Biological Sciences Curriculum Study

• emphasizing the *Curriculum Study*
• A non-profit organization established in 1958
• Our work is theory-based research and development projects resulting in
  – science curriculum materials,
  – professional development programs,
  – evaluation reports, and
  – empirical studies

• 3 lines of research in service of student learning
  – Nature of Curriculum
  – Teacher Learning and Practice
  – Leadership and Policy
The Mission of BSCS

is to **transform** science teaching and learning through research and development that **strengthens** learning environments and **inspires** a global community of scientifically literate citizens.
Overview of Session

• Considering the nature of science as practiced by scientists and students
• Framing Ideas about Science and Learning
• Characteristics of scientific explanations
• Research about Inquiry-based Instruction
• Research about Inquiry-based Curriculum
• Putting the Data-based Story Together
What do you think?

1. How are these two enterprises similar and different?
   • Science as scientists do it
   • Science in the classroom

2. Turn to a neighbor and discuss at least 3 similarities and 3 differences
Framing Ideas About Science & Learning
ArtScience

What is Art?

What is Science?

Where do Art and Science meet?
“Science presumes that the things and events in the universe occur in consistent patterns that are comprehensible through careful, systematic study.”

(American Association for the Advancement of Science [AAAS], 1989)
What are the characteristics of science that set the stage for school science?

- Scientists believe that the world is understandable.
- Science is not the search for the truth, but the search for more precise ways to explain and predict how the world works.
- The practice of science employs logical reasoning to connect evidence with conclusions.
- Science is all about sense-making—using logical reasoning to connect observations and data with accepted scientific explanations.

(AAAS, 1989)
How People Learn

Three key ideas emerged from the literature:

1. Learners come to class with preconceptions.
2. Learners need to develop a deep factual understanding based in a conceptual framework.
3. Learners need to set goals and analyze progress toward them.

(National Research Council, 2000)
Using Explanations to Increase Learning

- Explanations are rarely a part of classroom practice, but students need to be explicitly taught about explanations.
- Students have difficulty using appropriate evidence and including the backing for why they chose the evidence in their written explanations.
- Students typically discount data if the data contradicts their current theory.
- During classroom discourse, discussions tend to be dominated by claims with little backing to support their claims.
- Understanding of scientific principles is linked to ability to develop explanations.  
  (McNeil et al., 2006)
Research About Inquiry-based Instruction
Inquiry Synthesis by EDC

• 51% of studies showed positive impacts of inquiry science instruction on student content learning
• 33% showed mixed impact
• 14% showed no impact
• 2% showed negative impact

www.cse.edc.org
Teacher Practice

In a survey of 5,278 teachers

• Teaching practices and student objectives characteristic of inquiry consistently occurred with less frequency and emphasis than traditional teaching methods and learning goals.

• Only 12% of HS teachers said that they had “implemented recommendations from the National Science Education Standards in [their] science teaching” to a great extent.

(Hudson et al., 2002)
Fidelity of Implementation

• Inquiry-based instructional materials must be implemented with high or medium fidelity to improve student learning.

• Inquiry-based instructional materials implemented with low fidelity result in learning gains equal to traditional materials.

(Taylor, Van Scotter, & Coulson, 2007)
The Influence of Teacher Beliefs

• Teachers are more likely to implement inquiry-based instructional materials with high or medium fidelity if they believe that
  – Science is a way of understanding the world.
  – The teacher’s role is to guide students toward understanding.
  – Students are responsible for their own learning and all students are capable of learning.

(Carlson Powell, 1999)
A Key Characteristic of Effective Inquiry Instruction

• Effective inquiry-based instruction relies on significant scaffolding to guide student learning, and commonly involves timely direct instruction.

(Krajcik, Czerniak, & Berger, 1999; Schmidt, 1983; Schwartz & Bransford, 1998)
Research About Inquiry-based Curriculum Materials
Curriculum Materials

• Middle school students using the inquiry-based materials showed significantly higher learning gains than students in comparison classrooms. Specifically,
  
  – The treatment group had significantly higher pass rates on state standardized tests than the comparison group.
  
  – The effects were both cumulative (more exposure to inquiry-based units resulted in higher achievement on the tests) and enduring (the learning gains were evident a year and a half after participation in the units).

  (Geier et al., in press; Hickey, Kindfeld, Horwitz, & Christie, 1999)
A BSCS Experimental Study

• Equal numbers of students (ages 14-16) were randomly distributed into treatment and control groups.

• The treatment group experienced science instruction about sleep based on an instructional model that incorporates the findings from HPL and uses inquiry-based strategies.

• The control group learned about sleep through commonplace teaching practices.

• The teacher, content, instructional time, and assessments were held constant.

supported by the Office of Science Education at the National Institutes of Health
Results of the Experimental Study

• Students in the inquiry-based group had significantly higher posttest scores than students in the commonplace group.

• The commonplace unit resulted in significantly lower posttest scores for non-whites, yet no significant difference by race was present in the posttest scores of students in the inquiry-based group. There was also no significant differences in the pretest scores of white and nonwhite students in either group. In other words, NOT using inquiry increased the gap.

• Students in the inquiry group had significantly higher scores for claims and reasoning than students in the commonplace group.

(Wilson et al., 2010)
Achievement Gaps and C&I

• Several studies state that teaching science as inquiry reduces gaps (Kahle, Meece, & Scantlebury, 2000; Marx et al., 2004)

• Specifically, Kowalski et al. (2009) found that
  – HS students using inquiry-oriented curriculum materials demonstrated large, significant learning gains from pretest to posttest and the gains were not dependent on a student’s membership in any specific group (FRL status, race/ethnicity, or gender) once math level and pre-test score had been taken into account.
International Comparisons

• Based on an analysis of countries participating in TIMSS, top achieving countries have a more focused curriculum AND a more coherent curriculum

  – A **focused curriculum** has fewer topics (for example in the US grade 3 math has 50 more topics than the curriculum for Japan or Korea).

  – A **coherent curriculum** makes connections between big ideas through careful articulation, logical sequencing, and hierarchical placement.

(Houang & Schmidt, 2008)
Instruction, Fidelity, and Assessment

• Week-long forensics unit taught using 2 distinct instructional modes – verification inquiry and guided inquiry (1705 MS/HS students, 24 teachers, 7 schools)

• Guided inquiry instruction produced a greater change in test scores and stronger growth, particularly for high school students.

• Students in the guided-inquiry classrooms of teachers with high RTOP scores had higher scores and stronger growth than the other students. However, students in guided inquiry classrooms taught by teachers with low RTOP scores tended to score lower and had poorer growth than the students in the verification classrooms.

• School poverty level had a substantial effect on score and growth in score; however, students in the high-poverty schools showed a greater benefit from guided inquiry than did students in the low-poverty schools.

• The authors concluded that inquiry approaches are not incompatible with high-stakes test performance, particularly if teachers' fidelity of enactment of the inquiry lesson is enhanced by intensive PD experiences.

Curriculum and Professional Development: Together make a difference

• Study funded by the U.S. Department of Education
• Compared the use of *BSCS Science: An Inquiry Approach* with “Business-as-Usual” (BaU) science instruction.
• Design: cluster randomized trial (CRT) – participating teachers and students were assigned to treatment condition by school
• Treatment schools used BSCS Science in grades 9 and 10, with teachers receiving 7 days of professional development
• BaU schools used the materials and practices that they had used in prior years.
• Duration of the intervention duration was 2 academic years, from the beginning of grade 9 in 2009 through the end of grade 10 in 2011.
• The sample included 11 districts, 18 schools, 64 teachers, and 4,105 students.
Results

• Students in treatment schools scored higher on the state test on average than students in BaU schools at a statistically significant level (p=0.035).
• Students in treatment schools scored 3.1 percentile points higher on the state test than BaU schools.
• Instruction in the treatment classrooms more frequently engaged students in inquiry-oriented learning activities.

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The Most Compelling Data Indicate That

• Inquiry-based curriculum and instruction must be used together.
• Professional development often improves the use of inquiry-based materials.
• High quality inquiry-based C&I are distinguished by features such as
  – An overt and planned learning sequence – not random discovery learning;
  – A coherent flow of ideas with factual information intentionally connected to larger concepts and contexts;
  – Carefully scaffolding students’ opportunities to develop the abilities to conduct inquiries;
  – Emphasizing how to develop scientific explanations; and
  – Explicitly attending to how people learn.
Summary of Findings: Improving Understanding

- Paying attention to how people learn matters.
- Teacher beliefs matter.
- Curriculum materials can support the teaching of inquiry.
- Curriculum materials can eliminate achievement gaps.
- Inquiry-based instruction can eliminate achievement gaps.
- Inquiry-based instruction supported by complementary materials and professional development produces the most compelling results for learning, regardless of the assessment tool.
THANK YOU!

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Bibliography


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