Science and Engineering for Grades 6-12: Investigation and Design at the Center

Webinar on Pre-service and In-service Professional Learning
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nas.edu/Science-Investigation-and-Design

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The Board on Science Education and the National Academy of Engineering ran this study. They are part of the National Academies of Sciences, Engineering, and Medicine.

- A non-governmental organization founded in 1863
- Bring together committees of experts in all areas of scientific and technological endeavor
- Address critical national issues and give advice to the federal government and the public

Study Sponsors:
Committee Members

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Committee Charge

• Review research on science investigation and engineering design for middle and high school students conducted since publication of *America’s Lab Report* (National Research Council, 2006)

• Review will include research and evaluations of innovative approaches, such as computer modeling or use of large on-line data sets that have become more widely available since publication of the original report.

• Provide guidance for designing and implementing science investigation and engineering design for middle and high school students taking into account the new vision for science education embodied in the *Framework for K-12 Science Education* (National Research Council, 2012) and standards based upon it.
Context of our Study
Primary conclusion:
Investigation and design are more effective for supporting learning than traditional teaching methods.

What does this mean?
• Students work to make sense of phenomena or solve challenges in a way that integrates all three dimensions of the Framework
• Over time, students’ sense-making increases in depth and sophistication, as they make connections between concepts.
Report Chapters

• K-12 Science Education Past and Present
• Learning and Motivation
• How Students Engage with Investigation and Design
• How Teachers Support Investigation and Design
• Instructional Resources for Supporting Investigation and Design
• Preparing and Supporting Teachers to Facilitate Investigation
• Space, Time, and Resources
• The Education System and Investigation and Design
• Conclusions, Recommendations, and Research Questions
Why investigation and design?

- Teachers can use students’ curiosity to motivate learning by choosing phenomena and design challenges that are interesting and engaging to students, including those that are locally and/or culturally relevant.

- Inclusive pedagogies can support the learning of all students by situating differences as assets, building on students’ identities and life experiences.
How is the classroom different?

Science investigation and engineering design entail a **dramatic shift** in the classroom dynamic.

- **Students** ask questions, participate in discussions, create artifacts and models to show their reasoning, and continuously reflect and revise their thinking.

- **Teachers** guide, frame, and facilitate the learning environment to allow student engagement and learning.
How is assessment different?

Teachers
• Provide multiple opportunities for students to demonstrate their reasoning and show understanding of scientific explanations about the natural world.
• Observe student learning and embed assessment into the flow of learning experiences
• Allow students (and themselves) to reflect on learning
Teacher Guidance

The full Interactive Infographic is available at
https://www.nap.edu/resource/25216/interactive/
How do we support teachers in making this shift?
The professional learning continuum

- From preservice programs...
- ...to summer and school-year professional development sessions...
- ...to a teacher’s experience in his or her classroom...
- ...to formal and informal work between colleagues
Teacher Professional Learning

1. Professional learning changes throughout a teacher’s career. Professional development should be specific to the learner.

2. Engaging educators in making sense of science phenomena and engineering challenges should **model classroom instruction**, while addressing the needs of adult learners.

3. **Reflection on teaching and learning** is essential to move from professional development to implementation in the classroom.

4. **Application** of professional development instructional strategies and resources enhances teacher learning.

5. Professional development should address the specific **needs of each teacher’s student population**.

6. **Teachers are professionals** who learn throughout their career and implement research based strategies that best meet their student needs.
RECOMMENDATION 4:
High-quality, sustained, professional learning opportunities are needed to engage teachers as professionals with effective evidence-based instructional practices and models for instruction in science and engineering

- Administrators should identify and encourage participation in sustained and meaningful professional learning opportunities for teachers to learn and develop successful approaches to effective science and engineering teaching and learning.

- Professional development leaders should provide teachers with the opportunity to learn in the manner in which they are expected to teach, by using Framework aligned methods during professional learning experiences.

- Teachers should receive feedback from peers and other experts while working throughout their career to improve their skills, knowledge, and dispositions with these instructional approaches.

- Professional development leaders should prepare and empower teachers to make informed and professional decisions about adapting lessons to their students and the local environment.

- Administrators and education leaders should provide opportunities for teachers to implement and reflect on the use of Framework-aligned approaches to teaching and learning.
• **Engage teachers as professionals**
  – Honor and respect expertise teachers bring to PD
  – Establish appropriate learning environments
  – Respect teachers as adult learners

• **Sustained professional learning opportunities**
  – Duration of learning episodes
  – Coherence with evidence-based approaches

• **Practices**
  – Instructional practices & strategies
  – Use appropriate practices for the PD

• **Models** for instruction in science and engineering
  – Engage teachers in investigation and design
  – Models quality science teaching and learning
  – Provide resources for teachers to try out the advocated instructional approaches in own classroom
Supporting Professional Learning

• **Application of instruction consistent with the professional development** is essential for professional learning.
  – Sustained professional learning resides with the individual teacher and extends beyond workshops and professional development programs.
  – Individual and shared reflection on teaching and learning enhances the application in the classroom

• **Resources** consistent with the professional development approaches help sustain instructional changes.
  – Resources include - PPTs from PD sessions, books and articles describing the philosophical approaches of the PD, lessons and/or instructional units, formative assessments, and videos showing instruction consistent with advocated instructional approaches.
  – Ongoing access to professional development providers is important for teachers to validate the application of learning.
Questions?
RECOMMENDATION 5:
Undergraduate learning experiences need to serve as models for prospective teachers, in which they experience investigation and design as learners.

- College and university faculty should design and teach science classes that model the use of evidence-based principles for learning and immerse students in Framework-aligned approaches to science and engineering learning.

- Faculty should design and teach courses on pedagogy of science and engineering that use instructional strategies consistent with the Framework.

- College and university administrators should support and incentivize design of new courses or redesign of existing courses that use evidence-based principles and align with the ideas of the Framework.
Implementing recommendation 5:  
Science courses for future teachers

- Content drawn from the standards integrated with pedagogical practices

- Currently, primarily effectively implemented for elementary education majors—opportunities to expand to pre-service teachers at middle and high school levels

- Keys to success:
  - Make use of the practices
  - Provide opportunities to reflect on the learning process
Implementing recommendation 5: Intro/general education courses

- Where most future teachers get their science—engineering is rare

- Not typically designed to align with Framework-based standards or teaching methods

- Integrating more investigation and design will benefit future teachers AND future incoming students

- Keys to success:
  - Not known yet
Implementing recommendation 5: Teacher preparation programs

• Typically do not include science content courses

• Can include course-based research in required courses (UTeach model is an example)

• Can work with science departments to advise students into appropriate courses

• Keys to success:
  – Not known yet
Implementing recommendation 5:  
Research experiences for future teachers

- Undergraduate research experiences are a net benefit that engage students in many *Framework*-aligned practices

- Can be targeted for future teachers: STAR program pairs students with a researcher AND a master teacher

- Key components:
  - Reflection on applications to teaching
  - Help for students to integrate research into teaching
Implementing recommendation 5 SUMMARY: Promising practices

• Lots of opportunities for work in this area to understand how future teachers’ undergraduate science learning experiences can influence their teaching.
Summary

• Investigation and design are more effective for supporting learning than traditional teaching methods.
• Putting investigation and design at the center has a big impact on what teachers do in the classroom.
• Recommendations 4 and 5 describe ways to support current and future teachers in making this transition.
• Changes along the continuum of professional learning:
  – Science learning and research opportunities for pre-service teachers
  – High-quality, sustained professional development opportunities
  – Examples of success in both areas are available and could be more widely adopted.
QUESTIONS?

More Information on the report and registration links for the webinar can be found at *nas.edu/Science-Investigation-and-Design*

Today’s Presenters for the Webinar on Pre-service and In-service Teaching Professional Learning

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