SCIENCE 2020

A vision for the next ten years

Felicia Keesing
Bard College

?

A vision for science in general

A vision for future researchers, future citizens, **and** future professsors

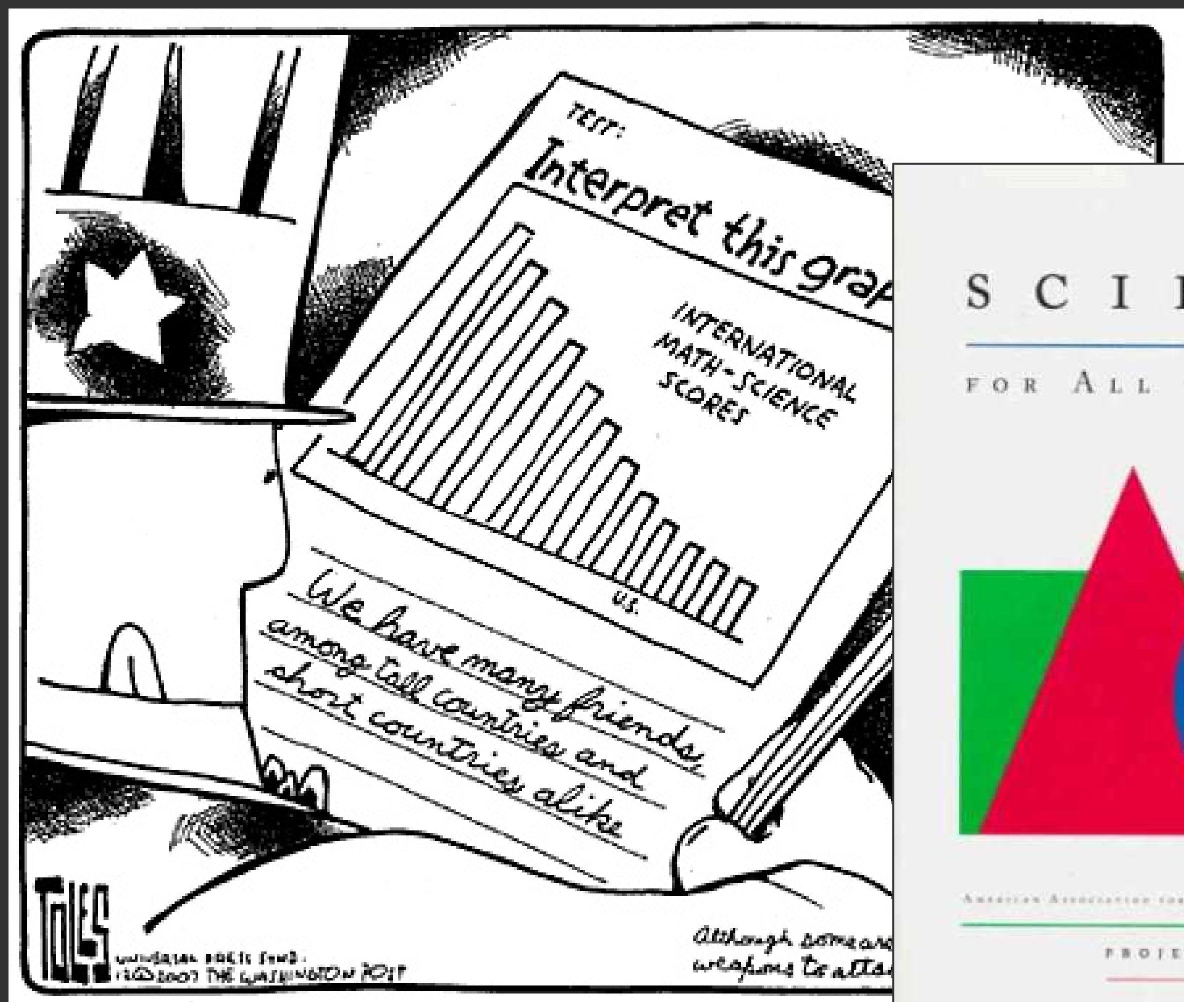
A vision building on a decade of progress

Why reform science education?

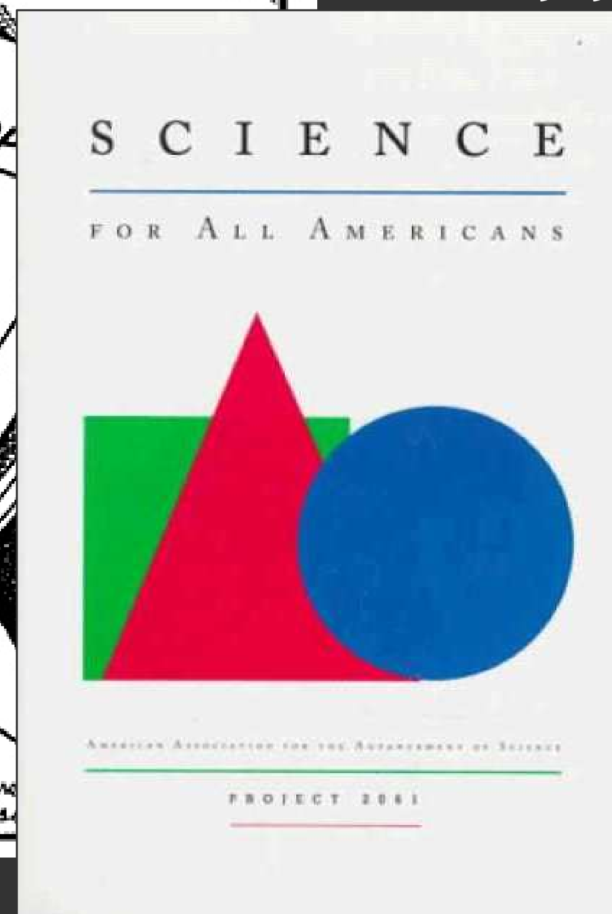
2007

Keesing
Case Studies Conference 2010

Why reform science education?

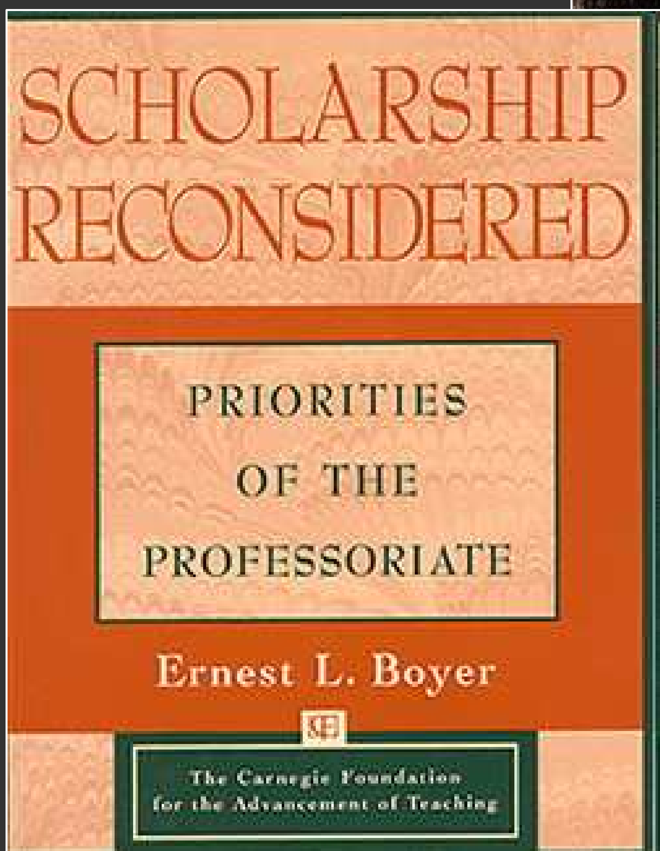


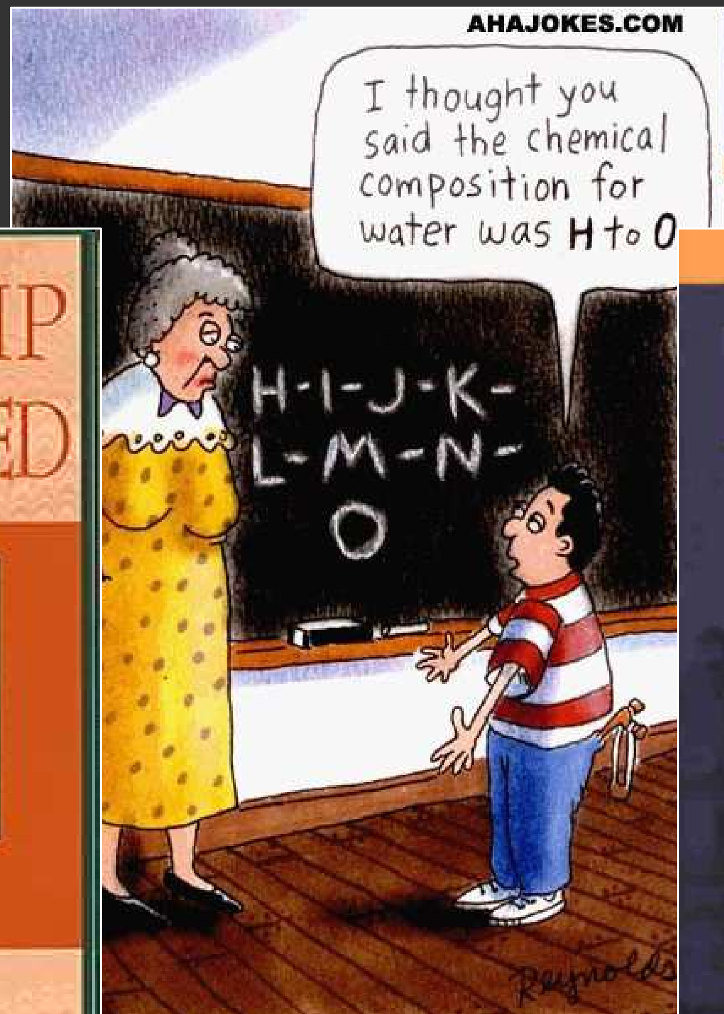
1989



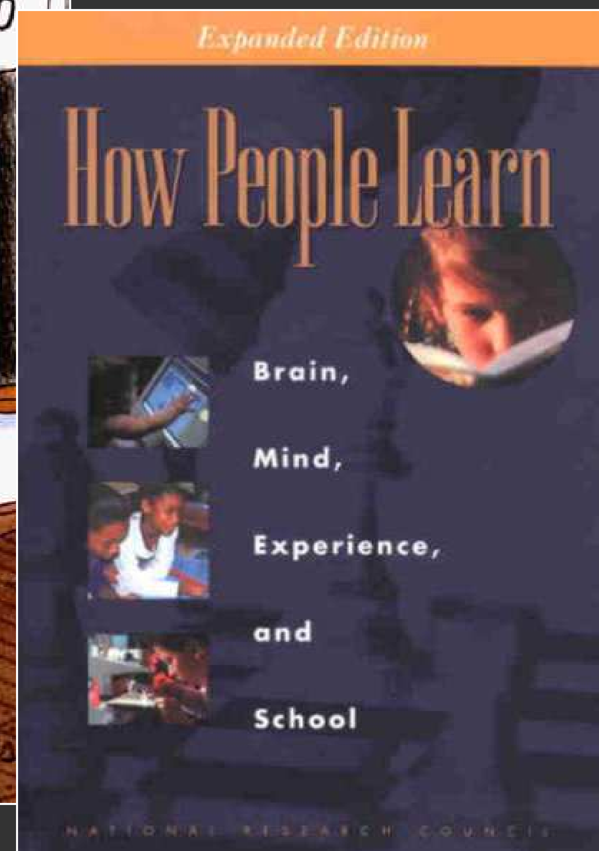
Why reform science education?

1997





1999



Why reform science education?

Workforce quantity & quality

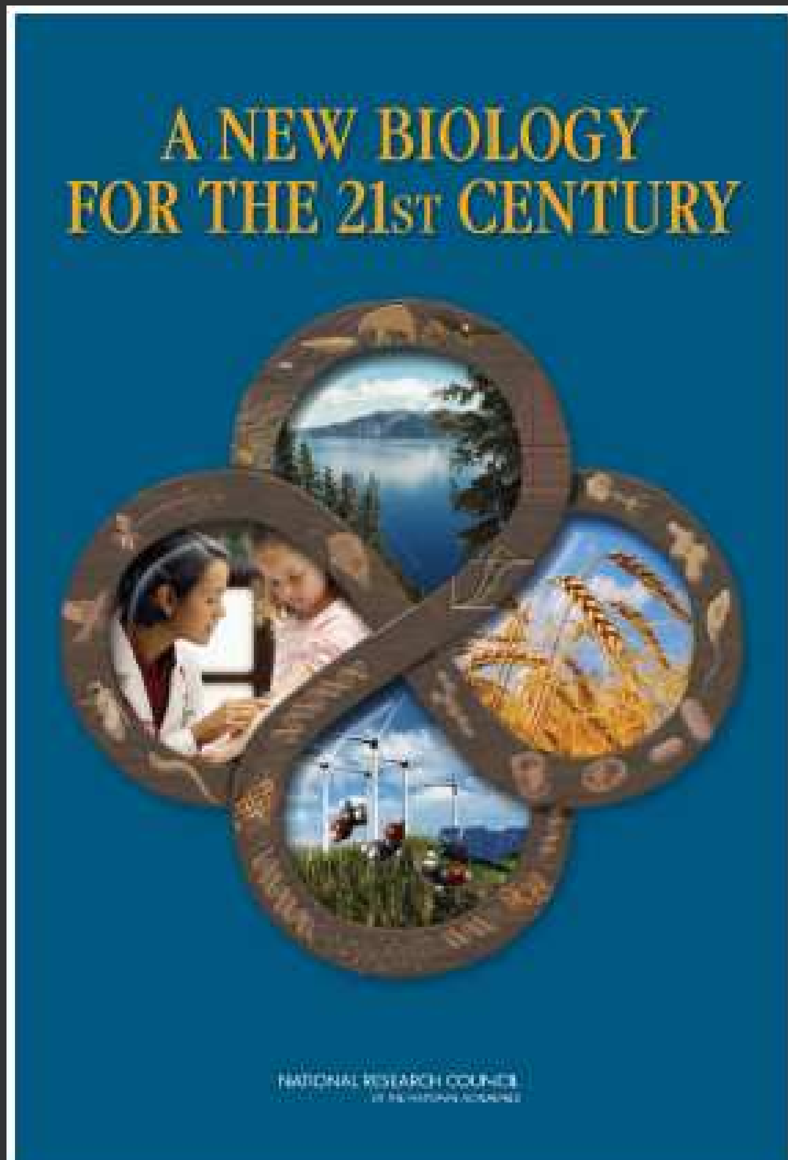
Science literacy

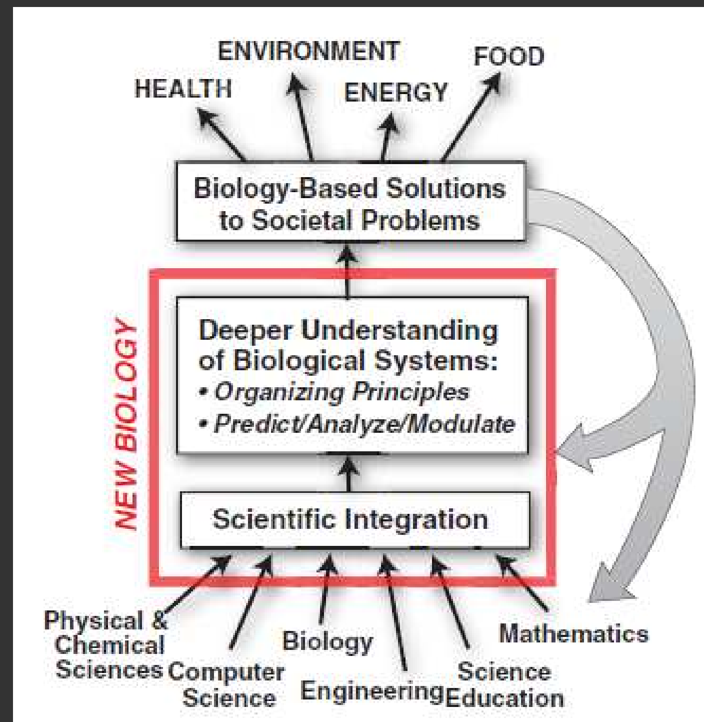
Professional excellence

What we know

Workforce preparedness

- Future of fields: multidisciplinary, computational, systems-oriented, collaborative, applied(?)


A NEW BIOLOGY FOR THE 21ST CENTURY
NATIONAL RESEARCH COUNCIL


ENVIRONMENT
FOOD
HEALTH
ENERGY
Biology-Based Solutions to Societal Problems
NEW BIOLOGY
Deeper Understanding of Biological Systems:
• Organizing Principles
• Predict/Analyze/Modulate
Scientific Integration
Physical & Chemical Sciences
Computer Science
Biology
Engineering
Science Education
Mathematics

NRC 2009

What we know

Workforce preparedness

- Future of fields: multidisciplinary, computational, systems-oriented, collaborative, applied(?)
- Quality
  - Core concepts and competencies

What we know

Workforce preparedness

Framework for Science Education Standards

NEWS

NATIONAL ACADEMY OF SCIENCES
NATIONAL ACADEMY OF ENGINEERING
INSTITUTE OF MEDICINE
NATIONAL RESEARCH COUNCIL

FROM THE NATIONAL ACADEMIES

August 2010

Four concepts from each field

Generating and evaluating scientific evidence

Understanding development of scientific knowledge

Participating in scientific practices

What we know

Workforce preparedness

- Future of fields: multidisciplinary, computational, systems-oriented, collaborative, applied(?)
- Quality
  - Core concepts and competencies
  - Disciplinary integration (seminars, research, intro)


THIS IS AN INTERDISCIPLINARY PROGRAM IN WHICH PHYSICS STUDENTS TRY TO HIT PSYCHOLOGY STUDENTS WITH PENDULUMS.
PROMISING!
AAAAAAA!
MY PROFESSORS HAD AN ONGOING COMPETITION TO GET THE WEIRDEST THING TAKEN SERIOUSLY UNDER THE LABEL "INTERDISCIPLINARY PROGRAM."

What we know

Workforce preparedness

- Future of fields: multidisciplinary, computational, systems-oriented, collaborative, applied(?)
- Quality
  - Core concepts and competencies
  - Disciplinary integration (seminars, research, intro)
  - Collaboration
  - Diversity
- Quantity
  - Introductory courses (better)
  - Hands-on research experiences (more & better)

What we know

Science literacy

- Global problems require informed citizenry


SO, WHAT'S THE BIG DEAL? WHAT COULD GO WRONG?!
NEWS
HUMAN STEM CELL RESEARCH DEBATED


The New York Times

CHINA'S DISPUTES IN ASIA BUTTRESS INFLUENCE OF U.S.

Violence Amid a Snag in Mideast Peace Talks

New Treatments Are Challenging Mammogram's Need, Study Says

Angry Voters Shout 'Recall' At City Halls

On the Ground on Health Care

Mammograms' Value in Cancer Fight at Issue

Damian Dovarganes/Associated Press

A radiologist reviewing mammogram images at the Elizabeth Center for Cancer Detection in Los Angeles. Most health officials recommend the screenings, but experts disagree over their value.

By GINA KOLATA

Published: September 22, 2010

What we know

Science literacy

- Global problems require informed citizenry
  – ?
- Number of courses

Table 3: Percent of Adults Qualified as Civic Scientifically Literate in 33 Countries, 2005.

	CSL
Sweden	35%
United States	28
Netherlands	24
Norway	22
Finland	22
Denmark	22
Bulgaria	19
Iceland	18
Belgium	18
Germany	18
France	17
Switzerland	17
Czech Republic	17
Luxembourg	17
Hungary	15
Great Britain	14

J. Miller 2006

Available at http://www.arcsfoundation.org/pittsburgh/JMiller.pdf

What we know

Science literacy

- Global problems require informed citizenry
  - ?
- Number of courses
- Transfer
  - Core concepts and competencies (Miller)
- Undergraduate teaching has high leverage
  - Trains future K-12 teachers
  - Affects adult science literacy
  - Models effective pedagogy for future professors

What we know

Professional excellence

- Reward structures are a barrier
- Faculty training is a barrier
- Education is changing

Free online biology courses

Massachusetts Institute of Technology (mit.edu)
Introductory Biology Course
Molecular Biology Course
Cell Biology Course
University of Utah (utah.edu)
Principles of Biology Course
Human Physiology Course
University of Massachusetts, Boston (umb.edu)
General Biology I Course
General Biology II Course
University of California, Berkeley (berkeley.edu)
General Biology Course
General Biology Laboratory
General Biology Lecture
Carnegie Mellon University (cmu.edu)
Modern Biology Course
University of Leeds (leeds.ac.uk)
Human Biology Course

What we know

Professional excellence

- Reward structures are a barrier
- Faculty training is a barrier
- Education is changing
- Evidence works(?)

How do we effect change?

- Accumulate evidence of what works
  - E.g. how to teach collaboration, which core concepts, how to train multidisciplinary scientists
  - And how to use it
- And why
  - Value of science literacy to policy
  - Effect of pedagogical practices on student choices

How do we effect change?

- Improve pedagogy (where's the leverage?)
  - (Re)train faculty (e.g. Wisconsin summer institute)
  - Provide resources

Case Studies in Science

State University of New York at Buffalo

- An "easy" way to start improving pedagogy?
- Many resources available
- Could case studies be a "gateway drug"?

You Are Not the Mother of Your Children

by

Stephen R. Cronin
Department of Biology and Chemistry
Ave Maria University, Ave Maria, FL

How do we effect change?

- Improve pedagogy (where's the leverage?)
  - (Re)train faculty (e.g. Wisconsin summer institute)
  - Provide resources
    - BEN, HHMI "Cool Science", Science Education Alliance, …, "Boogle"
    - Technology – clickers, sophisticated graders, vodcasts
    - Communities of teaching and learning
    - Provide evidence – syntheses of results of what works
      - NRC and WCER workshops 2008
  - Motivate faculty and administration
    - Provide evidence
    - Provide resources

Themes of Science 2020

- Keep doing what we have been doing
  - Improving pedagogy
  - Improving curricula
  - Improving training
- Use leverage
  - Introductory undergraduate classes
  - Case studies
  - Influential faculty members, dept. chairs
  - Strategic planning committees

Themes of Science 2020

- Focus on core concepts & competencies
  - For future scientists & engineers
  - For future citizens
  - For future faculty
- (Re)new focus on science literacy
  - Problem-oriented for concepts?
  - Approach-oriented for competencies?
    - Modeling, experiments, comparisons
  - Increase required courses for non-majors?

What is Science 2020?

- Focus on collection, evaluation, synthesis and dissemination of evidence

Assessment

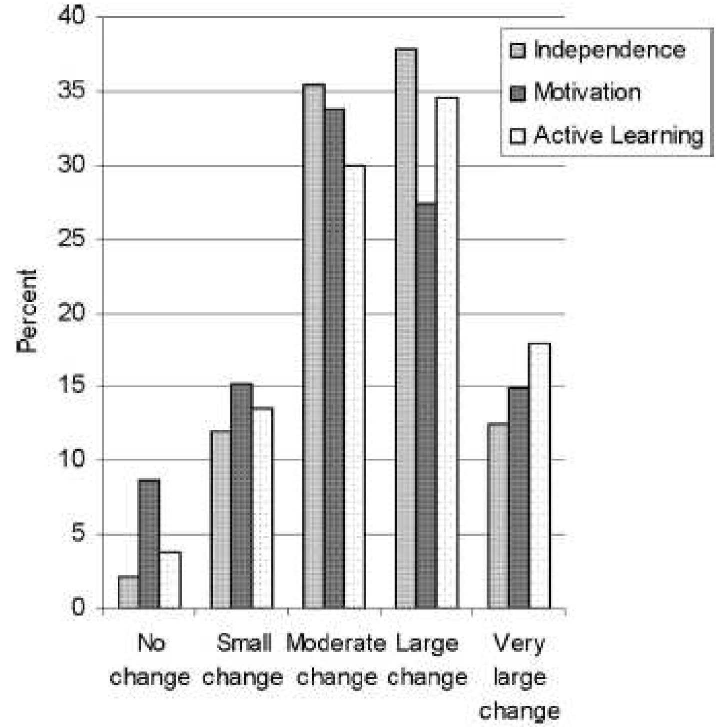


Figure 3. The bar chart shows the percentage of respondents who reported their behavior in courses in their field after the completion of a summer undergraduate research experience. The three items were as follows: "I feel that I have become better able to think independently and formulate my own ideas"; "I feel that I have become more intrinsically motivated to learn"; and "I feel that I have become a more active learner."

Lopatto 2007
CBE Life Sci Educ 6(4): 297-306

Table 6. Learning gain items on which members of the underrepresented group showed significantly higher mean gains than the comparison group

Item	Underrepresented group[a]	Comparison group[b]
Ability to integrate theory and practice	3.84 ± 0.98	3.69 ± 0.99
Understanding that scientific assertions require supporting evidence[c]	3.93 ± 1.1	3.57 ± 1.2
Ability to analyze data	3.91 ± 1.0	3.69 ± 1.0
Understanding science[c]	3.84 ± 0.99	3.48 ± 1.1
Learning ethical conduct[c]	3.49 ± 1.2	2.99 ± 1.3
Learning lab techniques	4.13 ± 1.1	3.92 ± 1.2
Ability to read primary literature	3.78 ± 1.0	3.48 ± 1.2
Skill in how to give an effective oral presentation	3.70 ± 1.2	3.31 ± 1.3
Skill in science writing	3.48 ± 1.1	3.05 ± 1.2
Self-confidence	3.68 ± 1.1	3.46 ± 1.1
Understanding of how scientists think[c]	3.71 ± 0.98	3.50 ± 1.0
Learning to work independently	3.99 ± 1.0	3.74 ± 1.1
Becoming part of a learning community	3.95 ± 1.0	3.67 ± 1.1

Lopatto 2007
CBE Life Sci Educ 6(4): 297-306

Pergamon

Learning and Instruction 13 (2003) 533–568

Learning and Instruction

www.elsevier.com/locate/learninstruc

Abstract

This meta-analysis has two aims: (a) to address the main effects of problem based learning on two categories of outcomes: knowledge and skills; and (b) to address potential moderators of the effect of problem based learning. We selected 43 articles that met the criteria for inclusion: empirical studies on problem based learning in tertiary education conducted in real-life classrooms. The review reveals that there is a robust positive effect from PBL on the skills of students. This is shown by the vote count, as well as by the combined effect size. Also no single study reported negative effects. A tendency to negative results is discerned when considering the effect of PBL on the knowledge of students. The combined effect size is significantly negative. However, this result is strongly influenced by two studies and the vote count does not reach a significant level. It is concluded that the combined effect size for the effect on knowledge is non-robust. As possible moderators of PBL effects, methodological factors, expertise-level of students, retention period and type of assessment method were investigated. This moderator analysis shows that both for knowledge- and skills-related outcomes the expertise-level of the student is associated with the variation in effect sizes. Nevertheless, the results for skills give a consistent positive picture. For knowledge-related outcomes the results suggest that the differences encountered in the first and the second year disappear later on. A last remarkable finding related to the retention period is that students in PBL gained slightly less knowledge, but remember more of the acquired knowledge.


SCIENCE
2020
TRANSFORMING
SCIENCE
EDUCATION
FOR
EVERYONE