NGSS and Smart Science® Education

The Next Generation Science Standards (NGSS), with their emphasis on investigation, are forcing states and districts across the country to review and revise their science curricula. Professional development (PD) for these standards has taken front seat ahead of other science PD.

The Smart Science® online lessons were developed years before NGSS and even before the famous "America's Lab Report" (ALR) was published. Yet, they fit well with both the ALR recommendations and the NGSS requirements because they were created by scientists whose greatest concern centered on students understanding the nature of science rather than memorizing long lists of science vocabulary, formulas, and procedures.

The NGSS puts forth its recommendations with three areas of information.

1. Performance Expectations
2. Foundations
3. Coherence

The first area, Performance Expectations, sets forth specific topics and their expectations. However, unlike old standards, these expectations begin with words such as "Construct," "Conduct," "Develop," "Apply," and "Plan." Smart Science® experiments support these expectations.

The second area, Foundations, explains that every Performance Expectation may support a Practice, a Disciplinary Core Idea (DCI), and a Crosscutting Concept.

The third area, Coherence, connects each Performance Expectation to other Performance Expectations and to both ELA and math standards in the Common Core.

You will find references to modeling and to engineering design throughout the standards as well, illustrating that NGSS relates well to the STEM movement.

How will Smart Science online science lessons help teachers meet the NGSS standards? The answer is — in every way, and they're getting better.

First, some background on Smart Science lessons will help in following the explanations. These lessons use a 5+1 learning pedagogy.

1. Engage students with a video, modest text, and some opinion questions related to the lesson topic.
2. Challenge students to make predictions, which may be based on models of data behavior, while providing plenty of background material that students may use to help decide on the predictions to make.
3. Interact with real experiments to make hands-on measurements; students may choose to use only some of the available experiments. The data are shown in both graphical and tabular formats.
4. Answer questions designed to ensure students were paying attention during data gathering and to delve into the deeper implications of those data.

5. Write about the experimental experience (constructive response) in a series of prompted text areas.

+. Explore implications of this lesson material in other areas through an open-ended project-based activity.

Performance Expectations

Smart Science Education will be expanding its coverage of the NGSS performance expectations to fill in a few minor gaps. The technology already has the tools necessary. For example, it has used online activities not involving measurement but still using real images and videos. It also has the feature of “wet” labs, also known as do-it-yourself (DIY) labs. These are done in the classroom or kitchen away from the computer with results being entered into the computer afterward.

Foundations

Foundation #1: Eight Practices

1. Asking questions and defining problems

    Every Smart Science® experiential (experiment-based) lesson starts with some focusing questions followed by predicting outcomes. These both request that students ask questions.

2. Developing and using models

    Many of the lessons have qualitative or quantitative predictions, models of the behavior that may occur. The selected or written prediction is kept before the student during the experimentation phase to ensure that the chosen model remains uppermost while measurements are being made. Results may prompt a student to modify that prediction.

    At the teacher’s option, a curve fit may be made to the data values. This fit represents a model that students should relate to the actual phenomenon being studied.

3. Planning and carrying out investigations

    Students may choose among experiments and then measure each value collected interactively. Their care in measurement affects the data quality. Some lessons have students deciding how to categorize results. After finishing with one experiment, students choose which one to do next.

    Many students will do every single experiment, a sometimes exhausting exercise in the more advanced lessons. Teachers guide students to choose carefully as scientists often must do.

4. Analyzing and interpreting data

    The questions after the investigation and the online written lab report encourage students to figure out what their data mean. Making measurements may not fully engage students in thinking about the lesson topic. They must be queried and then asked to put the results and conclusions in their own words, which is exactly what the Smart Science® system requires.

5. Using mathematics and computational thinking

Some science lessons are qualitative; others are quantitative. The quantitative ones involve mathematics in a number of ways. They may request mathematical data analysis or understanding terms such as period, amplitude, and phase. Lessons with multiple achievement levels will have more mathematics at the higher levels.

6. Constructing explanations and designing solutions

The report phase of each lesson has the purpose of asking students to construct explanations for what they observe. They are prompted to do so in a series of text areas that may be augmented with essay questions about the specific lesson.

7. Engaging in argument from evidence

Teacher materials encourage teachers to have their students present their data and conclusions for an entire student group. Teachers then can monitor the discussion to ensure that all arguments arise from evidence and not conjecture.

The reports also provide a mechanism for students to review their data and consider it as evidence to support their conclusions.

8. Obtaining, evaluating, and communicating information

The extra exploration activities extend the lesson experience. They often require students to seek out information and write about what they find out.

Foundation #2: Disciplinary Core Ideas (DCI)

These are too numerous to list here.

Here's one example from fourth-grade physical science.

Practice: 4-PS3-1. Use evidence to construct an explanation relating the speed of an object to the energy of that object.

DCI: PS3.A. Definitions of Energy — The faster a given object is moving, the more energy it possesses.

Smart Science example: *Pendulums and Energy*. This lesson compares the kinetic and potential energy of a pendulum bob as it swings and uses the student measurements rather than a theoretical equation.

Here's one from fourth-grade life science.

Practice: 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

DCI: LS1.A. Structure and Function — Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

Smart Science example: *Stem Structure*: This lesson examines the structures of many plant stems in detail to correlate functional aspects of the stem with the appearance of the structures.

Finally, here is one from fourth-grade earth and space science.

Practice: 4.ESS2-1. Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.

DCI: ESS2.A. Earth Materials and Systems — Rainfall helps to shape the land and affects the types of living things found in a region. Water, ice, wind, living organisms, and gravity break rocks, soils, and sediments into smaller particles and move them around.

Smart Science example: *Erosion and Slope*: Examine the erosion channels with differing slopes in a stream table.

Foundation #3: Crosscutting Concepts

1. Patterns

Patterns exist everywhere in the lessons, from the daily tides to seed germination. Each lesson involves graphical display to help elucidate patterns.

2. Cause and effect: mechanism and explanation

You can hardly analyze science experiments without seeing cause and effect. The daily tides lesson encourages students to figure out what causes tides. Elastic and inelastic collisions lessons require analysis to figure out what quantities are conserved. Determining molar ratios from precipitates has a similar outcome.

3. Scale, proportion, and quantity

Scale is a great topic for Smart Science® lessons. Certainly, they cover the impact of time quantity on falling objects, and you'll find many other examples as well.

4. Systems and system models

Each experimental lesson addresses a system, whether it's biological (e.g. seed germination and pollution), chemical (e.g. electrochemical series), physical (e.g. collisions), or earth-based (e.g. tides).

5. Energy and matter: flows, cycles, and conservation

A number of lessons address conservation of various quantities. More are being prepared.

6. Structure and function

You find this feature being addressed in some lessons, such as compound pendulum. This area will be expanded as the system grows beyond the current 250 lessons.

7. Stability and change

Feedback plays a critical role in stability. Students should understand the difference between positive and negative feedback. Some Smart Science lessons illustrate this effect and more are being prepared.

The Nature of Science

The nature of science perfuses the entire Smart Science® system. It's hard to escape when you're doing real experiments, when you make predictions before beginning experimentation, and when you have to explain your results at the end. The quizzes before and after the experimentation ensure that the students focus on what's important and figure out principles rather than memorizing derived "facts" and formulas.

Engineering Design

Smart Science® lessons are being built to incorporate more engineering activities. The system already has the technical capabilities to carry these out. Engineering, in this context, involves two different sorts of activities. Students must investigate specific properties of objects used in the engineering tasks. Students also must design and create solutions to problems using these objects while understanding their properties.

The first of these activities fits nicely into the same template as the science lessons. The materials and measurements are real. The second fits into our "wet" lab (aka DIY) template. Many wet labs have already been incorporated into Smart Science® lessons. Many more will be built to focus more closely on engineering.

A. Defining and delimiting engineering problems

B. Designing solutions to engineering problems

C. Optimizing the design solution

Science, Technology, Society, and the Environment

The Smart Science® system has a series of environmental lessons that address some of the issues surrounding this topic. More are being added.