Successful K–12 STEM Education

Identifying Effective Approaches in Science, Technology, Engineering, and Mathematics

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

Committee on Highly Successful Schools or Programs for K-12 STEM Education

Board on Science Education and Board on Testing and Assessment
Division of Behavioral and Social Sciences and Education

THE COMMITTEE

- Adam Gamoran, Chair, University of Wisconsin-Madison
- Julian Betts, University of California, San Diego
- Jerry Gollub, Haverford College
- Max McGee, Illinois Mathematics and Science Academy
- Milbrey McLaughlin, Stanford University
- Barbara Means, SRI International
- Steve Schneider, West Ed
- Jerry Valadez, California State University, Fresno

COMMITTEE'S CHARGE AND APPROACH

- Identify criteria for determining success in K-12 STEM education
- Hold a workshop on May 10-11, 2011 (www.nationalacademies.org/bose)
- Assess other available evidence
  - NRC reports *Taking Science to School* ,*How People Learn*, *Systems of State Science Assessment*, *Engineering in K-12 Education*, *America's Lab Report, Adding it Up*
  - Other syntheses and large-scale studies

ASPECTS OF STEM COVERED IN THE REPORT

- S, T, E, M as separate curricular areas
- Heavy emphasis on math and science

THE NEED TO IMPROVE STEM LEARNING

- **Successful K-12 STEM is essential for scientific discovery and economic growth**
- **Too many students leave school unprepared**
  - 75% of 8th graders are not proficient in mathematics
  - 10% of 8th graders meet international benchmarks in science
  - Gaps among students from different race/ethnic and economic backgrounds are wide

GOALS FOR U.S. STEM EDUCATION

1. Expand the number of students who pursue STEM careers, and increase women and minority participation.

2. Expand the STEM-capable workforce and increase women and minority participation.

3. Increase STEM literacy for all students.

PAUSING FOR REFLECTION

Expand the number of students who pursue STEM careers, and increase women and minority participation.

Expand the STEM-capable workforce and increase women and minority participation.

Increase STEM literacy for all students.

- **Does your school or district have explicit goals for science education?**
  - If yes, how do they fit with the three broad goals above?
  - If no, what do you see as the goals for science education in your school or district? ?

THREE AREAS OF SUCCESS

1. Student outcomes

2. STEM-focused schools

3. STEM instruction and school conditions

STUDENT OUTCOMES AS CRITERIA FOR SUCCESS

- Achievement tests
- Test scores are not the whole story
  - Example: Thomas Jefferson High School of Science & Technology
    - Inspire joy
    - Foster innovation
    - Promote ethical behavior and the shared interests of humanity
  - Ability to use STEM knowledge outside of school

STEM-FOCUSED SCHOOLS

- **Three types of specialized schools**
  1. Selective STEM schools
     - Mainly high schools that enroll small numbers of highly talented and motivated students
  2. Inclusive STEM schools
     - Organized around STEM disciplines but without selective admissions criteria
  3. STEM-focused CTE schools
     - Mainly high schools, aim to foster engagement and to prepare students for STEM-related careers

STEM-FOCUSED SCHOOLS

- Limited research base to compare effectiveness
- Potentially promising findings for each type of school
  - Success in selective schools occurs through student research experiences
  - Inclusive schools promote engagement and modestly lift test scores
  - Mathematics instruction and occupational education can be successfully integrated in CTE schools
- Specialized programs in regular schools such as AP and IB may also promote advanced study and career preparation

PRACTICES AS CRITERIA FOR SUCCESS

- Research base is much stronger
- "Practices" include instruction and school conditions

EFFECTIVE INSTRUCTION

- Effective instruction capitalizes on students' early interest, builds on what they know, and provides experiences to engage them in the practices of science and sustain their interest
  - Consistent with the *Framework for K-12 Science Education*
- Effective instruction can occur in all school types

PAUSING FOR REFLECTION

Effective instruction capitalizes on students' early interest, builds on what they know, and provides experiences to engage them in the practices of science and sustain their interest

- Name a few things you do in your classroom that are consistent with the vision for effective science instruction.
- What other strategies would you like to incorporate into your teaching? What supports do you need to incorporate those strategies?

KEY ELEMENTS SUPPORTING EFFECTIVE INSTRUCTION

1. A coherent set of standards and curriculum
2. Teachers with high capacity to teach in their disciplines
3. A supportive system of assessment and accountability
4. Adequate instructional time
5. Equal access to high-quality learning opportunities

SCHOOL CONDITIONS THAT SUPPORT LEARNING

1. School leadership as the driver for change
2. Professional capacity of faculty and staff
3. Parent-community ties
4. Student-centered learning climate
5. Instructional guidance for teachers

RECOMMENDATIONS FOR DISTRICTS

- Consider all models of STEM-focused and comprehensive schools
- Devote adequate instructional time and resources to K-5 science
- Ensure that STEM curricula are focused on core topics, are rigorous, and articulated as a sequence
- Enhance K-12 teacher capacity
- Provide instructional leaders with professional development to create supportive conditions

RECOMMENDATIONS FOR POLICY MAKERS

- Elevate science to the same level of importance as reading and mathematics
- Develop science assessments aligned with standards and emphasize science practices
- Invest in a coherent, focused, and sustained set of supports for STEM teachers
- Support research that addresses key gaps in current knowledge

FINAL REFLECTIONS: SOME QUESTIONS TO CONSIDER DURING INTERACT

- What actions can you take to begin putting some of the ideas in this report into practice right away?
- What kinds of changes in your school and district would be required implement these ideas?