A Course on the History of Physics Education in the U.S.

The Independent

VOL. LXVII. NEW YORK, THURSDAY, JULY 8, 1909 No. 3162

A Needed Reform in Science Teaching

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AT the meeting of the American Association for the Advancement of Science, which was held at

widespread and rapidly deepening among educators generally. For the last five or six years they have been gradually awak-

What are your reasons for being in physics education?

Given that, what are some of the reasons you might want to investigate the history of physics?

Our Goals for the Course

- Become aware of the research and curricular reform efforts that have taken place in the U.S.

- Place today’s research and reform movements within the context of previous analogous efforts

- Evaluate the effectiveness of various physics education reform efforts, analyze successes and shortcomings, and design new reform efforts based on insights from this historical analysis

- Recognize the complexity of reform

Core Questions and Themes
(characteristic of each historical period)

- Why teach physics?
- How to teach physics?
- To whom should physics be taught?
- What physics should be taught?

Content Sections

- Organized chronologically
- Segmented by key issues

Take note of themes that run through all sections as we briefly summarize each section

Origins of physics education in the U.S., 1860-1884

- Physics teaching in high schools spread rapidly, but there were very few student labs and less than 5% of population graduated from high school
- Physics instructors proclaimed support for “inductive method” [i.e., experiments precede enunciation of principles] despite very limited availability of lab facilities

First U.S. “Active-Learning” Physics Textbook:

Alfred P. Gage, *A Textbook of the Elements of Physics for High Schools and Academies* (Ginn, Boston, 1882).

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Aims and Methods of the Teaching of Physics (1884), p. 120.

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The move toward laboratory science instruction 1884-1902

- Physics still taught to to around 5% to 10% of population
- Advocated experimental courses so students learn to rely on “nature” instead of “authority” to answer questions
- Tension about whether high school physics was for preparation for life or preparation for college

Teaching Physics by Guided Inquiry: The Views of Edwin Hall

"…It is hard to imagine any disposition of mind less scientific than that of one who undertakes an experiment knowing the result to be expected from it and prepared to work so long, and only so long, as may be necessary to attain this result…

Teaching Physics by Guided Inquiry: The Views of Edwin Hall

"…It is hard to imagine any disposition of mind less scientific than that of one who undertakes an experiment knowing the result to be expected from it and prepared to work so long, and only so long, as may be necessary to attain this result…I would keep the pupil just enough in the dark as to the probable outcome of his experiment, just enough in the attitude of discovery, to leave him unprejudiced in his observations, and then I would insist that his inferences…must agree with the record…of these observations…the experimenter should hold himself in the attitude of genuine inquiry." [from Smith and Hall, pp. 277-278]

New Movement
1903-1910

- Concerns about the poor quality of high school physics instruction (only 30% passing College Entrance Exam)

- Overcrowding of high school curriculum, overreliance on math and measurement resulted in memorization, misconceptions, and distaste for physics

- Tension between preparing students for college and preparing students for life. Teachers blame colleges, univ. faculty blame the high schools.

Are you noticing any themes running through?

Project Method, and beginnings of PER, 1911-1914

- Consensus that physics education must focus on more “practical” and “interesting” problems related to everyday life
- Beginnings of “project method” in which students were engaged in lengthy investigations on practical questions
- Beginnings of research in physics education
- Beginnings of “general science” movement

Reorganization of Secondary Curriculum 1915-1922

"The common assumption is that the cause lies in the fact that the pupils are not interested in science as it is taught. Hence, the doctors are bringing up all sorts of sugar-coated pills, which are guaranteed to be palatable, whether efficacious or not. One says: Drop out a formal physics course entirely, and slip in the principles of physics while the children are running their toy motors or their automobiles. I shall call this remedy "toy science," and I use the term merely to describe, not to derogate. Another labels his remedy "project science," and argues that, while the pupils are figuratively swallowing a delightful tennis game, it is possible, unknown to them, to slip in a spoonful or two of the wholesome castor oil of physics. A third scrambles all the sciences into a delicious potpourri, and calls it "general science." (Millikan, 1917, p. 382-383)

Dominance by educationists, 1923-1947

- Dominance of “physics in everyday life” perspective
- High school textbooks focused on technological devices
- Isolated cases of physics education research, focused on curriculum testing
- University-based physics educators founded AAPT, focused on college level

Re-engagement by physicists, rise of curriculum reform, 1948-1966

- Explosive expansion of NSF-sponsored in-service physics teacher training
- Proliferation of NSF-funded content-focused, inquiry-based K-12 physical science curriculum projects
- “Two-track” system with dominant traditional technology-focused high school curricula competing with new inquiry-based concept-focused curricula

What themes did you notice?

Themes and Core Questions that We Notice

- Why teach physics?
- How to teach physics?
- To whom should physics be taught?
- What physics should be taught?

Rise of Modern PER 1960-1989

Arons articulated principles for curriculum development:

- "question asking prior to concept formation and modeling"
- "physics idea first, formal name afterwards"
- "inferences drawn from models"

(Arons, 1955; Arons, 1976)

Karplus integrated physics research methods with ideas from educational psychology

- *The learning cycle; formal reasoning processes*

(Karplus, 1964; Karplus, 1977)

Reif investigated students' problem-solving ability in the context of physics

(Reif, Larkin, and Brackett, 1976)

McDermott initiated Ph.D. program in PER at U. Washington (1973)

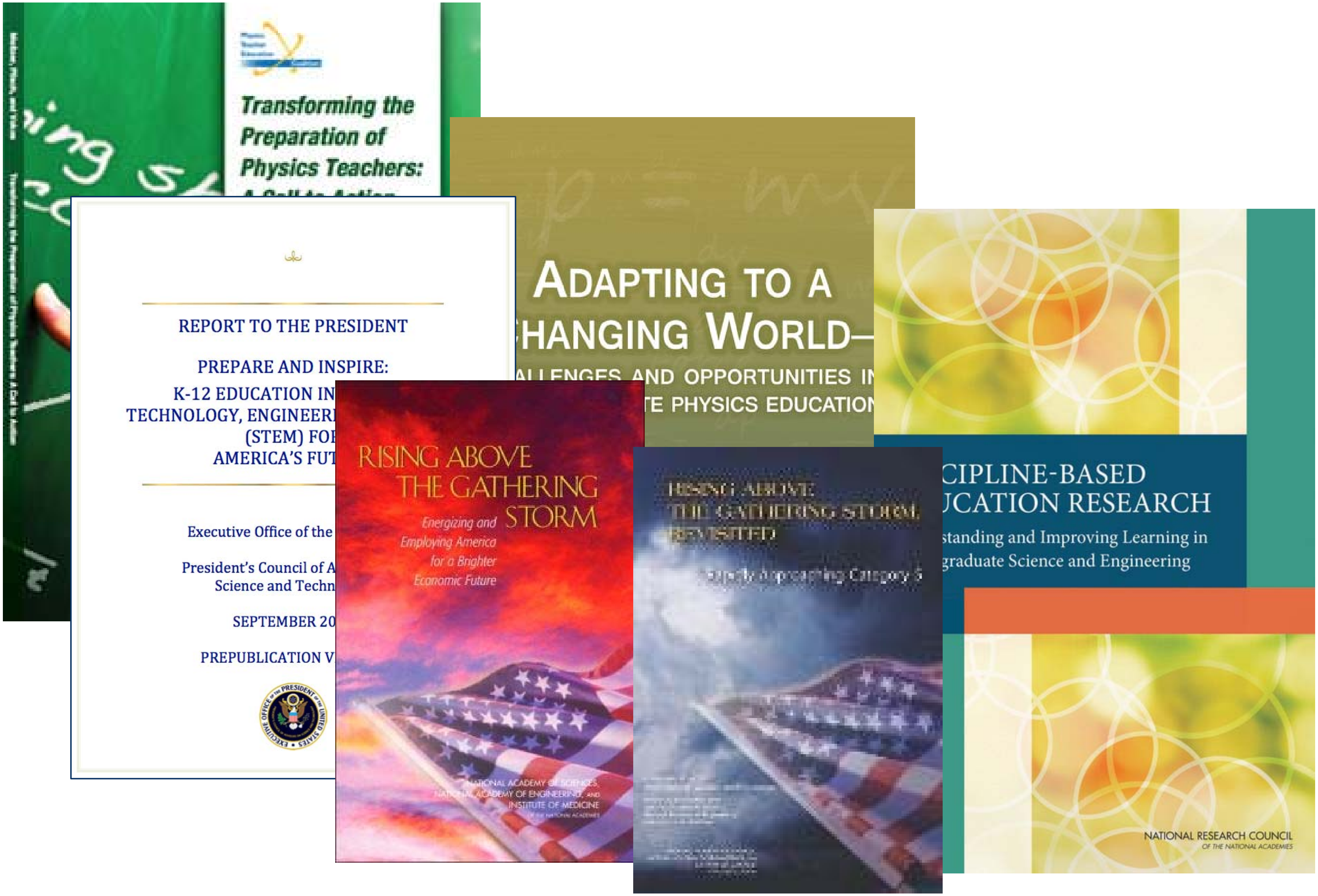
Combined carefully articulated curriculum with systematic research

(Trowbridge & McDermott, 1980, 1981; McDermott, 1984)

Themes of Modern PER, 1989-2001

- Emergence of conceptual physics, “honors” physics, and AP physics courses in high school with dramatic rise in enrollment
- Virtual disappearance of “progressivist” technology-focused high school curricula
- Beginnings of systematic physics education research at the college and university level
- PER very strongly influenced by curricular reform movements of the 1950s-1960s
- Impact of “Modeling Instruction” on HS physics

The Present Day: STEM Education in National Discourse (2001-2014)



The Paper: Structure

- Intro – importance of the course and purpose
- Goals of course and Themes (Why teach physics? How to teach physics? To whom should physics be taught? What physics should be taught?)
- Content of Course: Chronological Segment Summaries (with 4-5 references in each section)
- Challenges and Tradeoffs
- Table with Key Names, Key Issues, Key Questions, Textbooks of time period

The Paper: A table we might include

KEY NAMES and EVENTS	KEY ISSUES	PEDAGOGICAL/QUESTIONS
rigins of physics education in the .S., 1860-1884 **ey events:** physics plays increasing ole in school curricula; rising opularity of inductive method **ey readings:** Spencer,[1] Huxley,[2] yndall,[3] Clarke,[4] Wead,[5] Youmans,[6] age[7]	**Key issues:** popularity of inductive method, beginnings of laboratory instruction Answers to themes: (a) teach physics to 5% of population, (b) teach primarily through lecture, demo, (c) teach physics to strengthen students' thinking and reasoning ability, and to develop understanding of science and the scientific method	Questions for discussion: (a) Despite the widespread support expressed for the inductive method in the 1884 survey, there was and had been very little individual laboratory instruction in physics up until that time. What can account for the enthusiasm for the inductive method when so little practical experience was available with teaching in this manner? <textbook question>
he move toward laboratory science nstruction, 1884-1902 **ey names:** Hall, Gage, Millikan **ey events:** Harvard Descriptive List, extbooks of Gage, Millikan, and Hall, ommittee of 10, Committee on ollege Entrance Requirements, ormation of College Board	**Key issues:** institutionalization of laboratory instruction, courses for college prep. vs. general education, lists of experiments, dominance of high schools by colleges (a) still teach physics to around 5%, gradually increasing to around 10% of population; (b) significant increase in student lab work, now often the predominant method of instruction; (c) same reasons as before, but now also college prep, and also to learn to carry out and interpret experiments with real systems and objects--to learn to rely on "nature," instead of "authority," to provide answers to questions.	a. Questions for discussion: (1) Why did individual laboratory instruction so suddenly (within 20 years) change from a marginal activity to a dominant and required activity? (2) What were the primary learning goals for physics teachers as expressed or implied by (a) Harvard's Descriptive List, (b) the Committee of 10 Report, and (c) Hall's textbook on teaching? Comments: add discussion regarding the significantly increasing degree of formalization and mathematization of high school physics during this period <textbook question>
ew Movement, 1903-1910 **ey names:** Mann, Woodhull, Dewey, illikan **ey events:** New Movement circulars, ymposium on Teaching Physics	**Key issues**: college entrance requirements, dominance of Descriptive List	Questions for discussion: (1) Although the reformers expressed broad and diverse goals, they focused their attention (e.g., in the "Survey") on specifying experiments and curricular topics; why did they do this, and what were the consequences of doing it? (2) To what extent, and by whom, was there any explicit (or implicit) defense of a

Thoughts?

- On our paper organization?
- Content?
- Number of references
- Will it provide adequate support?
- Other?