



# Science and Engineering for Grades 6-12

## Investigation and Design at the Center

### A Guide for Principals

#### KEY POINTS

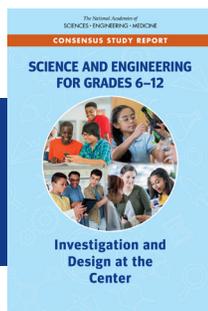
- A fundamental shift in how we teach science and engineering is needed to prepare students for the future. **Making science investigation and engineering design the central approach for teaching and learning science and engineering is a more effective and engaging way for students to learn.**
- Classrooms that engage students in science investigation and engineering design help them develop the STEM knowledge and competencies needed to make informed personal and political decisions and be ready for college and careers.
- It is critical to actively work to ensure that all students have equitable opportunities to engage in investigation and design.
- Principals are essential to supporting the necessary improvements to classroom practices, professional development, and instructional resources required to implement investigation and design.

#### PRINCIPALS CAN HELP BY

- Learning about investigation and design and sharing information on the benefits with parents.
- Ensuring professional learning opportunities provide teachers with instructional models and resources, mirror what should happen in the classroom, and are grounded in science and engineering.
- Providing time and structures, such as common planning periods, for teachers to work collaboratively to learn and implement new approaches and to reflect upon their own progress.
- Advocating for space and time for student to engage in science and engineering investigations.
- Developing policies and procedures that ensure **all** students have investigation and design opportunities.

**In these ways, you can support improvements in the teaching of science and engineering in your school, bring a broader spectrum of students into relevant and motivating learning environments, and help students to grow and learn.**

The Framework for K-12 Science Education, which guides the science education of many U.S. students, presents a vision for how students can learn more effectively about science and engineering. **Science investigation and engineering design** is a learning strategy that builds on the Framework in which students ask questions, participate in discussions, reason with evidence, and continuously reflect and revise their thinking. The students increase their understanding of foundational concepts of science and engineering, and improve their critical thinking and problem-solving skills. The science investigation and engineering design approach is a major refinement of the idea of inquiry and different from memorizing content or teaching the scientific



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

<https://nationalacademies.org/Science-Investigation-and-Design>

method. Teachers have developed many strategies for helping students to remember lots of scientific information, but that is no longer the focus of science and engineering learning. You play a key role in helping teachers receive the support they need to learn ways to structure instruction and support student learning.

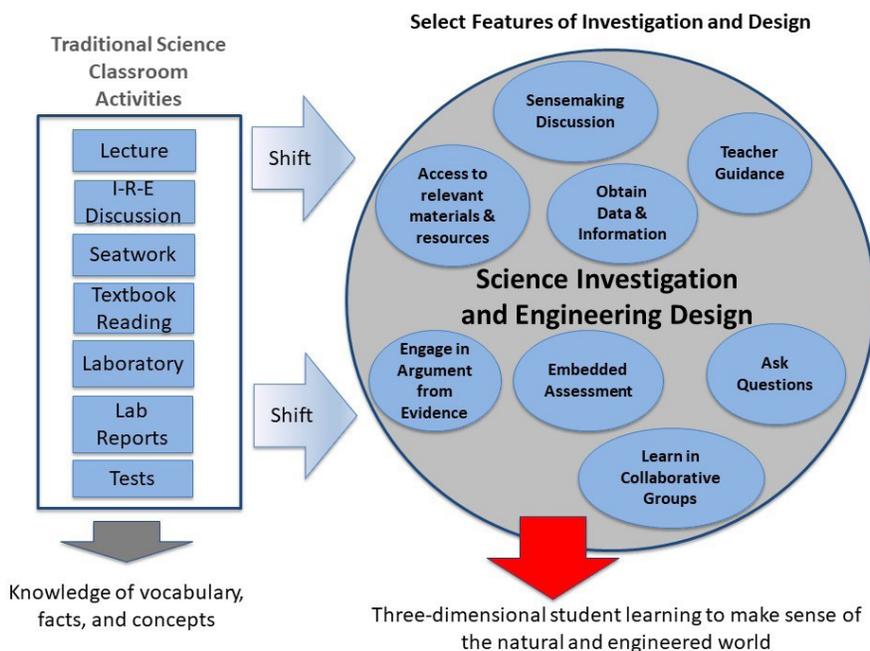
Through this common-sense approach, teachers structure instruction and support student learning so that the science content and skills combine and unfold in sequence for students. Science investigation and engineering design requires big changes to classroom practices and to professional development. **You play a critical role in implementing science curriculum and supporting teachers as they put investigation and design at the center of learning.** The 2018 National Academies report, *Science and Engineering for Grades 6-12: Investigation and Design at the Center*, provides guidance on how to get started. This brief focuses on ways you can support students, teachers, and administrators in using science investigation and engineering design.

## SCIENCE INVESTIGATION AND ENGINEERING DESIGN IN THE CLASSROOM

Putting science investigation and engineering design at the center of the classroom can help students learn about key concepts, strengthen critical thinking skills, and ultimately develop a life-long interest in science. Instead of memorizing content and repeating common laboratory exercises, all students engage with phenomena and challenges and ask questions, gather and analyze information, develop explanations, and communicate what they have learned. This helps them to make sense of the world around them. Figure 1 illustrates the shift.

When classes center science investigation and engineering design, teachers provide ongoing opportunities for students to show their reasoning and understanding of scientific explanations about the natural world. Instead of conducting frequent summative testing, teachers might assess student learning by observing, monitoring, and responding during the course of classroom investigation and design. Teachers use targeted discourse strategies to encourage students to share their reasoning; this sharing of student reasoning then informs instructional choices and provides a way for students to reflect on their own learning.

Because students are at the center of science investigation and engineering design, the classroom has a different structure and students are not all working on the same tasks at the same time. This approach gives the classroom a different energy than a traditional classroom; students talk and interact as they take ownership of their own learning. Students investigate specific observable events, which we call **phenomena**, in order to make sense of the world around them. They might explore phenomena such as why onions make you cry, or why you can sometimes see the moon during the daytime, or why we have fewer bees now than in the past. The students develop arguments and construct explanations, instead of



**Figure 1** Select features of science investigation and engineering design and how they differ from activities in traditional science classrooms. NOTE: The boxes in the list on the left contain examples of approaches used in traditional science classrooms. The small circles on the right represent examples of features of learning via investigation and design. The examples are not exhaustive, and many other approaches are possible within investigation and design.

learning vocabulary words or completing worksheets. When you visit a classroom engaged in science investigation and engineering design, there are a number of questions you can ask yourself to help see details of the approach (see Box).

Examples of investigation and design include:

- Students develop a design for a device that collects harmful plastics from local waterways.
- Students develop a pictorial or physical model to show how the flow of energy into an ecosystem causes change in the seasonal rate of growth of grass.
- Students develop an explanation for why the deer mice in the Sandhills of Nebraska area are a different color from the deer mice in surrounding areas.

## PRINCIPALS PLAY A KEY ROLE IN SUPPORTING TEACHERS

Putting science investigation and engineering design at the center of the classroom can help your students learn about key concepts, strengthen critical thinking skills, and ultimately develop a life-long interest in science. *As a principal you play a key role in ensuring school policies support high quality learning opportunities for all students so that a broader spectrum of students is engaged in relevant and motivating approaches to learning through science investigation and engineering design.* You can support teachers as they move toward this approach by providing well-aligned instructional resources; ensuring opportunities to engage in research-based professional learning experiences that engage teachers in investigation and design; and providing adequate time for teachers and staff to learn about inclusive pedagogies that promote equitable participation of all students. Figure 2 shows a vision of science investigation and engineering design in action by laying out roles for principals, teachers, and students.

## SOME STEPS YOU CAN TAKE

- **Ensure instructional resources provide teachers with ideas, structures, and guidance** for using phenomena and design challenges to help students learn science ideas by thinking and operating like scientists and engineers.
- **Provide access to sustained professional learning opportunities for teachers in which they dive deeply into science and engineering instructional resources that put investigation and design at the center of learning.** Ensure teachers have guidance and support as they implement changes. The opportunity to work in groups with colleagues and reflect upon their own learning is essential to integrating student-centered practices into the classroom. Teachers cannot be expected to implement this vision for teaching and learning of science and engineering while old models of professional development are utilized.

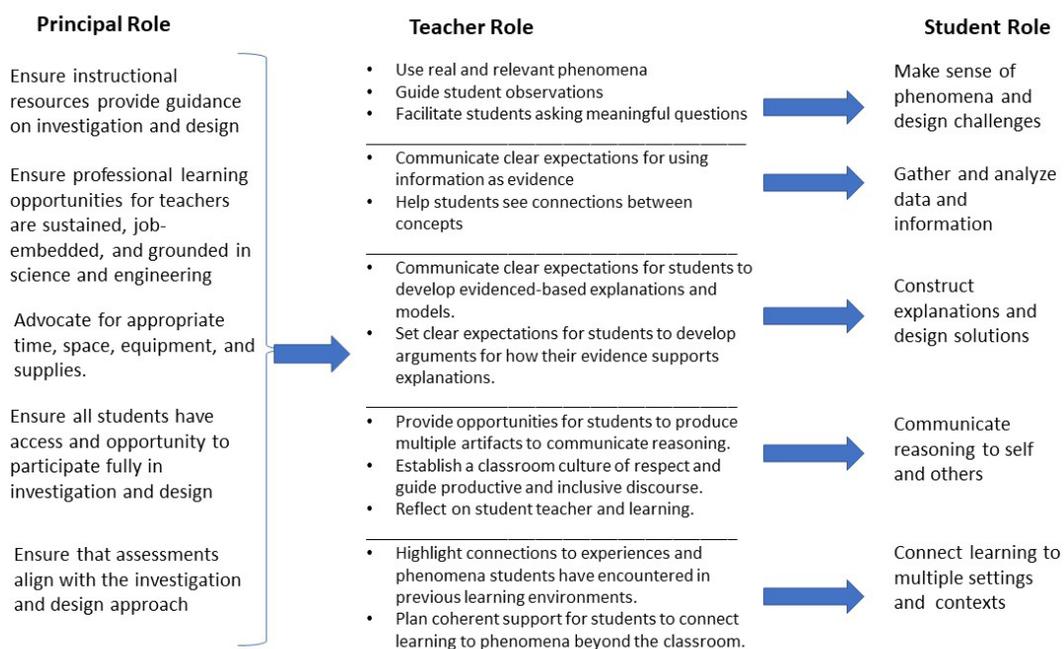
### SCIENCE INVESTIGATION AND ENGINEERING IN THE CLASSROOM

When visiting a classroom these questions can help you see investigation and design in action.

- Are students observing, reflecting upon, and discussing the causes of what they think is happening?
- Are students developing and asking questions about how these phenomena work in the natural and engineered world?
- Are students bringing prior knowledge and previous experiences that are relevant to the experience?
- Are students constructing explanations for the causes of phenomena and developing models to explain the relationships among the components of the systems?
- Are students being encouraged to develop their own argument for how the evidence gathered in the investigation supports their explanation? Are they using these arguments to test solutions to the challenges posed in the classroom?
- Are students consistently communicating their ideas through writing and speaking and are they using evidence to support their explanations?

- **Ensure opportunity and access for all students.** Take steps to address the deep history of inequities in which not all students have been offered a full and rigorous sequence of science and engineering learning opportunities, by supporting the implementation of investigation and engineering design-based approaches to science and engineering instruction across all grades and in all schools, and track and manage progress towards full implementation. Ensure that teachers have the opportunity to learn about and practice implementing inclusive pedagogies that consider the diverse backgrounds and goals of the students. Examine and address resource gaps in facilities, materials, time for professional learning, and time for science.
- **Advocate for flexible spaces and more time for science and engineering instruction and ensure that equipment and supplies are available.** Science investigation and engineering design approaches work best in large flexible spaces that provide ways for students to display their thinking and to store their work in progress if class periods are not long enough for investigations to be completed. Safety issues related to materials used and to class size and space should also be considered.

**You play a critical role in helping teachers improve science and engineering learning for all students. Carefully chosen policies can help improve the teaching of science and engineering in your school; these changes will help all students be more successful in high school, college, or with whatever they choose to do after graduation.**



**Figure 2** Roles for principals, teachers, and students in middle and high school science investigation and engineering design.

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