

## Book Review

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

National Academies of Sciences, Engineering, and Medicine (US). 2019. *Science and engineering for grades 6-12: investigation and design at the center*. Washington (DC): The National Academies Press. 328 p. ISBN-13: 978-0309482608. <https://doi.org/10.17226/25216>

**I**N THE RECENTLY (2019) PUBLISHED VOLUME, *Science and Engineering for Grades 6-12: Investigation and Design at the Center*, the National Academies of Sciences, Engineering, and Medicine revisits the National Research Council's study of high school science it published in 2006 as *America's Lab Report: Investigations in High School Science* (NRC 2006). This 2019 study concentrates on the laboratory experiences of today's students—and the teachers' and schools' readiness to engage these middle and high school students—in actively doing science and engineering. This is achieved through an ongoing analysis of evidence and observed examples. The authors explain, "Science investigation and engineering design provide a structure and a vision for meaningful student learning."

*Science and Engineering for Grades 6-12* describes a variety of ways that teaching and learning can shift toward investigation and design, using methods that build from "current research in how students learn toward the realization of the new vision in the classroom." The main focus of this report is on student learning. As the authors state,

Students learn by doing. Science investigation and engineering design provide an opportunity for students to *do*. When students engage in science investigation and engineering design, they are able to engage deeply with phenomena as they ask questions, collect and analyze data, generate and utilize evidence, and develop models to support explanations and solutions.

This volume starts by examining the past status of middle and high school science instruction as well as defining what science investigation and engineering design actually involve. It goes on to discuss students, investigation and design, and the actual nature of science and engineering.

The first 3 chapters present a short overview of science instruction in the United States, along with a history of how investigation has been incorporated into past middle and high school science classes. Along with definitions of design and engineering, the text includes a short overview of learning and learning theory.

The real meat of the report is included in chapters 4, 5, and 6. These are the "how to" chapters. The reader is instructed on how to put investigation and design at the *center* of the instruction process, and specifically how to engage the student in the investigation and design process. Examples given include having students:

- *develop a design* for a device that collects plastics that have made their way to a local waterway and are *causing* native marine life to die prematurely,
- *develop a model* to show how the flow of energy into an ecosystem causes *change* in the seasonal rate of growth of grass, and
- *construct an explanation* for how *changes in the quantity* of grass cause *changes* in the population of deer mice in the Sandhills of Nebraska.

A number of well-constructed illustrations that compare three-dimensional learning with a more traditional linear classroom approach to science instruction are included. (One example is an illustration where laboratories are a part of the instructional process, but not at the center of it.)

Chapter 5 continues with suggestions about how teachers can support this central position of investigation and design in the curriculum. Chapter 5 is a professional development chapter for teachers that want to transition to this pedagogy. This PD begins to tell teachers how to build classes around both the students' investigation of phenomena and their designing of solutions to observed problems. This introduction to the teachers' roles in incorporating investigation and design includes a table with examples of how the teacher can support student learning during this process. This table is organized by features or elements of the science investigation and engineering design process. This section of the report includes a number of helpful suggestions and examples that can be used in the middle and high school science classroom.

Chapter 6 includes instructional resources for supporting investigation and design pedagogy. As

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teachers transition to putting investigation and design at the center of their science instruction, having a wealth of resources is tantamount to success. Of course, many types of resources and tools can help teachers to develop effective instruction. This chapter discusses the role of these resources in light of the information presented in the previous chapters. Instructional resources needed for this three-dimensional approach to science teaching are very different from traditional science teaching resources. These differences are explained, along with how to find and use effective teaching resources for design learning and student investigations. Examples students can access include:

- climate data, such as temperature and precipitation across years, from the National Oceanic and Atmospheric Administration (NOAA);
- data about ocean acidification on such variables as dissolved carbon dioxide, pH, and oxygen from NOAA;
- water quality data from the United States Geological Survey (USGS); and
- astronomy data from web sources such as NASA.

This section concludes by discussing the role of technology resources on investigative and design learning and teaching. A variety of technology tools are discussed and reviewed including probeware, wearable sensors, portable computer devices like tablets and smartphones, and traditional computers. Computer-based technology tools support students in scientific investigation by promoting access and allowing students to collect a range of scientific data and information.

Chapters 7, 8, and 9 of the report concentrate on teacher preparation and support for transitioning the classroom environment to a model where investigation and design are at the center of science instruction. How to change teacher instruction and school facilities are the focus. This includes how to provide proper facilities and ensure safety in the classroom/laboratory during science investigation and engineering design activities and instruction. Included in this discussion is how to make science learning a priority in our country's middle and high schools. This section concludes by discussing the entire education system and investigation and design. Previous reform efforts are discussed in relation to this new emphasis on doing, rather than learning about, science and design.

The report concludes, in chapter 10, by discussing 10 conclusions about investigation and design and making 7 recommendations about how to change science instruction in our schools. As with all good science, the volume ends with 23 new questions to ponder along with answers that were discovered.

The National Academies of Sciences, Engineering, and Medicine's *Science and Engineering for Grades 6-12: Investigation and Design at the Center* is a report as well as a textbook. It is rather complete, but the inclusiveness of the history of science education—along with the background on past

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science education reports and studies—makes this volume somewhat cumbersome. For the classroom teacher to benefit from this study, the “how to do it” needs to be a bit more obvious. The intended audience might well be teacher educators and education curriculum specialists, but the real benefit would be to the classroom educator. The teacher that is planning lessons, and actually incorporating investigation and engineering design, will benefit most from the suggestions, graphs, and resources listed. Fortunately, the National Academy of Sciences has included a set of very helpful resources with this volume. The report can be purchased—or downloaded for free—from the book's web site at <https://www.nap.edu/catalog/25216/science-and-engineering-for-grades-6-12-investigation-and-design>. In addition to links for the report itself, the National Academies Press provides links to report highlights and a series of resource videos—including 2 webinars that describe investigation and engineering design and explain how teachers can put engineering design at the center of their science curriculum. The available videos include:

- "Science and Engineering for Grades 6-12: Investigation and Design at the Center,"
- "Overview of Science and Engineering for Grades 6-12: Investigation and Design at the Center," and
- "Webinar 2: Instruction with Investigation and Design at the Center."

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