
  
**THE Blueprint**  
for EDUCATIONAL CHANGE™

**Research-Based Practices  
For Science**

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**Agenda**

- The Need for Science Education
- Science Education Research Today
- The “Consumer Report” on Science Programs
- The TAMU Study for Effective Science Instruction
- Take-Aways for District Leaders



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**The Need for Science Education**



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## The Need for Science Education

- According to the U.S. Department of Labor, of the twenty fastest growing occupations projected for 2014, fifteen of them require significant science or mathematics preparation
- Our standard of living, changing economy and workplace depend on it
- Global competition and our national security interests are strengthened by it

Science, mathematics, and technology are



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## Do Dropouts Still Shock Us?

- Nationally, 1.2 million students drop out of school every year<sup>1</sup>
- Dr. Steve Murdock stated that the effective high school dropout rate for Hispanics in Texas is nearly 50 percent<sup>2</sup>
- 43% of Central Texas students are Hispanic and this student population is increasing faster than for the rest of Texas<sup>3</sup>
- A *conservative* estimate of the cost to Central Texas of a single class year of dropouts is \$425 Million<sup>4</sup>

1: Secretary of Education Arnie Duncan, Face the Nation, Sunday September 6, 2009  
2: The Academy of Medicine, Engineering, and Science of Texas, The Next Frontier, 2009  
3: E3 Alliance analysis of TEA ASES data, 2007-08  
4: Rouse, C. E. (2006). Labor market consequences of an inadequate education. Paper prepared for the symposium on the Social Costs of Inadequate Education, Teachers College of Columbia University, October 2005.



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## Science Gaps are Huge

### National Results:

- While Texas students rank relatively well in reading and math, our 8<sup>th</sup> graders ranked 37<sup>th</sup> of all states on the 8<sup>th</sup> grade Science NAEP Test (2007)

### Regional Results:

- Serious achievement gaps right here in Central Texas



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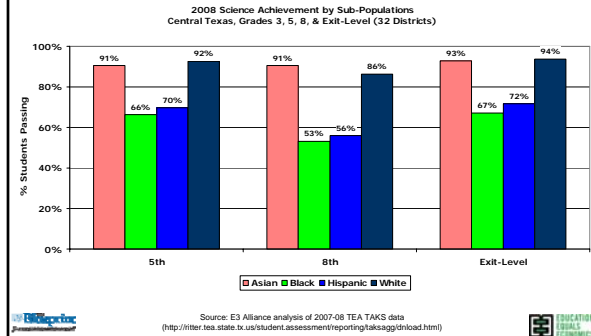
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## CT Science Achievement Gaps Range from 26 to 39 Percentage Points




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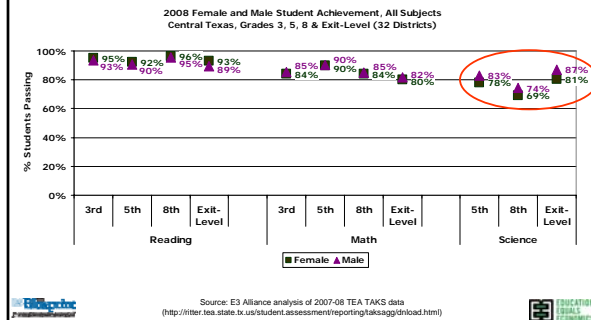
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## CT Females & Males on Par in ELA & Math But NOT in Science

### Gender Gaps of 5-6 Percentage Points




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## Too Few Science Teachers

- The average Texas teacher salary ranked 35<sup>th</sup> nationwide in 2007 (National Education Association)
- Science teacher salaries quickly stagnate, resulting in teachers leaving the classroom to seek higher paying positions in administration or the private sector<sup>1</sup>
- In 2007, about 4,000 Texas math and science teachers left the classroom, costing the state an estimated \$27 million to replace them<sup>2</sup>
- Implementation of the state 4x4 requirement will require 140 additional science teachers in Central Texas alone<sup>3</sup>

1: The Academy of Medicine, Engineering, and Science of Texas (TAMEST). The Next Frontier, 2009  
2: TAMEST, 2009  
3: Fuller, E.J. (2008b). Analysis of the Impact of the 4x4 Course Requirement in Central Texas Public High Schools. E3 Alliance. Austin, TX.

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## Impact on Global Competitiveness

The National Academy's Report *Rising Above the Gathering Storm* illustrated a precarious US economic position:

- The United States graduates about 70,000 engineers annually, yet *more than half come from overseas*
- India matriculates about 250,000 engineers and China has even greater number
- If this trend continues, *within a few years, 90% of all scientists and engineers in the world will live in Asia*

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## What Can We Do?

➤ TAMEST Education Committee Report on **Texas K-12 Math and Science Education** had the following recommendations:

- Recruit, reward and retain high quality STEM teachers
- Support STEM curricula that engages and encourages students
- Match STEM concepts to higher education and industry needs and reward students and schools that meet them

*47% of Dropouts said the major reason for dropping out was that classes were not interesting<sup>1</sup>*

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## SCIENCE EDUCATION RESEARCH TODAY

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## Science Education Research: Meta-Analysis & Research Reviews

- Meta-analysis → Many studies taken together
- Using 2 kinds of studies
  - Randomized assignment (RA; a.k.a. RCT)
  - Comparison study (CS; a.k.a. QED)
- RA & CS hard to do in education  
→ *Classrooms, not washing machines*

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## Meta-Analysis & Research Reviews Using RA & CS Studies

- RA & CS are “Gold Standard” in education research?
  - Problem 1: Lack of RA & CS studies
  - Problem 2: Conditions not entirely “natural”
- These studies, however, can tell us *something*
- RA & CS research can tell us about
  - Effects on “student achievement”
  - Effects on “student learning”

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## The “Consumer Report” on Science Programs

- Source: Urban Institute
- Research review of studies on **78** science programs
- But only **21** programs had research of high quality
- These programs had studies that:
  - Had a rigorous research design (RA or CS)
  - Reported effect on student achievement
  - Had high quality & valid data
- Description of effects use specific language
  - “Positive”, “Mixed”, “Indiscernible” effects

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## Key for Symposium Consumer Reports

Science Programs & Evidence of Effects on Student Learning



+ Strong evidence of positive effects

~L Limited evidence of effectiveness



☒ No qualifying studies or No studies meeting eligibility requirements

■ Program not reviewed



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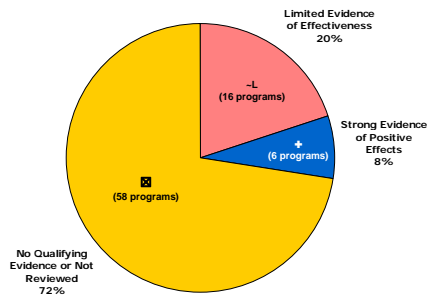
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## Summary of Consumer Report Ratings for Science



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## Urban Institute Found 6 Programs with Evidence of **Strong Effects** on Student Achievement in Science

- National Science Curriculum for High Ability Learners
- DESIGNS/DESIGNS II
- Center for Learning Technologies in Urban Schools (LeTUS)
- Foundational Approaches in Science Teaching (FAST)
- World Watcher/Learning About the Environment (LATE)
- Physics Resources and Instructional Strategies for Motivating Students (PRISMS)



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## Research-Based Teaching Strategies for Effective Science Instruction

- Also known as “The TAMU Study”
- Source: Texas A&M University, College of Science, Center for Mathematics & Science Education<sup>1</sup>
- Meta-analysis of ~400 studies on science instruction; only 62 studies qualified for inclusion
  - Had a rigorous research design (RA or CS)
  - Reported effect on student achievement
- The TAMU Study yielded 8 instructional strategies
  - Each strategy reported with an “effect size”

1: Schroeder, C.M., Scott, T.P., Tolson, H., Huang, T., Lee, Y. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching*, 4(1), pp.1436-1460.

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## What does the TAMU Study Tell US about Effective Science Instruction?

- Reports effect size & number of studies
  - Generally, effect size in education research
    - ♦ Above 0.8 is “strong”
    - ♦ 0.5 to 0.8 is “moderate”
    - ♦ Less than 0.5 is “weak”
  - Number of studies → ranges from 2 to 15 studies
- Reliability of results
  - 0.9 effect size & many studies versus
  - 0.5 effect size & 2 or 3 studies

1: Schroeder, C.M., Scott, T.P., Tolson, H., Huang, T., Lee, Y. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching*, 4(1), pp.1436-1460.

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## Recommended Science Instructional Strategies

### 1. Enhanced context strategies

- Effect size = 1.48, 6 studies
  - Incorporating real-life situations/data as contexts for problem solving
  - Using problem-based learning
  - Include field investigations

### 2. Collaborative grouping strategies

- Effect size = 0.96, 3 studies
  - Various opportunities for students to work as a team

Schroeder, C.M., Scott, T.P., Tolson, H., Huang, T., Lee, Y. (2007). A meta-analysis of national research: Effects of teaching strategies on student achievement in science in the United States. *Journal of Research in Science Teaching*, 4(1), pp.1436-1460.

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## Recommended Science Instructional Strategies

### 3. Questioning Strategies

- Effect size = 0.74, 3 studies

Examples:

- Responding to student questions with guiding follow-ups such as “What is your evidence?”
- Increased wait time
- Question students at the beginning of a lesson or unit to determine prior knowledge



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## Recommended Science Instructional Strategies

### 4. Inquiry Strategies

- Effect size = 0.65, 12 studies

Examples:

- Exploration, asking questions, and constructing explanations about natural phenomena based on evidence collected by students
- Obtaining and making sense of data



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## Recommended Science Instructional Strategies

### 5. Manipulation Strategies

- Effect size = 0.57, 8 studies

- Use concrete, tangible experiences that engage auditory, visual, tactile and kinesthetic learners.

Examples:

- Employ scientific tools to collect data;
- Build and use models or simple machines and tools,
- Create maps, graphic organizers, or diagrams.



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## Recommended Science Instructional Strategies

### 6. Assessment Strategies

- Effect size = 0.51, 2 studies
- Use of diagnostic assessment prior to instruction, formative assessments during instruction and summative assessment after instruction to guide teacher decisions and evaluate effectiveness of instruction
- Other assessment methods, such as science journals, self-assessments such as rubrics, and performance tasks, were all found to be effective

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## Recommended Science Instructional Strategies

### 7. Instructional Technology Strategies

- Effect size = 0.48, 15 studies
- Examples:
- Podcasts for instruction, connecting with other students or scientists via the Internet, virtual field trips, using the Internet to analyze real-world data, computer simulations.

### 8. Enhanced Materials Strategies

- Effect size = 0.29, 12 studies
- Teachers modification of pre-existing lessons, resources or activities to better address the needs of their students.

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## Take-Aways from This Morning

- What does it mean when a meta-analysis reports that your favorite strategy has “limited effects” on student achievement?
- What can you take away from the two studies we reviewed today?
- What from this morning do you want to take back to the office? What do you want to take back to schools in your district?

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***Thank you and enjoy lunch!***

***See you back here at 12:15 pm!***



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