Innovation Curriculum

Classroom Lesson 4

Test & Analyze

Lesson Overview
Students will continue the GSA Innovation Process by completing the following steps: 1) test their solutions; 2) analyze the results of their tests

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1. Test their solutions
2. Analyze the results of their tests

Time Frame: 1–2 weeks

- Part 1: Test - 45–120 min (in class), 1–2 weeks (outside class)
- Part 2: Analyze - 45–120 min (in class)

Core Concepts

- Testing is required to determine whether a solution is viable
- There are many possible ways to test a solution
- A solution can be revised and refined according to feedback collected from testing

Lesson Objectives

Students will be able to:

- Test a solution using useful and appropriate methods
- Collect and analyze feedback and data
- Summarize feedback and data, identifying trends and themes
- Revise their solutions based on the results of testing

Lesson Inquiry Question: What can we learn from testing a solution?

Materials Needed

- Journals (optional)
- Copies of any resources below that you wish to share with students
- Templates for Deliverable 4—see Appendix C

Journal Opportunity (optional)

Students who are keeping science journals may want to use them before and after each step (testing and analyzing) to set personal learning goals for each step and evaluate how well those goals were met.

NGSS Alignment

Lesson 4 provides opportunities for students to engage in the following Science & Engineering Practices (SEPs).

- ***Practice 1*** – Asking Questions & Defining Problems
- ***Practice 2*** – Developing & Using Models
- ***Practice 3*** – Planning & Carrying Out an Investigation
- ***Practice 4*** – Analyzing & Interpreting Data

- ***Practice 6*** – Constructing Explanations & Designing Solutions
- ***Practice 7*** – Engaging in Argument from Evidence

This lesson is directly aligned with the following Performance Expectations.

- ***HS-ETS1-2.*** Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Educators may align the lesson to additional Performance Expectations and/or Disciplinary Core Ideas (DCIs) through challenge selection and/or the provision of specific related research resources.

Part 1: Test

Estimated Time
45–120 minutes (in class; 1–2 class periods)
1–2 weeks (outside class, depending on testing procedures—e.g., gathering feedback from user testing may require additional time)

Preparation: Explain to students that it is now time for them to test their solutions. Return each team's research plan (Deliverable 3) with your comments and feedback. Encourage teams to review their plans together, revise them as needed, and be sure that each team member has a role to play and tasks to perform in the testing process.

Remind students that before they begin testing they must clearly identify the following:

- The variable(s) they are testing, including:
  - independent variable(s)
  - dependent variable(s)
- The method(s) they will use to obtain reliable results, including:
  - controlled variables and *how* they will be controlled
  - procedural steps
  - observational study vs. controlled experiment
  - control group vs. experimental group (if applicable)
  - data collected
  - feedback collected (from whom and questions)
  - number of samples (i.e., how many times the test will be repeated)

Procedure
1. Have each team consider and compile a list of people from whom they would like to solicit feedback on their solution, in addition to any testing. Encourage students to seek feedback from as many people as possible, including mentors, advisors, local experts, classmates, and potential users.

2. Have teams arrange times and places to test their solutions and collect feedback.

3. Before students begin testing, ask them to spend some time planning how they will set up their tests and collect feedback.

- If they are conducting a scientific experiment or observational study, encourage students to consider how many times they will repeat the experiment to obtain accurate results. When determining how many samples will be recorded, the general rule is that more is better. A sample size of 30 or more is ideal from a statistical perspective. That said, 30 or more repetitions may not be practical due to time and resource constraints. Smaller sample sizes yield results that are less reliable (less statistically significant), though they may be sufficient.

- If students are conducting user testing, suggest that they establish a list of questions and a procedure to gather feedback in a systematic way. Have students consider whether they can conduct a scientific experiment or observational study *in addition to* gathering user feedback, or by asking specific questions for which the responses may be analyzed statistically. Share the following documents, as applicable, to help students plan.
    - Get Feedback: IDEO's Design Kit outlines four steps for getting feedback on a prototype
    - Test Your Prototype & Get Feedback: This resource provides instructions and a template for capturing and incorporating feedback on a prototype
    - Testing With Users: The Bootcamp Bootleg from Stanford University's Institute of Design explains why and how to test a prototype with users and provides a 4-step procedure for testing in "Testing with Users" (card 35; page 38)

4. Remind students to gather and record feedback and results carefully as they test their solutions. Most teams will benefit from assigning one person to be in charge of this task. Encourage them to create tables or charts for data collection to keep results organized.

5. Remind students to take photographs and/or video footage during testing to be used in the final presentation. They should consider images/video of methods, supplies, interviews, and results.

Part 2: Analyze

Estimated Time:
45–120 minutes (in class; 1–2 class periods)

Preparation: Have teams gather all of the data and feedback they collected during testing, along with the materials from Lesson 3 in which they formulated hypotheses about their solutions and identified questions for the testing process to answer. Explain that now teams must analyze their test results to determine what the data and feedback reveal about their design solutions. You may also want to introduce or review the analysis or statistical methods you want students to use in Step 1.

Procedure
1. Invite teams to meet to review and analyze the data they collected during testing. There are a variety of options for doing so. Have students use one or more of the following tools, depending on their skill level.

- Visual graphs and charts, such as histograms, bar graphs, box plots, and pie charts
- Descriptive statistics, such as mean, median, mode, range, percentiles, and standard deviation
- Advanced statistical analyses, such as hypothesis testing using *t*-distributions or *z*-distributions, or Chi square testing

For more information about statistical analysis, see Additional Resources on p. 9.

2. As they complete their analyses, encourage teams to consider and respond to questions such as the following.

- Do our test results support our hypothesis? Why or why not? How do we know, based on our statistical analysis?
- Have we chosen the best tools for statistical analysis? Should we try anything else?
- Is there a relationship between variables? Is it a correlation or a causative relationship? How do we know?
- Do the test results answer other questions we were testing for? If yes, what are the answers? If no, why not? Were there problems with our testing methods? Did we collect enough data and feedback from enough sources?
- If our results were unexpected, why?
- How can we revise and improve our solution and/or testing methods in the next iteration?

Feedback Opportunity: Check in with each team to ensure that they are analyzing and interpreting their data correctly, and to help them troubleshoot any issues that have arisen or make sense of results that puzzle them.

Deliverable 4

Using the Deliverable 4 template (Appendix C), have students outline the following in two pages or less.

- **Data/Feedback:** Summarize the data you obtained from experiments and/or feedback you gathered.
- **Lessons Learned:** Summarize the most important findings from your testing.
- **Next Steps:** Describe how you plan to refine your solution based on what you learned and conduct further testing. Will you modify your testing methods?
- Include a **visual representation** (e.g. photo, sketch, diagram, flow chart, etc.) or description of your prototype with your submission as an attachment.

Terms and Concepts

- ***data***: observations and/or measurements collected in a study, investigation, or experiment
- ***data analysis***: the process of evaluating data using analytical and logical reasoning. Data analysis can include graphical representations, descriptive statistics, and hypothesis testing.
- ***causation:*** a relationship between two variables in which changes in one variable cause changes in the other variable. A controlled experiment is usually necessary to determine a causal relationship.
- ***correlation:*** a relationship between two variables; as one variable changes, the other also changes in a predictable pattern. One variable may cause the other to change, or both variables may be caused by a third variable (known or unknown). Sample studies generally show only correlative relationships between variables.
- ***controlled experiment:*** an experiment in which data are collected by randomly dividing subjects into two groups: the control group and the treatment group. In the egg drop example, experimenters could drop half of the eggs using the test parachute (treatment group) and half of the eggs without the parachute (control group). The results from the two groups can be compared to determine whether the treatment resulted in a statistically different outcome. (While a controlled experiment produces more reliable results, there are times when it is not practical to create a control group and a treatment group. In some cases, the act of controlling variables can alter a situation such that the results are not useful in reality. For example, it is often not practical to create control groups and treatment groups in studies of animal behavior in the wild. When animal behavior studies are conducted in captivity, the experiments can be controlled, but the results may only be true in captivity and may not translate to behavior in the wild.)
- ***observational study:*** a study in which data (measurements, survey questions, etc.) are collected without attempting to affect or manipulate the subject(s) of the study. In the egg drop example, experimenters could simply drop the eggs (the subjects) using the parachute to see whether they break. In this case, the results of an observational study may not show a strong correlation between the parachute and egg breakage, because it is unknown how many eggs may have broken without the parachute and if the parachute actually affected the results.

Additional Resources

Test

These resources offer more information about designing experiments and conducting various types of research.

- Designing Studies (Khan Academy) https://www.khanacademy.org/math/statistics-probability/designing-studies#experiments-stats-library
- Designing a Study (Schmoop) http://www.shmoop.com/basic-statistics-probability/designing-study.html
- Research Designs https://explorable.com/research-designs

Analyze

Students may find the following resources helpful when analyzing data and conducting statistical analyses.

- What is Data Analysis? http://study.com/academy/lesson/what-is-data-analysis-definition-overview.html
- Statistics and Probability https://www.khanacademy.org/math/statistics-probability
- t-Tests http://www.statisticshowto.com/t-test/
- Box-and-Whisker Plots http://www.shmoop.com/basic-statistics-probability/box-whisker-plots.html
- Scatter Plots and Correlation http://www.shmoop.com/basic-statistics-probability/scatter-plots-correlation.html

The Scientific Method

This resource explains six steps of the scientific method—from asking and researching an initial question to presenting the results of testing and analysis—with links to additional information about each step.

- http://www.sciencebuddies.org/science-fair-projects/project_scientific_method.shtml

Lesson 4 Hyperlink Index

Get Feedback: IDEO's Design Kit outlines four steps for getting feedback on a prototype. http://www.designkit.org/methods/57

Test Your Prototype & Get Feedback: This resource provides instructions and a template for capturing and incorporating feedback on a prototype. https://d3gxp3iknbs7bs.cloudfront.net/attachments/174c74a3-a4d4-475b-be39-4097cdf620ce.pdf

Bootcamp Bootleg: Resource cards created by the dSchool at Stanford University's Institute of Design. https://dschool.stanford.edu/resources/the-bootcamp-bootleg

- *Testing With Users:* card 35; page 38