then, when it appears that the majority of the class is well on the way to solving the problem, the instructor will often go to the board and sketch the solution, addressing aspects of the problem that proved particularly troublesome.

III. Use of “Flash Cards”

Each of our students has a set of six cards ($8\frac{1}{2} \times 5\frac{1}{2}$ in) labeled A, B, C, D, E, and F that are used to signal the instructor their answers to questions. Multiple-choice questions related to a particular concept are presented, either by overhead projection or written on the board. These questions usually precipitate lively class discussion regarding the different choices. Students within a group will debate with each other; sometimes one group challenges another group’s decision. After a time of thought and discussion, students are asked to give a response by holding up one of their flash cards. (The final multiple-choice option may be “Don’t Know” or “Not Sure” to encourage all students to participate.)

We have used the cards in three different ways: (1) all students hold up their flash cards simultaneously (this method best preserves the anonymity of the individual responses); (2) students hold up their cards as soon as they think they have the answer; (3) all “A” responses are solicited, then all “B’s,” and so on (omitting the “Don’t Know” option). The instructor surveys the flash cards and reports the breakdown of responses. If there is substantial support for two or more choices, students are encouraged to give arguments in favor of their response; this frequently leads to further discussion and debate. We try to use flash-card questions very frequently, sometimes as many as ten times in a single class period.

Flash-Card Questions. Questions employed with the flash cards emphasize qualitative and proportional reasoning, solution strategies for problems (such as free-body diagrams), order-of-magnitude estimates, and vector concepts of magnitude and direction. (Many such examples are in the Workbook by Reif.[12]) Specific quantitative responses are de-emphasized, but are still solicited to culminate the analysis of a particular problem. We stress questions such as: “Is quantity *A* greater than, less than, or equal to zero? Greater than, less than, or equal to quantity *B*?” “If *A* is doubled, would *B* be doubled, quadrupled, or unchanged?” “Does vector *C* point north, south, east, or west? Is its magnitude closer to 10, 100, 1000, or 10^6?” The challenge for the student thus becomes one of determining



Kandiah Manivannan *is assistant professor of physics in the Department of Chemistry and Physics at Southeastern Louisiana University (Hammond, LA 70402). He received a Ph.D. in theoretical physics from SUNY at Stony Brook in 1986 and then began a research career in experimental and theoretical biophysics. His current research centers on the cellular mechanisms of biological clocks. He was an NSF Fellow at the Center for Biological Timing at the University of Virginia, where he was also visiting assistant professor of physics. He has a special interest in physics instructional demonstrations and has presented dozens of demonstrations to audiences of all ages and educational levels. He is involved in physics education reform aimed at increasing the level of active student participation in the classroom learning environment.*

After I accepted a tenure-track faculty position at Iowa State University in 1998, Lillian invited me to give my first national invited talk at the summer AAPT meeting. She also invited me to spend that summer in Seattle, working as an instructor in the Summer Institute.

GB2 9:30 a.m. Effectiveness of Instruction on Force and Motion in an Elementary Physics Course Based on Guided Inquiry*

Invited-*David Meltzer, Iowa State Univ., Dept. of Physics/Astronomy, Ames, IA 50011-3160; 515-294-5440; dem@IAstate.edu*

Student understanding of force and motion were investigated over a four-year period in the context of an inquiry-based, one-semester elementary physics course for nontechnical students. Instruction was designed to address the student difficulties that were identified. It was found that a majority of the students mastered the distance/velocity relationship and substantially improved their graphing and problem-solving skills. However, only a minority mastered the concept of acceleration and the force/motion relationship. Fundamental misconceptions of basic topics in kinematics and dynamics persisted with great tenacity.

*Supported in part by NSF grants #DUE-9354595, 9650754, and 9653079.

Participating in the work of the PEG for the entire summer of 1998 was another transformative experience for me, as it provided comprehensive exposure to the many aspects of the PEG's work. It helped guide my focus as I built my own research group at Iowa State, investigating student understanding of physics concepts. Our initial focus was on students' ideas in thermodynamics.

In 2004, as part of her efforts to disseminate PER ideas to the broader physics community, Lillian organized a session at the American Physical Society April meeting and invited me to discuss my group's investigations of student learning of thermodynamics.

Abstract for an Invited Paper
for the APR04 Meeting of
The American Physical Society

Students' reasoning regarding heat, work, and the first law of thermodynamics[1]

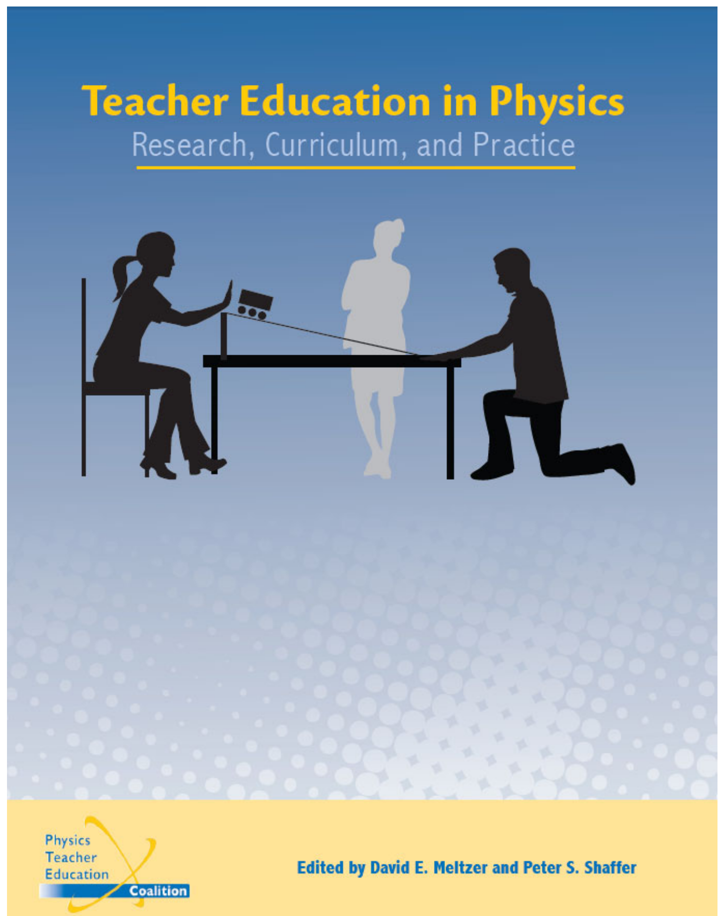
DAVID E. MELTZER, Department of Physics and Astronomy, Iowa State University

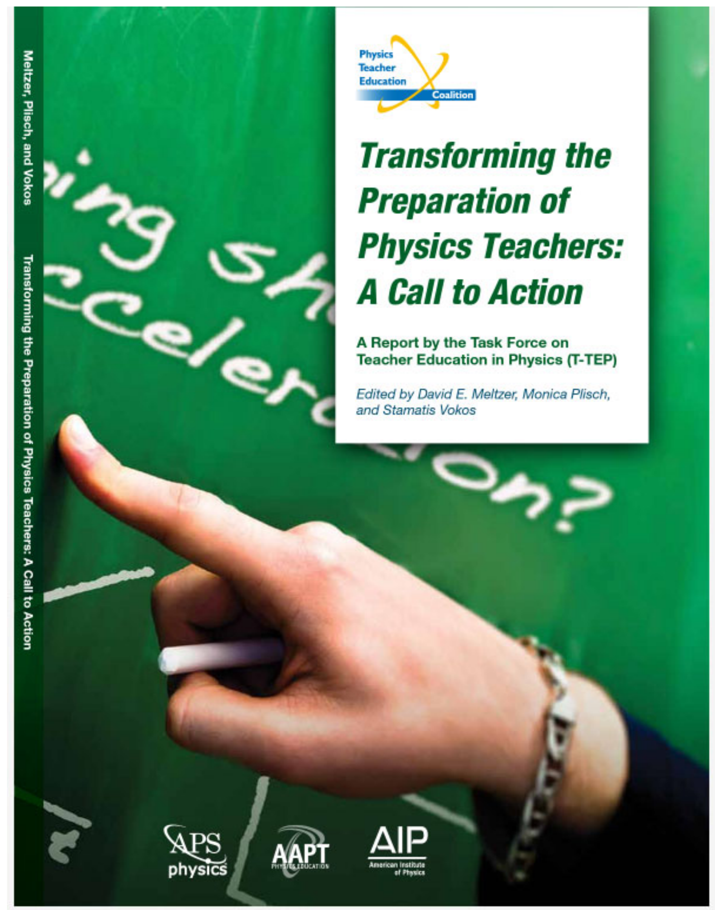
I will present results of an investigation into students' reasoning regarding heat, work, and the first law of thermodynamics in an introductory calculus-based physics course. Responses to written questions by 653 students in three separate courses were very consistent with results of detailed individual interviews carried out with 32 students in a fourth course. Although most students seemed to acquire a reasonable grasp of the state-function concept, there was a widespread and persistent tendency to improperly over-generalize this concept to both work and heat. A large majority thought that net work done and/or net heat absorbed by a system during a cyclic process must be zero, while only 20% or fewer were able to make effective use of the first law of thermodynamics even after instruction was completed. Students' difficulties seemed to stem in part from the fact that heat, work, and internal energy all share the same units.

[1]Supported in part by NSF DUE-#9981140

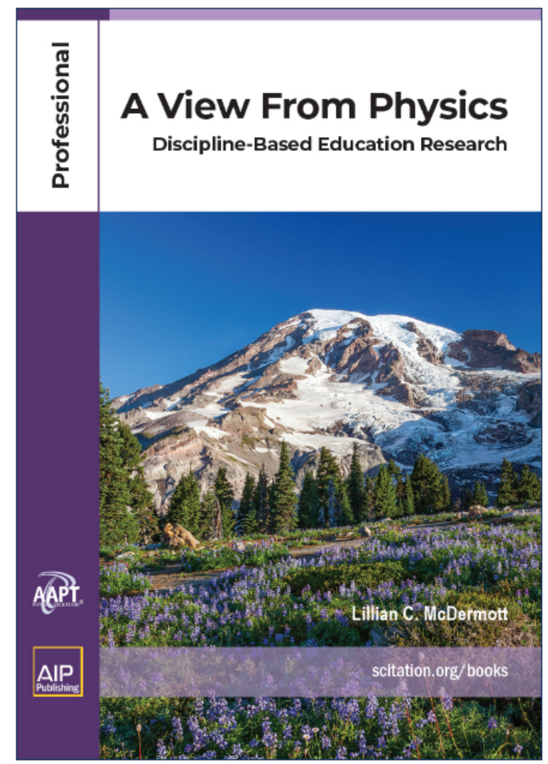
In 2005, after Iowa State decided to eliminate physics education research as a formal research endeavor, Lillian invited me to move to Seattle as a visiting scientist, where I could continue with the work that was supported by my three concurrent NSF grants.

In 2007, Lillian was instrumental in my becoming a consultant to the PhysTEC project for the American Physical Society. I was able to remain in Seattle and continue working with the PEG, where I also became a part-time 8th-grade physical science teacher at a school for gifted children.





I was hired in 2008 as a tenured faculty member at a new education college at Arizona State University. Shortly before I left, Lillian called me into her office to discuss a new manuscript she had started that would outline the history of the UW Physics Education Group. Thus began an 11-year collaboration between us that never really ended, as I helped to edit and bring to publication the manuscript after Lillian's passing in 2020.



In 2013, as part of her effort to expand PER internationally, Lillian organized a session at the European Science Education Research Association (ESERA) in Cyprus, and invited me to give a talk on the history of PER in the U.S.

ESERA 13 CONFERENCE 2-7 September 2013 Nicosia, Cyprus

INVITED SESSIONS | PROGRAMME | PRE-CONFERENCE | DATES | REGISTRATION | BOOKINGS | VENUE | TRAVEL INFO | FAQS

Home Page / Proposal view

Proposal view

Proposal Type:	Symposium
Strand:	17. Science Education Research: Methods and Trends
SIG:	N/A
Scheduling category:	Physics
Type	Invited Symposium
Title	DBER – A View from Physics
Abstract	Disciplined-based education research *(DBER)* in science differs from traditional education research in that the main emphasis is on issues related to the learning and teaching of specific science content. The primary motivation has been to improve the effectiveness of instruction in a particular discipline, but the results can also contribute more generally to the development of educational theory and methodology. The context in this Symposium is physics. Analogies to other sciences, however, are readily made.

Chairperson

First Name	Last Name/Surname	Institution	Country	E-Mail
Lillian C.	McDermott	University of Washington	United States	lcmcd@phys.washington.edu

Supporting and Disseminating PER

- Lillian was always encouraging and supporting new PER faculty
- The education of physics teachers was a lifelong commitment for her, beginning in 1970 and for a half-century beyond.
- She was unceasing in her efforts to spread PER to the broader physics community, both in the United States and throughout the world
- She encouraged both short- and long-term visitors to the PEG in Seattle, knowing that the more exposure people had to the groups' faculty and students, watching them in action and participating in the work, the more effective would be their own efforts in physics education research

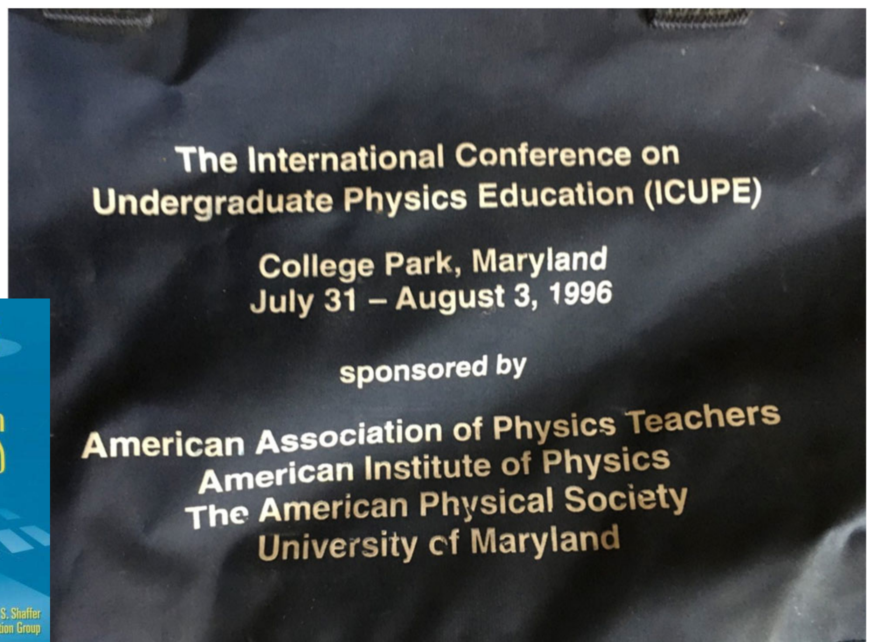
1996

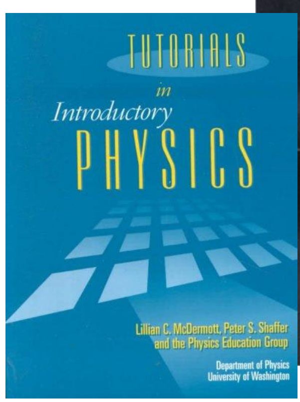
Center for Research in Mathematics and Science Education

CRMSE San Diego State University

UC San Diego

San Diego State University





Lillian C. McDermott: Recipient of the Robert A. Millikan Lecture Award

With the Robert A. Millikan Lecture Award we honor one of our teachers among teachers. I use that phrase because this person's contributions go beyond the direct interaction with her students. This person is teaching us; teaching the teachers of physics. The Robert A. Millikan Lecture Award is given for "notable and creative contributions to the teaching of physics." This year's awardee is Dr. Lillian McDermott from the Physics Department of the University of Washington.

Lillian C. McDermott received her Ph.D. in experimental nuclear physics from Columbia University in 1959. She was born in New York City and did her undergraduate work at Vassar College. In 1961, she became an instructor at City College in New York. She left this position in 1962 to move to Seattle and taught at Seattle University from 1965–1969. She has taught at the University of Washington since 1967. She began a full-time appointment as assistant professor in 1973 and has been a full professor since 1981. She is currently director of the Physics Education Group, in which students earn the Ph.D. in physics for research in physics education.

Her current research is on identifying and addressing specific difficulties students have in learning physics. Lillian does something that all physics teachers claim to do, only she does it with the care of a researcher in search of fundamental answers. Her papers usually start with the phrase, "Student understanding of..." or "Student difficulties with..." In these papers she shares the insights of her exceptional research, insights that all of us who profess to be physics teachers should have deeply ingrained in our world views. She shows us that concepts that we think we are teaching, that we think we are testing on, and that we think students understand, just are *not* getting across to our students. When you look at the students' understandings a different picture emerges. That new picture is largely a result of Dr. Lillian McDermott's quest for truth.

It gives me great pleasure to represent the AAPT Awards Committee of the American Association of Physics Teachers and your colleagues in presenting you as the 1990 recipient of the Robert A. Millikan Award "for notable and creative contributions to the teaching of physics."

Gerald F. Wheeler
Chair, AAPT Awards Committee
28 June 1990

Millikan Lecture 1990: What we teach and what is learned—Closing the gap

Lillian Christie McDermott
Physics Department FM-15, University of Washington, Seattle, Washington 98195

I. INTRODUCTION

Today science education is one again *enjoying* a period of crisis. The verb has been deliberately chosen for its positive connotation. Appropriate or not, frequent reference in the

the college level, though less dramatic, is nevertheless one of ferment. There is considerable enthusiasm for the development of new instructional materials for a variety of college populations, ranging from committed science and engineering majors to general education and liberal arts

Center for Research in Mathematics and Science Education
CRMSE
San Diego State University

1997

Valerie:

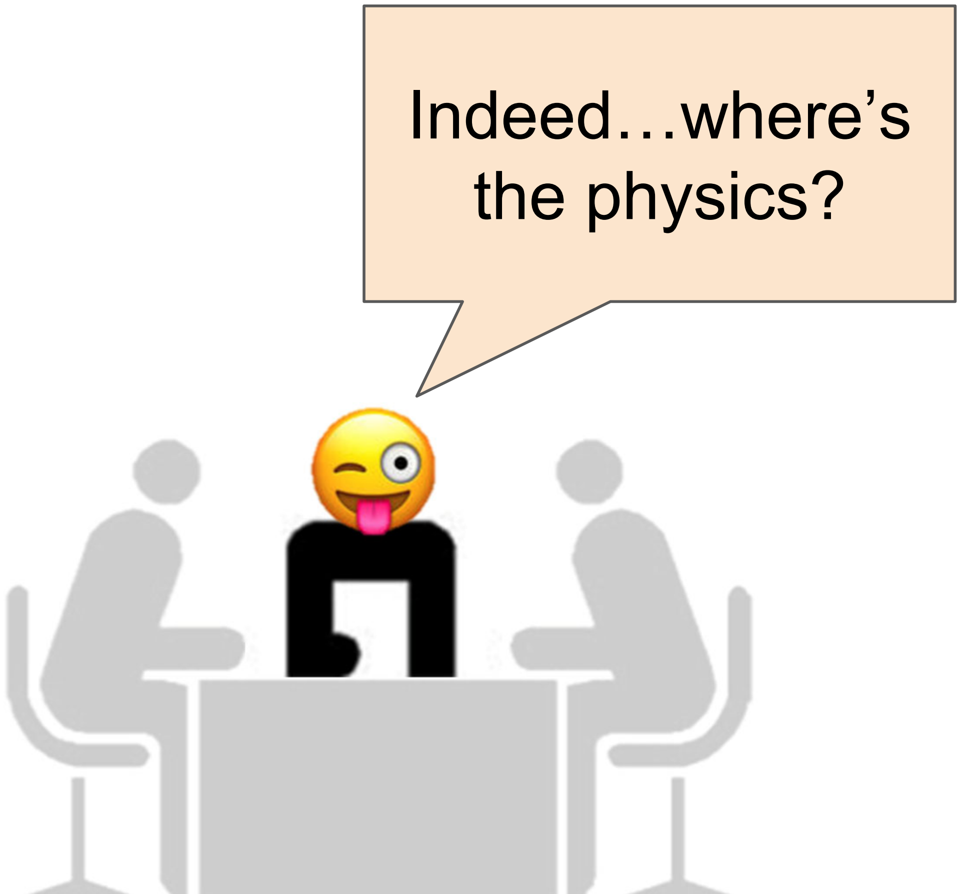
Bla, bla students, bla bla learning, bla bla data

Fred:

Tell Lillian your dissertation idea

Lillian:

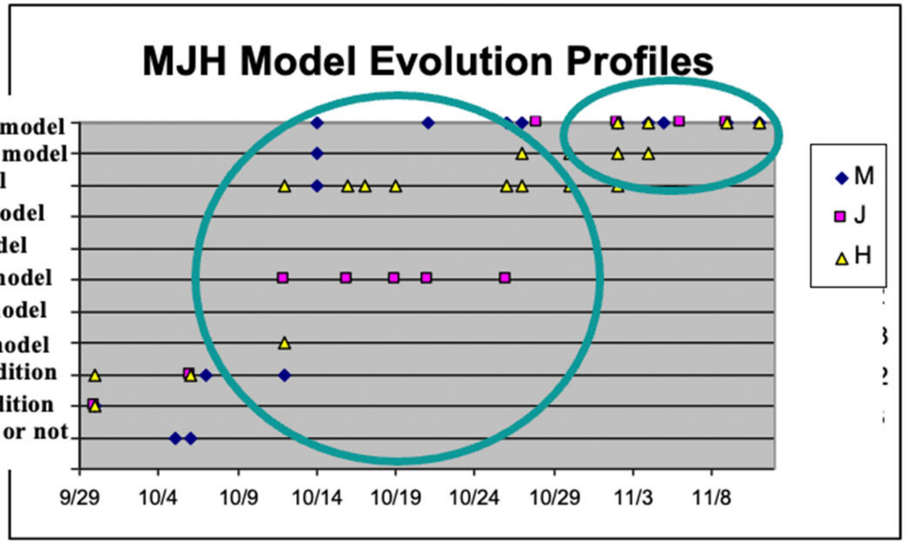
Where’s the physics?

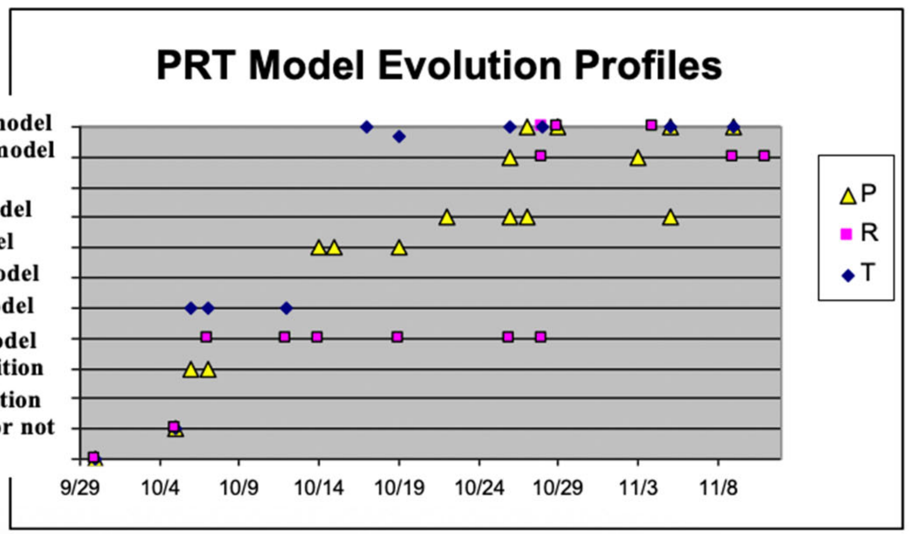


PER is not only in the *context* of physics, but also the research is done through the *epistemology of physics*.

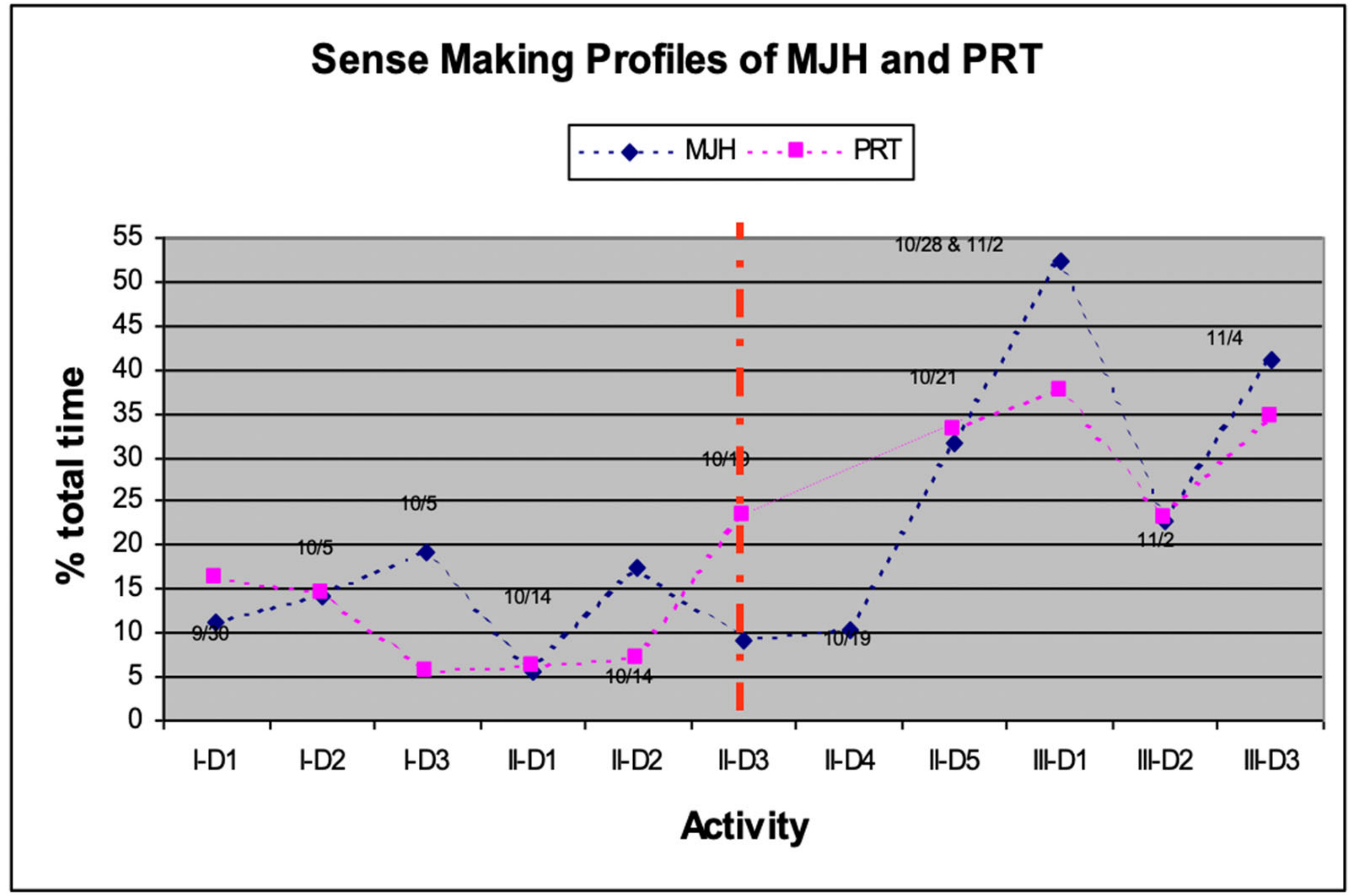
2001

Results: Individual Student's Model Evolutions





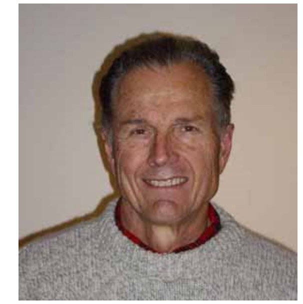
Evolution of the Groups' Scientific Behavior



School of Education
UNIVERSITY OF COLORADO **BOULDER**

2001

Learning Assistant Program
UNIVERSITY OF COLORADO **BOULDER**



Learning Assistant (LA) Pedagogy Course

Sociocultural theory

Qualitative research

Small vs. Large enrollment courses

2005

Learning Assistant Program
UNIVERSITY OF COLORADO **BOULDER**

AAAS
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

D B E R

PER is not only in the *context* of physics, but also the research is done *through the epistemology* of physics.

2005

Learning Assistant Program
UNIVERSITY OF COLORADO **BOULDER**

AAAS
AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

DBIEER

Discipline-Based, Epistemologically-Informed, Educational Research

PhysTEC

Physics Teacher Education Coalition

Physics for Teachers Program

2008

UNIVERSITY *of* WASHINGTON

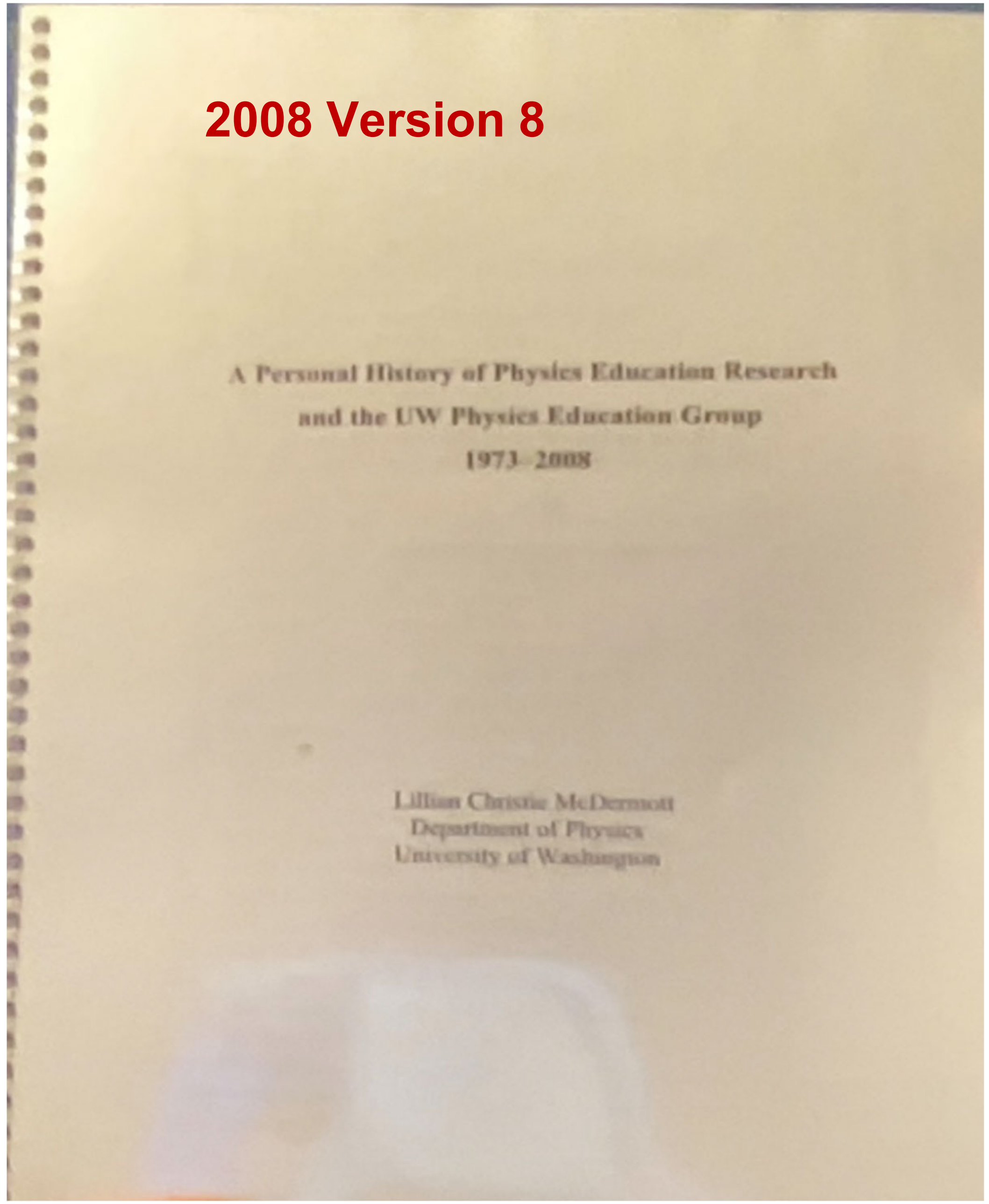
Streamline to Mastery

UNIVERSITY OF COLORADO **BOULDER**

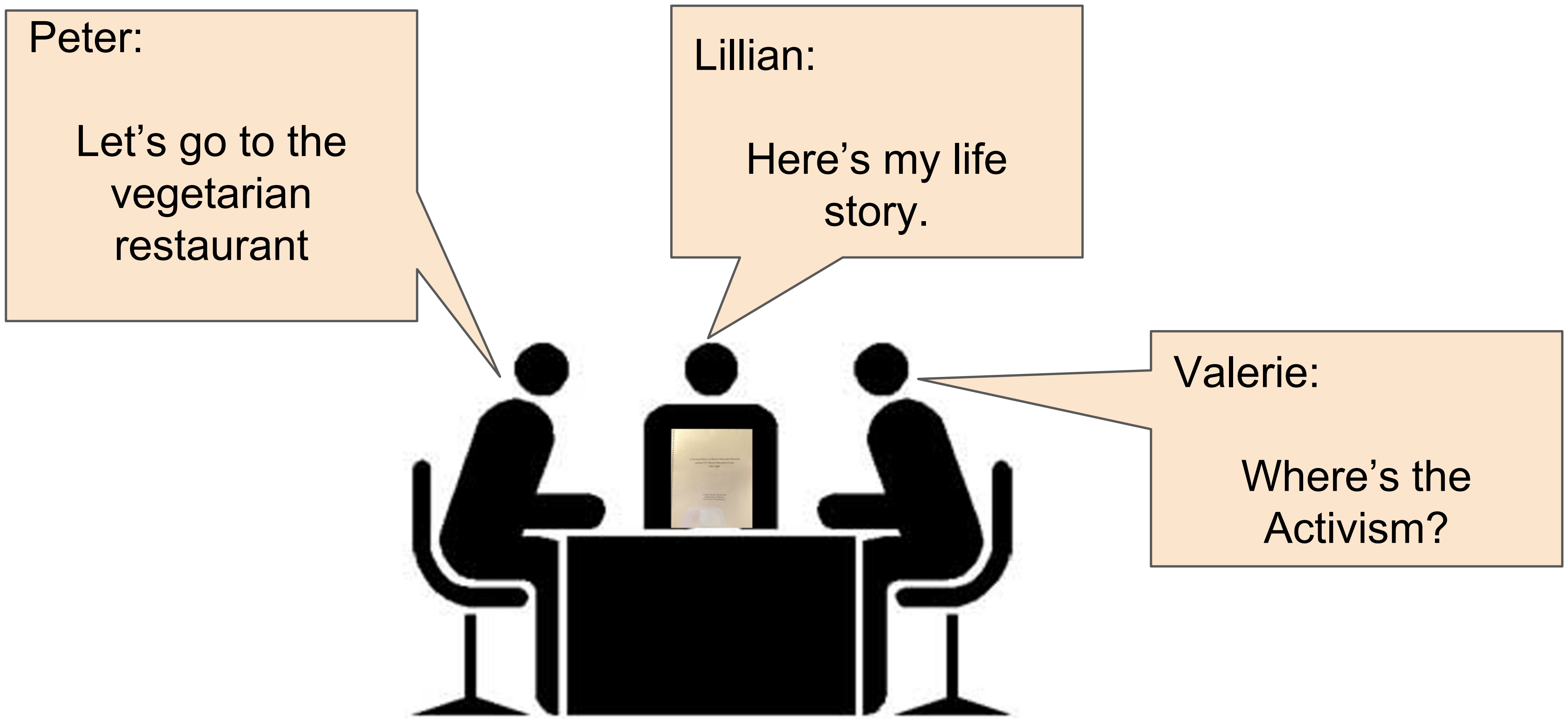
PEER *physics*

cultivating expert learners, not just expert knowers

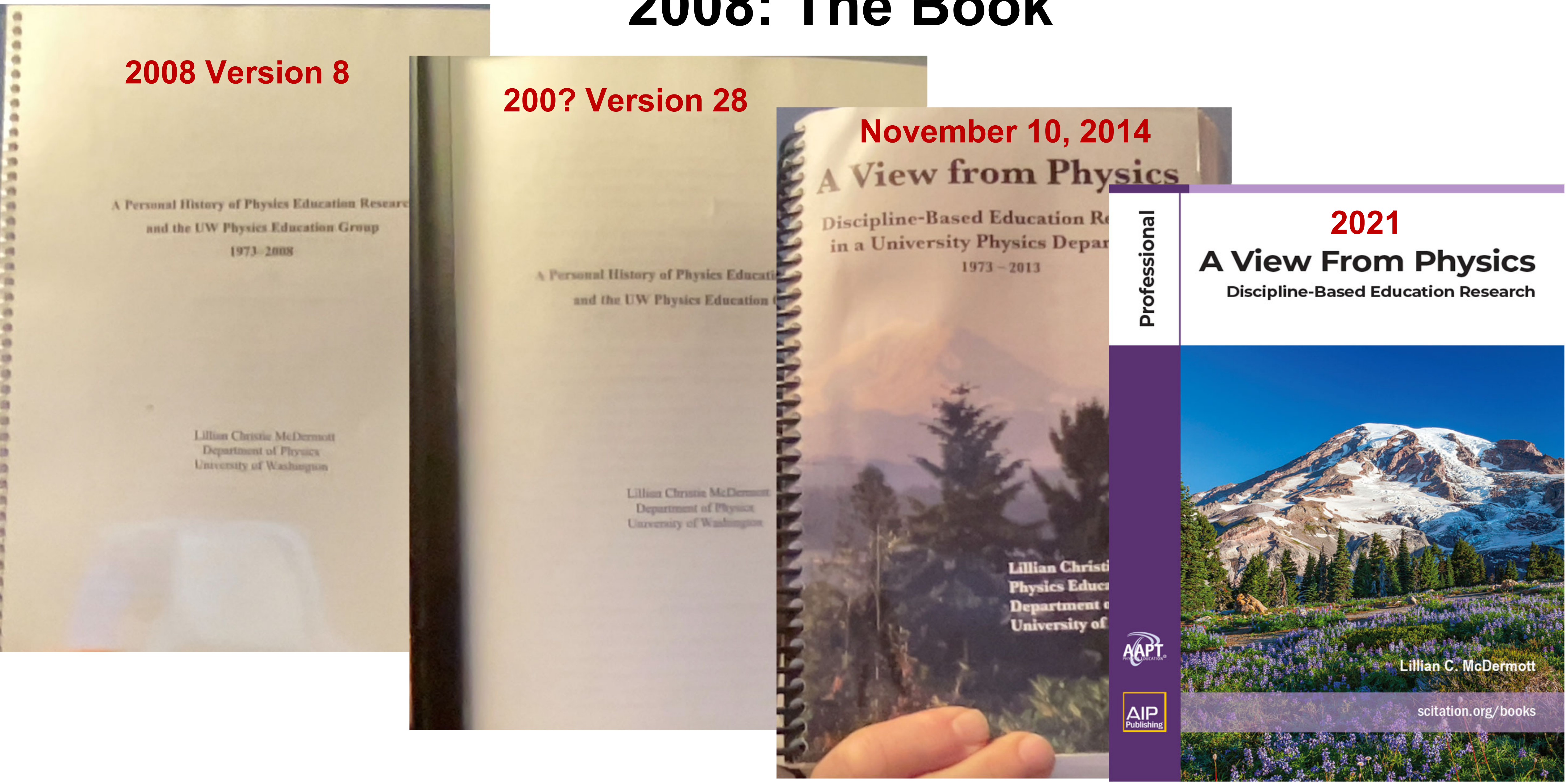
2008: The Book



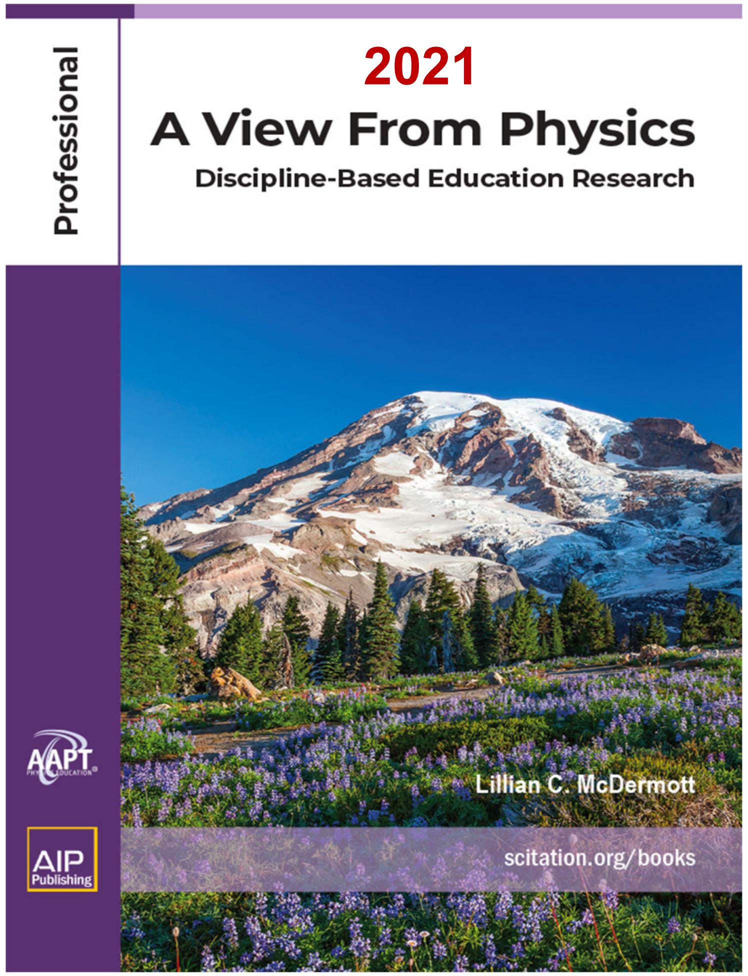
2008: The Book



2008: The Book



2008: The Book



Chapter 1: The Path to Physics Education Research at UW

Chapter 2…

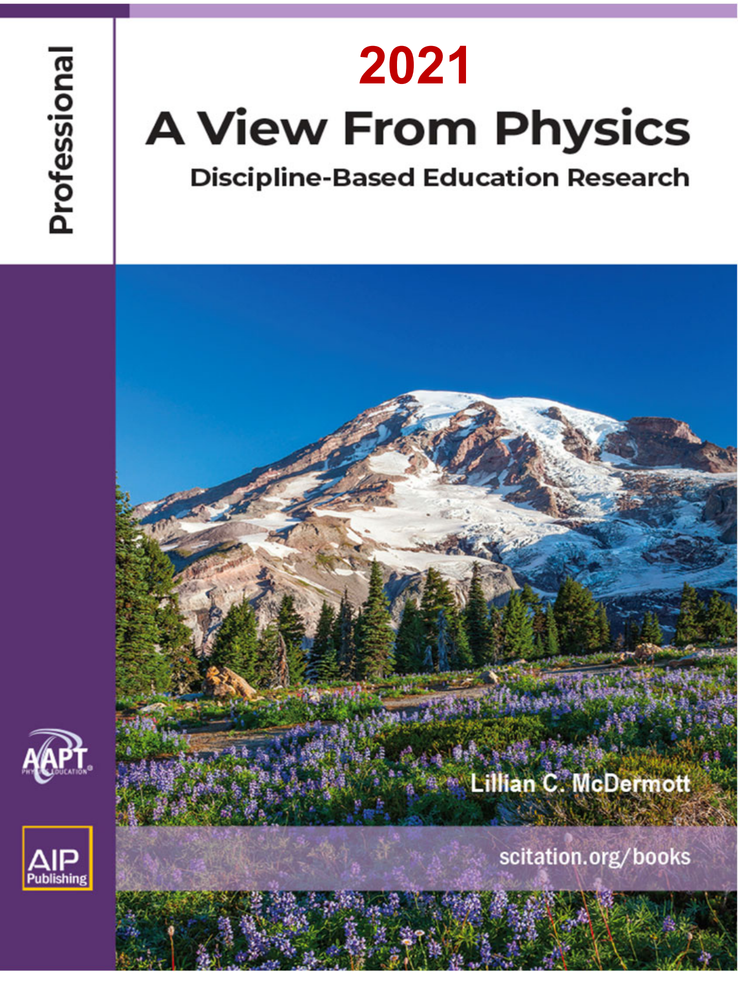
Chapter 3…

Chapter 4…

…

Chapter 10: Conclusions…

2008: The Book



Appendix A

Appendix B

Appendix C

Appendix D

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Appendix I

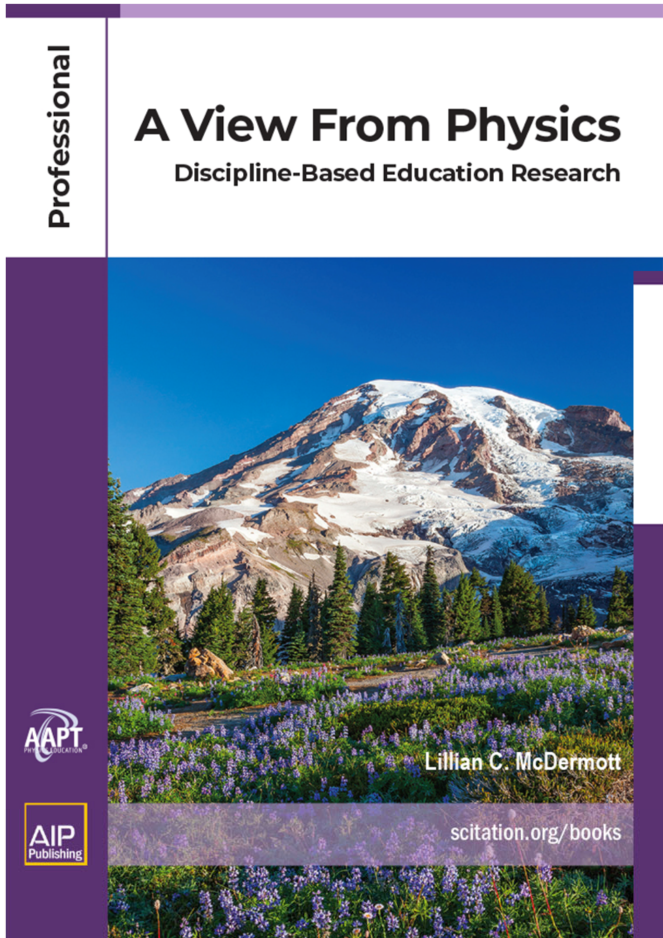
Coda: A Closing Opinion on Science Education Research, Reflections on Women in Physics, and a Personal Postscript

Lillian as an Inspiration

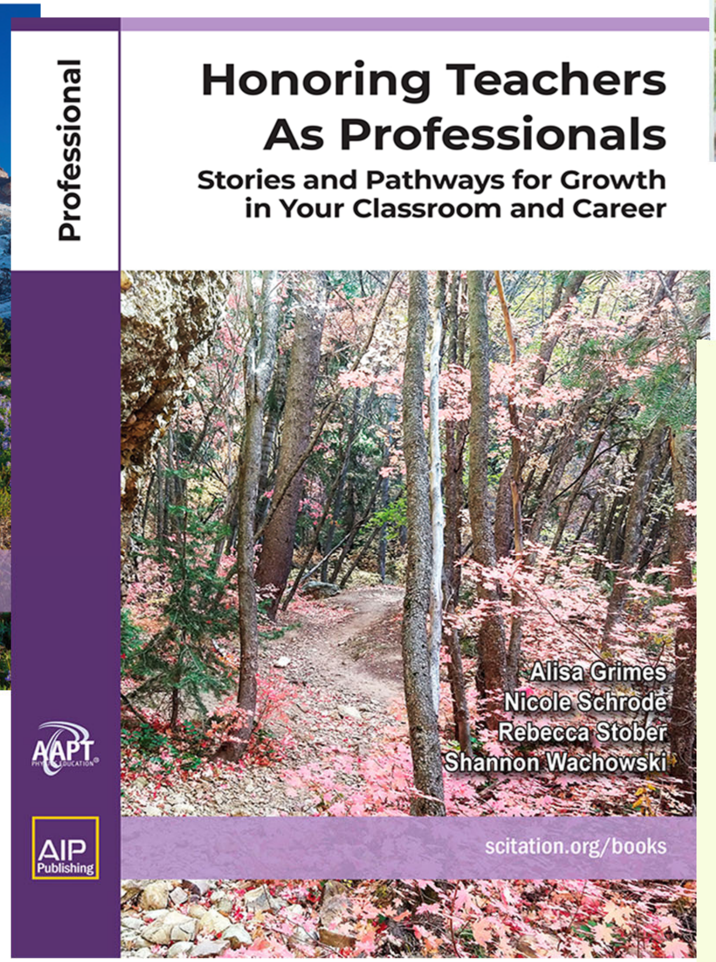
Broader Impacts of Lillian McDermott’s Work

- Lillian McDermott’s Physics Education Group (PEG) has played a major role in the reform and restructuring of undergraduate physics education in the United States during the past 50 years.
- The PEG helped bring physics teacher education into the modern era, transitioning from the initial reforms of the 1950s and 1960s to the research-informed and research-validated methods used today.
- As one of the largest and longest-lived physics education research (PER) groups in a university physics department, the PEG set an unsurpassed standard of quality, quantity, and rigor of its research endeavors and curriculum development.
- By leading the way for PER to be accepted as a legitimate field of research for professional physicists, the PEG helped open the door for Discipline-Based Education Research in other science fields as well.

2021



2021



Streamline to Mastery

UNIVERSITY OF COLORADO **BOULDER**

PEER physics

cultivating expert learners, not just expert knowers

Chapter 1: Fostering Community and Collaboration

Chapter 2: Cultivating Confidence and Professionalism

Chapter 3: Conducting Educational Research

Chapter 4: Impacting Educational Policy

Chapter 5: Empowering Students

Chapter 6: Becoming an Agent of Change

”Due to collaboration within the [Streamline to Mastery] program, we began to see ourselves as professionals, researchers, and master teachers. We now see ourselves as agents of change who believe we can be leaders within the field.”

Lillian McDermott

Mentor, Model, and Inspiration

Activist and Agent of Change