Sensational Science Instruction!

Are you new to high school equivalency science instruction and looking for information about preparing students for test success? Are you an experienced teacher looking for more science teaching resources? This interactive session will meet your needs whether you are teaching completely online, hybrid, or face-to-face.

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Today's Objectives

At the end of today's workshop, I will be able to:

- Explain skills and knowledge gaps students have in science and social studies
- Describe teaching methods to improve students' scientific understanding
- Access appropriate teaching resources

How to Approach Science Instruction

"Science is a way of thinking much more than it is a body of knowledge."

- Carl Sagan

"Think of science as a verb. You have to do it."

- Jeff Goodman, Appalachian State University

Science Skill and Knowledge Gaps

Gap 1

Analyzing scientific and technical arguments, evidence and text-based information

- Reconcile multiple findings, conclusions, or theories
- Express scientific information or findings verbally

Gap 2

Applying scientific processes and procedural concepts

- Design a scientific investigation
- Reason from data or evidence to a conclusion
- Make a prediction based upon data or evidence
- Understand and apply scientific models, theories, and processes

Gap 3

Reasoning quantitatively and interpreting data in scientific contexts

- Describe a data set statistically
- Determine the probability of events

The Curiosity Factor: Human Wonder Research

Is the light traveling down the cord and out the plug causing the packet to sink?

Is rubbing my hand on my hair causing the packets to sink?

Is mind control moving the packet?

What do you observe every time the packet moves?

What is your hypothesis as to why the packet moves?

Why does the packet move?

Adapted from Goodman, 2012

To find this site with more human wonder research topics, Google: **human wonder research app State**

How to Think Scientifically

"Science, stripped down to its essentials, is just a method for figuring things out: you look at some situation, come up with a possible explanation, and try it to see if it works. If it does, great, if not, try something else. Repeat until you find an explanation that works.

"This does not demand a complicated skill set. It's really not much more than you need to be a functioning adult in modern society. And most people have, at one time or another, used exactly this procedure.

"If you've ever cooked without a recipe, you have the mental skills needed to be a scientist. You come up with new dishes in essentially the same manner as you solve scientific problems: you make a guess that cooking two particular ingredients together in some way will be delicious, then you do it, and taste to see if you're right. That's the scientific method right there, and millions of people have done it at some point in their lives.

"If you have ever repaired anything– a car, a dripping faucet, a blown fuse– you have the mental skills needed to be a scientist. You fix problems in everyday life in the same way that you attack scientific problems: you make a guess as to the source of the problem, you try the appropriate solution for that sort of problem, and see if it worked. That's how science works, and millions of people make their living doing this without ever realizing that they're thinking scientifically."

Chad Orzell, Everybody Thinks Scientifically, Uncertain Principles Blog

Steps in the Scientific Method

Make Observations

Science begins with observation. Observation is getting information through sight, hearing, smelling, tasting, and touching.

My coffee stayed warm for two hours in my Thermos® cup. My cold drink only stayed cold for one hour in a plastic cup.

Ask Questions

Science begins with observation and continues with wonder. Humans are full of questions about what we discover from our senses. Why is the sky blue? Why do rotten eggs smell? We can ask questions using the five w's and one h: who, what when, where, why, and how. The question has to be one that can be tested through an experiment.

What kind of cup is the best insulator?

Create a Hypothesis

Once we have done some research about our question, we can create a hypothesis, an educated guess based on observation and research. A good hypothesis is a possible explanation that can be tested with an experiment.

A Thermos® cup will keep hot water warm the longest.

Design an Experiment

Scientists design experiments where one variable is changed (experimental) and the others are kept the same (controlled). Certain experiments may have a control and experimental group. The variables stay the same in the control group while one variable is changed in the experimental group. The control group shows what happens if nothing changes so it can be compared with the experimental group.

In this experiment, the controlled variables are the water temperature, the amount of water poured in the cups, and the room temperature. The experimental variables are the different types of cups.

> **I heat water to 160 degrees and put an equal amount into three kinds of cups: a Thermos® cup, a plastic cup, and a Styrofoam cup.**

Collect and Analyze Data

While doing the experiment, we observe what happens and collect data. The data describe what happened in the experiment and is usually shown in charts, graphs, and tables.

Cup type	Thermos®	Plastic	Styrofoam
Initial Temp	160	160	160
Water temp after 30 minutes	105	88	95
Water temp after 60 minutes	92	74	84
Water temp after 120 minutes	84	70	75

Draw Conclusions

Using our analyzed data, we now see if our hypothesis is right. The conclusion is our written statement that says what we think about our hypothesis. Scientists repeat their experiments many times to make sure their conclusions are right.

> **My hypothesis is correct: The temperature in the Thermos® cup was the highest after 120 minutes, therefore a thermos cup is the best insulator.**

Communicate the Results

Finally, we describe the research we have done, the hypothesis, the experiment, the data, and our analysis so we can share it with others. This is done through reports, oral presentations, and journal articles. This can give other scientists a chance to repeat the experiment and see if their results match.

Science Experimental Design Practice

11 Questions you can turn into <u>simple, low-cost</u> experiments to teach experimental design:

1. Does adding aspirin to water keep flowers fresh longer?

2. How does the height from which a ping-pong ball is dropped affect the bounce height?

3. Which type of cup is a better insulator (Styrofoam, Thermos®, plastic, etc.)? Compare temperatures of hot water over time.

4. How does activity (lying, sitting, walking, running) affect pulse rate?

5. Which color of M&M's will people choose from a bowl or will they care? (This requires you to have an even number of each color of M&M evenly mixed in the bowl and not to tell the test subjects what you're testing.)

6. Compare how moldy a slice of bread will get over time under different storage conditions (in a plastic bag, left out, in a paper bag, etc.).

7. Compare how long it will take water to evaporate out of different shaped containers.

8. Roll a marble or a car down a ramp. How does the height of the ramp affect how far it goes? (This can also be set up to test how the rolling surface affects distance rolled if height remains the same and rolling surface is changed.)

9. How does the temperature of water affect how quickly it will dissolve an Alka Seltzer?

10. Does the size of a coin affect how long you can spin it on its edge before it falls? (Compare dime, penny, nickel, quarter, dollar coin). (This is a great activity to discuss the challenges in doing controlled experiments. How can we make sure the spin is the same each time?)

11. Which shape of paper falls fastest: An unfolded sheet of paper, a paper folded in fourths, or a sheet of crumpled paper? Or can you create a different shape with paper that falls even faster?

For each of these experiments, identify:

A. Hypothesis
B. Many controlled variables
C. 1 Experimental (changed) variable
D. How you will collect data
E. How data will be evaluated

Experiments # 1 – 10 Jeff Goodman, Appalachian State University, # 11 GED® Testing Service

Experimental Design Graphic Organizer

What do you notice about what you are studying?
What is your question?
What is your hypothesis?
How will you set up your experiment? What are your controlled (things that stay the same) and experimental (one change) variables?
How will you collect your data?
How do you know if your hypothesis is right? If . . . then . . .
How will you show your results?

Coal Slurry Storage and Health Effects

When coal is mined from the ground, it is coated with dirt and rocks. To save transport costs and increase its value, coal is washed with water mixed with chemicals to remove the dirt before being shipped to a power plant. This process creates a huge amount of wastewater called coal slurry. Coal slurry is mostly water and mud, but it also contains the chemicals used in the wash process and coal particles. Coal particles may contain heavy metals like mercury or arsenic that can be dangerous to humans. To deal with coal slurry waste, mining companies may create ponds or pump the slurry into abandoned coalmine shafts.

Critics of putting coal slurry into mineshafts claim that chemicals and heavy metals seep into local drinking water and cause health problems for local residents. Mining companies say storing coal slurry in mineshafts is environmentally responsible and that there is little chance for chemicals to get into local drinking water supplies.

In 2008, Massive Coal Company began to put coal slurry in four abandoned mineshafts near Prenter Hollow, West Virginia. In 2010, local residents began complaining about the quality of their drinking water and noticed increases in health problems such as cancer, birth defects, and headaches.

The chart below lists results of water tests done near Prenter Hollow every year from 2007 to 2011 for common chemicals contained in coal slurry. **Circle or highlight every piece of evidence in this chart that supports the view that coal slurry dumping in abandoned mine shafts caused an increase in harmful chemicals in the ground water near Prenter Hollow West Virginia**. Slurry storage near Prenter Hollow began in 2008.

Local Water Samples Taken from Wells near Prenter Hollow West Virginia, 2007 - 2011

Heavy Metal or Organic Compound	2007	2008	2009	2010	2011
Mercury	.002*	.001	.01	1.6	6.3
Chromium	5.1	5.1	4.9	4.8	5.1
Selenium	1.1	1.0	1.1	1.0	1.1
Arsenic	.8	1.0	2.0	4.5	9.9
4-Chloroaniline	0	.2	1.7	9	45
Barium	6	5	12	567	2,345
Cadmium	2.3	2.3	7.9	12.5	56.7
Antimony	2	4.5	11	19	92

*** All figures in this chart are in parts per million**

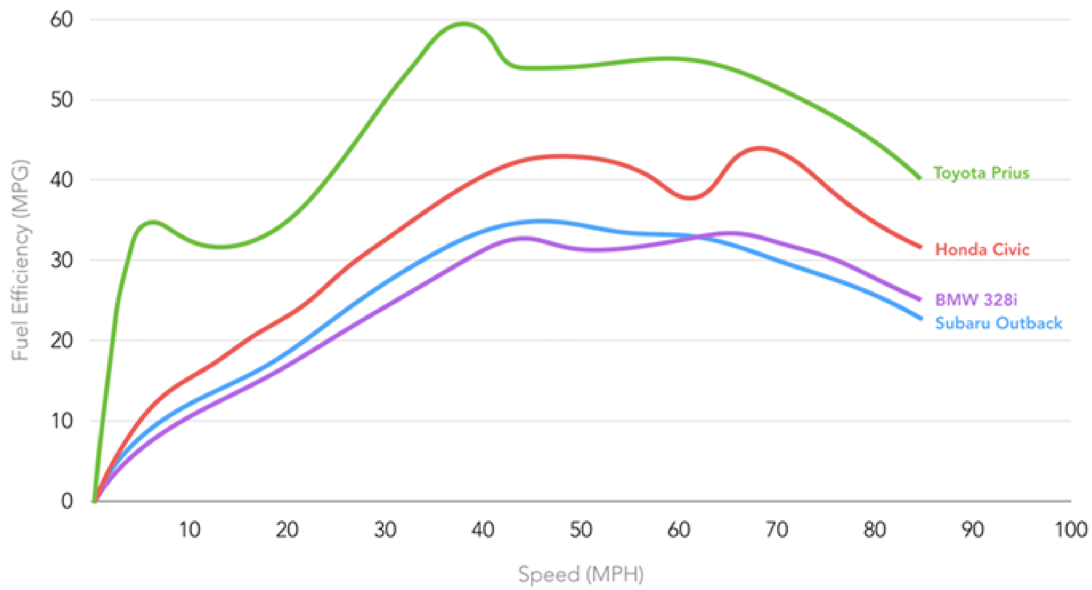
Draw a Conclusion

Does it seem that there has been an increase in harmful chemicals in the water near Prenter Hollow West Virginia? What evidence supports this?

It's All About the Evidence!

For years, auto engineers believed that the faster a car went over 45 miles per hour (mph), the worse fuel efficiency it had in miles per gallon (MPG). The chart below shows results of recent fuel efficiency testing of four cars:

Fuel Efficiency of Toyota Prius, Honda Civic, BMW 328i, and Subaru Outback



Note: The Toyota Prius is a gas/electric hybrid vehicle while the Honda Civic, BMW 328i, and Subaru Outback are gas-powered cars.

1. What evidence from the graph is there to show that gas-powered cars have their best fuel efficiency between 60 and 70 miles per hour?

2. What evidence from the graph is there to show that gas-powered cards have their best fuel efficiency between 40 and 50 miles per hour?

3. What evidence from the graph is there to show that gas/electric hybrid cards have their best fuel efficiency under 40 miles per hour?

4. What overall conclusion can we draw from the graph about miles per gallon and speed? What is the connection between how fast we drive and our miles per gallon?

Design an Experiment: Cafeteria Trays

Sarisa McLeod, cafeteria manager at Enormous State University, wants her two dining halls to practice sustainability while saving money. She is concerned about how much food students throw away which costs Enormous State thousands of dollars every year.

Ms. McLeod knows of other universities that stopped using cafeteria trays and found they saved money. The theory is that cafeteria trays make it easier for students to take more food than they will eat. With no trays, students take less food and waste less food.

Enormous State has two dining halls both of which serve the same food and about the same number of students each day.

Design an experiment to test the hypothesis that banning cafeteria trays will lead to less food waste. Include the following in your experimental design: experimental setup, procedure for data collection methods, and criteria for evaluating the hypothesis.

Experimental Setup
Procedure for Data Collection
Evaluating the Hypothesis

Answer Key

Pg. 8   Coal Slurry Storage and Health Effects: Draw a Conclusion

Of the eight substances shown in the table, six show large increases in the period from 2008 to 2011:

Mercury
Arsenic
4-Chloroaniline
Barium
Cadmium
Antimony

This supports the view that coal slurry dumping in abandoned mine shafts caused an increase in harmful substances in the ground water which may be impacting local residents' health.

Pg. 9   It's All About the Evidence!

1. The BMW 328i has its best fuel efficiency (highest miles per gallon (MPG)) at 65 miles per hour. The Honda Civic has its best fuel efficiency at 68 miles per hour.

2. The Subaru Outback has its best fuel efficiency at 45 miles per hour.

3. The Toyota Prius has its best fuel efficiency at 38 miles per hour.

4. Most cars get their best fuel efficiency (MPG) between about 40 and 70 miles per hour. Cars get fewer MPG as they accelerate from 0 to 40. Cars also get fewer MPG at speeds get over 70 MPH.

Pg. 10 Design an Experiment: Cafeteria Trays

Experimental Setup
The hypothesis is that banning cafeteria trays will result in less food waste. Since there are two dining halls that both serve the same number of students, one dining hall will serve as the control group that will continue to use trays while the other dining hall will be the experimental group and stop using trays. Everything else in both cafeterias will remain the same.

The experiment will have two trials that each last one week. In the first, Cafeteria A will be the experimental group and stop using trays and cafeteria B will be the control group and continue to use trays. In the second trail, Cafeteria B will be the experimental group and stop using trays and cafeteria A will be the control group and continue to use trays.

Procedure for Data Collection
During both trials, the food waste in each cafeteria will be weighed for one week and totaled.

Hypothesis Evaluation Criteria
If the cafeteria food waste is less when trays are not used, the hypothesis that not using cafeteria trays will result in less food waste is right.