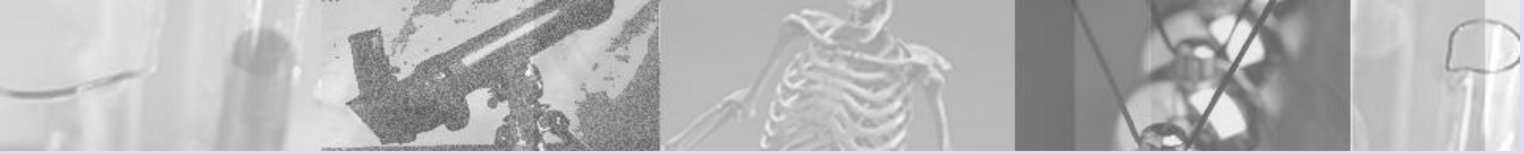

STEM Discipline Faculty in Support of Teacher Education

Dr. Cherilynn A. Morrow
Georgia State University

for the MSP Workshop entitled:

Best Practices for Science Teacher Professional Development

Earth Space Science Partnership
Penn State University
17 May 2011

cmorrow@gsu.edu

THE NEED

From Chapter 1 of the Glenn Commission Report (2000)*:

“Our children are not just losing the ability to respond to the challenges already presented by the 21st century, but …” [they are also losing the ability to respond to the *potential* of the 21st century]. “We are failing to capture the interest of our youth for scientific and mathematical ideas. We are not instructing them to the level of competence they will need to live their lives and work at their jobs productively. Perhaps worst of all we are not challenging their imaginations deeply enough.”

*pp 4-5, *Before It's Too Late*, National Commission on the Mathematics and Science Teaching for the 21st Century, 2000

THE NEED

21st Century Skills

1. Global Awareness
2. Creativity & Innovation
3. Solving, complex, multi-disciplinary, open-ended problem solving
4. Thinking critically about information
5. Communication
6. Civic responsibility and leadership

Before It's Too Late, National Commission on the Mathematics and Science Teaching for the 21st Century, 2000

High-Level Advocacy

"I now view effective science education partnerships between scientists and precollege education science teachers in a completely different light - as the only hope for lasting systemic change in precollege science education and, therefore, as an important national priority for the United States."

- Bruce Alberts, 1993

President, National Academy of Sciences

Scientists and Science Education Reform: Myths, Methods, and Madness

by

James M. Bower
Co-Director: Caltech Precollege Science Initiative
Associate Professor of Biology
California Institute of Technology
Pasadena, California

http://www.nationalacademies.org/rise/backg2a.htm

....perhaps the most important personal consequence of my involvement with science education reform has been a growing awareness of how poorly I have taught my own students. Prior to involvement in this project, I knew remarkably little about good science education. After ten years of involvement with precollege science, I have become profoundly aware of the negative effect the poor teaching of science in colleges and universities has on the rest of the educational system. In many ways, colleges and universities set the standards for the entire educational system. So, while I wish to encourage scientists to contribute to the public schools, the most significant consequence for students of this involvement may very well be fundamental reform in the way we educate our own students. After all, the curriculum we ourselves control should be the easiest to change. - James Bower, 1995

Penn State and Georgia State both belong to this national network

SMTI
Science & Mathematics Teacher Imperative

Association of Public and Land-Grant Universities
1307 New York Avenue, NW, Suite 400
Washington, DC 20005-4722

Science & Mathematics Teacher Imperative

Supported with funding from
National Science Foundation

The Monotillation of Traxoline

It is very important that you learn about traxoline. Traxoline is a new form of zionter. It is monotilled in Ceristanna. The Ceristannians gristerlate large amounts of fevon and then bracter it to quasel traxoline. Traxoline may well be one of our most lukized snezlaus in the future because of our zionter lescelidge.

Directions: Answer the following questions in complete sentences.

1. What is traxoline?
2. Where is traxoline monotilled?
3. How is traxoline quaselled?
4. Why is it important to know about traxoline?

Attributed to Judy Lanier

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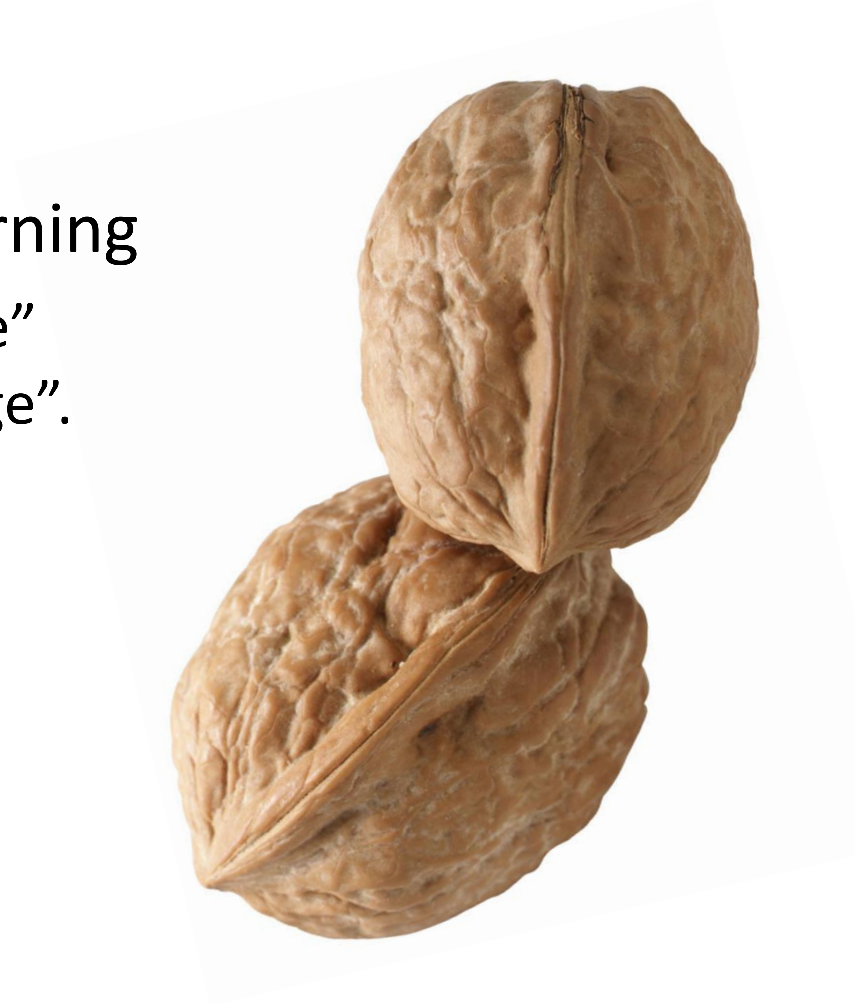
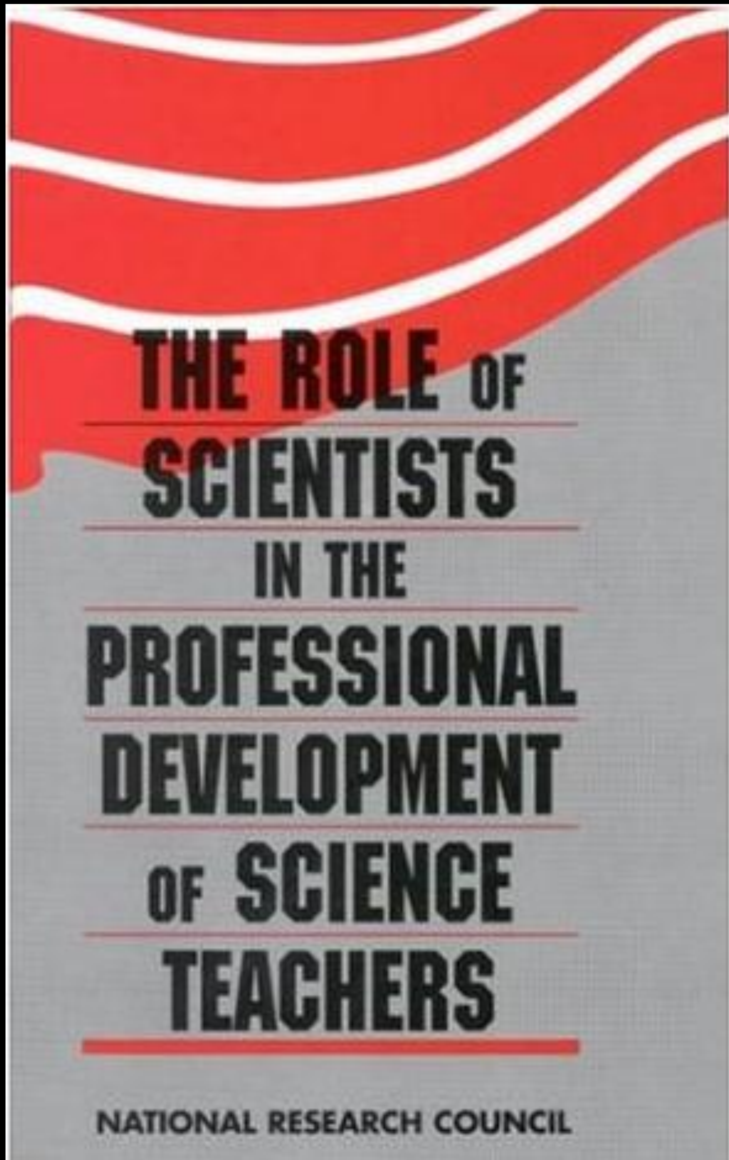
Modern Science Education Reform in a nutshell

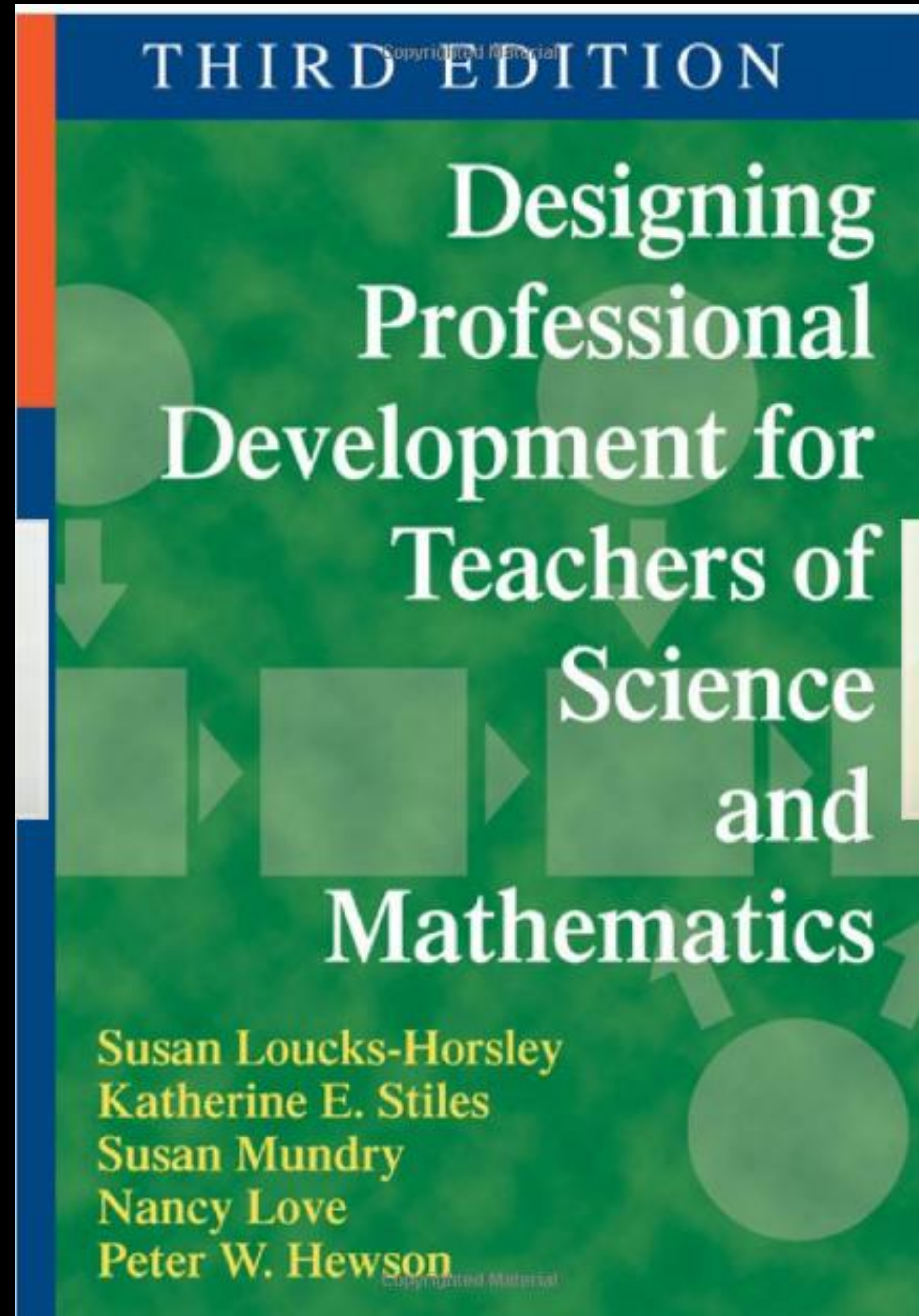
- Students as "scientists" with teachers as facilitators of learning
  - Teacher as "a guide on the side" rather than a "sage on the stage".

- "Inquiry-based" process of teaching & learning
  - "The way scientists *do* science rather than the way they were *taught* science."




THE ROLE OF
SCIENTISTS
IN THE
PROFESSIONAL
DEVELOPMENT
OF SCIENCE
TEACHERS
NATIONAL RESEARCH COUNCIL

1996


THIRD EDITION
Designing
Professional
Development for
Teachers of
Science
and
Mathematics
Susan Loucks-Horsley
Katherine E. Stiles
Susan Mundry
Nancy Love
Peter W. Hewson

2010

Attributes of an Effective Professional Learning Opportunity for K-12 Teachers

1. directly aligned with students learning needs;
2. intensive, ongoing, and connected to practice;
3. focused on the teaching and learning of specific academic content;
4. connected to other school initiatives;
5. intent on creating time and space for teachers to collaborate and build strong working relationships with each other and with capable partners;
6. continuously monitored and evaluated.

Similarities

- Everything that SLH says that K-12 science teachers need to improve their practice has a parallel in terms of what scientists need to improve their own teaching practice.
- Ongoing partnerships and collaborations between Scientists and K-12 Teachers are an excellent way to serve both, and a make a powerful, positive difference.

OPERA: Doing Science: Learning Science

Doing Science

- Raise fundamental question of interest
- Research what is already known (literature search)
- Plan & implement experiment
- Reflect on results and how they affect what was known before
- Communicate learning via talks & papers – peer assessment

Learning Science

- Engage students, Excite Curiosity. OPEN inquiry
- Elicit PRIOR knowledge of students and PREDICTIONS.
- EXPERIENCE or hands-on EXPLORATION/EXPERIMENT
- REFLECT on results and explain how they relate to prior knowledge/predictions.
- APPLY/ASSESS - communicate learning for student & teacher assessment

What are Opportunities for Current and Future Scientists to Develop More Scholarly Awareness and Practice of Teaching & Learning in Science?

- **As Undergraduates**
  –
  –
  –
- **As Graduate Students**
  –
  –
  –
- **As Faculty members**
  –
  –
  –

What are Opportunities for Current and Future Scientists to Develop More Scholarly Awareness and Practice of Teaching & Learning in Science?

- **As Undergraduates**
  - Observing and experiencing how Skilled College Instructors Teach
  - Serving as Peer Instructor for Introductory Courses
  - Doing a K-12 Classroom Internship [“First Taste of STEM Teaching”]
- **As Graduate Students**
  - Participating in an NSF G-K12 Program
  - Participating in *some* Lab Instructor Training Programs
- **As Faculty members and Research Scientists**
  - Participating in workshops at professional society meetings
  - Attending an MSP or other workshop or institute (e.g. HHMI)

Beyond Institutes & Workshops

- Susan Loucks-Horsley's (SLH's) book calls for:

"ongoing, sustained collaborative learning beyond institutes and workshops"

WHY?

Beyond Institutes & Workshops

- SLH calls for “ongoing sustained collaborative learning beyond institutes and workshops”
  - Partnering with a practicing K-12 teacher to enhance capacity for inquiry-based teaching informed by pedagogical content knowledge.
  - Collaborating with an education researcher to enhance capacity for measuring student learning and attitudes.

Comparing Approaches to Teaching

A Conventional Approach

The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and asks students to memorize the names of the different types of trees according to the sort of bark and leaves they have.

Comparing Approaches to Teaching

A Conventional Approach	A Hands-On Approach
The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and asks students to memorize the names of the different types of trees according to the sort of bark and leaves they have.	The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and takes students to the park and asks them to match the pictures with the real trees.

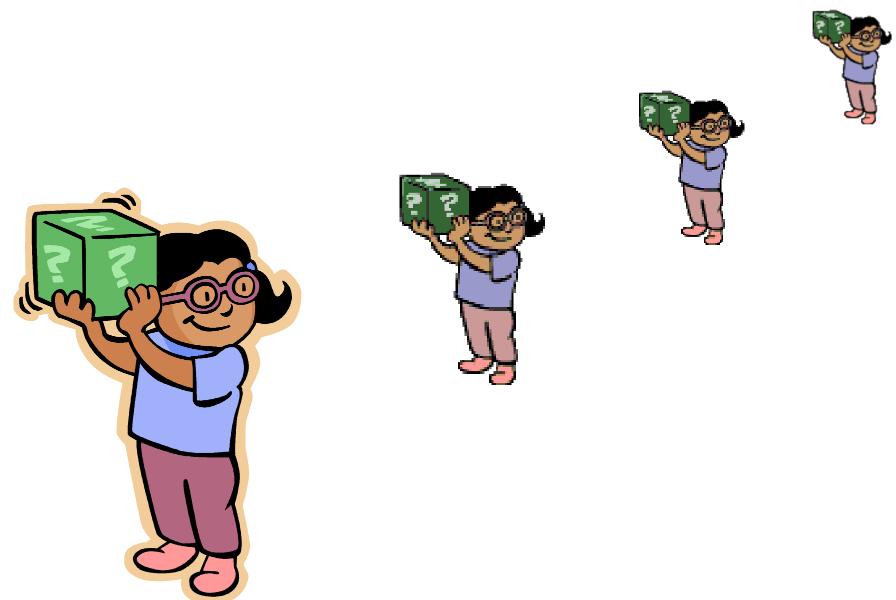
Comparing Approaches to Teaching

A Conventional Approach	A Hands-On Approach	An Inquiry-Based Approach
The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and asks students to memorize the names of the different types of trees according to the sort of bark and leaves they have.	The teacher tells students that trees can be classified by examining their bark and their leaves. She shows pictures of trees in a textbook and takes students to the park and asks them to match the pictures with the real trees.	The teacher tells students that scientists classify trees by the different features they have. She asks them to come up with ideas for what features would distinguish one tree from another. She takes them to the park to explore their ideas and to make observations and gather data that would help them create their own classification scheme for trees. They later compare their own results with established schemes.

Hands-on ≠ Inquiry-based

How could hands-on with sea shells become an inquiry-based activity?

≠



17 May 2011

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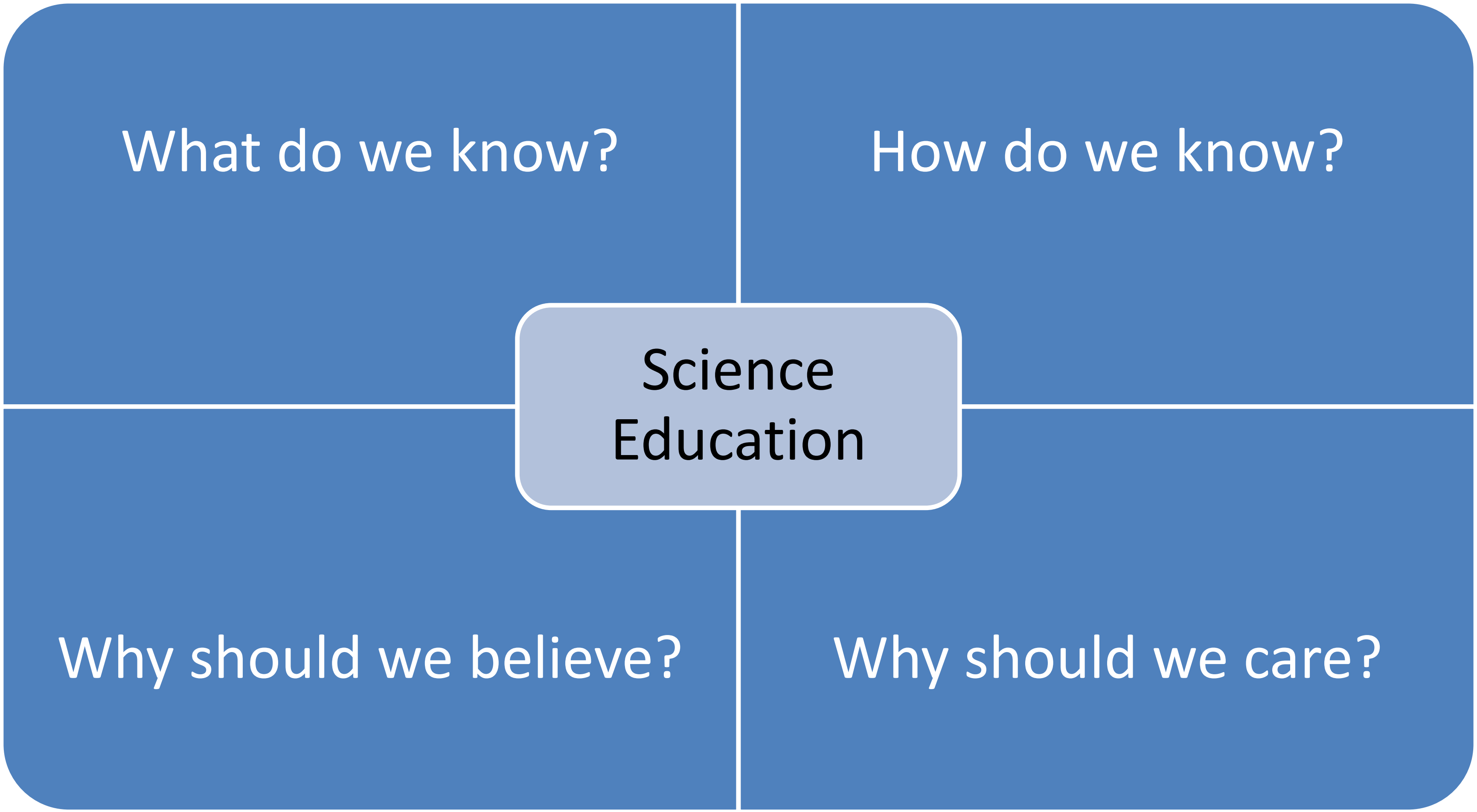
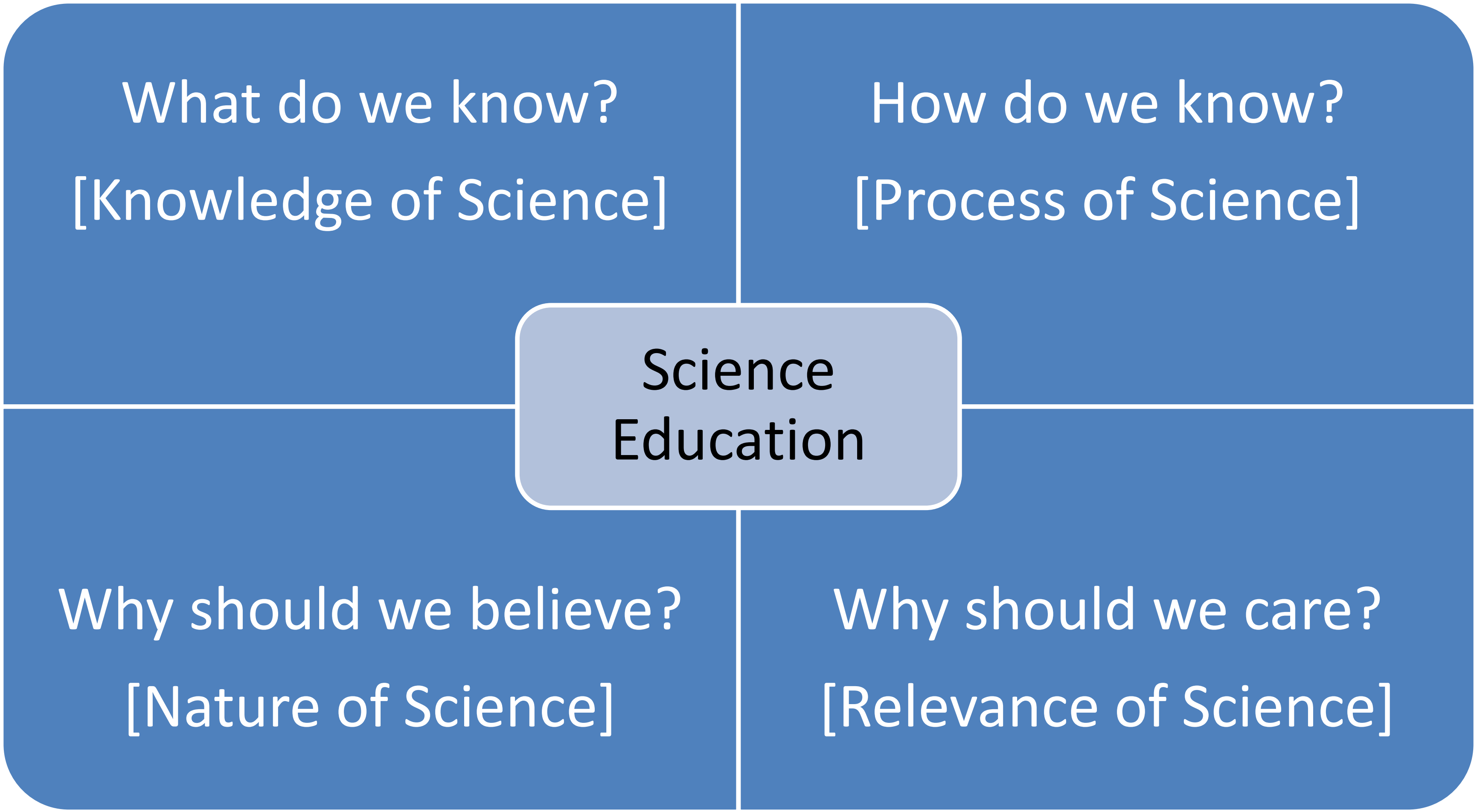
Art Eisencraft – NSTA 2011 Presentation

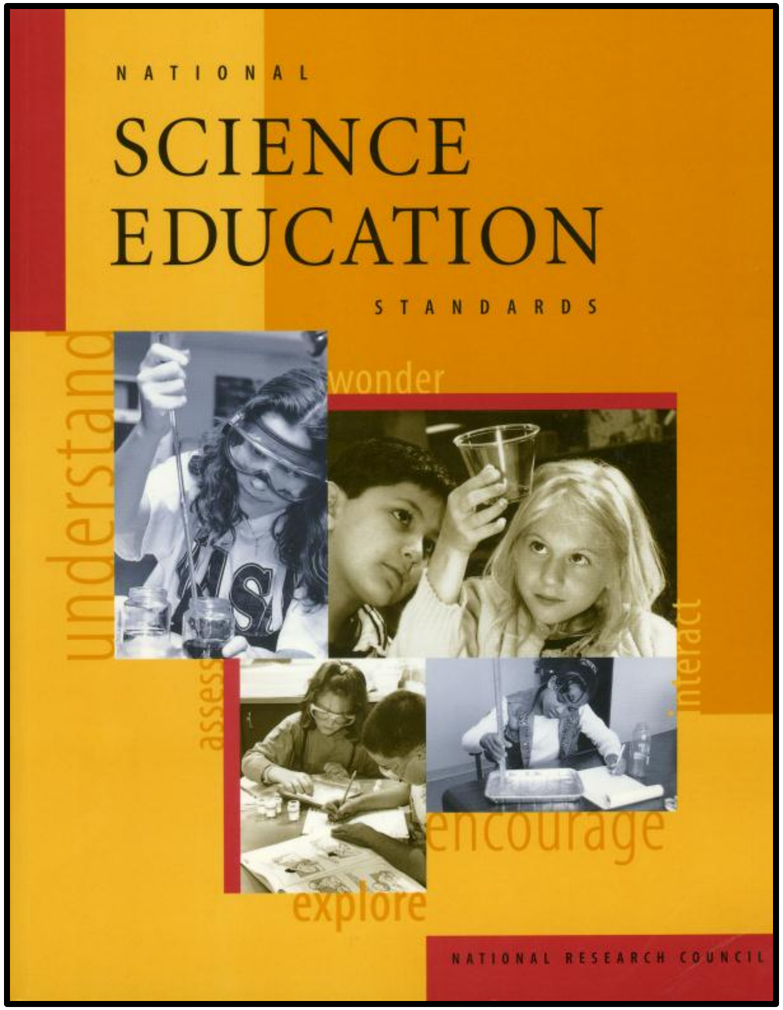


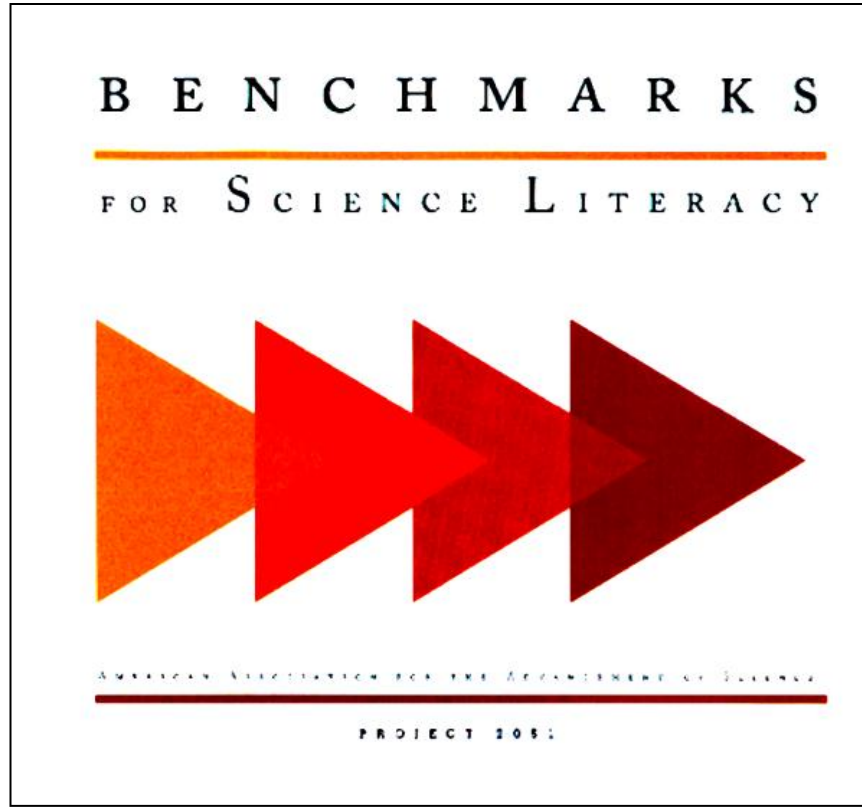
Art Eisencraft – NSTA 2011 Presentation

[Mapped to terms from Science Standards]



National K-12 Science Education Standards





AGU Endorsement of the
AAAS Benchmarks and NRC Standards

Adopted by AGU Council December 2001

Art Eisencraft – NSTA 2011 Presentation

[Mapped to terms from Science Standards]

What do we know?

[Knowledge of Science]

How do we know?

[Process of Science]

Abilities of Inquiry

Science Education

Why should we believe?

[Nature of Science]

Understanding Inquiry

Why should we care?

[Relevance of Science]

New NRC Framework for K-12 Science Education

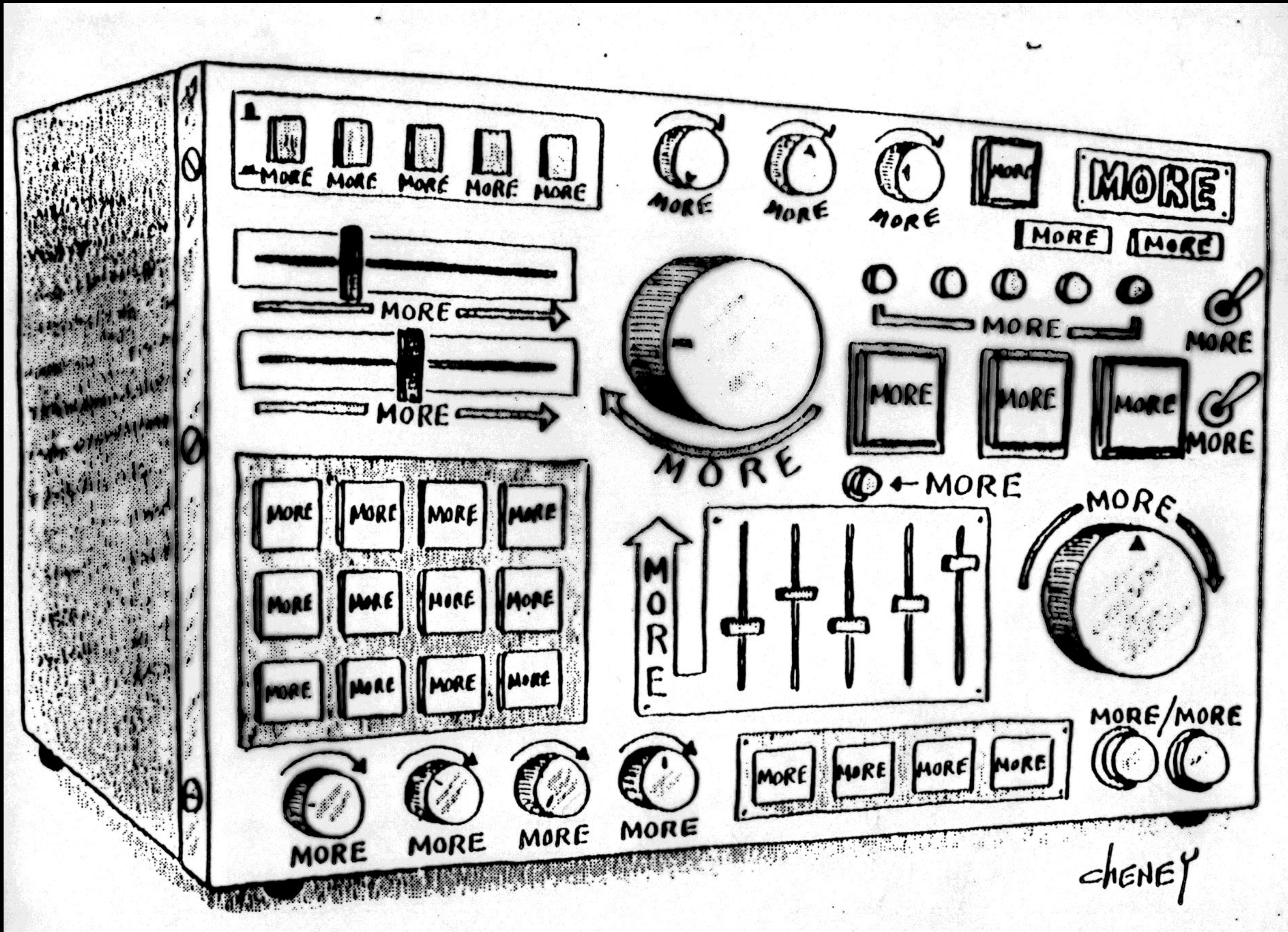
"Conceptual Framework to Guide the Development of Next Generation Standards for K-12 Science Education".

- **Funded by the Carnegie Corporation,** NRC began work early in 2010 to develop a conceptual framework to guide the development of the next generation of science education standards.
- NRC Identifies Summer 2011 as Target Release Date for Framework to Guide Next Generation of Science Education Standards
- When the final framework is complete, Achieve, Inc., will begin the science standards writing process based on this framework. To read the update, visit the National Academies website.

Why are next-gen standards needed?

- The previous NRC Science Education Standards and AAAS Benchmarks for Science Literacy are 15 years old. Since then teaching and learning science has generated new findings about how students learn science.
- From the past 10-15 years, we know a great deal more now about how standards are implemented at the state level and the challenges inherent in translating standards into curriculum, instruction, and assessment.
- General agreement that most current standards lead to curricula and textbooks that contain too many topics covered in too little depth. The new conceptual framework aims to address this issue.
- NRC's development of a new conceptual framework is the first step in a process that can inform state level decisions and achieve a research-grounded basis for improving science instruction and learning across the country.

"LESS" is "MORE"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Why are next-gen standards needed?

- focusing on essential concepts and practices so students have the time and opportunity to develop in-depth understanding.

- Core ideas are those ideas that have the greatest explanatory value in the disciplines of science. Identification of these core ideas will help organize and focus science curriculum, instruction and assessments on the most important aspects of science. The framework will illustrate how students can engage with these ideas over multiple grades.

K-12 Science Education Standards

At their best, standards contain Fundamental Concepts and Core Ideas. Our missions and science investigations can be used as inspirational contexts for teaching these BIG IDEAS that cross disciplinary boundaries.

Systems

Cycles

Energy Transfer & Transformation

Forces & Motions

Pattern & Scale

Science as Inquiry

K-12 Science Education Standards

Which BIG IDEAS could you use for the science topics
you would most like to share with teachers?

CORE IDEAS	SCIENCE TOPICS
Cycles	Seasons & Moon Phases
Systems	Climate Change
Energy Transfer & Transformation	Renewable Energy
Forces & Motions	Planetary Orbits
Pattern & Scale	Plate Tectonics
Science as Inquiry	ALL of them!!

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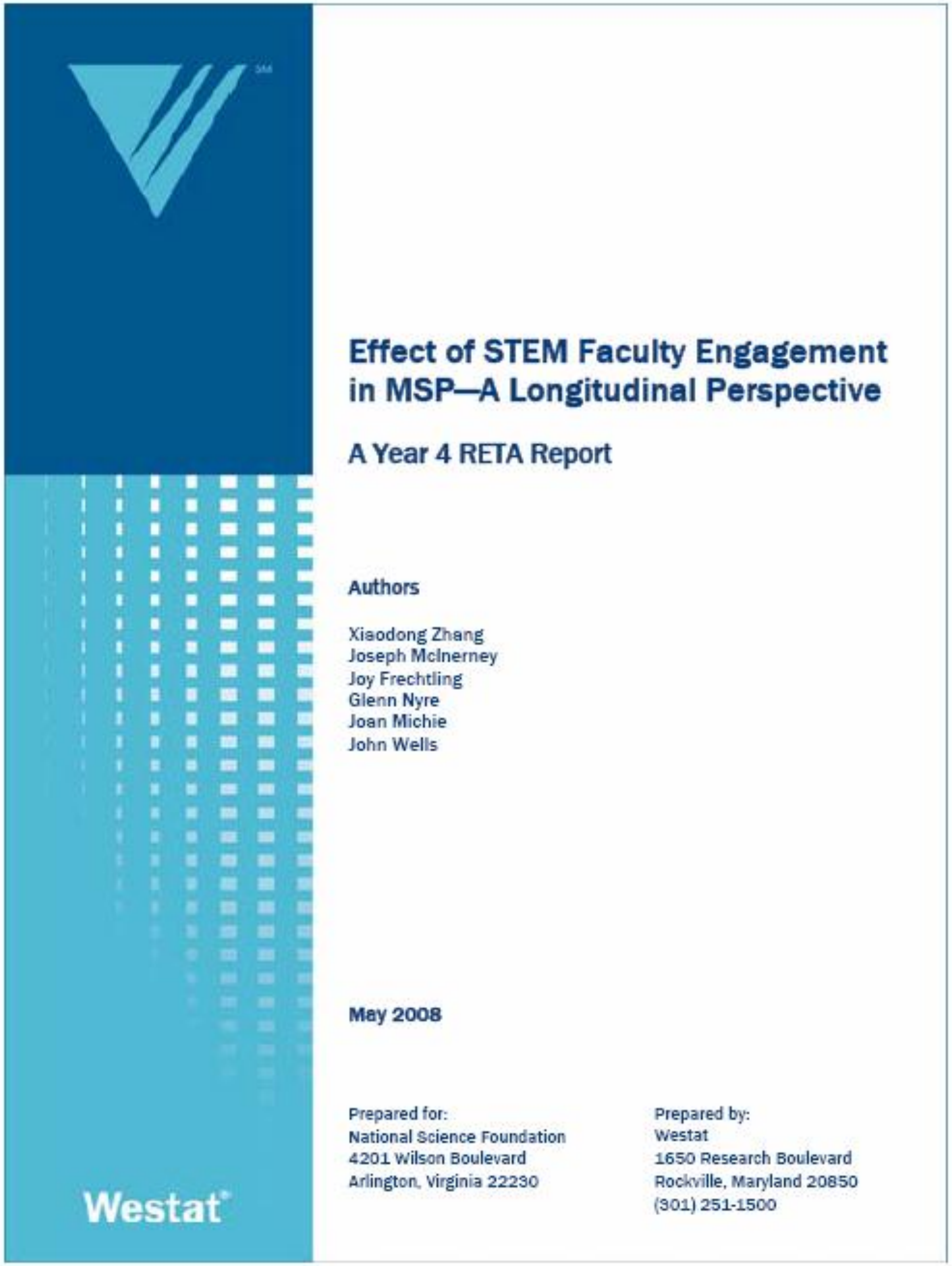
NSF Math Science Partnerships (MSP) Evaluation Report

- The MSP program posits that disciplinary faculty hold the knowledge that K-12 teachers need, and that if faculty are substantially involved, the chain of professional knowledge will be strengthened and result in improved student achievement.

- The **Westat** study is aiming to examine this assumption empirically.



Effect of STEM Faculty Engagement in MSP—A Longitudinal Perspective

A Year 4 RETA Report

Authors

Xiaodong Zhang
Joseph McInerney
Joy Frechtling
Glenn Nyre
Joan Michie
John Wells

May 2008

Prepared for:
National Science Foundation
4201 Wilson Boulevard
Arlington, Virginia 22230

Prepared by:
Westat
1650 Research Boulevard
Rockville, Maryland 20850
(301) 251-1500

Westat

Westat Research Questions

- What methods (i.e., strategies, practices, and policies) are being used by the projects to engage STEM faculty in their activities, and how do these differ by type of institution of higher education (IHE)?
- What levels of involvement are garnered by various methods at different types of IHEs?
- To what extent does STEM faculty involvement contribute to increases in K-12 teacher content and pedagogical knowledge?
- To what extent does STEM faculty involvement contribute to student achievement?
- What are the policy implications for engaging STEM faculty?
- How does faculty involvement evolve, and does it appear to have the ability to be sustained?

Westat Findings

"Initially, many STEM faculty expected to see positive impacts on teacher content knowledge. As the projects mature, there is an increasing realization among faculty that **pedagogical skill is at least as important as content knowledge for K–12 teachers."**

What is the Difference Between Content Knowledge and Pedagogical Content Knowledge?

The Moon appears to change shape every month because:

1. a piece of the Moon falls away at night
2. the shadow of Earth is cast upon the Moon, making part of the Moon's surface appear dark
3. clouds partially block our view of the Moon, making it appear to change shape
4. the portion of the Moon's surface we see lit up changes as the Moon orbits Earth
5. the slow rotation of the Moon changes the parts of the Moon we see lit up from Earth.

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What is the Difference Between Content Knowledge and Pedagogical Content Knowledge?

A large truck collides head-on with a small compact car. During the collision

___1. the truck exerts a greater amount of force on the car than the car exerts on the truck.

___2. the care exerts a greater amount of force on the truck than the truck exerts on the car.

___3. neither exerts a force on the other, the care gets smashed simply because it gets in the way of the truck.

___4. the truck exerts a force on the car but he car does not exert a force on the truck.

___5. the truck exerts the same amount of force on the car as the car exerts on the truck.

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What is the Difference Between Content Knowledge and Pedagogical Content Knowledge?

Take a moment to devise your own question that takes account of BOTH content knowledge and pedagogical content knowledge (PCK)

___1.

___2.

___3.

___4.

___5.

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Tips for Leading Inquiry-based Learning

1. Provide enough base knowledge and tools to set the stage for successful inquiry. Make the inquiry worthy, with real potential for inviting students to increase the degree of self-reliant thinking that will allow them to enjoy a discovery experience.
2. Know what common misunderstandings are related to your content and be equipped with a useful questioning strategy to help students engage in the higher order thinking needed to reason their way out to proper understanding. [applying pedagogical content knowledge]
3. Pose thought provoking questions and follow-up purposefully with other leading questions depending on what the student says. In general, "answer questions with questions" rather than "telling answers." Help students be reflective. Let them take their time when they need to think. **[magical minute]**
4. Don't give away answers at the beginning of the process. Resist the temptation to tell all the answers in an authoritative or didactic manner, especially when students are struggling. Allow exploration, including trial & error.
5. Provide opportunities for students to develop and answer their own questions.
6. Admit to not knowing all the answers yourself. Invite resourcefulness.

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Leading InQuiry Means

Q & Q

NOT

Q & A

DO Ask! Don't *Tell*.

17 May 2011

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Lecture is not ALL bad unless Lecture is ALL there is

 C. A. Morrow cmorrow@gsu.edu

Art Eisencraft in Active Physics Video Inquiry-based unit on Optics

1. Hands-on exploration with lenses. What do they do?
2. Chalk-talk/Lecture on how the lens equation works
3. Interactive class discussion about how the overhead projector must be working to do what it does.
4. Quantitative lab activity that makes measurements and leads to discoveries about the lenses
5. Student teams ***inquire*** into how the optics of the eye works and generate a presentation for the class?

GRADUATE students at a Space Physics Summer School at Boston University engaged in active learning (THINK-PAIR-SHARE)

Westat Findings

"Perhaps **the biggest surprise** is that participating STEM faculty increasingly acknowledged learning from the MSP experience in terms of becoming better teachers themselves, understanding K–12 perspectives, being exposed to teamwork and connections, and conducting research activities. The improvement of teaching in ways that are more active, collaborative, and student-centered for the STEM faculty **is one of the unintended consequences of the MSP activity."**

Morrow Comment:

It is perhaps (past) time to make improved STEM Teaching for Higher Education faculty an ***intended consequence of the MSP Experience***, not only for the INDIVIDUAL but also for the ORGANIZATION.

Successful Scientist-Educator Partnerships
P-A-R-T-N-E-R

- **P** is for Professional & Personal development (e.g. science knowledge, knowledge of education, communication skills, experience with understanding and addressing educational needs, perspective on exemplary practice, confidence in collaboration and leadership);
- **A** is for Appreciation (for one another as professionals in allied realms of endeavor);
- **R** is for Respect (for partner's professional expertise);
- **T** is for Trust (safety to reveal to your partner what you know and don't know; able to be critical friends; able to ask for what you need);
- **N** is for Needs (awareness of the practical needs of each partner – time constraints, meeting science standards, promotion & tenure);
- **E** is for Enjoyment; and
- **R** is for Responsibility (for navigating the challenges of the partnership, for addressing the needs of the learners, and for providing evidence of student learning).

Westat MSP Findings

Good news

K–12 teachers report:

- Value of collaboration and teamwork;
- improved approaches to teaching and learning;
- increased knowledge of subject matter content;
- increased confidence both as teachers and as colleagues with higher education faculty.

Good news

The STEM faculty report:

- Value of collaboration of teamwork;
- new ideas about teaching and learning
- more knowledge of the K–12 education system;
- a broader understanding of education overall.

Westat MSP Findings

Bad News

- Relatively few faculty members in the university STEM fields are willing to participate;
- Few benefits extend beyond those faculty who are direct participants;
- Few systemic changes have been made in IHE systems, especially the reward structure;

As an individual change process, MSP seems to be successful for many participants: As an organizational change process, MSP seems to be less successful.

WHAT TO DO? There are some incremental changes that may have long-term impact. Impact on student achievement is as yet uncertain.

Rows: RAPID

a memorable way to frame and communicate the full spectrum of Teacher Education

- R = Recruitment
- A = Advisement
- P = Preparation
- I = Induction
- D = Development

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Matrix of Roles for STEM Discipline Faculty in Support of Teacher Education

	SERVICE	INSTRUCTION	RESEARCH
RECRUIT	LOW: MED: HIGH:	LOW: MED: HIGH:	LOW: MED: HIGH:
ADVISE			
PREPARE			
INDUCT			
DEVELOP	LOW: MED: HIGH:	LOW: MED: HIGH:	LOW: MED: HIGH:

3rd draft Developed by C. Morrow Georgia State University (cmorrow@gsu.edu), stimulated by Analytic Framework of Coble et al.

THINK-PAIR-SHARE

Consider how would you represent in your professional dossier the time you spend mentoring a research experience for 1) a graduate student, 2) an undergraduate; 3) a high school teacher.

N/A:	Not Applicable
SERVICE:	Service to University, Society & Profession
INSTRUCTION:	Teaching & Learning
RESEARCH:	Research & Equivalent Creative Works
OTHER:	Please specify

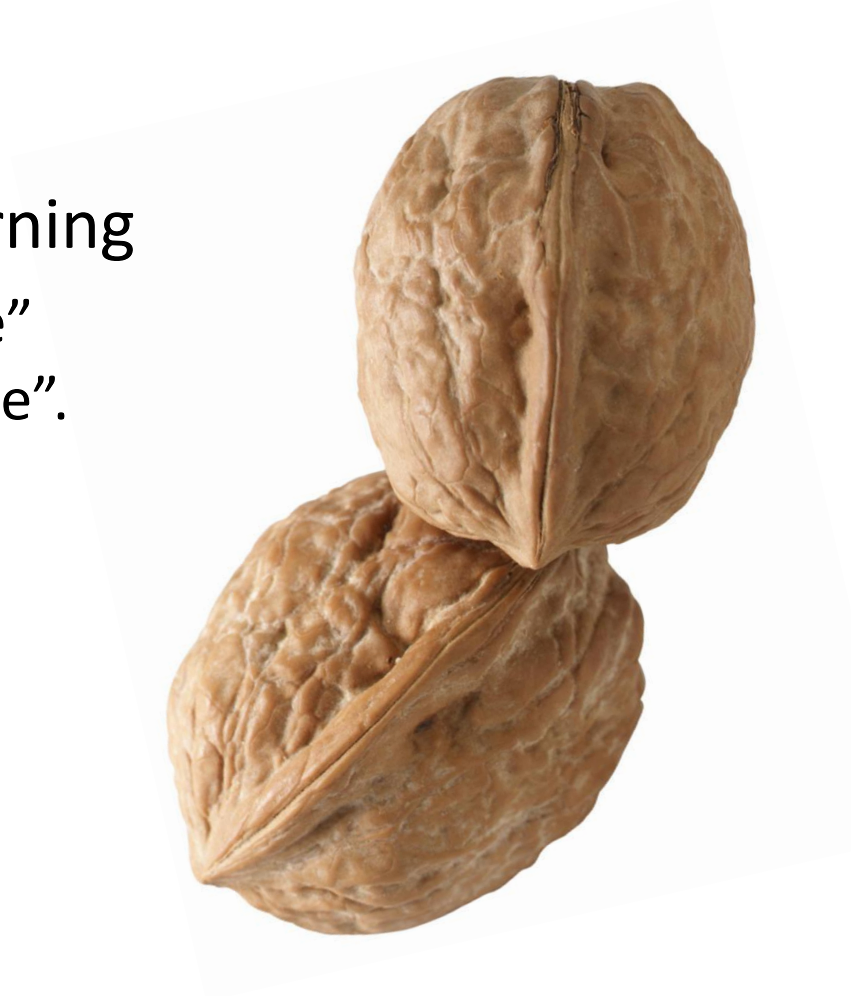
What Factors Matter?

1. *Nature of Engagement*
2. *Amount of Time,*
3. *Who* the Audience is,
4. Funded or Un-funded activity,
5. Whether Design, Organize, Teach, Present, Facilitate (do these words matter?)

SUMMARY

Modern Science Education Reform in a nutshell

- Students as "scientists" with teachers as facilitators of learning
  - Teacher as "a guide on the side" rather than a "sage on the stage".
- "Inquiry-based" process of teaching & learning
  - "The way scientists *do* science rather than the way they were *taught* science."



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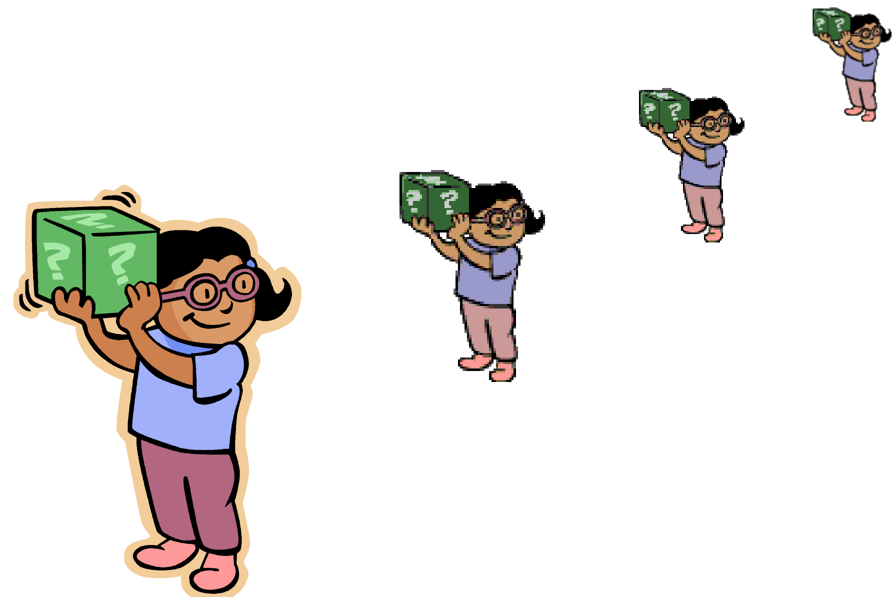

Art Eisencraft – NSTA 2011 Presentation
[Mapped to terms from Science Standards]

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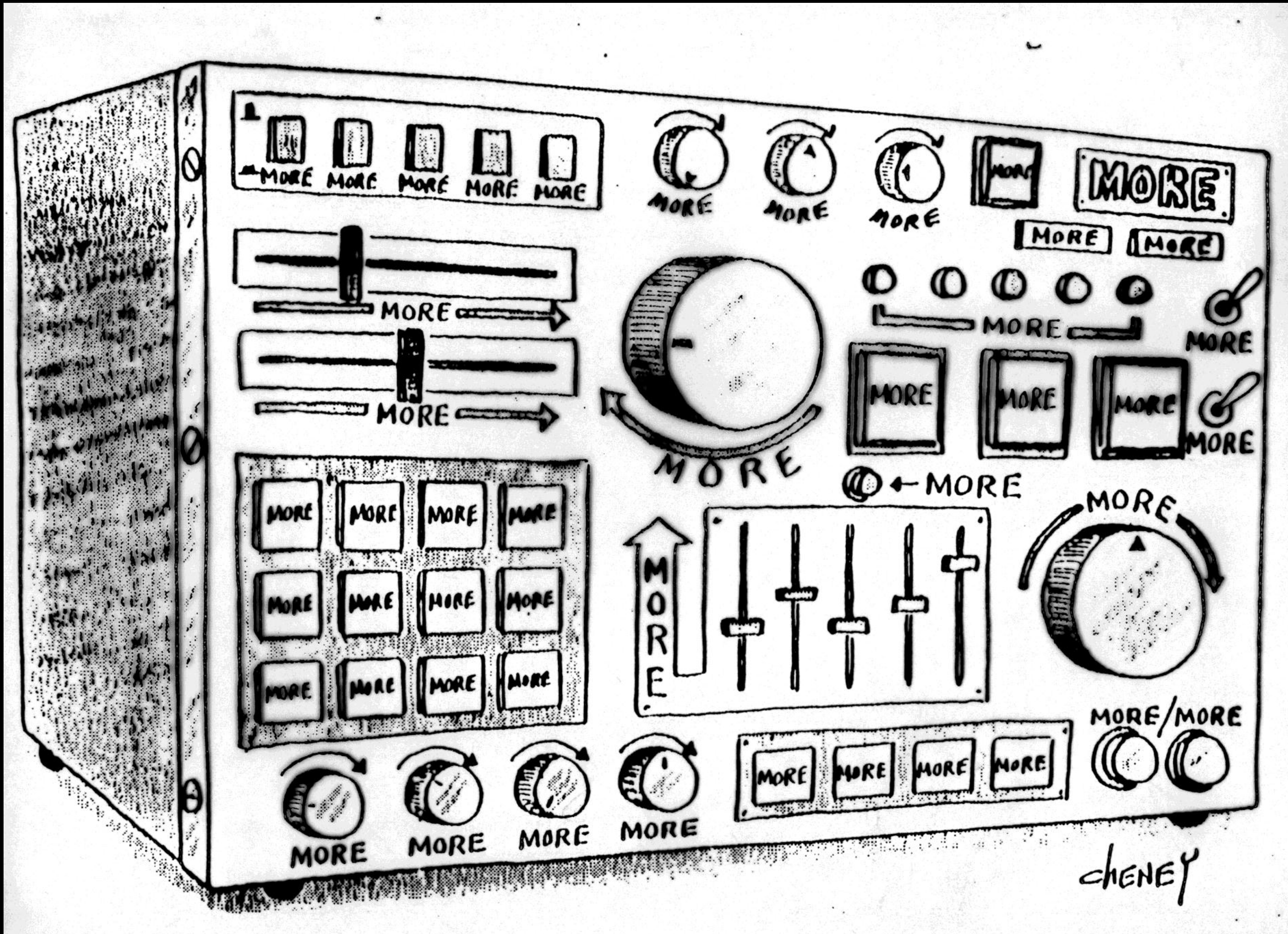
"LESS" is "MORE"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Westat Findings

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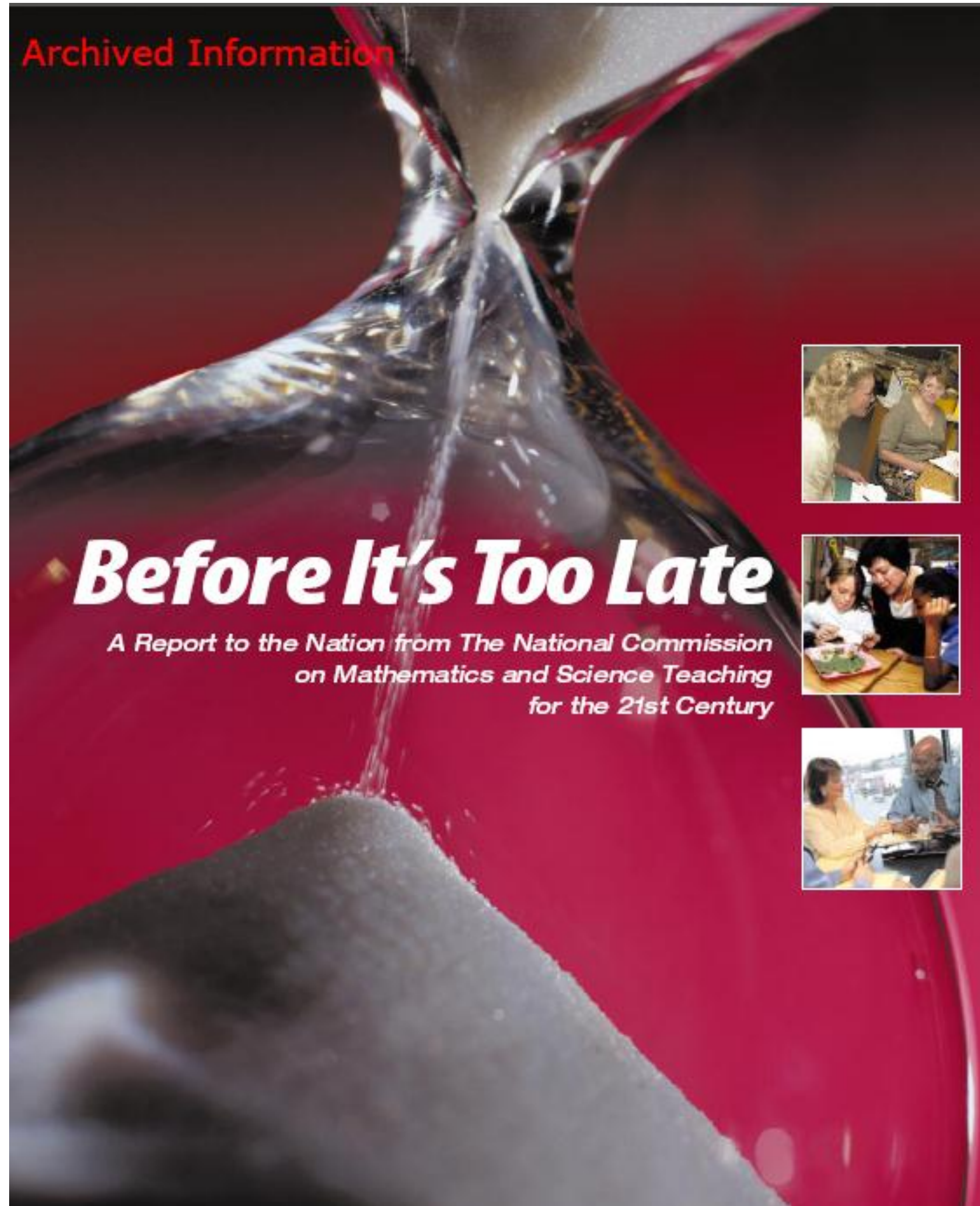
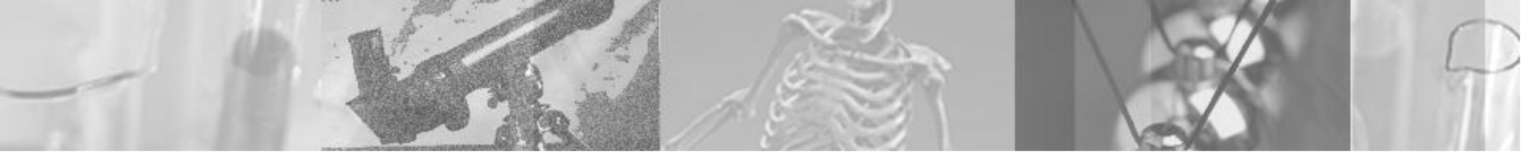


Before It's Too Late, National Commission on the Mathematics and Science Teaching for the 21^{st} Century, 2000



Key Point

- **Scientists and the institutions in which they work are being counted upon to embrace K-12 educators as colleagues in the STEM workforce and to work together to address the deep challenges of producing a 21^{st} century workforce capable of meeting 21^{st} century challenges with skill and innovation.**

- **Can we make the needed adjustments in our policies, programs, reward structures, and institutional cultures "before it is too late"?**

- **Your efforts in partnerships with teachers are an essential part of the needed transformation.**