Planning & Carrying Out Investigations

Science & Engineering

Scientists and engineers investigate and observe the world with essentially two goals: (1) to systematically describe the world; and (2) to develop and test theories and explanations of how the world works.

The first goal, which includes, careful observation and description, often leads to identification of features that need to be explained or questions that need to be explored. The second goal requires investigations to test explanatory models of the world, their predictions and whether the inferences suggested by these models are supported by data. Such investigations require the ability to design experimental or observational inquiries that are appropriate for answering the question being asked or testing a hypothesis. This process begins by identifying the relevant variables and considering how they might be observed, measured, and controlled (constrained by the experimental design to take particular values).

See A Framework for K-12 Science Education, 2012, p. 59 for the entire text for Practice 3: Planning and carrying out investigations.

In the video below from BozemanScience.com, Paul Andersen explains how investigations are used by scientists to answer questions and by engineers to test designs. He delineates between investigative and observational science. He demonstrates the formation of good questions and the design of an effective investigation.

https://youtu.be/QTfcyGlVVWo?list=PLi8HVli-fejYMV_aB3-hYUwR14W7Ouran

Planning & Carrying Out Investigations Progression through Gradebands:

Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions. • With guidance, plan and conduct an investigation in collaboration with peers (for K). • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. • Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question. • Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons. • Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal. • Make predictions based on prior experiences.	Planning and carrying out investigations to answer questions or test solutions to problems in 3–5 builds on K–2 experiences and progresses to include investigations that control variables and provide evidence to support explanations or design solutions. • Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered. • Evaluate appropriate methods and/or tools for collecting data. • Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution. • Make predictions about what would happen if a variable changes. • Test two different models of the same proposed object, tool, or process to determine which better meets criteria for success.	Planning and carrying out investigations in 6-8 builds on K-5 experiences and progresses to include investigations that use multiple variables and provide evidence to support explanations or solutions. • Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim. • Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation. • Evaluate the accuracy of various methods for collecting data. • Collect data to produce data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions. • Collect data about the performance of a proposed object, tool, process or system under a range of conditions.	Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan an investigation or test a design individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to problems. Consider possible confounding variables or effects and evaluate the investigation's design to ensure variables are controlled. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. • Plan and conduct an investigation or test a design solution in a safe and ethical manner including considerations of environmental, social, and personal impacts. • Select appropriate tools to collect, record, analyze, and evaluate data. • Make directional hypotheses that specify what happens to a dependent variable when an independent variable is manipulated. • Manipulate variables and collect data about a complex model of a proposed process or system to identify failure points or improve performance relative to criteria for success or other variables.

Progression from NGSS Appendix F pgs. 7-8.

Activities

Three Conceptual Change Activities are included to help teachers and students Confront Beliefs:

- Planning & Carrying Out Investigations Activity #1: Data Collection Method Report
- Planning & Carrying Out Investigations Activity #2: Marshmallow Catapult Challenge
- Planning & Carrying Out Investigations Activity #3: Pringles Challenge

Also refer to Student Work in the Practice for real-life examples of how MPRES teachers have applied this Practice.
The purpose of these activities is to engage teachers in the Practice of Planning and Carrying Out Investigations. The emphasis is NOT on the activity itself, but rather the conceptual change related to the practice. Consumers of the Toolkit are reminded to not get wrapped up in the activity, but rather continually reflect on the conceptual nature of the Practice to gain deeper understanding.
To facilitate conceptual change throughout each activity, you should consider the following questions. These questions are also repeated at key points in each activity to assist you.

Awareness Questions:

1. From the background information, what new awareness do you have about planning and carrying out investigations?
2. In a 3-Dimensional classroom, who do you think needs to be planning and carrying out investigations?
3. What questions did the background raise for you?

Expose Belief Questions:

1. What are your current beliefs about this practice?
2. In what ways do you think you are using this practice?
3. What challenges do you see to using this practice?

Debrief activities by focusing on the conceptual understanding of the practice using the prompts (Resolving Belief Questions, Extend the Concept Questions, and Go Beyond Questions) included on the left side of each activity page.

Resolve Belief Questions:

1. In what ways did this activity change your beliefs about planning and carrying out investigations?
2. How could you assist students in refining this practice?
3. What are the key components in planning and carrying out investigations that students need?

Extend the Concept Questions:

1. How do you currently help students with planning and carrying out investigations in your classroom?
2. What do you currently teach that lends itself to engaging students in this practice?
3. Review a recent lesson you taught and evaluate the effectiveness of engaging students in planning and carrying out investigations.

Go Beyond Questions:

1. Ask a colleague to observe one of your lessons OR video yourself teaching and reflect on your application of this practice.
2. Use the EQuiP Rubric for Lessons & Units: Science(PDF format) to evaluate a recent science lesson you taught.