HITCHED:

an innovative approach to learning about sustainability and experimental design

a product of
Project GEMS (Gifted Education in Math and Science)

a cooperative effort between
Warren County Public Schools
and
The Center for Gifted Studies at Western Kentucky University

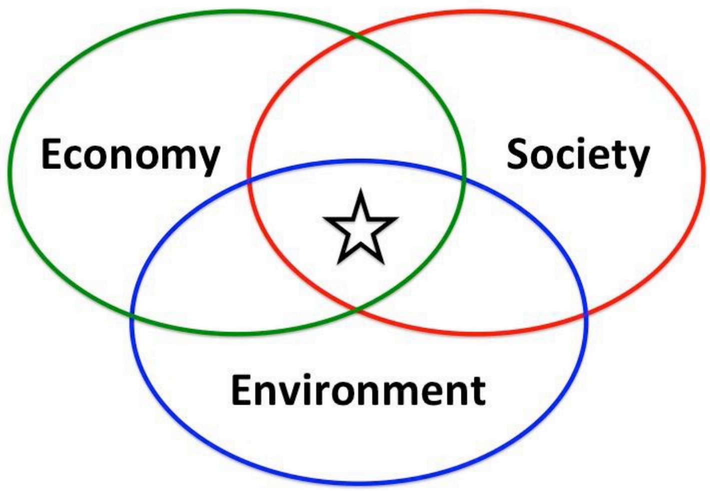
Table of Contents

Unit Overview

The naturalist John Muir once noted, “When we try to pick out anything by itself, we find it hitched to everything else in the Universe.” This unit is an exploration of Muir’s hypothesis. It is a study of the connectedness of seemingly disparate parts. Even more, it is a study of our own connectedness, both to one another and to the world around us.

Sustainability is a broad, multifaceted concept. It is also a timely topic. Yet it is so much more than a “green” or environmental issue. Sustainability is really about finding balance in our lives. It is an honest examination of the many ways in which we are “hitched” to everything else. It is an attempt to understand the economic, environmental, and social implications of our everyday choices.

In fact, one can visualize sustainability as a Venn diagram representing the intersection of those three domains: economy, environment, and society. The most sustainable solution to any conundrum is the one that keeps all three in balance.



Simply put, we can engage in certain behaviors over time with few negative repercussions. Conversely, the sum effect of other behaviors can be quite destructive. The result is a continuum of benefits and consequences. Clearly, this truth can be applied to the environment. But it also applies to our health. It applies to personal and institutional finance. It applies to human relationships.

This unit is not intended to be a comprehensive study of every aspect of sustainability. It is, rather, an introduction. The lessons and activities in this unit are centered on the notion of **conservation**. To conserve is to save, to protect, to preserve, or to use wisely. Conservation, then, is the thoughtful, prudent, intentional use of our resources. However, even as sustainability is broader than the environment, so, too, is conservation more than responsible energy management.

And students will find that, timely as this discussion may be, it is certainly not unique to their own generation.

The Innovation Model

This unit is designed to explore the concept of sustainability through the lens of **innovation**. The word innovation is ubiquitous these days. From industry press releases and politicians' speeches to the newest textbook series, the word innovation is everywhere. But how often, as educators, do we give our students opportunities to innovate? When do they have opportunities to explore the creative process?

If you ask your students when they have an opportunity to be creative at school, they will likely tell you: art class, music class, recess. Rarely will a child cite math, science, or social studies as subjects that encourage creativity! Yet, creativity and innovation are processes that stimulate thinking and generate new ideas across disciplines. Forward thinkers in all disciplines innovate. And, if we want our students to innovate, we must show them what innovation looks like.

The heuristic on the following page is designed to help students and teachers visualize the process of innovation and apply it to their curriculum. Each of the bold verbs (connect, inquire, create, analyze, enhance, communicate) represents a portal, an entry point into the innovative process. Depending on one's strengths, an individual might tend to enter through the portal of Inquire, Analyze, or Communicate. In those areas that are not my strength, I may rely on the skill and expertise of my colleagues and collaborators.

The Innovation Model honors the importance of every element in the creative process. I may take great satisfaction in the new product I develop. However, the one who can effectively evaluate my work or clearly market my ideas is every bit as vital to the process as I am. To notice, relate, wonder, imagine, reflect, respond, share. Those contributions often provide the spark that ignites the innovative process.

The innovative process itself is nonlinear in nature, with no set beginning point and no definite end. For that reason, today's innovators routinely build on the work of innovators from previous decades or centuries. Our students' grasp of historical connection is critical if they are to shape the future in positive ways.

Experimental Design

Close your eyes and imagine a scientist at work. What is she doing? Envision a mathematician on the job. What does his work look like? More to the point, do your students ever have the opportunity to do work like that?

Sometimes our students are observers during a **science demonstration**. The demonstration has value as a vehicle for communicating procedures or conveying other information. But the student is not an active participant. The teacher asks the questions. The teacher wears the protective equipment. The teacher handles the tools. During such an activity, the children don't do science—the teacher does science. In fact, it calls to mind the image of a magician at work. And the magician's message is subtle but clear: *Do not try this at home!*

On the other hand, we sometimes offer our students a **science recipe**. If you check the shelves of your classroom or your school library, you are sure to find books of science "experiments" that employ simple household items. Unlike a demonstration, the goal here is for students to be very hands-on. However, the student is required to do almost no scientific thinking. The question is predetermined. The materials are identified. The procedure is listed. Students are told what data to collect and how to record it. In fact, these books often predict the outcome of the experiment—along with an explanation of why it will happen! Science, apparently, is *easy as pie*. But how often does that scenario reflect the work of a real scientist or mathematician?

Though the science recipe can serve a valid purpose as a building block, our ultimate goal is to give our students opportunities for true **scientific investigation**. This is uncomfortable territory for some teachers, because it involves taking on the role of a facilitator and giving students more individual responsibility. However, it is possible—and preferable—for students to ask the research question. For students to identify their independent variable. For students to determine the tools they will need, the procedures they will use, and the data they will collect. Most importantly, it is important for students to evaluate their own hypothesis and wrestle with the question, "What did I learn?" True, when we give our students more latitude, there is an increased likelihood that something unexpected will happen. But that is okay, because authentic learning occurs in those moments, too.

In summary, engaging students in experimental research is central to the Innovation Model. Whether introducing a new topic through guided investigation, or assessing a standard through a culminating performance event, the inquiry process empowers students to do the work of real scientists and mathematicians.

Much like the Innovation Model itself, it is essential for students (and teachers) to realize that the process of inquiry is non-linear. Unlike the traditional presentation of the scientific method, which begins with a question and ends with a lab report, the inquiry process often leads to more questions than it answers!

Please note the following key words and concepts:

Variable:
True scientific inquiry assumes the test of a single independent variable. Teach students to identify the variable they are testing.

Control:
Other than a single independent variable, all other aspects of the experiment must remain constant. Students should be able to identify the variable they are testing.

Prediction:
Through a stated hypothesis, students will begin their investigation by anticipating the end result.

Tools:
Scientists and mathematicians observe; they measure; they collect data. Students should determine the tools they will need to conduct their investigation.

Replicate:
It is critical that students state their methodology clearly, allowing for repeat tests and enabling others to validate their findings.

Learning:
Students will learn much during the course of an investigation. Simply stating *"I learned that my hypothesis was right"* is not enough. And an incorrect hypothesis does not indicate failure—it indicates learning!

Questions:
Questions really do drive scientific investigation. However, the goal of an experiment is not merely to answer the initial research question. The inquiry process should actually lead to additional questions for further research. And this leads to more science!

A Note on Implementation

How will you implement the ideas in this unit? Certainly, there is no set structure or schedule for the classrooms across our country. Do you have 18 students or 32? Are you self-contained or departmentalized? You may enjoy the luxury of block scheduling, with an hour and a half to engage your students in learning. On the other hand, you may have 45-minute class rotations, with barely enough time to get your materials out before it is time to clean up for the next group. It is even possible that you may want to utilize this material in an enrichment setting, which often adds a layer of complexity as you only see your students once each week.

In the past, various elements of this unit have been used with high ability students in grades 3-6 in a weekly enrichment setting. Yet they have also been differentiated for use with gifted students in grades 7-10 during an intensive three-week summer camp. The bottom line is that you will need to make decisions and modifications that enable you to use this material in your own unique setting.

Time permitting, it would be ideal to approach the four components of this study—food, waste, housing, and energy—as a single unit. (Each section also includes a menu of extension activities, each of which could take one or more class periods.) One could even divide the unit into four parts and do one piece each quarter. That would still provide continuity over time while allowing the unit to supplement other curricula you are required to cover.

Finally, though this likely deemphasizes the broader thematic nature of this unit, a teacher may simply choose to focus on one aspect of sustainability and explore it more deeply. A six-week study of energy, complete with readings about Mountaintop Removal and a field trip to a hydroelectric facility, could inspire a young person to envision a more sustainable future for us all.

Introduction

Before you begin any unit of study, it is always wise to conduct some sort of pre-assessment. Keep in mind that a preassessment does not have look like a traditional test. It is merely a way to measure what students know before they begin the unit of study. Your students will come to you with different backgrounds and experiences, different schema, varying degrees of understanding. The preassessment is an opportunity for students to show you what they already know. Then, based on the data you collect, you can tailor this learning experience to meet the individual needs of your students.

Here are two different types of preassessment. One involves a series of writing prompts. (To facilitate the pacing of Day One, you might consider assigning these at various points during your Introduction. Or you might opt to use a single prompt.)

1. During lunch one day, you and a friend are discussing the new unit your teacher has been so excited about. “Sustainability,” your friend says. “Isn’t that like tree huggers and stuff?” Based on your current level of understanding, how would you explain the concept of Sustainability to your friend?

2. How does the topic of Sustainability impact your own life? In what way(s) do you feel personally connected to the issue?

3. During the course of this unit, we will spend time debating the pros and cons of various issues. Can you anticipate at least two potential debate topics related to the concept of Sustainability? Based on your current level of understanding, which “side” would you be on?

The second component of this pre-assessment is simply asking your students to tell what they know about some of the key terms listed in the back of this unit. It would not be necessary for students to define them all. A representative sample will give you a good idea of their prior knowledge: CAFO, Hydroponics, Conservation, Vermicomposting, Net-Zero, Renewable Energy, Mountaintop Removal, Independent Variable, Replicate.

Remember, students can be very sensitive about not knowing things. Please reassure them that it is okay to be unfamiliar with these concepts at this point in the unit. They’ve not even had the opportunity to learn anything yet! Remind them, as well, that your goal is simply to establish a baseline for their learning. And the only way a student can see how much she has grown is if she has a clear grasp of where she started.

After completing some portion of the preassessment, share the John Muir quote from the Unit Overview. (You might want to write it on chart paper or project it on a multimedia screen.) Ask students to discuss the quote with their tablemates, then share out as a whole group. What is Muir’s meaning? Do you agree or disagree?

What are some examples of this “hitching”? What might be some inherent dangers of viewing the world as a series of disconnected parts? How is this quote connected to the topic of sustainability?

This would be a good time for several willing students to share their responses to the first writing prompt. How would your students define sustainability?

The Berea College website offers this useful definition: “Sustainability refers to the capacity of a society to meet current needs without degrading the ecological, social, and economic systems on which the society will rely for meeting future needs.” (http://www.berea.edu/sustainability/about/)

This notion of engaging in some present activity that could have a degrading effect on the future should be simple enough for students to grasp. Consider eating fast food, for example. Chances are that most of your students do this with some degree of regularity. But eating it three times a day for a month? (Perhaps some of your students are familiar with Morgan Spurlock’s documentary *Super Size Me.*) Or consider buying a video game or a new pair of shoes. Again, this is probably something most of your students have done. But what would be the effect if they did this every week? (And the effect is the same, incidentally, for families, businesses, institutions and governments that spend beyond their means.) Sustainability, quite simply, is the opposite of that.

Share the Venn diagram showing the connectedness of Society, Environment, and Economy. Does that resonate with your students? How are the three areas linked? Are there things that might be economically beneficial, but would not be viable for society or the environment? By contrast, are there things that might be good for the environment, but bad for people?

What if the three labels on the Venn diagram were changed to People, Planet, and Profit? Does that change one’s perception? Does one sound less ambiguous? Does one seem more positive? Which one do students prefer?

Finally, share with your students a short preview. This unit will touch on four topics to which we are all connected:

Food: What we choose to eat and where that food comes from
Waste: What happens to the things we don’t want anymore
Housing: How we go about creating a satisfying living space
Energy: Where we get our power and the broader implications of those choices

Truly, this unit is an attempt to better understand the economic, environmental, and social implications of our everyday choices.

Section One: Food

A discussion of food is a wonderful place to begin this study of sustainability. Most of us love to eat. ("When's lunch?") And most of us have some sense of what is healthy—even if, in reality, we choose to eat foods that may not be good for us. But there seems to be a tremendous lack of understanding when we think about where our food comes from.

Perhaps some of that lack of understanding is because we'd really rather not know. But I'm afraid sometimes we're just so far removed from the process that we need to be educated. Once a very bright sixth grader was researching food systems in my class. When the student came across the acronym USDA and inquired about its meaning, I explained it was the United States Department of Agriculture. To which the student replied, without a trace of irony, "What does the United States Department of Agriculture have to do with our food?"

Yes, our American food system is definitely hitched to the USDA. And, for better or worse, we are hitched to this American food system. Get ready to think about industrial farming, GMOs, corn subsidies, and alternative gardening techniques such as **hydroponics** and **vertical gardening**. But first, what's in that burger?

Lesson 1 – Science Demonstration: Hamburger Helper?

Perhaps you've seen photos of fast food that's been left on a counter top for days, weeks, months, even a full year. This activity is a nice hook to get your students thinking about what we eat and the potential ramifications of our food choices. And, though the observation period may span several weeks, the initial setup is fairly straightforward. Depending on the amount of time you have, you might even consider pairing this with your Introduction. This would be a great way to bring Day One to a close!

As indicated by the title of this lesson, this activity is more of a demonstration than a science recipe or a true science experiment. However, note that there are many building blocks to help our students think like scientists.

First and foremost, you will want to stress the importance of healthy skepticism. What will happen to fast food left on a shelf or table for an extended period of time? Who knows! The main thing is you don't believe anything just because the Internet says it is true. You don't believe it because your teacher says it is true. You don't even believe it because a *scientist* says it is true. Scientists question and scientists confirm on the basis of their own independent investigation.

Secondly, leaving a cheeseburger on a shelf for a month doesn't really prove anything. If there is no independent variable, there is nothing to test—and therefore no experiment. This activity will develop the idea of using an independent variable to make comparisons during an experiment, as well as emphasizing the need to keep other conditions controlled.

Finally, this is a wonderful opportunity to involve your students in data collecting. What data might they collect? What can be measured? What tools will they need? You will guide that discussion at this point so you can give students more freedom in the future.

To begin with, you will need to purchase a selection of hamburgers. It would be perfect if this lesson aligned with a day they were serving burgers in your school cafeteria! At the very least, you will want to bring in two or three plain burgers from well-known fast food establishments. To make a good comparison, it is also good to have a burger you prepared at home, perhaps using ground beef from a local farmers' market.

Explain the purpose of this activity to your class and initiate a discussion: What is the independent variable in this activity? In other words, what is the one thing you are trying to test? Why is it important that all the burgers were purchased on the same day? Why is it important that each of the hamburgers is "plain"? What might be the effect if one was plain, one was a cheeseburger, one had ketchup and mustard, and one had lettuce and tomatoes? In short, if you want to test the effect of time on several types of burgers, they must be as similar as possible. (Some students may even note, correctly, that all burgers should be the same weight when you start. However, while that is technically true, slight variations in weight will not diminish the outcome of this activity.)

Next, encourage your students to make some hypotheses. What do they predict will be the outcome of this activity? If they anticipate the burgers spoiling at different rates, on what prior knowledge do they base that prediction? And why does it really matter? If one burger spoils quickly and another remains basically intact, what have we learned? What might be the implications for our personal health? This will likely be an ongoing discussion, but it does beg the question: “What does one normally do with a hamburger?” We chew it up and swallow it and attempt to digest it. We eat it, of course!

You will also want to get your students thinking about data collection. (Depending on your class size, it might be helpful to divide your class into groups, assigning each group a different burger to monitor.) During the next few weeks—or months—of observation how could the students document changes to these hamburgers? A sketch or drawing would, of course, be one option. Most classrooms now have access to digital cameras, and that would be a very professional way to document this project. Are there things that could be measured? If so, what tools would be required? One option would be weighing the burgers periodically using a balance or electronic scale. Another idea would be measuring changes in the diameter of the hamburger or the buns. If there is a change in diameter, what might be the cause? Be sure to emphasize that scientists measure using the metric system because it is an internationally accepted standard. That enables scientists to communicate effectively with likeminded people around the globe. (Not to mention it’s much simpler to convert units based on powers of ten!)

One final note on variables and controls. You will have to determine where in your classroom to conduct this activity. Ask your students for their input. Should you put them in a dark closet? What about a bookshelf? A sunny windowsill? Would it be a problem to put some in a closet, some on a bookshelf, and some on the windowsill? Clearly, you do not want the environment to become a variable, thus skewing the results of the activity. Also, the class should agree on some consistent schedule for recording data. Will they record observations, take photographs, weigh and measure daily? Each Monday? Twice per week? For the scientist, consistency is key.

The next step is waiting. Depending on your preference, this could literally last for several weeks or even months. But this activity is guaranteed to rouse the curiosity of your students—and any other guests who may visit your classroom. In the end, you will want students to think about ways to clearly communicate their procedure. Some other healthy skeptics may be eager to replicate their work!

Lesson 2 – Feeding the World Is Big Business

Here's a quick activity to connect the discussion of **industrial farming** to the hamburger observation.

How much would a hamburger cost at fast food restaurant? Not much. Maybe $1.00? Now ask your students to brainstorm all the potential costs associated with getting that hamburger into your hands:

· Cost of the land on which the beef was raised
· Food and water for the animal
· Veterinary costs
· Salary for the farmer who raised the beef
· Slaughterhouse and/or meat processing fee
· Wheat for the bun
· Fertilizer
· Pesticide
· Possible irrigation costs
· Salary for the farmer who raised the grain
· Facility in which the grain was milled into flour
· Facility in which the flour was baked into bread
· Miscellaneous transportation and fuel costs
· Fast food restaurant employees
· Advertising (beef industry, fertilizer and pesticide companies, fast food restaurant)

Doesn't that make you stop and wonder how a burger can be purchased for a mere dollar? Part of the answer lies in government subsidies, assistance which supports the agriculture industry, often ensuring farmers a set price for growing—or occasionally for not growing—certain commodities. Another component of the answer is that agriculture today bears little resemblance to the nostalgic image of a small family farm. No, the 21st century agriculture industry is a well-oiled machine.

This unit will recommend two documentaries. (*Food, Inc*. is included here, and *The Last Mountain* in chapter 11. Others are suggested as optional extension activities.) Naturally, you are always advised to preview any documentary before you share it with your class. *Food, Inc.* does include brief footage of **Concentrated Animal Feeding Operations** and animal processing facilities. However, it definitely offers a pointed look at the state of farming in America today. It will probably take a couple class periods to watch this film in its entirety. Or you may prefer to share only certain excerpts with your students. Either way, *Food, Inc.* is bound to raise more than a few questions.

Along the way your class will encounter:

· Michael Pollan (*Omnivore's Dilemma*) and Eric Schlosser (*Fast Food Nation*), authors and noted critics of the typical American diet and the food system from which it comes

· Carole Morrison, a chicken farmer who was released from her contract with Perdue when she refused to completely enclose her large industrial chicken house

· Joel Salatin, "High Priest of the Pasture" and proprietor of Polyface Farm, whose approach to farming can only be described as the antithesis of industrial

· Barbara Kowalcyk, who unsuccessfully appealed to Congress for legislative reform after her young son, Kevin, died as a result of exposure to E. coli while eating a hamburger

· BPI, a leader in the beef processing industry that addresses the problem of E. coli contamination by washing ground beef in ammonia—then washing off the ammonia

· Moe Parr, an Indiana farmer who was sued by the Monsanto Corporation on charges that he encouraged "seed saving," a crime because they own a genetic patent on their seeds—and any subsequent offspring their seed might produce

· Gary Hirshberg, a proponent of **certified organic** farming, whose Stonyfield Farms products are now found on the shelves of Wal-Mart superstores

Before you share this documentary with your students, engage them in a discussion about **bias**. As stated in the first lesson, a respectable scientist does not believe everything she hears. Here are some points to consider:

Does *Food, Inc.* provide a balanced message, or does it elevate a single perspective?

Do the makers of this film seem to have an **agenda**? If so, what do you think they are trying to accomplish?

How would you define **propaganda**? Does this documentary fit your definition of the term?

After viewing *Food, Inc.*, you will ask your students to respond to one or two of the following prompts. You may wish to assign prompts randomly to ensure that several viewpoints are represented. (Your students will be better prepared to write if you share all the prompts with them before they watch the documentary.) When they are done writing, allow some time for your students to share their responses in small groups, then use their writing as the basis for a whole class discussion.

1. What new information did you learn about the American food system? Were there aspects of this documentary that made you feel shocked or surprised?

2. As you watched *Food, Inc.*, what information did you question? Are there parts you find unbelievable? What facts do you want to check?

3. What character or what storyline resonated most with you? Did you feel a genuine sense of empathy, or do you think the filmmakers were trying to play on your emotions?

4. What people or what organizations might be opposed to the information shared in *Food, Inc.*? Why do you think they would disagree?

5. Do you think this film could motivate someone to make any lifestyle changes? If so, how might one shop differently, eat differently, consume differently, live differently?

Lesson 3 – Alternative Gardening Methods

After the last lesson's focus on modern agriculture as big business, it may surprise your students to know that our federal government once actively promoted home gardening. If possible, use your projector to share this image with your class:

Some of your students may already be familiar with the circumstances surrounding this poster. The context was World War I, and some of your students may enjoy looking for similar images on the Internet. Obviously, our country was facing a national crisis, and ordinary citizens were encouraged to do their part by raising a Victory Garden. There was even a School Garden Army under the Bureau of Education!

Isn't it interesting that something so old can suddenly seem new again? The local food movement is rapidly gaining momentum across the country. However, there was a time when all food was local. When Michelle Obama initiated the planting of a large garden on the White House lawn, she was merely following in the footsteps of Eleanor Roosevelt and Abigail Adams!

If one's only reference point for food production is plowed fields and large tractors, many of your students might believe they have no capacity for growing what they eat. However, this lesson will give them an opportunity to study a variety of non-traditional gardening techniques, of which many are being practiced in densely populated urban areas.

Here are a handful of websites to help your students begin exploring some great ways to garden:

Container Gardening:
- http://www.gardengirltv.com/container-gardening.html
- http://www.thetinylife.com/tag/bucket-garden/

Vertical or Rooftop Gardening:
- http://urbangardenmagazine.com/2010/08/growing-up-in-manhattan/
- http://www.woollypocket.com/

Raised Beds or Square Foot Gardening:
- http://www.squarefootgardening.org/
- http://www.mysquarefootgarden.net/

Hydroponics:
- http://www.instructables.com/id/Hydroponics---at-Home-and-for-Beginners/
- http://www.jasons-indoor-guide-to-organic-and-hydroponics-gardening.com/

Aquaponics:
- http://www.aquaponics.net.au/system600a.html
- http://gemsacademy1.edu.glogster.com/aquaponics/

The students' goal will be to create a presentation explaining one of these alternative gardening methods to their classmates. Students may choose to create a basic PowerPoint or Keynote presentation, or they may decide to use one of the free Web 2.0 tools such as Glogster, Prezi, Animoto, or PhotoPeach. That decision will ultimately be based on the students' wishes, your own comfort level, and everyone's access to technology.

As the students begin, use these guiding questions to connect their work back to The Innovation Model. Note that some of the bullets (Connect, Inquire, Analyze, Enhance) are related to the content itself, while others (Create, Communicate) pertain more to the students' presentation.

Connect: How does this method of gardening reflect the 3 R's: Reduce, Reuse, Recycle?

Inquire: What special knowledge, materials, or procedures are necessary for this method of gardening?

Analyze: Does this method of gardening present any special benefits or obstacles?

Enhance: How could you refine this method of gardening for application in your own home or school?

Create: Does your presentation reflect professional-level work? (i.e. clarity, organization, use of time, etc.)

Communicate: Are you communicating with your peers in appropriate ways? (i.e. focused presentation, adequate voice level, etc.)

Also, please see the information on the following pages regarding the use of The DAP Tool as a rubric for assessment.

Clearly, this is not something that can be completed in a single class period. In fact, it may take one class period to introduce the activity, another to do the basic research, two more to develop the presentation, and a final period or two for presentations. Feel free to modify as needed, such as reducing he number of research options or having students work in teams of two.

Differentiation and Assessment Using Student Products

In their book *Strategies for Differentiating Instruction: Best Practices for the Classroom* (2015) Dr. Julia Roberts and Dr. Tracy Inman of The Center for Gifted Studies at Western Kentucky University introduced the Developing and Assessing Products (DAP) Tool for assessing student work. Their work *Assessing Differentiated Student Products: A Protocol for Development and Evaluation* (2015) further developed DAP Tools.

The DAP Tool provides a framework for designing and assessing products at various levels. For example, two students with different abilities might be working in the same content area (science) and creating the same product (a PowerPoint presentation), yet—due to their varying levels of ability—their work will be evaluated using different criteria.

The DAP Tool has four basic components: content, presentation, creativity, and reflection. The students' work is scored based on an evaluation of each of these criteria. While many educators are familiar with a four-tiered evaluation model (e.g., Novice, Apprentice, Proficient, and Distinguished), the DAP Tool offers an additional performance level:

6 - Professional Level
5 - Advanced Level
4 - Proficient Level
3 - Progressing Level
2 - Novice Level
1 - Non-Performing Level
0 - Non-Participating Level

The acknowledgment of a Professional Level of performance offers an extra measure of challenge for all students. The fact is, professionals do produce posters, videos, websites, pamphlets, short stories, paintings, and speeches. And recognizing the quality of professional work provides students with a standard to which their own work can be compared. Note, too, that each DAP Tool includes a category for student self-reflection, a critical piece of any project.

DAP Tool samples are included in this unit for both the Alternative Gardening Methods PowerPoint (Lesson 3) and the Living Small Design Challenge Model (Lesson 9).

MODEL Tier 1 —DAP TOOL

CONTENT								
	• Is the content correct?	0	1	2	3	4	5	6
	• Has the content been thought about in a way that goes beyond a surface understanding?	0	1	2	3	4	5	6
	• Is the content put together in such a way that people understand it?	0	1	2	3	4	5	6
PRESENTATION								
Representation	• Does the model clearly look like what it represents?	0	1	2	3	4	5	6
Construction	• Does the construction make the model stable? Are the materials appropriate for the construction?	0	1	2	3	4	5	6
Labels	• Are the labels clear? Are the labels mostly free from usage, punctuation, capitalization, and spelling errors? If sources are used, are they cited correctly?	0	1	2	3	4	5	6
CREATIVITY								
	• Is the content seen in a new way?	0	1	2	3	4	5	6
	• Is the presentation done in a new way?	0	1	2	3	4	5	6
REFLECTION								
Content	• What connections can you make between what you have learned by completing this project and previous learning?	0	1	2	3	4	5	6
Product	• In what ways could you improve your product when completing this product with a different assignment?	0	1	2	3	4	5	6
Learning	• How did the amount of effort affect your learning about the content and creating the product?	0	1	2	3	4	5	6

Comments

____

____

____

Meaning of Performance Scale:
6—PROFESSIONAL LEVEL: level expected from a professional in the content area
5—ADVANCED LEVEL: level exceeds expectations of the standard
4—PROFICIENT LEVEL: level expected for meeting the standard
3—PROGRESSING LEVEL: level demonstrates movement toward the standard
2—NOVICE LEVEL: level demonstrates initial awareness and knowledge of standard
1—NONPERFORMING LEVEL: level indicates no effort made to meet standard
0—NONPARTICIPATING LEVEL: level indicates nothing turned in

Note. Adapted from *Strategies for Differentiating Instruction: Best Practices for the Classroom (2nd ed.)* (p. 246), by J. L. Roberts and T. F. Inman, 2009, Waco, TX: Prufrock Press. Copyright © 2009 by Prufrock Press. Adapted with permission.

MODEL Tier 2 —DAP TOOL

CONTENT								
	• Content is accurate and complete.	0	1	2	3	4	5	6
	• Content has depth and complexity of thought.	0	1	2	3	4	5	6
	• Content is organized.	0	1	2	3	4	5	6
PRESENTATION								
Representation	• The model makes the viewers see the purpose (whether realistic and/or symbolical).	0	1	2	3	4	5	6
Construction	• The model clearly exhibits knowledge of a scale and uses it appropriately. If a realistic representation, the scale is measurable. If a symbolic representation, the model may or may not follow a measurable scale and may communicate ideas by dramatically altering the scale or only scaling objects relative to one another.	0	1	2	3	4	5	6
	• The model is constructed with detail. Materials enhance the meaning of the model.	0	1	2	3	4	5	6
Labels	• Labels are clear and pertinent. They match the key. They are free from usage, punctuation, capitalization, and spelling errors. Sources, when used, are thoroughly cited.	0	1	2	3	4	5	6
CREATIVITY								
	• Originality is expressed in relation to the content.	0	1	2	3	4	5	6
	• Originality is expressed in relation to the presentation.	0	1	2	3	4	5	6
REFLECTION								
Content	• Reflections include connections to previous learning and questions raised for future learning.	0	1	2	3	4	5	6
Product	• Reflections include improvements made over other times the product was created as well as suggestions for improvements when creating the same product in a future learning experience.	0	1	2	3	4	5	6
Learning	• Reflections include analysis of self as a learner, including effort, work habits, and thought processes.	0	1	2	3	4	5	6

Comments

____

____

____

Meaning of Performance Scale:
6—PROFESSIONAL LEVEL: level expected from a professional in the content area
5—ADVANCED LEVEL: level exceeds expectations of the standard
4—PROFICIENT LEVEL: level expected for meeting the standard
3—PROGRESSING LEVEL: level demonstrates movement toward the standard
2—NOVICE LEVEL: level demonstrates initial awareness and knowledge of standard
1—NONPERFORMING LEVEL: level indicates no effort made to meet standard
0—NONPARTICIPATING LEVEL: level indicates nothing turned in

Note. Adapted from *Strategies for Differentiating Instruction: Best Practices for the Classroom (2nd ed.)* (p. 247), by J. L. Roberts and T. F. Inman, 2009, Waco, TX: Prufrock Press.

MODEL Tier 3 – DAP TOOL

CONTENT								
	• Content is accurate and thorough in detail.	0	1	2	3	4	5	6
	• Product shows complex understanding and manipulation of content.							
	• Product shows deep probing of content.	0	1	2	3	4	5	6
	• Organization is best suited to the product.	0	1	2	3	4	5	6
PRESENTATION								
Representation	• The model employs a new idea in the representation whether that representation is real or symbolic.	0	1	2	3	4	5	6
Construction	• The construction as to the detail and materials is unique to highlight the model's purpose. More than one piece of sensory information is incorporated into the construction.	0	1	2	3	4	5	6
Labels	• Labels effectively direct the purpose of the model. They are error free, with correct usage, punctuation, capitalization, and spelling used. All sources are cited correctly with the citation placed appropriately.	0	1	2	3	4	5	6
CREATIVITY								
	• Innovation is evident in relation to the content.	0	1	2	3	4	5	6
	• Innovation is evident in relation to the presentation.	0	1	2	3	4	5	6
REFLECTION								
Content	• Reflections analyze and evaluate connections to previous learning and project insightful future connections.	0	1	2	3	4	5	6
Product	• Reflections analyze and evaluate the product components in light of past and future creations of the same product.	0	1	2	3	4	5	6
Learning	• Reflections include analysis of self as a learner and project how changes to the process would increase capacity as a learner.	0	1	2	3	4	5	6

Comments

____

____

____

Meaning of Performance Scale:
6—PROFESSIONAL LEVEL: level expected from a professional in the content area
5—ADVANCED LEVEL: level exceeds expectations of the standard
4—PROFICIENT LEVEL: level expected for meeting the standard
3—PROGRESSING LEVEL: level demonstrates movement toward the standard
2—NOVICE LEVEL: level demonstrates initial awareness and knowledge of standard
1—NONPERFORMING LEVEL: level indicates no effort made to meet standard
0—NONPARTICIPATING LEVEL: level indicates nothing turned in

Note. Adapted from *Strategies for Differentiating Instruction: Best Practices for the Classroom (2nd ed.)* (p. 248), by J. L. Roberts and T. F. Inman, 2009, Waco, TX: Prufrock Press.

Extensions

Activity: If your students are interested in better understanding farm subsidies and the ubiquity of corn in the American diet, have them become Corn Sleuths. Ask each student to bring in two or three pantry items with the ingredients listed on the label. (Note: Students can take the items back home at the conclusion of the activity.) Students can determine how to categorize the products. It is truly amazing to observe how many things contain corn or some corn byproduct!

Site Visits: This section really lends itself to getting out of the classroom. Nearly every region of the country has some local farmers who eschew the industrial model. Perhaps you live in an urban area where your students could visit a rooftop garden. And a trip to a farmers' market is always a big hit. Students love getting a taste of fresh fruits and vegetables.

Readings: For those students interested in raised bed or Square Foot Gardening, a wonderfully simple option for school or small family gardens, Mel Bartholomew's *All New Square Foot Gardening: How to Grow More Food in Less Space* is the perfect resource. It is unlikely that your schedule will permit your students to read an entire text, but a few excerpts may be appropriate. *Food Fight: The Citizen's Guide to the Next Food and Farm Bill* by Daniel Imhoff explores the politics behind the American food system. And students with an interest in unhealthy trends may enjoy Eric Schlosser's *Fast Food Nation* or *Salt Sugar Fat: How the Food Giants Hooked Us* by Michael Moss.

Documentaries: On the subject of unhealthy trends, some of your students are probably already familiar with *Super Size Me*, in which Morgan Spurlock eats McDonald's three meals a day for a month. Just seeing what it does to his liver should be a deterrent. And, finally, *Farmageddon* is an interesting look at our government's alleged crusade against those who would procure their food outside the industrial food system. As with anything else you might read or watch, a discussion of bias would be entirely appropriate.

Section Two: Waste

Do you feel a sense of pride when you set your recycling bin curbside each Thursday? Is your plastic container overflowing with remnants of cardboard packaging, soda cans, and empty plastic water bottles? What could be any more eco-friendly than all that recycling? Well, for starters, maybe you didn't need to drink all that soda to begin with. Perhaps you could try drinking tap water in a refillable container. (After all, some reports suggest that a percentage of bottled water is just tap water repackaged and sold to consumers.) And what about that cardboard packaging? Aren't there more efficient and innovative options for packaging our goods?

It's been said that the three R's—Reduce, Reuse, and Recycle—are listed in that order for a reason. Recycling is not the answer to a waste problem in a world whose population has topped 7 billion people. It's better than mindlessly tossing things in a landfill, but just imagine all the energy that's expended in the recycling process, beginning with that big truck that so conveniently collects your weekly recycling. A far better solution would be finding new ways to reuse what we have. And best of all would be to use less.

But, you see, the things is, we're all consumers. We view advertisements, we purchase products, we use them, and we throw them away. Except there is no such place as "away." Everything is somewhere—even if it is a swirling patch of garbage floating in the Pacific Ocean—and we are all connected to it.

This section helps students become more aware of the various ways we are connected to this issue, as well as proposing one way we can begin "re-visioning" what is trash and what is not. And there's also a cool science activity that involves playing with worms!

Lesson 4 – Consumerism and "The Life Cycle of Stuff"

As a lead in to this lesson, give your students an assignment the day before. Give each student a kitchen-size plastic trash bag and a pair of latex gloves. Their task is collect anything they would have normally thrown away over the course of the next twenty-four hours. Old homework? In the bag. Junk mail? In the bag. Fast food wrappers? In the bag. Apple core? In the bag. (Students can still use some discretion. For example, you should certainly make an exception for any toiletry items.) And don't forget, you need to participate, too!

The goal of this activity is to get a better sense of how much "trash" we typically generate. When students bring their bags to class, weigh each bag on a scale. Who brought in the most trash? The least? How much was generated by the entire class? Then divide the items into three categories: **Landfill**, Recycling, and Compost. (Lesson 5 addresses the idea of composting. For the purposes of this lesson, you can simply explain that category includes organic matter such as apple cores, banana peels, etc.) What percentage of the trash your class collected could have gone somewhere other than the landfill? Many larger institutions find that they are only recycling about 15% of their "garbage," with the remainder destined for the dump.

Share with your students an important historical connection. At one point in our nation's history, the issue wasn't keeping waste out of the landfill via recycling and composting—the issue was getting litter off our landscape and into the landfill. Show students this video of Chief Iron Eyes Cody, sometimes called "The Crying Indian," from the Keep America Beautiful campaign of the early 1970s. (They might also enjoy the "Suzy Spotless" PSA from the same era.)

http://www.aef.com/exhibits/social_responsibility/ad_council/2278

Does litter seem to be a major problem in your region of the country? Why or why not? There are likely several answers to that question. Education has definitely made a difference. Quite simply, we know better. However, another consideration is the availability of curbside trash pickup. Do all of your students have access to a service that magically makes their trash "disappear" on a weekly basis? Forty years ago, that was not an option for many people. In some rural parts of the country, it is still not an option today. But most municipalities do have a solid waste management system in place. What about recycling? For some folks, it's as easy as carrying a bin to the curb. A **single stream recycling** system is very common—the customer does not even have to do any sorting. In other locations, people have to transport their recycling to a specified location. And some areas have no convenient recycling options at all.

If reducing is even more desirable than recycling, we need to rethink where all this "stuff" comes from in the first place. In his book *The Conundrum*, David Owen makes the case that this excess is merely a response to consumer demand. We are developing an environmental consciousness in the United States, but we'd really like to buy a new product to help us reduce our ecological footprint. Can't we just purchase a 55" flat screen television with Energy Star certification? Can't we just buy a new Prius hybrid? Can't we just replace all our incandescent light bulbs with compact fluorescents?

Yet this increased demand for goods also means an increased demand for manufacturing. Is this good or bad? That is a point for debate. Certainly, our economy benefits from a high degree of manufacturing and sales. We just need to be aware of the costs that come both before and after our purchases.

Annie Leonard has brought this issue into focus through her project "The Story of Stuff." (http://www.storyofstuff.org/) Her work is available in book format, as well as a 20-minute online movie. Leonard's tone is somewhat strident; once again, be sure to include a discussion of bias, tone, and agenda in connection with this video. Leonard contends that we are all very much connected to this issue because "stuff" has a life cycle. At every phase of a product's life cycle, there are practices and by-products that may be potentially harmful to us and to our environment.

Another presentation of the same content comes from the United States Environmental Protection Agency:

http://www.epa.gov/climatechange/climate-change-waste/

According to the EPA, a product's life cycle generally follows this path: 1. Materials Extraction, 2. Manufacturing, 3. Distribution, 4. Usage, and 5. End-of-Life Management. Clearly there are costs—both monetary and environmental—associated with our consumption. Interestingly, the EPA links these costs to the topic of **climate change**. Though there is ongoing debate regarding the causes and effects of climate change, we can all make an impact by using less.

Consider the following questions for review:

1. We typically think very little about where our "stuff" comes from and where it goes. Did you have any "aha" moments as we learned about "The Life Cycle of Stuff?"

2. Had you considered the ways we are connected to the topic of sustainability via the issue of **consumerism**? How are you already playing a role as a consumer in this society? What would be the impact—either positive or negative—if we truly committed ourselves to using less?

3. The Kentucky farmer and author Wendell Berry has said on more than one occasion: "If we want to stop the impoverishment of land and people we ourselves must be prepared to become poorer." What do you think he means by that? How would you respond?

Lesson 5 – Rethinking Trash: Composting and Vermicomposting

This is a fun design/build project that encourages students to re-vision the idea of waste. This lesson is not so much about using less, but about choosing to view things as treasure rather than trash.

Composting is not a new idea. In fact, it is the entirely natural process of organic material breaking down, decomposing, and returning to the earth. Yet, for the sake of convenience, a tremendous quantity of organic material ends up in our landfills every day. In grocery stores, restaurants, hotels, schools, and homes, rarely do we take the time to separate our organic and inorganic waste.

The practice of composting is currently gaining momentum. Granted, it does take a bit of forethought to redirect our organic material. But many institutions are finding it feasible to divert these items from our landfills. New York City is even encouraging the practice in its urban high-rises. Check this link from National Public Radio to listen to a recent news story or read a transcript of the feature:

http://www.npr.org/blogs/thesalt/2013/06/27/196269850/NYC-RECYCLING-REBOOT

Composting is very doable in rural and suburban areas, and it makes for quite an interesting school project. This lesson will probably take at least one class period for introduction and research, a couple class periods for construction, and an additional class period to develop a campaign to get the whole school on board.

This five-minute YouTube video with Scott Meyer, editor of *Organic Gardening* magazine, will help explain the basics of composting:

http://www.youtube.com/watch?v=ZAMy_ZJ0Xa8

Meyer touches on the science behind the process. It is important that the compost gets plenty of oxygen. Turning it occasionally is advisable. Maintaining a proper balance of "green" and "brown" matter will keep your compost healthy, as will a proper level of moisture. Students are always anxious to know what you can and cannot compost. Essentially anything that was once living will decompose. Pretty much any remains of fresh fruits and vegetables are fair game. However, you do not want to attract animals. For that reason you will not add meats and oils to your compost. You would also be cautious about including pickles or salad with dressing on it. Vinegar and salt act as preservatives, and the whole point of composting is to encourage the contents to decompose. But you will be amazed by the things you can compost: leaves, grass clippings, kitchen scraps, egg shells, an old bouquet of flowers, rabbit manure, water from your aquarium—even hair and dryer lint!

There are many different compost bin designs, and students can find an overview of several types here courtesy of the University of Wisconsin Cooperative Extension Service:

http://www3.uwm.edu/Dept/shwec/publications/cabinet/html/compost/Bin%20 Plans.htm

Have your students weigh the pros and cons of these four options:

1. Open Compost Pile
2. Wooden Pallet Compost Bin
3. Wood and Screen Compost Bin
4. Compost Tumbler

Once they have selected a design, they should also consider the following questions:

· Which design did you choose and why?
· What materials do you plan to reclaim and were do you plan to find them?
· What materials will need to be purchased?
· What tools will be required to build the compost bin?
· What challenges do you anticipate?
· Do you plan to make any enhancements to the original design plan?
· What is a reasonable deadline for this project?

Organizers for the two above activities are included on the following pages.

Finally, if you are feeling brave enough to introduce worms to the composting process, you might want to give vermicomposting a try. Building a bin is relatively simple, and you can keep it right in your classroom. You will have your students thinking about their lunches in a whole new way!

Here is a very basic plan for a vermicomposting bin:

http://www.instructables.com/id/Wormery-Worm-Composter/

If you find any part of this intimidating, rest assured that the students' learning and enjoyment will far outweigh your trepidation. The overall costs will be minimal, and the PTA is often a good source of funding. (After all, this is a service project that will give back to the school.) And you probably have many willing parents who would loan small tools and volunteer to oversee their use. Happy composting!

Compost Pile	Pro	Con

Compost Bin	Pro	Con

Compost Bin w/ Screen	Pro	Con

Compost Tumbler	Pro	Con

Design Selection

Which design did you choose and why?

Reclaim Materials

What materials do you plan to reclaim?
Where will you find them?

Materials

What materials do you plan to purchase?

Tools

What tools will be required to construct the compost bin?

Anticipate

What challenges do you anticipate?

Enhance

Do you plan to make any enhancements to the original design plan?

Timeline

When is a reasonable deadline for this project?

Notes/Wonderings

Lesson 6 – Science Recipe: Worm Behavior and Adaptations

Credit for this lesson belongs to the Environmental Outreach Program of the Savannah River Ecology Laboratory (SREL), a research unit of the University of Georgia. This study of worm behavior and adaptations dovetails nicely with the prospect of using worms to dispose of unwanted kitchen waste. If one is to create an appropriate habitat for red wigglers, it is imperative to know what environmental factors will help the worms to thrive.

A summary of this activity follows below, but more explicit details may be found at the SREL website (http://srel.uga.edu/kidsdoscience/kidsdoscience-behavior.htm). There you will find detailed rationale, a PowerPoint presentation, and information regarding worm anatomy. This activity is designed for use with students in grades 3-6.

As the title implies, students are given generous guidelines to follow. Yet, compared to the "Hamburger Helper?" demonstration, they are somewhat more involved as decision-makers and stakeholders. This is also an excellent opportunity to get students collaborating in work groups of three or four.

This lesson consists of three distinct activities, each of which monitors the worms' response to a specific stimulus: light, moisture, and odor. Preparation involves gathering the following inexpensive materials: Six-quart plastic lidded storage containers, such as those made by Sterlite®, commonly available at discount stores (the containers used for the light investigation will require modified lids to accommodate flashlights); moist paper towels; flashlights; kitchen timers or stopwatches; ammonia (for the odor investigation); and worms.

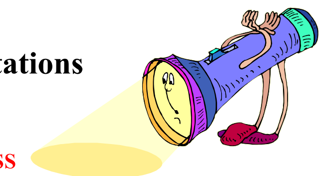
Ask students to review the data collection sheets—produced by SREL—included on the following pages. What will they be measuring? (time is measured as a control, as is the number of worms) What is the significance of performing multiple trials? In what ways is observation an essential form of data collection?

Unless you have an unusually small class, it will be most expedient to facilitate this investigation by assigning each work group a different variable to test. When all tests are complete, bring the whole class back together to debrief their research findings. How can the students connect this learning to their vermicomposting project? Also, don't forget to see if this investigation promoted inquiry. Your students may have more questions now than they did when they started. And that's just fine!

Date ______________ Teacher ___________________ Name ______________________________

WORM EXPERIMENTS WITH LIGHT

Activity 4 4th Grade: Animal Behavior and Adaptations



Experiment 1

EARTHWORM RESPONSE TO WHITE LIGHT / DARKNESS

my HYPOTHESIS

If I give a worm a choice between a dark area and an area lit by a flashlight, **then** I think the worm will choose ____.

1. **SET UP YOUR EXPERIMENT:** Moisten 2 paper towels and place them in the bottom of your experimental chamber. Place 2 worms in the center of the chamber. Cover the chamber with the lid, making sure the black construction paper divides the chamber in half. Place the flashlight over the hole and turn it on.

2. **TIME YOUR EXPERIMENT:** Set your timer for 10 minutes. While you are waiting, observe 2 new worms on an observation tray with your partner. Answer the questions on the back of this data sheet.

3. **COLLECT YOUR DATA: Carefully** remove the lid from your experimental chamber when the timer goes off. Observe the behavior of your worms. Where did they end up? Record the results below in the column labeled **Trial Number 1** using a **check mark** (✓) for each worm.

4. **REPEAT THE EXPERIMENT:** Get two new worms and repeat your experiment. Record your results in the column labeled **Trial Number 2** using a **check mark** (✓) for each worm.

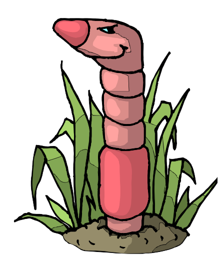
Worm's Response	Trial Number 1	Trial Number 2
Chose **light area**		
Chose **dark area**		
Unusual behavior (The worm did not move, it had half its body on each side of the line, or it climbed the sides.)		

5. **SUMMARIZE THE DATA YOU COLLECTED:**

How many worms, total, ended up in the **Light Area:** __________

Dark Area: __________

Unusual Behavior: __________



Did your results support your hypothesis? **YES** **NO**

behavior-data sheet 25 March 2004
Savannah River Ecology Laboratory [www.uga.edu/srel/]

Date ______________ Teacher ___________________ Name ______________________________

EARTHWORM RESPONSES TO LIGHT

General Observations

- What shape is the earthworm? ____
- What color is the worm? ____
- Does the earthworm have: eyes?________ ears?________ a nose?________ a mouth? _________
- How long is it in centimeters? ____
- Are there any differences between the top and bottom of the worm? __________________________
- Is there a difference between the front and back end of the worm? __________________________
- Describe how the skin of an earthworm feels: ____

  ____
- How does the worm move? ____
- Can earthworms move backwards? ____
- What does an earthworm do when it comes to an obstacle? ___________________________
- Do you think an earthworm has a skeleton?___________ Why or why not? ___________________

  ____
- If you hold an earthworm in your hand, what does it do? ___________________________________

Observations Related to Worm Responses to Light

- What happens when you shine white light on the worm? ___________________________________

  ____

  ____
- If you cover half of your observation chamber so it is darker, what do the worms do? ____________

  ____

  ____
- If you use the "pinhole" light to shine on different parts of the worm, how does it respond? _______

  ____

  ____
- Draw a picture of your earthworm below or on a blank piece of paper.

Date _____________ Teacher __________________ Name ____________________________

WORM EXPERIMENTS WITH MOISTURE

Activity 4 4th Grade: Animal Behavior and Adaptations

Experiment 2

EARTHWORM RESPONSE TO A MOIST PAPER TOWEL / A DRY PAPERTOWEL

my HYPOTHESIS

If I give a worm a choice between a moist paper towel and a dry paper towel, **then** I think the worm will choose ____.

1. **SET UP YOUR EXPERIMENT:** Place a flat, moist paper towel in one half of the chamber and a flat, dry paper towel in the other half. Place 2 worms in the center of the chamber. Cover the chamber with the lid.

2. **TIME YOUR EXPERIMENT:** Set your timer for 10 minutes. While you are waiting, observe two new worms on an observation tray with your partner. Answer the questions on the back of this data sheet.

3. **COLLECT YOUR DATA: Carefully** remove the lid from your experimental chamber when the timer goes off. Observe the behavior of your worms. Where did they end up? Record the results below in the column labeled **Trial Number 1** using a **check mark** (✓) for each worm.

4. **REPEAT THE EXPERIMENT:** Get two new worms and repeat your experiment. Record your results in the column labeled **Trial Number 2** using a **check mark** (✓) for each worm.

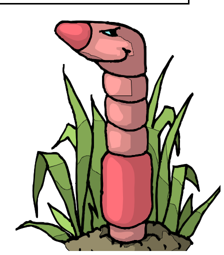
Worm's Response	Trial Number 1	Trial Number 2
Chose **moist paper towel**		
Chose **dry paper towel**		
Unusual behavior (The worm did not move, it had half its body on each side of the line, or it climbed the sides.)		

5. **SUMMARIZE THE DATA YOU COLLECTED:**

How many worms, total, ended up on the **Moist Paper towel:** __________

Dry Paper towel: __________

Unusual Behavior: __________



Did you results support your hypothesis? **YES** **NO**

Date ______________ Teacher ___________________ Name ______________________________

EARTHWORM RESPONSES TO MOISTURE

General Observations

- What shape is the earthworm? ____
- What color is the worm? ____
- Does the earthworm have: eyes?________ ears?________ a nose?________ a mouth? _________
- How long is it in centimeters? ____
- Are there any differences between the top and bottom of the worm? __________________________
- Is there a difference between the front and back end of the worm? ___________________________
- Describe how the skin of an earthworm feels: ____________________________________

  ____
- How does the worm move? ____
- Can earthworms move backwards? ____
- What does an earthworm do when it comes to an obstacle? __________________________
- Do you think an earthworm has a skeleton?___________ Why or why not? ___________________

  ____
- If you hold an earthworm in your hand, what does it do? ____________________________

Observations Related to Worm Reactions to Moisture

- What happens when you place the worm on a moist towel? _____________________________

  ____

  ____
- What happens when you place the worm in a cup of water? _____________________________

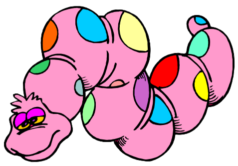
  ____

  ____
- How do worms react to rough textures like sandpaper? ______________________________

  ____

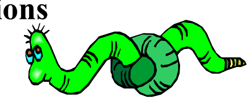
  ____
- Draw a picture of your earthworm in the space below or on a blank piece of paper:

Date ______________ Teacher ___________________ Name ______________________________



WORM EXPERIMENTS WITH ODOR

Activity 4 4th Grade: Animal Behavior and Adaptations



Experiment 3

EARTHWORM RESPONSE TO AMMONIA ODOR / NO ODOR (WATER)

my HYPOTHESIS

If I give a worm a choice between an ammonia odor and no odor (water), **then** I think the worm will choose ____.

1. **SET UP YOUR EXPERIMENT:** Place 2 flat, moist paper towels in the bottom of your test chamber. Add a few drops of ammonia solution to one side of the chamber but do NOT add ammonia to the other side. Place two worms in the center of the chamber. Cover the chamber with the lid.

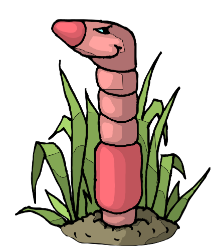
2. **TIME YOUR EXPERIMENT:** Set your timer for 10 minutes. While you are waiting, observe two new worms on an observation tray. Answer the questions on the back of this data sheet.

3. **COLLECT YOUR DATA:** **Carefully** remove the lid from your experimental chamber when the timer goes off. Observe the behavior of your worms. Where did they end up? Record the results below in the column labeled **Trial Number 1** using a **check mark** (✓) for each worm.

4. **REPEAT THE EXPERIMENT:** Get two new worms and repeat your experiment. Record your results in the column labeled **Trial Number 2** using a **check mark** (✓) for each worm.

Worm's Response	**Trial Number 1**	**Trial Number 2**
Chose **ammonia odor**		
Chose **no odor (water)**		
Unusual behavior (The worm did not move, it had half its body on each side of the line, or it climbed the sides.)		

5. **SUMMARIZE THE DATA YOU COLLECTED:**



How many worms, total, ended up on the **Ammonia Odor:** __________

No Odor (water): __________

Unusual Behavior: __________

Did your results support your hypothesis? **YES** **NO**

Date ______________ Teacher ___________________ Name ______________________________

EARTHWORM RESPONSES TO ODOR

General Observations

- What shape is the earthworm? ____
- What color is the worm? ____
- Does the earthworm have: eyes?________ ears?________ a nose?________ a mouth? _________
- How long is it in centimeters? ____
- Are there any differences between the top and bottom of the worm? ___________________________
- Is there a difference between the front and back end of the worm? ___________________________
- Describe how the skin of an earthworm feels: ____

  ____
- How does the worm move? ____
- Can earthworms move backwards? ____
- What does an earthworm do when it comes to an obstacle? _________________________________
- Do you think an earthworm has a skeleton?___________ Why or why not? ___________________

  ____
- If you hold an earthworm in your hand, what does it do? ___________________________________

Observations Related to Worm Reactions to Odor

- What happens when you place a worm on a paper towel moistened with water? ________________

  ____

  ____

- What happens when you place the worm on a moist paper towel with a sweet smell? ____________

  ____

  ____

- What happens if you give a worm a choice between an ammonia odor and a sweet smell? ________

  ____

  ____

- Draw a picture of your earthworm in the space below or on a blank piece of paper:

Extensions

Websites: Younger students, especially, will enjoy learning more about worms from Vermi the Worm (http://www.calrecycle.ca.gov/vermi/) or Squirmin' Herman (http://urbanext.illinois.edu/worms/index.cfm).

Site Visits: This section really lends itself to going places. We are all connected to the topic of waste, but do we know how? Take your students on a free trip to a recycling center, a landfill, or a wastewater treatment facility.

Readings: David Owen's book *The Conundrum* was already mentioned in Lesson 4. It provides an interesting counterpoint by suggesting that some of our efforts to be more sustainable may not be helping us reach that goal. Another project the students may be interested in is Colin Beavan's *No Impact Man*. Beavan set out to live for a year with his wife and child while making no impact on the environment. His book chronicles that journey.

Documentary: Teens will relate to the young men in *Garbage Dreams*. Members of the Zabaleen, a subculture in Cairo, Egypt, have the role of sorting through the city's trash to find things they can recycle as a source of income. That may sound like the worst job in the world—until your job is outsourced to a foreign recycling company. This film exposes a hard reality that is very different from the one our students know.

Extensions

Websites: Younger students, especially, will enjoy learning more about worms from Vermi the Worm (http://www.calrecycle.ca.gov/vermi/) or Squirmin' Herman (http://urbanext.illinois.edu/worms/index.cfm).

Site Visits: This section really lends itself to going places. We are all connected to the topic of waste, but do we know how? Take your students on a free trip to a recycling center, a landfill, or a wastewater treatment facility.

Readings: David Owen's book *The Conundrum* was already mentioned in Lesson 4. It provides an interesting counterpoint by suggesting that some of our efforts to be more sustainable may not be helping us reach that goal. Another project the students may be interested in is Colin Beavan's *No Impact Man*. Beavan set out to live for a year with his wife and child while making no impact on the environment. His book chronicles that journey.

Documentary: Teens will relate to the young men in *Garbage Dreams*. Members of the Zabaleen, a subculture in Cairo, Egypt, have the role of sorting through the city's trash to find things they can recycle as a source of income. That may sound like the worst job in the world—until your job is outsourced to a foreign recycling company. This film exposes a hard reality that is very different from the one our students know.

Section Three: Housing

What could be more basic than our shelter, the place we choose to live? That may be a house, an apartment, or a mobile home, but we all want some personal space that reflects something about who we are and what we value.

How does housing fit into this discussion of sustainability? In part, there are the materials used and their impact on the environment, as well as the energy demands of a large American home. But our home also says something about our lifestyle choices and what we are willing to sacrifice to make those dreams a reality.

This section explores the American Dream of home ownership, as well as some non-traditional design concepts. Students will have a chance to think about the economic and environmental implications of the "McMansion" phenomenon, and they will have another design build opportunity—this time creating their own model home with sustainable features.

Lesson 7 – Design Your Dream Home

This lesson begins with a fun, low stress form of preassessment. You are simply going to ask your students to design their dream home. Supply them with a variety of materials: graph paper, poster board, colored pencils, markers, rulers, etc. You will really see some students' artistic abilities rise to the surface during this activity! Since the overarching theme of this unit is sustainability, you are likely to see some "green" features: solar panels, gardens, water catchment systems, etc. However, you are just as likely to see swimming pools, game rooms, media centers, servants' quarters, and indoor basketball courts. There really are no wrong answers. This is just a hook to initiate the conversation about American housing ideals.

Give students enough work time so they don't feel rushed. If time is an issue, you could always let them start working in class and finish at home. (Remember, though, that some students may not have access to materials and art supplies at home.) It is always important for the students to have opportunities to share their work, so you should reserve time for them to present their Dream Home to their tablemates or to the class. You could even address this need with a "gallery walk" in which half the students move about the room while the others curate their exhibits.

What would one of these Dream Homes cost? Bring in a selection of classified ads or real estate guides so your students can get a feel for the cost of a fine home. Perhaps a home in your area would cost $300,000 to $500,000. In terms of basic economics, what would it truly cost to own one of these homes? Direct your students' attention to an online mortgage calculator such as:

http://www.mortgagecalculator.org/

Imagine a few simple inputs. Assume the cost of the new home is $300,000 and you have no money to use as a down payment. With an interest rate of 5% and a term of 30 years, the monthly payment would be over $1900. That's almost $24,000 per year in mortgage payments—to say nothing of utilities, maintenance, etc. But the real number to notice is total amount paid over 30 years: $692,267.35. In fact, the amount of interest paid will be $264,017.35. That's nearly equal to the original cost of the home! If your students have easy access to technology, allow them some time to experiment with the input values on the mortgage calculator using examples from the local real estate guide.

Now for a contrast. What if the goal was not bigger, grander, more luxurious, more expensive? What if the goal was to create a small, efficient living space? Share with your students The Cube Project, an initiative led by Dr. Mike Page of the Psychology Department of the University of Hertfordshire.

http://www.cubeproject.org.uk/

Take a moment to watch the six-minute video on the website. This 3-meter cube breaks nearly every convention one might imagine for designing a dream home—with the possible exception of the large, flat panel, "energy-saving telly" mounted to the wall. (And this is just a little preview for the design challenge your students will tackle in Lesson 9.) As you discuss the video, consider whether this design has any practical application at all. Are there people in the world who would benefit from such a structure? What about in America? How would the decision to live in a 3-meter cube impact your lifestyle choices? What would be simpler? What would be more difficult? Why do you think this project was initiated by a Psychology Department, rather than an Architecture Department?

To close out this lesson, ask your students to take the "100 Things Challenge." Though it may be easier to make a 100-item wish list of things you'd like to own, this activity requires participants to itemize the things you would keep if you pared your possessions down to 100 items. (Yes, teachers, you need to make a list, too!) This really forces us to think about what is essential in our lives. What items are necessary for health, hygiene, or basic survival? What items have sentimental value? What "luxury" items would you keep? Some students will obsess over reducing their list to 100, while others will have difficulty getting past #83. And the students will enjoy prompting one another throughout the activity: Did you remember a toothbrush? What about a set of silverware? How many pairs of shoes do you have? Feel free to interpret this activity as needed to maintain peace in your classroom. (For example, you might allow a package containing three pairs of socks to count as a single item.)

When the students are finished, give them an opportunity to share their lists. In what ways are the lists similar? In what ways do the lists reflect the personalities of individual students? What did the students—and the teachers—learn about themselves as they participated in this activity?

Lesson 8 – Alternative Housing

For most of us, the notion of a house may look a lot like it did in preschool—a square with a triangle on top. The building materials likely resemble those used by the Three Little Pigs—wood, bricks, or straw. (Well, maybe not straw.) This lesson is about re-visioning how a house can be constructed. That means opening our minds to other designs, other floor plans, other building materials.

For this activity, students will be divided into work groups. (Again, three is probably the magic number.) Each group will investigate one of the websites below, then share back with the class the things they've learned in jigsaw fashion. This would be a great time to use some Web 2.0 tool such as Glogster to share these resources with your students. That way, students will be able to go back and explore other methods that might pique their interest when the share time is over.

The Traditional American Home: (http://www.dongardner.com/) Granted, there is more than one traditional American home design. Here you will find floor plans for farmhouses, cottages, bungalows, colonial style homes, and many more. This website will serve as good baseline against which to compare the other designs and building methods students will be investigating.

Homes That Are (Almost) Round: (http://www.deltechomes.com/) Deltec bills itself as "The Original Green Builder." These homes are not your basic square with a triangle on top. They have anywhere from eight to twenty-plus sides! How might it change your lifestyle if you lived in a circular home? In what ways is this construction method supposed to be superior to more traditional methods?

Shipping Container Houses: (http://logicalhomes.com/) No doubt we've all seen stacks of shipping containers floating in a harbor or zipping down the highway behind a tractor-trailer. Imagine repurposing one or more of those containers as a living space. Shipping container homes can be configured in über contemporary designs. Note, especially, the use of passive solar.

Earthship Biotecture (http://earthship.com/) The earthship is the brainchild of architect Michael Reynolds, who has been designing provocative, "radically sustainable" living spaces since the early 1970s. Many of his designs incorporate unconventional materials—such as discarded car tires—and are intended for "**off-grid**" living. In other words, the dwellings are completely self-contained and unhitched from public utilities.

Straw Bale Construction: (http://www.strawbale.com/) Well, what do you know! Looks like building with straw was an option after all! With walls made of stacked straw bales covered with plaster, these dwellings resemble the adobe houses of the American southwest. This website claims that a straw bale house can cut energy costs by up to 75%. However, their designs are not necessarily conservative. Some of them exceed 3000 square feet!

Tiny Houses: (http://www.tumbleweedhouses.com/) Much like the 3-meter Cube House, Tumbleweed Tiny Houses are all about living small. Many of them are designed to be **net-zero**, producing as much energy as they use. Architecturally, tiny houses resemble traditional home designs in miniature. Many of their designs are between 100-150 square feet and can be towed behind a vehicle. Of course, you can leave your tiny house in one place. But this helps homeowners circumvent some of the zoning ordinances that would apply to permanent structures.

As students peruse their chosen (or assigned) website, have them consider the following:

1. What do you see that is interesting or unusual? Would you like to live in a home like this? Why or why not?

2. What design features are typical of these homes? (large windows, vaulted ceilings, hallways, porches, basements, etc.)

3. In terms of square feet, what is the range in the size of these homes?

4. Can you get a sense of what it might cost to construct a house like this?

5. In what ways is space used creatively? Does your home feature an open floor plan, or is the space divided into many smaller rooms?

6. Do you notice any “green” or smart design features?

7. Would homeowners be likely to face any zoning challenges if they attempted to build one of these structures in your neighborhood?

Lesson 9 – Living Small Design Challenge

Ask your students how they might mark off 150 square feet on the floor of the classroom. (It is possible that you might have 12”X12” floor tiles, which would make the task of making a 10’X15’ rectangle fairly simple.) Have two students take masking tape a mark that area on the floor. 150 square feet is a very small space! How many students can fit inside the rectangle? If this was the perimeter of your house, where would you put your kitchen? Your bed? Your bathroom?

In the previous lesson, some students presented about the Tumbleweed Tiny House. Many of the Tumbleweed designs are between 130-150 square feet. In Lesson 7, everyone learned about the 3-Meter Cube House. That house has a footprint of just under 97 square feet.

Designing a home is, indeed, a challenge. Some people spend years working toward a degree in architecture. In all likelihood, your class has had little experience making a blueprint or floor plan, so this will be a new experience for them. For this activity, students are asked to design a home that is 200 square feet or less. It should include everything necessary for basic living: living space, sleeping space, kitchen, bathroom, storage. Aside from its small size, students should also take into consideration any “green” or environmentally friendly features that might add to the overall sustainability of their home.

To begin with, students will need a supply of graph paper, pencils, rulers, and perhaps calculators. This time it would be best for students to work independently, rather than in pairs, teams, or groups. (There will be so many opinions regarding home design, it might be difficult for a group to come to consensus!) The students’ design can be of any geometric shape, but it should stay within the 200 square foot limit.

Students also need to be conscious of scale. For example, does each square on the graph paper represent one square foot? Or does it take four or nine squares to equal a square foot? There is no wrong answer, but each student’s plan will need to communicate the scale they are using. In addition, they will need to apply that same scale to any furniture or appliances within the home. How big is a standard bed? What size is a typical toilet? Any features the students add to their plan should adhere to their scale. (Incidentally, I’ve seen a lot of hallways that are one or two feet wide. You might encourage your students to think critically about hallways. They are fixtures in ranch style homes, but very often that space could be better utilized in other ways. Especially in tiny houses.)

Make yourself available to assist students. This is not an easy project, but you can help them do good work. Double-check their measurements. Help them find answers to their questions. Encourage them to use the lines on their graph paper.

If you have time and you think your students would benefit from the additional challenge, this project can be taken to another level that is extremely rewarding. Once the students have developed accurate floor plans, why not turn those into a three-dimensional representation of the home? Cardboard or foam board—available through craft stores and office supply stores—can be used for constructing walls, floors, roofs, and furnishings. (Be sure to offer students some safety guidelines if they will be using X-acto knives for cutting the board.) Students should still attend to scale, this time including windows and doors as appropriate. A great effect is to make the roof removable, so others can look inside your tiny house and see the actual living space!

The following pages include DAP Tools, first introduced in Lesson 3, for assessing models. These DAP Tools are designed for use with three-dimensional models, but they can be easily modified for use with blueprints or floor plans.

POWERPOINT Tier 1 —DAP TOOL

CONTENT								
	• Is the content correct?	0	1	2	3	4	5	6
	• Has the content been thought about in a way that goes beyond a surface understanding?	0	1	2	3	4	5	6
	• Is the content put together in such a way that people understand it?	0	1	2	3	4	5	6
PRESENTATION								
Text	• Is the title clear? Does the text explain the topic without too much information on any one slide? Are headings and bulleted lists used well?	0	1	2	3	4	5	6
Graphics	• Are the graphics (e.g., illustrations, photos, videos, multimedia, etc.) important to the topic? Can videos be played in full screen? Is there a careful mixture of text and graphics? Are graphics proportional? Is white space used well?	0	1	2	3	4	5	6
Slides	• Do the slides make sense following one another in both how they look and in what they mean? Does the slideshow appeal to the audience? Does it have smooth transitions without sound? If music is used, is it played across all slides if appropriate? Are presenter notes available?	0	1	2	3	4	5	6
Delivery	• *Verbal*: Is the PowerPoint developed for the expected audience and purpose through its word choice, sentence structure, and tone? Is the voice clear? Is the delivery smooth? Are the strengths of the PowerPoint utilized for an effective presentation?	0	1	2	3	4	5	6
	• *Nonverbal*: Is eye contact maintained? Are appropriate facial expressions and gestures incorporated? Is the speaker poised and comfortable? Are the strengths of the PowerPoint utilized for an effective presentation?	0	1	2	3	4	5	6
Correctness	• Is the PowerPoint mostly free from usage, punctuation, capitalization, and spelling errors? If sources are used, are they cited correctly?	0	1	2	3	4	5	6
CREATIVITY								
	• Is the content seen in a new way?	0	1	2	3	4	5	6
	• Is the presentation done in a new way?	0	1	2	3	4	5	6
REFLECTION								
Content	• What connections can you make between what you have learned by completing this project and previous learning?	0	1	2	3	4	5	6
Product	• In what ways could you improve your product when completing this product with a different assignment?	0	1	2	3	4	5	6
Learning	• How did the amount of effort affect your learning about the content and creating the product?	0	1	2	3	4	5	6

Comments

____

____

____

Meaning of Performance Scale:
6—PROFESSIONAL LEVEL: level expected from a professional in the content area
5—ADVANCED LEVEL: level exceeds expectations of the standard
4—PROFICIENT LEVEL: level expected for meeting the standard
3—PROGRESSING LEVEL: level demonstrates movement toward the standard
2—NOVICE LEVEL: level demonstrates initial awareness and knowledge of standard
1—NONPERFORMING LEVEL: level indicates no effort made to meet standard
0—NONPARTICIPATING LEVEL: level indicates nothing turned in

POWERPOINT Tier 2 – DAP TOOL

CONTENT								
	• Content is accurate and complete.	0	1	2	3	4	5	6
	• Content has depth and complexity of thought.	0	1	2	3	4	5	6
	• Content is organized.	0	1	2	3	4	5	6
PRESENTATION								
Text	• Title enhances the PowerPoint. Text highlights most important concepts in topic in clearly organized slides. Text is limited to key ideas. Headings and bulleted lists enhance the PowerPoint.	0	1	2	3	4	5	6
Graphics	• Graphics (e.g., illustrations, photos, videos, multimedia, etc.) add information to the topic and proportional. Videos are shown in full screen. Layout design is organized and attractive. White space is used well.	0	1	2	3	4	5	6
Slides	• Slides maintain continuity in form and purpose. Slides have smooth transitions. Slideshow keeps audience's attention through graphics, text, and special effects, not sound effects. Presenter notes are available.	0	1	2	3	4	5	6
Delivery	• *Verbal:* The purposeful use of varied syntax and precise diction aids in audience understanding. Tone is consistent with purpose. Speaker's voice is strong and clear with appropriate intonations and pronunciations. Speaker exhibits confidence yet stirs interest in the audience. The PowerPoint strengths are intentionally developed for an effective presentation.	0	1	2	3	4	5	6
	• *Nonverbal*: Eye contact, facial expressions, and other forms of nonverbal communication aid in audience understanding, gain their trust, and further the purpose. The PowerPoint strengths are intentionally developed for an effective presentation.	0	1	2	3	4	5	6
Correctness	• The PowerPoint is free from usage, punctuation, capitalization, and spelling errors. Sources, when used, are thoroughly cited.	0	1	2	3	4	5	6
CREATIVITY								
	• Originality is expressed in relation to the content.	0	1	2	3	4	5	6
	• Originality is expressed in relation to the presentation.	0	1	2	3	4	5	6
REFLECTION								
Content	• Reflections include connections to previous learning and questions raised for future learning.	0	1	2	3	4	5	6
Product	• Reflections include improvements made over other times the product was created as well as suggestions for improvements when creating the same product in a future learning experience.	0	1	2	3	4	5	6
Learning	• Reflections include analysis of self as a learner, including effort, work habits, and thought processes.	0	1	2	3	4	5	6

Comments

____

____

____

Meaning of Performance Scale:
6—PROFESSIONAL LEVEL: level expected from a professional in the content area
5—ADVANCED LEVEL: level exceeds expectations of the standard
4—PROFICIENT LEVEL: level expected for meeting the standard
3—PROGRESSING LEVEL: level demonstrates movement toward the standard
2—NOVICE LEVEL: level demonstrates initial awareness and knowledge of standard
1—NONPERFORMING LEVEL: level indicates no effort made to meet standard
0—NONPARTICIPATING LEVEL: level indicates nothing turned in

POWERPOINT Tier 3 – DAP TOOL

CONTENT								
	• Content is accurate and thorough in detail.	0	1	2	3	4	5	6
	• Product shows complex understanding and manipulation of content.	0	1	2	3	4	5	6
	• Product shows deep probing of content.	0	1	2	3	4	5	6
	• Organization is best suited to the product.	0	1	2	3	4	5	6
PRESENTATION								
Text	• Title reflects purpose. Text highlights most important concepts in clear, concise manner with careful thought given to amount and type of information on each slide.	0	1	2	3	4	5	6
Graphics	• Proportional graphics (e.g., illustrations, photos, videos, multimedia, etc.) enhance meaning. Videos, if used, are in full screen to enhance slideshow. Thoughtful manipulation of color, layout, and font reflects purpose. Use of white space enhances slideshow.	0	1	2	3	4	5	6
Slides	• The continuity of the slides (i.e., font, color, background, movement, sound, and special effects) enhances the meaning. Slideshow engages the audience through its graphics, text, appearance, movement, sounds, and special effects. Music, if used, enhances the slideshow, playing across each slide. Presenter notes are well utilized.	0	1	2	3	4	5	6
Delivery	• *Verbal:* The intentional use of varied syntax and powerful diction enhances audience understanding. Effective rhetorical devices emphasize main ideas. Speaker's voice is strong, clear, and effective. Speaker exudes passion for the topic while being in total control of the presentation and audience. The nuances of the PowerPoint are maximized to engage the audience.	0	1	2	3	4	5	6
	• *Nonverbal:* Purposeful eye contact, facial expressions, and other forms of nonverbal communication enhance audience understanding and emphasize the purpose. The nuances of the PowerPoint are maximized to engage the audience.	0	1	2	3	4	5	6
Correctness	• The PowerPoint is error free, with correct usage, punctuation, capitalization, and spelling used. All sources are cited correctly with the citation placed appropriately.	0	1	2	3	4	5	6
CREATIVITY								
	• Innovation is evident in relation to the content.	0	1	2	3	4	5	6
	• Innovation is evident in relation to the presentation.	0	1	2	3	4	5	6
REFLECTION								
Content	• Reflections analyze and evaluate connections to previous learning and project insightful future connections.	0	1	2	3	4	5	6
Product	• Reflections analyze and evaluate the product components in light of past and future creations of the same product.	0	1	2	3	4	5	6
Learning	• Reflections include analysis of self as a learner and project how changes to the process would increase capacity as a learner.	0	1	2	3	4	5	6

Comments

____

____

____

Meaning of Performance Scale:
6—PROFESSIONAL LEVEL: level expected from a professional in the content area
5—ADVANCED LEVEL: level exceeds expectations of the standard
4—PROFICIENT LEVEL: level expected for meeting the standard
3—PROGRESSING LEVEL: level demonstrates movement toward the standard
2—NOVICE LEVEL: level demonstrates initial awareness and knowledge of standard
1—NONPERFORMING LEVEL: level indicates no effort made to meet standard
0—NONPARTICIPATING LEVEL: level indicates nothing turned in

Extensions

Websites: There are a variety of free home design suites available on the Internet. One that is currently available is Autodesk Homestyler (http://www.homestyler.com/), but you could easily find others that perform the same function. One of the coolest tools on the Internet is Sketchup (http://www.sketchup.com/), a powerful application that allows the user to design in 3-D. Originally developed by Google, educators can request a free license for classroom use. Do not be worried about introducing your students to technologies you have not mastered yourself. There is definitely a learning curve, but our students can often collaborate to solve problems more quickly than we can. The key thing is for us to give them a chance.

Site Visits: Green architecture is a gaining popularity across the United States, especially at the institutional level. You may have opportunities in your own area to arrange a guided tour a new facility with **LEED certification**. The U. S. Green Building Council designates Leadership in Energy & Environmental Design certification to qualifying structures. Typical features might include energy efficiencies such as solar panels or geothermal heating and cooling, as well as renewable building materials such as bamboo flooring. (http://www.usgbc.org/leed)

Readings: As your students explore different building options, don't be limited to the websites listed in this lesson. Your local library probably has shelves of books dedicated to floor plans and home design. (I am particularly partial to the work of Sarah Susanka, author of *The Not So Big House*.) Check out an armload of these books and bring them into your classroom.

Documentary: *Tiny: A Story About Living Small* is a documentary following Christopher Smith and his girlfriend, Merete Mueller, as they endeavor to build a tiny house with no prior background in construction. (http://tiny- themovie.com/)

Section Four: Energy

In this final section, students will explore the complexities of energy production. As with the production of goods, discussed in some detail in Lesson 4, energy is produced in direct response to consumer demand. David Owen observes in *The Conundrum* that the typical modern home uses far more energy than its counterpart from the 1970s. Sure, we now have appliances with Energy Star ratings. But we have many more of them. The size of the average home has doubled or tripled, and our energy demands have skyrocketed.

It is easy to suggest a move away from fossil fuels, but how close are we to that reality? One of the first activities in this section, borrowed from the National Energy Education Development (NEED) Project (http://www.need.org/) helps students understand where our energy really comes from. For every new solution that presents itself, there are controversies and backlashes against those controversies. Consider the promise of natural gas and clean coal. Yet there remain many unanswered questions about extraction. Ultimately, there are no easy answers, because every question touches the lives of people, as well as the economy and the environment.

This section culminates with a scientific investigation as students design an experiment to test the efficiency of compact fluorescent light bulbs. Are they real energy savers, or are they just a keen marketing ploy, appealing to our predilection for buying new things?

Lesson 10 – Where does our energy *really* come from?

This lesson begins, as usual, with a bit of connecting. Based on your students' scientific background, what do they know about energy? Some of them will probably recall the standard definition: energy is the ability to do work. They are probably familiar with the concept of potential energy (sometimes called stored energy) and kinetic energy (energy in motion). And students are probably aware that energy is present in many forms, and those forms are constantly changing. The nuclear reactions taking place within the sun have the capability of baking cookies in a solar oven. **Energy transformation** enables my body to take the chemical energy stored in those cookies and convert it to the kinetic energy that powers a bicycle.

When we speak of energy in the United States, we are typically referring to the energy required to produce electricity or the energy required to power an automobile or other form of transportation. The opening activity, featuring prediction sheets developed through The NEED Project, will focus on energy used in the production of electricity. (Many free curriculum materials are available from The NEED Project and may be downloaded directly through their website and reproduced for educational purposes.)

Students will work first individually, then in small groups, to rank the order of ten different sources of electricity: **biomass**, coal, geothermal, hydropower, natural gas, petroleum, propane, solar, wind, uranium. (The source making the greatest contribution to production would receive a one; the source making the least contribution would be ranked number ten.) These predictions are then compared against actual statistics from the year 2010.

As students work through this exercise, what surprises do they find? Did they expect coal and natural gas to be such key players? Did they expect that all **renewable energy** sources combined would total only about 10%? In some circles, it might be popular to advocate reducing our dependency on fossil fuels. However, we are a long way from finding an alternative.

Depending on where you live, you may not see much evidence that coal accounts for nearly 45% of our nation's electricity. On the other hand, you may not see much evidence for natural gas. The next lesson will explore one aspect of coal. Please review the website of America's Natural Gas Alliance to see which states are most connected to natural gas. (http://www.anga.us/) Their interactive map entitled "Natural Gas in My State" is very revealing. Nebraska gets about 1% of its electricity from natural gas. In Oklahoma that number jumps to 41%. In Florida, it's 62%. The point is that one's perspective is very much influenced by geography. And even though we don't see it firsthand in our state, we are still all connected via the power grid.

The last activity in this lesson is another free online interactive. It would be best if each student could have access to their own computer, though this could also work in teams of two. Chevron sponsors a neat website called Energyville:

http://www.energyville.com/

In this game, students work to power a virtual town using a variety of resources—including nine of the ten mentioned above. (It turns out propane just doesn't play much of a role in electricity production.) As students add utilities, their overall economic, environmental, and security impact is monitored. Over time, a combination of positive events (advances in photovoltaic technology reduce the price of solar panels) and negative events (terrorist attacks) take place. Students must make modifications in response to these events. In the end they are awarded points and they can compete against each other.

Does Chevron bring any bias to this discussion? Probably so. But the overall message is one of balance and moderation. Relying on any one source is just not a viable solution. The real answers will involve multiple options and a fair-minded vision that looks toward the future.

Electric Connections

Get Ready

Make an appropriate number of copies of the *Electric Connections Game Instructions* and the *U.S. Electric Power Generation Sources* worksheets found on pages 6 and 7.

Get Set

Divide the class into groups of three to five students.

Go

- Give each student a copy of the game instructions. Review the instructions with the students.
- Have the students individually rank the ten sources of energy in order of their contribution to U.S. electricity production. Give them two minutes to complete this task.
- As a group, give the students six minutes to rank the ten sources of energy. When they are finished, give each student a copy of the *U.S. Electric Power Generation Sources* sheet. Have students transfer their individual and group rankings to the appropriate column.
- Provide the students with the rankings for column one:

  Biomass–6
  Coal–1
  Geothermal–8
  Hydropower–4
  Natural Gas–2
  Petroleum–7
  Propane–10
  Solar–9
  Uranium–3
  Wind–5

***Electric Connections* teaches students how different energy sources contribute to the generation of electricity. This activity demonstrates the advantages of working together in a group and reinforces the ideas of group sharing and cooperative learning.**

Grades

- 5-12

Preparation

- Low

Time

- 20 minutes

Electric Connections
GAME INSTRUCTIONS

Forty percent of the nation's energy is used to make electricity today. Experts predict that this figure will continue to increase. The U.S. is becoming more dependent on electricity to meet its energy needs as we depend on more technology. To meet the growing demand, many energy sources are used to generate electricity. Some energy sources produce a substantial amount of the electricity we consume, while others produce less than one percent.

Individual Instructions

Your task is to rank the ten sources of energy in order of their contribution to U.S. electricity production. Place a number one by the source that provides the largest amount of electricity, a number two by the source that provides the second largest, down to a number ten by the one that provides the least amount of electricity. Use critical reasoning skills to determine the order.

Group Instructions

Starting at the top of the list, ask members to contribute any knowledge they have about each energy source. Brainstorm by asking group members questions such as:

- Is this source limited to a certain area of the country?
- Are there any problems or limitations associated with this source?
- Have you ever seen a power plant that uses this particular source of energy?

One person in the group should take notes. Once the group has gone through the list, it should divide the ten energy sources into three levels of importance: the top three most significant energy sources, the middle four moderately significant energy sources, and the bottom three least significant energy sources. The group should then rank the ten sources of energy in order of their contribution to U.S. electricity production.

SOURCES USED TO GENERATE ELECTRICITY

SOURCE	YOUR RANK	GROUP RANK
BIOMASS		
COAL		
GEOTHERMAL		
HYDROPOWER		
NATURAL GAS		
PETROLEUM		
PROPANE		
SOLAR		
URANIUM		
WIND		

Electric Connections

U.S. ELECTRIC POWER GENERATION SOURCES

SOURCES USED TO GENERATE ELECTRICITY

SOURCE	STATISTICS	RANK	YOUR RANK	ERROR POINTS	GROUP RANK	ERROR POINTS
BIOMASS	In 2010, biomass produced 56.5 billion kilowatt-hours of electricity, 1.4 percent of the nation's total. Biomass electricity is usually the result of burning wood waste, landfill gas, and solid waste.					
COAL	Ninety-two percent of the nation's coal is consumed by electric utility companies to produce electricity. In 2010, coal produced 1,850.7 billion kilowatt-hours of electricity, which was 44.9 percent of the nation's electricity.					
GEOTHERMAL	In 2010, geothermal power plants produced 15.7 billion kilowatt-hours of electricity, chiefly from facilities in the western U.S. Geothermal energy produced 0.4 percent of the nation's electricity.					
HYDROPOWER	Six percent of U.S. electricity is generated by 2,200 hydro plants nationwide. Hydro plants produced 253.0 billion kilowatt-hours of electricity in 2010. It is the leading renewable energy source used to provide electricity.					
NATURAL GAS	Natural gas produced 981.9 billion kilowatt-hours of electricity in 2010, generating 23.8 percent of the nation's electricity. Natural gas is used by gas turbines to provide electricity during peak hours of demand.					
PETROLEUM	Petroleum provided 0.9 percent of U.S. electricity, generating 36.9 billion kilowatt-hours of electric power in 2010.					
PROPANE	There are no statistics available for propane's contribution to electrical production. Very little propane, if any, is used to produce electricity.					
SOLAR	Solar energy provided less than one-tenth of one percent of U.S. electricity in 2010, amounting to 1.3 billion kilowatt-hours of electricity. Electricity was generated by solar thermal systems or photovoltaic arrays.					
URANIUM	104 nuclear power plants provided the nation with 19.6 percent of its electrical energy needs in 2010. Nuclear energy produced 807.0 billion kilowatt-hours of electricity.					
WIND	Wind energy produced 94.6 billion kilowatt-hours of electricity in 2010. Wind provided 2.3 percent of the nation's electricity. Most of the wind-generated electricity is produced in Texas, Iowa, and western states.					

ERROR POINTS TOTALS ________ ________

Error points are the absolute difference between your ranks and EIA's (disregard plus or minus signs).

Data: Energy Information Administration, Annual Energy Report

SCORING:

0-12 Excellent
13-18 Good
19-24 Average
25-30 Fair
31-36 Poor
37-42 Very Poor

Lesson 11 – No Easy Answers: Coal and Mountaintop Removal

Are you or your students familiar with mountaintop removal coal mining? It is not well known, yet it is a common practice in the Appalachian region of the United States. Essentially, mountaintops are pushed over into adjacent valleys, exposing narrow coal seams for extraction. Mountaintop removal (MTR) stands in contrast to the more traditional method of "deep mining," and it is also different from other forms of surface mining. Clearly, it is difficult to **reclaim** a mountain that now resembles the surface of the moon:

This lesson is primarily focused on building awareness. Students can form their own opinions, and they need to understand that different individuals and different communities will perceive this issue in different ways.

The Last Mountain is a documentary that emphasizes the vast distance between those varied perspectives. For coal company employees and industry executives, these jobs are their livelihood. For environmentalists—and even more for local families whose health and wellbeing is adversely affected by the practice—mountaintop removal is a tragedy.

As with the viewing of *Food, Inc.* back in Lesson 2, you can either show some excerpts from this documentary or you can use a couple class periods to view the film in its entirety.

Here are some questions to guide class discussion:

1. Were you aware of mountaintop removal prior to watching *The Last Mountain*? If so, where did you learn about it? If not, why do you think there is a lack of media coverage?

2. Certain disasters, such as the Deepwater Horizon Oil Spill in the Gulf of Mexico, are the focus of national attention. Is that a suitable parallel for something like mountaintop removal? Why, or why not?

3. This film featured several "ordinary" people, as well as a high-profile appearance from Bobby Kennedy, Jr. Whose story resonated with you most?

4. This method of mineral extraction is very regionalized. Do you think it is significant that this is happening in the Appalachian mountains of Kentucky, Tennessee, Virginia, and West Virginia? Can you imagine something similar taking place in the Sierra Nevadas or the Cascades?

5. The chief proponents of mountaintop removal cite economic benefits. Does this argument convince you that MTR is justified? If not, what alternatives would you offer the people living in that region who depend on coal jobs for their living?

It is tempting to think: "I've never seen this with my own eyes. It doesn't happen in my region of the country. I am not connected to the issue." However, the power grid is constructed in such a way that you may get your power from another state, and facility producing your electricity may get it's coal from yet another state. To close out this lesson, pull up the following website using your projector:

http://ilovemountains.org/my-connection

Simply type your zip code in the box that says "Are You Connected?" You may be surprised by what you find. Look up zip codes for other parts of the country. Are some regions more connected than others? The situation with coal is much like the situation with natural gas—not every family, not every state, not every geographic region is impacted the same way. But we all share the responsibility of seeking better solutions for our future.

Lesson 12 – Scientific Investigation: Incandescent vs. Compact Fluorescent Bulbs

It's finally time to present your students with an experimental design challenge and see what they can do. At this point, you will remove some of the supports that were previously in place with the demonstration and the recipe. For example, you won't provide a list of tools or materials. You won't dictate the procedures. You won't identify the independent variable and the necessary controls. But that does not meant you won't help your students. You will be available as a guide and a resource. And, depending on the age of your students and their ability to work and think independently, it may still be helpful to provide them with some sort of organizer. (For older, more experienced students, you may simply supply them with graph paper to document their experiment.)

A true experiment usually begins with a question. The experiment itself is simply a way to seek answers to the question. One technique to encourage questioning is to present students with a scenario:

At recess you were talking with a friend about your new effort to be more sustainable. "I'm going to help my family conserve energy by replacing all of our incandescent light bulbs with compact fluorescents."

Your friend was a bit skeptical. "I don't know," he replied. "I've heard that it's a good idea to switch, but I think that's just an advertising gimmick to sell more compact fluorescent light bulbs."

You are pretty sure the compact fluorescent bulbs are more efficient, but you don't have any proof. How could you design an experiment to compare the efficiency of the two bulbs and demonstrate to your friend that compact fluorescents are the better choice?

As you can see, this is very open ended. And, if this scenario was your starting point, both you and your students would become frustrated rather quickly. You may still be met with more than a few blank stares! But don't worry. You can help your students think through this and they'll come away feeling like real scientists.

Whether you assign work groups or students choose their own partners, three-person teams are ideal. Try to discourage anyone from working alone—it is almost always beneficial to have someone to help you think through complex tasks. And those who are determined to have a group of four or five can just form two groups instead of one.

To begin with, your work groups need to identify their research question. The question needs to be something more than, "Which light bulb is better?" How can you measure better? Is that an opinion based on aesthetics? Is it based on cost? Is it a function of how long the light bulb lasts? In this case, the real question has to do with saving energy.

For those groups needing more assistance, have them think once again about energy transformation. In this case, it is entirely possible that the chemical energy stored in coal was converted to heat, which produced steam, which turned a turbine, which generated electricity. This electrical energy has the potential to power an incandescent or a compact fluorescent light bulb. And what sort of energy is created in the process? Two obvious examples would be heat and light. Though observation data is often quite practical, this experiment really lends itself to data that can be measured. Do keep in mind it is possible that not all of your groups will design the same experiment. However, heat can be measured (using a thermometer) and lumens, or light output, can be measured (using a light meter).

You will also want to guide your students to think about independent variables and controls. The independent variable in this scenario should be the type of light bulb used. All other factors should remain the same. For example, if the incandescent bulb is rated at 40 watts, the compact fluorescent should be a 40 watt equivalent. (Though, in reality, the CF bulb may only use 10 watts of electricity.) If students are measuring light, that output should remain rather constant. However, if students choose to measure temperature, that will likely increase over time. How long will they let the bulb burn before taking a temperature reading? That time should be the same for each bulb. Heat will dissipate the further you are from the bulb. How near the bulb will students hold the thermometer? That is critical whether they are using an infrared or a mercury thermometer. Of course, the IR thermometer will take an instantaneous reading. If using a mercury thermometer, how long will students hold the thermometer by the bulb. And, the bulbs may become rather hot during this experiment—especially the incandescent bulb. If doing multiple tests, how long will the bulbs be allowed to cool before retesting?

These are questions each work group will need to think through, and they may not all come to the same conclusion. That is okay. Any variations in approach will enrich the discussion when groups share their results with the whole class.

It may be best to use one class period for students to design their experiments and another class to actually conduct the experiment. That would provide more time for you to conference with students, review their plans, ask questions, offer counsel, and gather the tools and supplies they select for this project. If you have access to an infrared digital thermometer, those are perfect for this activity. And it may be possible to borrow some items from a nearby high school or university.

Even if you choose to let your students create their own organizers, here are some key components they should be able to address:

Question (What do you want to learn?):
Hypothesis (What do you predict will happen? Why?):
Independent Variable (What is the *one thing* you will change in this experiment?):
Controls (What are some factors that will remain constant in this experiment?):
Tools/Materials (What things do you need in order to perform this experiment?):

Procedure (Tell step-by-step what you plan to do.):
Data (What data will you collect? How will you measure it? How will you record it?):
Conclusion (What did you learn?):

Please be a helper and an encouragement to your students. Designing an experiment is no easy task, but students will never learn to think and work like scientists if we do not give them the opportunity to try. They may struggle a bit, but that is when real learning takes place. And learning is the goal. As was mentioned previously, the conclusion should be something more than, “I learned that my hypothesis was correct,” or “I learned that my hypothesis was incorrect.” So many times, students truly believe they have failed if their prediction was wrong. Not so! Students, what did you learn?

Extensions

Activity: This activity may require a significant amount of parent assistance. That is a good thing. If we are going to ask our students to work at home, it should be work they are not able to do at school! The Lawrence Berkeley Lab, a U.S. Department of Energy National Laboratory operated by the University of California, has developed an online energy audit tool called Home Energy Saver:

http://homeenergysaver.lbl.gov/consumer/

This interactive tool asks for inputs such as age of home, size of home, number of residents, number of windows and doors, types of appliances, local energy prices, etc. The program then calculates a projected annual energy cost, as well as potential savings based on upgrades in six different categories—heating, cooling, hot water, large appliances, small appliances, and lighting, This definitely helps students see that we ware all connected to the energy issues, and our individual lifestyle choices do make a difference.

Site Visits: Where does your energy come from? The answer to that question will vary depending on where you live, but chances are your class could tour a production facility at no cost. Contact a coal mine, a coal fired power plant, a wind farm, or a hydroelectric facility. Let them know what you are studying and how this site visit fits into your curriculum. Remember that you aren't going in as investigative reporters. Rather, you are going with an open mind to gain firsthand knowledge of the complexities of our energy system.

Books: In connection with Lesson 11, selected readings from *Something's Rising: Appalachians Fighting Mountaintop Removal*, by Silas House and Jason Howard, is a collection of oral histories from people whose lives have been negatively impacted by mountaintop removal coal mining. Their stories help personalize an issue most people aren't even aware of.

Documentaries: If you've never watched someone set fire to water streaming from the tap of their kitchen sink, you might be interested in Josh Fox's *Gasland*.
This is a controversial exposé of the natural gas alternative—and in particular the extraction method known as hydrofracking. (You should also have your students read some articles rebutting Fox's critique.) Finally, for a more balance discussion of energy alternatives, see *Switch*, narrated by Dr. Scott Tinker, a geoscientist at the University of Texas.

Key Words

The following vocabulary is central to this discussion of sustainability, innovation, and scientific investigation. These terms are offered here without definition because there is no perfect ten-word explanation that captures the full essence of the concept. (And hard definitions are easily accessible through reference books or online resources.) Rather, students and teachers are encouraged to discuss meaning. Explore the nuance of these words, examine multiple perspectives, and, when appropriate, debate the validity of various viewpoints. A selection of words from this list may also be useful for the purpose of preassessment, gauging students' levels of understanding at the beginning of the unit.

Sustainability
Bias
Agenda
Propaganda
Industrial Farming
CAFO (Concentrated Animal Feeding Operation)
Certified Organic
Vertical Gardening
Hydroponics
Aquaculture
Conservation
Consumerism
"The Life Cycle of Stuff"
Climate Change
Landfill
Single Stream Recycling
Composting
Vermicomposting
LEED (Leadership in Energy & Environmental Design) Certification
Net-Zero
Off-Grid
Energy Transformation
Mountaintop Removal
Reclaimed Land
Hydrofracking
Renewable Energy
Hydroelectric
Power grid
Biomass

Innovation
Connect
Inquire

Create
Analyze
Evaluate
Communicate

Scientific Investigation
Science Demonstration
Science Recipe
Science Experiment
Question
Hypothesis
Independent Variable
Control
Procedure
Tools
Data
Conclusion
Replicate

The Innovation Matrix

The graphic on the following page is a very simple jot-down tool called The Innovation Matrix. When used in conjunction with The Innovation Model, it is useful for both planning and reflection.

William Butler Yeats is supposed to have said, "Education is not the filling of a pail, but the lighting of a fire." If one agrees with that premise, then we must also think seriously about student engagement. Beyond the mere acquisition of content, do our students have opportunities to be active participants in their own learning?

Certainly, each lesson will not involve every component of The Innovation Model. However, over the course of a unit, students should have multiple opportunities to make connections, to notice things and observe relationships. They should be encouraged to inquire, to question, to wonder. Students need to create things, to plan and design. They need to analyze their work—and let others evaluate it—and respond to their input by making enhancements and refinements to improve their work. Above all, our students need the chance to communicate in a safe environment, to share ideas openly and respond to the varied perspectives of others.

Do students have these opportunities in your classroom? The Innovation Matrix is a handy self-check to help us ensure that there aren't significant gaps in our instruction.

Connect	Inquire	Create
Analyze	Enhance	Communicate

Innovation Matrix