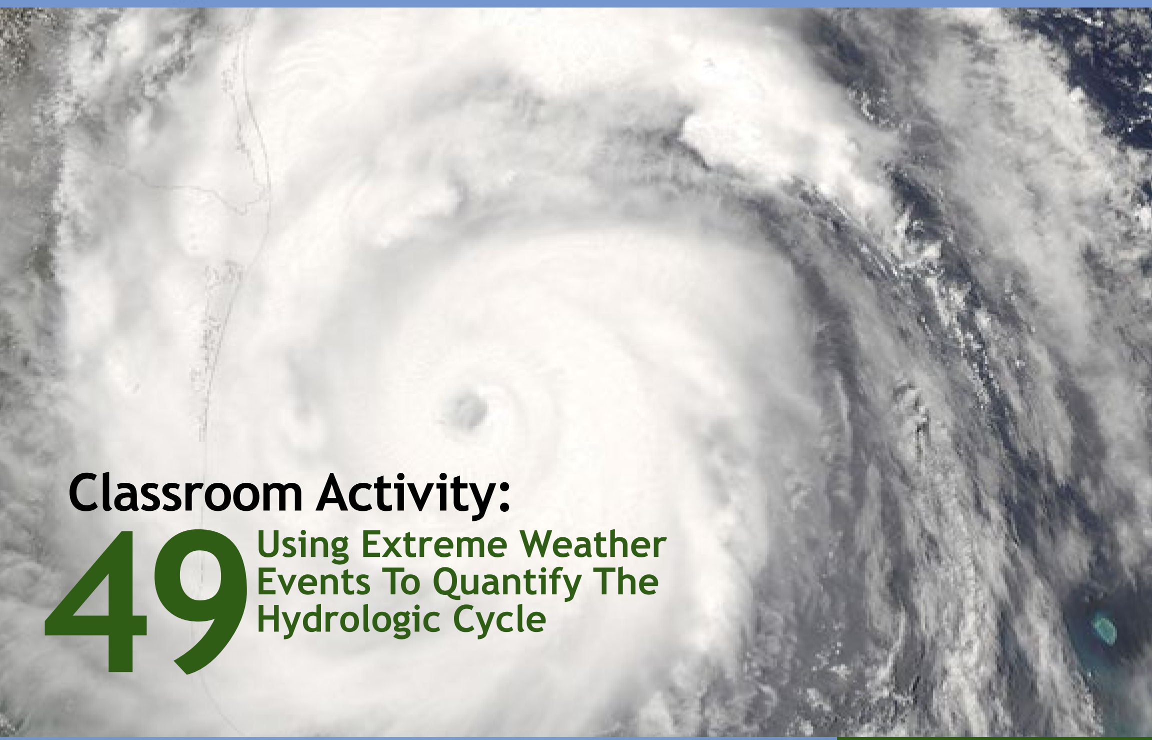
MSTA JOURNAL



Classroom Activity:

49 Using Extreme Weather Events To Quantify The Hydrologic Cycle

Articles

Classroom Activities

SPRING 2015
VOLUME 60.1
A Publication of the Michigan Science Teachers Association

MICHIGAN SCIENCE TEACHERS ASSOCIATION

MSTA
JOURNAL

Staff

Editor – Chris Chopp
Graphic Design & Layout – Shawn Detlor

Article Submission

Articles for publication in the MSTA Journal are invited on a contribution basis and are subject to editorial review. Please submit articles via email to Chris Chopp. Every attempt will be made to publish within a year after approval for publication.

Chris Chopp, MSTA Journal Editor
E-mail: choppc@comstockps.org

The MSTA Journal is published two times per year and sent to approximately 2000 MSTA members. Inquires should be sent to MSTA Office, 1390 Eisenhower Place, Ann Arbor, Michigan 48108. Phone (734) 973-0433. Fax (734) 677-2407. Membership information is available on our website: http://www.msta-mich.org

MICHIGAN SCIENCE TEACHERS ASSOCIATION

MSTA Board Members

Organizing Knowledge – Causally, Temporally, and Spatially.

BY Philip J. Gersmehl, Visiting Research Professor, Michigan Geographic Alliance, Central Michigan University — Dr. Gersmehl is Professor Emeritus, Department of Geography, University of Minnesota

The world is a big and messy place.

Scientists know this. It is why scientific statements are usually couched in probabilistic terms: we say "a 60 percent chance of precipitation" and "likely persistence of somewhat fitter genes" rather than "it will rain tomorrow" and "inevitable survival of the fittest."

A willingness, even a compulsion, to acknowledge uncertainty is an admirable trait. It is a key part of the gradual movement toward better theories. Unfortunately, it can also be a drawback in public debates, on a range of topics from vaccine effectiveness to climate change.

Meanwhile, deniers of global warming have the luxury of being able to base their statements on particulars rather than deal with probabilities. When asked by a newspaper reporter, "Do you believe that climate change is a problem?" they can cloud the issue by saying: "We've experienced climate change for a long time, highs and lows. In Michigan, we had the coldest winter ever last winter." Or they can counter with a memorable local fact: "We just had another six inches of global warming last night – it has been the snowiest winter in decades," or "the Great Lakes are six degrees below what they were a year ago." (All of these quotes are taken directly from published newspaper interviews with candidates for national political office – but this brief note is about concepts, not personalities, and therefore I do not want to trigger knee-jerk defenses of individual candidates by naming them.)

When faced with this kind of anecdotal argument, scientists can respond in several different ways. Interestingly, these responses correspond roughly to what the 18th-century philosopher Immanuel Kant called the "a priori" ways in which humans tend to organize information – causally, temporally, spatially, and quantitatively. Modern neuroscience has provided a wealth of empirical evidence that Kant was basically right – the human brain does indeed have structures or networks that sees to be "hardwired" to organize information in specific ways. This journal is not the place to provide all of the supporting evidence for that conclusion (for a review and list of 100 key research articles, see the Appendix to Chapter 6 in Teaching Geography, Guilford Press, 3rd edition, 2014).

My purpose in this short note is much more modest – to show how someone could respond in several qualitatively different ways to a statement about an unusually cold winter.

A **causal** response would try to identify logical processes by which a general global warming could produce a local area of unusual cold. In this case, the exceptionally snowy winters in Michigan in 2014 and 2015 were preceded by two of the strongest hurricanes ever recorded in the western Pacific Ocean. Both hurricanes carried enormous amounts of energy northward into the Bering Strait region. This northern area was already warmer than normal, due to the well-documented shrinkage of the Arctic ice pack and the resulting reduction in albedo that occurs when light-colored snow and ice are replaced with dark open water. The "pool" of relatively high temperature, in turn, influenced the path of the jet stream in a way that can push masses of cold air far south toward the equator (the so-called "Polar Vortex" that TV meteorologists seem to have discovered en masse in recent years, even though the term and the concept have been around for decades).

Logical chains of cause and effect like this may be scientifically compelling, but they also are complex. Moreover, in their fully developed form, they are mathematically forbidding. In short, scientists may be persuaded by a causal argument, but most climate deniers do not have either the background or the patience to listen to a long and complex logical chain.

Kant, however, suggested that a predisposition to seek causality is not the only way that human brains organize information. Let us, therefore, take his advice and look at two of his other a priori ways of organizing knowledge.

Temporal organization is the basis for generalizations like "the decade from 2001 to 2010 was nearly two degrees warmer than the 1960s average" or "eight of the ten warmest years in recorded history have happened since 2001." Statements like these are familiar to anyone who reads newspaper reports about climate change. Unfortunately, to someone without a strong math sense, a statement like "eight of ten warmest years have come since 2001" is no stronger than "last year had the most snowfall ever in Kalamazoo." In fact, the latter statement has the benefit of simplicity and concreteness. Moreover, any analysis of temporal trends is subject to "cherry-picking" the starting and ending dates. That is the basis for the frequent assertion that "the upward temperature trend basically stopped in the late 90s, and there has been no increase in temperature since then."

Spatial organization of knowledge, our third option, is less frequently used in the United States, partly because geography as a school subject is generally out of favor. I am a geographer, and my purpose in this note is simple – to offer a strategy for map analysis that is scientifically rigorous but easy to explain. I suggest that a simple quantitative spatial analysis can also shed useful light on the question of the day: "Can global warming be real if it is so cold in Michigan?"

About a year after the unusually cold weather of 2013-4, NOAA made its annual map of average temperature (Figure 1). To some who cites the unusual cold in Michigan to cast doubt on the reality of global warming, one could begin by saying, simply: "Just look at the map, very carefully. Try, systematically, to estimate the amount of territory that experienced below-normal temperatures, and compare that to the areas that had above-normal temperatures. If you want to be rigorous about it, count the rectangles in each color category."

Fortunately, it's an electronic map, so we could just let the computer count the areas. But to understand what is going on in that black box, it helps to do a few spatial analyses manually. In this particular case, the map has only 1744 colored rectangles. Counting them is not a daunting task. It is even easier just to focus on the extremes. Start by counting the number of areas that had "record coldest" years – there are only two rectangles with the darkest blue color. Another 13 areas were "much cooler than average." Meanwhile, there are 198 areas in the darkest red category, "record warmest." If that isn't persuasive enough, there are another couple hundred in the next group, "much warmer than average."

In short, the answer to the question, "Can global warming be real if it is cold in Michigan?" is a triple "yes:"

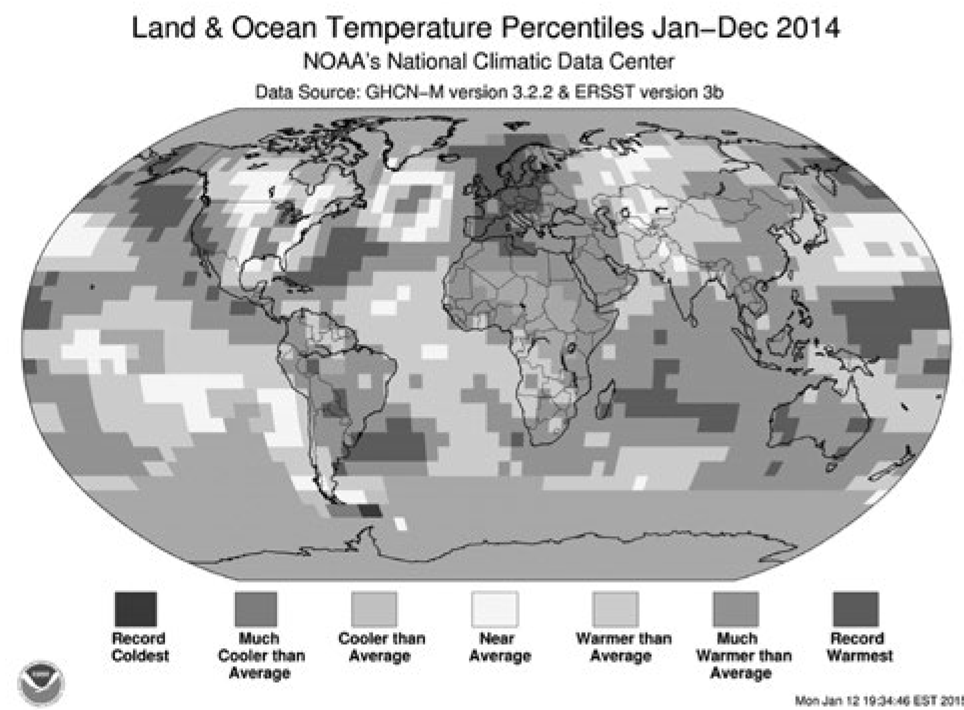
It is "yes" when we organize information **causally**, by looking at plausible effects of observed causes – hurricanes and jet streams and so forth.

It is "yes" if we organize information **temporally**, by tabulating average annual temperatures over a long period of time and comparing the present with the past.

And it is "yes" if we organize information **spatially**, by rigorously comparing Michigan with other areas of similar size around the globe.

Trying to give students the analytical skills to examine evidence from multiple perspectives does not mean we should "teach the controversy by offering equal time to any opinion, no matter how unsubstantiated." On the contrary, it could (and I think should) mean "learn how to organize information in different ways, and see if that leads you to the same conclusions."

Map source: *https://www.ncdc.noaa.gov/sotc/service/global/map-percentile-mntp/201401-201412.gif*



Choosing and Using Effective Children's Literature to Teach Science

By Samantha Burko, Preservice Teacher, Central Michigan University and Jim McDonald, Professor of Science Education, Central Michigan University and Director of the Central Michigan GEMS Center.

Trade books are often used when trying to incorporate subject matters with reading. They can be extremely useful for teachers who may not know much about a certain subject, or for teachers struggling to teach a certain topic to their students. Science is one area where teachers constantly struggle to get the concept across to the students. This is why science trade books are exceptionally beneficial. Teachers should, however, learn how to distinguish good trade books before implementing them into their classroom. Both the criteria for choosing a trade book and a way to teach it may be extremely valuable to all teachers.

Trade books can be great tools for teaching science concepts. However, when it comes to selecting good trade books, many teachers do not know what to look for. One of the most important qualities in a science trade book is the accuracy of information. Mayer (1995) suggests that the science content should be detectable without any misrepresentation that may cause the children confusion. As science is always changing, the information given should also be as up to date as possible (Butzow & Butzow, 2000; Fredricks et al, 1997; McMillan, 1993). Many trade books are done in correspondence with scientists or other experts. For example, Eric Carle's book, *The Very Hunger Caterpillar*, uses the word cocoon instead of chrysalis. This is a minor example of scientifically incorrect information. But it can be the beginning point for students' misconceptions.

When picking a trade book, teachers should look for evidence of the author's credibility. Every year, the National Science Teachers Association (NSTA) team up with the Children's Book Council (CBC) to put out a list of Outstanding Science Trade Books for Students K-12. The selection is based on the following criteria:

The book has substantial science content;

- Information is clear, accurate, and up to date;
- Theories and facts are clearly distinguished;
- Facts are not oversimplified to the point where the information is misleading;
- Generalizations are supported by facts and significant facts are not omitted; and
- Books are free of gender, ethnic, and socioeconomic bias.

This set of criteria is a good place to start for teachers who are unsure or lack experience on how to select a quality science trade book.

When it comes to implementing trade books in the classroom, it is best to read the books aloud. Calkin's (2000) implies that children's minds are free to anticipate, infer, connect, question, and comprehend when they are being read to. Students who may struggle with reading would have a greater chance of understanding the concept being taught and not be at a disadvantage. If there were enough books available for the students to read along with the teacher, then that would be the most beneficial. That way, the students would be able to spend time viewing the illustrations and connecting them to the text. The National Science Teachers Association states that inquiry-based teaching is a good way to approach science trade books. NSTA defines inquiry:

> *Scientific inquiry refers to the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work. Inquiry also refers to the activities of students in which they develop knowledge and understanding of scientific ideas, as well as an understanding of how scientists study the natural world. (p. 23).*

For example, one possible trade book is the Seeds of Science, Roots of Reading book, *Solving Dissolving*, written by Kevin Beals and illustrated by John Nez. If I were to use this book in my classroom, I would start by asking the students what they think the book is going to be about (dissolving). This would get them interested in finding out what it really is about. I would then discuss the different sections in the book. I would go over the Contents page, as well as the Glossary in the back. This book explores multiple different areas such as: "A mystery", "What Is Dissolving? "How Much Will Dissolve?", "Some Things Won't Dissolve", "Dissolving Is Not Melting", "Why Dissolving is Useful", and "Solving the Mystery". Because this book is broken up into so many sections, I could stop at each section and let the students discuss their own ideas. For example, after they read "Some Things Won't Dissolve," I would let them share what other things they think might not dissolve. I would be sure to record their ideas for each section. After going through all of the sections, I would revisit each part and let them experiment. Through experimenting, they will be able to discover for themselves what does and does not dissolve. Thus expanding on the knowledge they gained from this trade book. This is an example of how inquiry can be used to teach with scientific trade books.

When should teachers place the reading trade books to children in a unit of instruction? If you are going to use the children's literature in a 5E unit of instruction (Engage, Explore, Explain, Elaborate, and Evaluate) there no wrong time to use the book. Here are some hints for using a piece of children's literature in each phase of the 5E:

Engage: Using children's literature to get students interested, engaged, and motivated at the beginning of a unit is always a good idea. However, you don't want to read a book that is heavy on content and would prevent the children for understanding, observing, or collecting data during an investigation. If you tell all of the answers through reading the book, there is no reason for your students to discover something on their own. So choose a book or a part of the book that introduces the science concept but does not give away all of the answers. Using literacy strategies, reading the book to a certain point and having the students anticipate or predict what comes next would be perfect for the beginning of a unit.

Explore: A book that has some science activity or investigation ideas is good to read during this phase of the 5E. The purpose of the Explore stage is to give students a hands-on opportunity to investigate a science concept on their own with the teacher's guidance. Again, you do not want to choose a book that discusses the content in too much depth as to prevent the students from discovering things on their own.

Explain: A book that relates to the science content is well suited for the Explain stage of the 5E unit model. After hearing students' explanation for what happened in the Explore phase, a book can be used to reinforce that content, introduce vocabulary, or present the scientifically correct aspect of the phenomenon.

Elaborate: The Elaborate phase of the 5E is for students to apply the science concept under study to a new or different situation. If you can find a book that discusses the concept in a way that is different from an earlier book or that illustrates another aspect of the concept this is the right place to do it.

Evaluate: For a wrap-up or culminating part of your unit of instruction, using a book to get students thinking and reflecting about what they have learned is appropriate for this phase of the 5E. Perhaps you could read a book to the class and provide a writing prompt and have students describe hat they learned during the unit. Writing and drawing to illustrate their understanding would give you a better idea of what each student has learned during the unit.

Authors

Samantha Burko is a Language Arts major and an elementary preservice teacher in the Teacher Education Program at Central Michigan University. She is also a student assistant in the Central Michigan GEMS (Great Explorations in Math and Science) Education Center at CMU.

Jim McDonald is a Professor of Science Education in the Department of Teacher Education and Professional Development at Central Michigan University and the Director of the Central Michigan GEMS Center.

Please contact Jim McDonald at jim.mcdonald@cmich.edu or 989-774-1723 with any inquires about this article.

References

Butzow, C. M., & Butzow, J. W. (2000). ***Science through children's literature: An integrated approach*** (2nded.) Englewood, CO: Teacher Ideas Press.

Calkins, L. M. (2000). *The art of teaching reading*. Boston: Pearson Allyn & Beacon.

Carle, E. (1986). *The very hungry caterpillar*. New York: Penguin.

Crowson, A. F., & Hopper P. F. (2009). *The Use of Trade Books in Science Classrooms.* National Forum of Teacher Education Journal, 6, 1-5.

Fredericks, A., Blake-Kline, B. & Kristo, J. V. (1997). *Teaching the integrated language arts: Process and practice.* New York: Addis on Wesley.

Halsey, P. A., & Susan G. E. (2007). *Assessing Textbook Publishers' Recommendations for Using Children's Literature in Science*. Electronic Journal of Literacy Through Science, 6, 25-40.

Mayer, D. A. (1995). *How can we best use children's literature to teach science concepts?* Science and Children*, 32*, 16-19, 43.

McMillan, B. (1993). *Accuracy in books for young readers: From first to last check*. The New Advocate, 6, 97-104.

Energy and Me: Actual Calculations of Individual Carbon Footprints Can Change Individual Actions

BY Erin Oldani, Maxx Marano, Megan BorgesoN, Department of Teacher Education, College of Education and Honor College, Michigan State University, and Jane Rice, Science Education Specialist, Department of Geological Sciences and the Center for Integrated Studies in General Science, College of Natural Science, Michigan State University

This project was based on previous work supported by a grant from the National Science Foundation (DUE 0941820).

The last science class these future teachers will ever take – that's the course I teach and coordinate at Michigan State University. That one fact guides all the instructional decisions I make throughout the semester in terms of the science content on which I focus and the science practices I emphasize. What do I want these college students – these future teachers – to walk away with? What do I want them to understand and be able to do a year from now, five years from now, for the rest of their lives?

Informed decision-making – that's what it comes down to. I want this last science course to give these future teachers an understanding of a few foundational science concepts and practices that they can actually use when it comes to making decisions on personal and societal issues. Increasingly, it becomes clear that climate change (global warming) is one such issue that college students must understand and be able to take action on. And, since these students are future teachers, their ability to use science in everyday decision-making related to many issues will have an impact that is multiplied many times over in the lives of their future students.

In this article, my colleagues (three undergraduate students enrolled in Michigan State University's Teacher Education program) and I report on one such project in the course I teach (called Energy and Me) that was designed to foster informed decision-making. The project involved calculating energy usage to determine individual carbon footprints and then communicating to a wider audience the relationship between our collective carbon footprints and global climate change. Before we discuss the actual project, meet my colleagues:

My name is Maxx Marano, and I am currently pursuing becoming an elementary teacher specializing in urban education. I have always known I have wanted to be a teacher ever since I asked my mom to turn our guest room into a "school room" in third grade. Everyday I would beg my two younger sisters to play school with me. I would write up a schedule and craft lessons for my "students". My passion to become a teacher originates from the remarkable and inspiring teachers who I have had the wonderful chance to cross paths with and learn from.

I am Megan Borgeson, and I have wanted to be an elementary teacher since I was in elementary school. My kindergarten teacher, Mrs. Middleton, really inspired me with her dedication to teaching and her passion for working with children, and her influence really made me want to teach. My specializations are language arts and math, and I would like to teach the younger grades, K-3. My senior year of high school I took a class in which I worked for an hour every day with kindergarteners, and I would love to teach this grade.

My name is Erin Oldani, and I am here at Michigan State University to achieve my dreams in becoming an elementary school teacher. I have always found pride and passion in helping others figure new things out which is when I realized I wanted to do this for a living. The immense payback from students makes all the hard work worth it. My first grade teacher, Mrs. McLane at Isbister Elementary, has been my inspiration for many years now and is the reason I also want to teach first grade. She knew how to keep us engaged in our work while also making it a fun and inviting environment. I always loved going to school during this time and this is what I hope to share with my students. At school my specializations are in mathematics and teaching English to students of other languages (TESOL) along with a specialization in urban education.

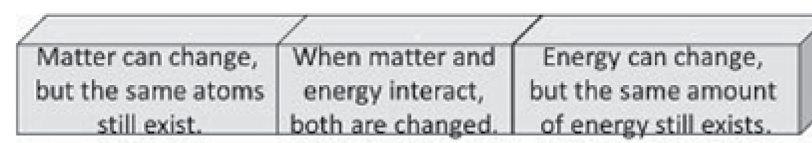
We've written this article in two voices. My voice (Jane Rice) is the teacher and the second voice (in italized font) is the collective voice of the three students. We believe this approach will allow readers to view the project from a teacher perspective and from a student perspective. While this project was done by undergraduate students, we believe it can be modified to be used at different grade levels, ranging from upper elementary through high school. The project primarily integrates disciplinary content across Earth science and physical science, but could easily be broadened to integrate life science (e.g., photosynthesis, cellular respiration in all organisms). The project also integrates science practices and crosscutting concepts with these disciplinary core ideas. Thus, this project can easily be aligned to the three dimensions of the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). We'll discuss each of these three dimensions as we describe the "Energy and Me" student project.

Student Participants

The first part of this project, the actual collection of the carbon footprint data, involved 80 students at Michigan State University (junior level) who were all in the elementary teacher education program. None of these students were science majors; rather they were education majors with a "teaching major", almost always in language arts or social studies. They had already taken the general education science courses required of all non-science majors at MSU. The course they were now enrolled in was a science course for teachers offered by the College of Natural Science. The goal of the project for these students was to collect and analyze their personal energy usage data (for transportation, electricity, and heating) and then use that data to explain their individual contribution to climate change and make decisions about their future energy use. The second part of this project involved a group of five future teachers (drawn from the larger group) who were all Honor College students. The goal of this part of the project was for these students (three of whom are authors of this article) to communicate to the public the science climate change and how individual actions can contribute or minimize the problem. This was done through a large wall display (see below).

Crosscutting Concepts

The science knowledge required to understand climate change includes several crosscutting concepts as well as disciplinary core ideas. One of the most powerful crosscutting concepts in NGSS focuses on the interaction of matter and energy with the conservation of each in physical and chemical changes. This NGSS crosscutting concept is "*Energy and matter: Flows, cycles, and conservation. Tracking fluxes of energy and matter into, out of, and within systems helps one understand the systems' possibilities and limitations.*" Rather than stating these principles in science terms, we express them in simple words that have meaning in everyday life. For example, instead of saying matter is conserved in physical and chemical processes, we expressly state what matter is conserved, or "lasts forever" - the atoms, not the molecules as many students believe. We use the idea of foundational building blocks to help students stay focused on this crosscutting concept which serves as the foundational for disciplinary core ideas in all content areas.



Disciplinary Core Ideas

Students need an understanding of some disciplinary core ideas in physical and Earth science in order to understand global climate change to the point of making informed decisions about personal actions. First, students need to apply the crosscutting concept of "matter can change, but the same atoms still exist" to the burning of fuels. An understanding of chemical changes begins in the upper elementary grades and continues through middle school and high school. However, many college students still struggle with what happens to the atoms in a fuel when the fuel is burned. In this course, when these future teachers were asked about burning fuels on a pre-assessment, over 90% said that the atoms in the fuel turned into heat energy. Even for adults, it's hard to believe that when one gallon of liquid gasoline (weighing about 6 pounds) reacts with oxygen (weighing about 21 pounds) the two substances turn into new invisible substances in the air, namely 20 pounds of carbon dioxide and 7 pounds water.

It is commonly mistaken that when an object, like fuel, burns it turns into energy. We can feel the heat and see the light, so why doesn't it? In class we used a model throughout the semester to represent changes like these. Paper clips represent the atoms in the fuel and paper strips represented the energy that was being used, transformed, or transferred. Have you ever heard of a paper clip turning into paper strip? No! So why would it be any different with atoms and energy? There is a universal law in science that both atoms and energy are forever (in physical and chemical changes). The amount that goes into a change will always equal the amount that comes out. Atoms will never change into energy and energy will never become an atom. So, when a fuel burns the atoms are still present but in different forms. It is the energy in the fuel that ends up as the light and heat that we can feel and see.

Do invisible gases have mass? Of course! This is a confusing topic because thinking about an invisible object having mass is unnatural. However, gases are made up of many atoms that are moving at a fast pace bumping and bouncing off of each other. Atoms are the building blocks of our whole world which means that they have to have mass. If atoms have mass and they make up the gases in our air, they too must have mass, invisible or not.

In Earth Science, students need to understand how energy from the sun interacts with Earth's surface to warm the air. We focus simply on light energy being absorbed by the surface and transformed into heat energy, which means the surface is warmed. The warmed surface then transfers heat energy to the atmosphere, warming the air. Certain molecules in the air (namely, carbon dioxide) interact with the heat energy in the atmosphere, with the result that the heat energy remains in the atmosphere longer before eventually radiating to outer space. This, of course, is the natural greenhouse effect that keeps Earth's temperature within a livable range. Once students connect this understanding of the heating of the atmosphere with their understanding of the burning of fuels in cars, furnaces, and power plants (lots of carbon dioxide molecules made and released to the air) they are able to explain global warming.

Climate change can be examined through the framework of the foundational ideas about matter and energy. Many actions requiring energy depend on energy from burning fuels. Burning fuels involves changing chemical energy in the fuel molecule into other forms of energy, such as electrical, heat, or mechanical energy. A fuel is some type of matter that has carbon atoms connected to other carbon atoms and/or to hydrogen atoms. It is necessary for a fuel to interact with oxygen. When this interaction (i.e., burning) takes place, different atom groups are formed (namely, lots of carbon dioxide molecules and water molecules). These atom groups are released into the atmosphere. This amount of carbon dioxide released in the atmosphere is also known as a carbon footprint.

Putting the explanation of global warming in a manageable, easy and visual way makes the concept less daunting. In class we created a visual representation of global warming through drawings that included labels at each area of the drawing. This representation helped us see the energy being transformed and transferred in relation to the different atoms the make up a fuel and the carbon dioxide in the atmosphere.

Science Practices

This project required students to actually do science, not just learn existing science knowledge. In other words, this project integrated science practices with the disciplinary core ideas. Students used models (both sketches and the hands-on paper-clip and paper-strip models of matter and energy). Students conducted their own investigation into their energy use. Students communicated this science knowledge in graphical displays and narrative writings. They constructed explanations and argued from evidence, especially in regards to their selected activities that would reduce their carbon footprint. Here's how the disciplinary core ideas, crosscutting concepts, and science practices were integrated together in our two-part carbon footprint project.

Carbon Footprint Project: Part One

The data for part one of the project was compiled by the 80 students in the course. The students tracked their energy usage for one month, keeping track of how much they used transportation, heat, and electricity. For transportation, students actually logged the miles they traveled along with the gas mileage of the vehicle they were in. From this data, they calculated how many gallons of gasoline needed to burn each month for their transportation needs. For heat, students looked at their heating bills to find out how much natural gas had to be burned to heat their air (furnace), water (gas water heater), clothes (gas dryers), and food (gas stoves). If students did not have access to their bills, they used the average amount for a Michigan household. For electricity, students chose eight electrical devices they used frequently and looked at the label on each to find out how much electrical energy was needed to run the device. They multiply this number by the number of hours they used the device in one month. Since this method only yielded a partial picture of electrical energy use, students then looked at their electric bills (or used the average for a Michigan resident) to determine their total electrical energy use for the month.

At the end of the month, students calculated their carbon footprint. A carbon footprint is a representation of how much carbon dioxide a person emits into the air due to daily activities, such as heating a house, turning on lights, and driving a car. All of these activities require a fuel to burn, either in a power plant, furnace, or car. When the fuel burns, more carbon dioxide enters the atmosphere. As a result, the excess CO_2 in the atmosphere traps even more heat in Earth's atmosphere, which causes global climate change.

After computing these numbers, students then chose one or more daily activities to change in order to decrease their carbon footprint. Examples of these activities included turning down the heat in a house, turning off or unplugging electrical devices, not using the clothes dryer, and driving less. Students calculated the actual decrease in pounds of carbon dioxide that would result from these changes.

Each student used their own data as the basis of a paper (called Energy and Me) in which they explained global warming and discussed their personal decision-making about actions that contribute to global warming. Students also completed objective test questions and answered subjective questions about their beliefs and actions.

The collecting data and calculating part of the project made me very conscious about my impact on the environment through my everyday actions. I was shocked that just driving my car puts 440 pounds of carbon dioxide into the environment every month. Since atoms are forever, this action is part of my carbon footprint that I am leaving on the earth. Also, learning what area of my life (transportation) puts the most carbon dioxide into the atmosphere and what appliances use more energy than others (the clothes dryer) is useful data. It helped me recognize where making changes can be the most effective - riding my bike and letting my clothes air dry. After gaining a strong understanding of climate change, I feel like it was my responsibility to make changes in my life and to educate others so they can decide if they can find their own ways to reduce their carbon footprint.

Carbon Footprint Project: Part Two

The results of the first part of the project were so impressive that I wanted to convey this information visually to a broader audience. This was the goal of the second part of the project, conducted by the five Honor College students. These students decided to make a large wall display showing each student's current carbon footprint and proposed decreased carbon footprint. In order to do this, they had each student make a paper cut-out of her/his footprint on colored paper. These paper footprints represented each student's initial carbon footprint. The honor students then reduced the size of these paper footprints on a copier at a percentage that equaled the percent reduction in carbon dioxide emissions for each individual student. For example, if one student proposed to reduce her carbon dioxide output by 400 pounds (perhaps by driving 400 fewer miles) and this reduction represented a 25% decrease in her baseline energy use, then her paper footprint was reduced in size by 25%.

Each student had written down actual steps they could take to achieve their percentage of decreased carbon dioxide emissions. After recording the percentage of each students' decreased energy use, we then wrote on each footprint the student's action plan for decreasing her/his carbon footprint. Writing out every idea, such as carpooling more or turning off lights, really made this project come to life and seem even more realistic. We also took photos from everyone who was involved with the project and added them to our display as well. This makes reducing carbon emissions seem even more possible, because anyone who looks at the display will see pictures of the actual people who participated and are making a difference. Additionally, we created posters that describe how climate change happens and how everyone can make a difference.

many students thinking ozone depletion was the cause. These beliefs changed by the post-assessment with over 80% correctly answering questions related to the cause of climate change.

I found several interesting patterns to student responses to survey questions they completed at the end of the project. The most enlightening response to me was in student answers to the question of the value of actually looking at the labels on their own personal electrical devices compared with looking up the same data online. Students overwhelming (89%) said that looking at the labels was more meaningful than gathering the data on the internet. In response to the question "Will your energy usage really change in specific ways now that you've completed this project?", the majority of students (82%) responded they were actually making real life energy usage changes. Students responded in one of two ways when asked about the most interesting part of the project. Many students were surprised that they used more energy than they had predicted they would; others were impressed to see how much of an impact an individual can make when taking action to decrease her/his carbon footprint.

Results: Individual Carbon Footprints

I saw impressive changes in students understanding of disciplinary core ideas and crosscutting concepts. As previously mentioned, most students initially were confused about the crosscutting concept related to matter and energy conservation. Almost all students believed that the atoms in any fuel turned into energy (primarily heat energy) when the fuel was burned. On the objective post-assessment, over 80% of the students now understood that the atoms in a fuel still exist after the fuel is burned, just in a different molecule. In terms of disciplinary core ideas, over 90% of students initially held erroneous beliefs about global warming, with

Results: Communicating Science Knowledge

Our goal for the display was to communicate with others the power of coming together to create change. Once an individual's attention is on the display, we wanted our message to be clear, informative, and easy for viewers to make a conclusion about. The eighty footprints of the individual participants come together to create a bigger picture. They are an expression of the impact that a group of people have when they all do their individual part to change an issue. We researched and included the results of our project on a bigger scale. If all Michigan State students made similar changes, we would put an estimated 17 million fewer pounds of CO2 in the air each month, and if all Michigan teachers did this, CO2 emissions would decrease by 37 million pounds.

driving, combining trips, or biking. In terms of energy use for electricity, the most frequent change reported was turning off lights

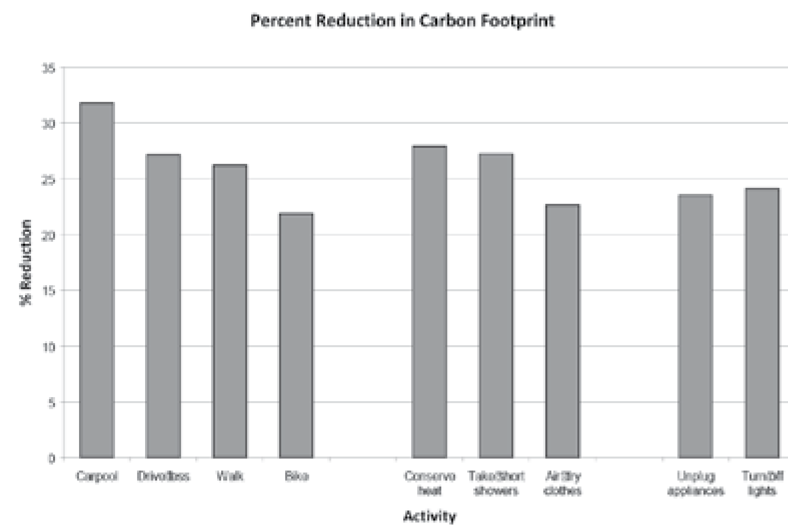
Completing the actual wall display was a great way for us to get a clear picture on how our daily activities are really affecting the environment. Completing this part of the project was insightful and worthwhile. It clearly shows how many students are already making an impact, and how just a few changes can really make a difference. Through the process of completing the display, we learned that what we are doing can be done by anyone, and reducing our carbon footprints seemed more realistic than ever.

The most frequent change students reported related to transportation energy use. Almost 75% reported that they would use less energy for transportation by carpooling (50% chose this action) or walking instead of

(37%) or other appliances/devices (35%). In terms of energy use for heating purposes, the most frequent change reported was turning down heat (13%), air-drying clothes, and taking shorter showers.

However, not all decisions led to equivalent decreases in carbon footprints. For example, a student who action plan focused on turning off lights only reduced her carbon footprint by 10% (as illustrated by an only slighter smaller projected footprint in the photograph. For another student, carpooling led to a much greater impact on reducing a carbon footprint, in this case by 44% (as seen in the much smaller projected footprint).

The collective carbon footprints shown in the hall display allowed students to see the pattern of which personal actions led to the greatest decrease in their carbon footprint. The projected decrease in carbon dioxide emissions was the greatest on average for students who chose to carpool (an average decrease of 31% in monthly carbon footprint).



Seeing the pieces of the project come together was nothing like seeing the complete display up on the wall finished. Being able to see the numbers and the drastic difference that we all can make as a collaborative whole was astounding. We knew that if we worked together we would be able to make a difference, but it is more real when the numbers are in front of your face and there are no excuses not to! The display is a true illustration of the power of one. If every individual makes a difference in their lives to fight against the rise in global warming, our world would be changed and for the better.

Discussion: Addressing Misconceptions

My finding that these college students (i.e, future teachers) held some of the same misconceptions of their future students is not surprising. One of these misconceptions was that atoms turn into energy when a fuel burns. This misconception has fundamental consequences when trying to understand climate change. If the atoms in gasoline, or coal, or natural gas are destroyed in burning, then there are no atoms available to make carbon dioxide molecules, and thus no increased heat energy in the atmosphere. My strategy to deal with this belief was to use the crosscutting concept of matter and energy conservation and interactions as the foundation for all the science topics in the course. Thus, when students began to learn about climate change, they had already developed a way of thinking that pushed them to keep track of atoms (and energy units). They knew the atoms had to be present in the molecules of some substance, even if that substance was invisible.

I went into this course with a very unclear concept of matter and energy. These topics had been addressed throughout my school career, but it was very hard to visualize exactly what happened to matter if it did not turn into energy and was not destroyed. This is especially difficult to comprehend when that matter is changing state, especially when it changes into a gas. My idea of burning fuel before this course was that when something is burned, it is destroyed. Therefore, it did not make sense that atoms still remained and entered our atmosphere as a gas after burning. In class, however, we learned how matter is never destroyed and cannot be turned into energy. Gaining an understanding on how matter works with visual representations and models was very beneficial toward my overall understanding of climate change. Once I understood how the process worked, it then became clear how the burning of a fuel does not destroy atoms, and the atoms still existed in different molecules.

A second misconception that actually prevents students from taking personal actions to minimize global warming is the belief that ozone depletion is the main cause. I asked students on the survey where this belief came from. Students said that they had connected global warming with ozone depletion on their own because both phenomena happen in the atmosphere. This misconception is problematic for making informed decisions. How can a person take action to decrease ozone depletion? The cause of ozone depletion has already been address with a ban on the manufacturing and use of chlorofluorocarbons. However, each individual has the power to take action on global warming many times each day in how they decide to use energy.

Discussion: Actually Doing the Science

I also found that many students lacked experience with household energy use, especially in terms of electricity and heating (not so much so with transportation, perhaps because we pay immediately at the point of purchase of the fuel that our vehicle will burn). In terms of electrical energy use, many students were unfamiliar with the fact that different electrical devices require different amounts of electrical energy to run. Initially, many students predicted that charging their cell phones and computers would be among the biggest contributors to their electric bills. Their reasoning, of course, was the number of hours that the device was using electrical energy per month. In the words of one student, "I had everything backwards originally. I thought that the amount of time you used the item held the key to how much energy use it would use." A cell phone charger may require only 10 watts while a microwave may require over 1000 watts.

Here is where actually looking at the energy use labels on electrical devices really helped students' understanding of the energy transformations that occur in household devices. An overwhelming majority of students in this project believed that actually finding energy usage labels on their electrical devices made the project more meaningful. One student commented, "If I had looked up appliances online it would have been less real and easier to say that I don't use that much energy but I can't deny my numbers." Another student commented, "I can excuse the numbers if they could possibly be wrong from the internet but if they are right in front of my eyes on things I use all the time there are no excuses."

In my high school chemistry class we were asked to complete an online calculation of our carbon footprint. We went on a website to answer questions about how long we used certain appliances, how much we drove, and the energy use from a household energy bil . After entering all of the data, the website calculated the number of planets that would be needed if the participant continued to produce that size carbon footprint. This project only reached the surface of the issue for me. I understand that resources are consumed at a tremendous rate, but the online calculation did not leave me with the knowledge of specific science content. I entered some numbers and then a website gave me a number back. Unfortunately, the activity did not involve science practices or actually doing the science.

Discussion: Changing Actions

I asked students on the survey if they would actually implement the change or changes on which they based the reduction in their carbon footprint. The majority of students responded they were actually making the real life energy usage changes. Most of these students provided specific ways they would change their current carbon footprint. While some students brought up their hesitations to actually change their energy use, most responses were similar to this student's: "I think it will change a little bit now that I'm aware of what I'm using. To change in a big way may not be realistic but if everyone changes in a small way it will really add up."

People are very routine based beings. We know how we like to do things, and we do them. This is what makes change so difficult. These changes we have accumulated throughout this project are absolutely necessary. If we want our environment and in turn the whole world to be a better place to inhabit, then it is up to us to do it and no one else. To me, this is a shout out to make a change. Little things like driving less and walking or air drying clothes instead of putting them in a dryer are easy to do. Ultimately, these change your lives very little. But together, making these changes can create a big difference. The difference we want to make.

Discussion: Informed Decision-Making

I also asked students what was most interesting aspect of the project. Students frequently responded that connection to personal decisions and actions was the most interesting and useful aspect of the project. These responses provide me with some evidence that I am making progress on my overall goal of students and future teachers being able to use science knowledge and practices for informed decision-making in their personal lives and in regard to societal issues. One student summarized this belief with “The most interesting thing was to see my effect on climate change with real data. I have always been told by science teachers that I always have an impact but that didn’t mean much because I never really understood how. This project allowed me to actually record and see how I personally impact climate change and how I can reduce my [carbon] footprint.” Another student responded with “I think that this made it easy to understand the impact that each of us have on climate change in a tangible way that isn’t as abstract.”

Students expressed their belief that this sense of personal empowerment could lead to even bigger impacts, especially through their future teaching. I asked students how they would respond to someone who argues that individuals may as well do nothing about climate change since one person would have such a little impact. Student responses focused on the power of collaboration of individuals coming together. This is where the hall display really makes the point.

We scaled up the results of the project to be relevant to MSU students and Michigan teachers. Hopefully our work speaks to the public showing that they can be contributors in efforts made to reduce carbon emissions in a positive way. Climate change is a gigantic, scary concept. Should individuals do nothing about climate change because one person will have little impact on such a big global issue? We don’t think so. We hope that the eighty footprints and thousands of pounds of CO2 not put into the air prove that individual actions matter in the larger picture of positively changing the world we all share.

I found this project to be one of the most satisfying ones I have ever done with students. The relevance of the topic as a societal issue lent a sense of urgency to students’ learning the science content. Students could then easily make informed decisions about their use of energy. As one student explained, “What if every person individually decided to make a change in her or his life? Then collectively the whole Earth would see immense changes. It starts with one person daring to create change and making an impact. That could be you!”

References

NGSS Lead States. (2013). Next Generation Science Standards: For States, By States. Retrieved from http://www.nextgenscience.org/

Rice, J, Doherty, JH, Anderson, CW (2014). Principles, First and Foremost: A Tool for Understanding Biological Principles. Journal of College Science Teaching, 43(3) 74-82.

Appendix 1. Selected Disciplinary Core Ideas in NSSS that relate to the project

Standard	Grades K-2	Grades 3-5	Grades 6-8	Grades 9-12
ESS2.D Weather and climate	N/A	N/A	N/A	The role of radiation from the sun and its interactions with the atmosphere, ocean, and land are the foundation for the global climate system. Global climate models are used to predict future changes, including changes influenced by human behavior.
ESS3.A Natural resources	Humans use natural resources for everything they do.	Energy and fuels humans use are derived from natural sources and their use affects the environment.	Humans depend on Earth’s land, ocean, atmosphere, and biosphere for different resources, many of which are limited or not renewable.	Resource availability has guided the development of human society and use of natural resources has associated costs, risks, and benefits.
ESS3.C Human impacts on Earth systems	Things people do affect the environment but they can make choices to reduce their impacts.	Societal activities have had major effects on the land, ocean, atmosphere, and even outer space.	Human activities have altered the biosphere, sometimes damaging it, although changes to environments can have different impacts for different living things.	Sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.
ESS3.D Global climate change	N/A	N/A	Human activities affect global warming. Decisions to reduce the impact of global warming depend on understanding climate science, engineering capabilities, and social dynamics.	Global climate models used to predict changes continue to be improved, although discoveries about the global climate system are ongoing and continually needed
PS1.A Structure of matter	Matter exists as different substances that have observable different properties.	Because matter exists as particles that are too small to see, matter is always conserved even if it seems to disappear.	The fact that matter is composed of atoms and molecules can be used to explain conservation of matter.	N/A
PS3.A Definition of energy	N/A	Energy can be converted from one form to another form.	N/A	The total energy within a system is conserved.

Appendix II. Related Science Practices in the Next Generation Science Standards

Asking questions and defining	We wondered how much of an impact our carbon footprints really had on the environment, and how we could take steps to reduce it. We also wondered how many actual pounds of CO2 were being put in the air by individuals over the course of a month.
Developing and using models	We created the footprint model to represent how much CO2 each person put into the atmosphere.
Planning and carrying out investigations	We had to decide the best way to collect our data and display it.
Analyzing and interpreting data	We took the data we collected from eighty students and analyzed it. We decided which information was relevant and what the results meant.
Using mathematics and computational thinking	We calculated how many pounds of CO2 were put in the air by students in one month, and the projected amount put in the atmosphere by teachers and MSU students in one month. We also calculated our own individual carbon footprints, graphed the individual contributions from heating, electricity, and transportation, and then compared our graphs to other students.
Constructing explanations and designing solutions	We explained how carbon dioxide gets into the air, and the ways in which our daily activities caused this. We also explained how to reduce a carbon footprint. Students designed solutions for lessening their impact on the environment by choosing activities that required less burning of fuels - air drying dishes, ride-sharing, using a radio for noise at night instead of a TV.
Engaging in argument from evidence	If every person makes a change, it can make a huge difference on a global scale. Individual graphs of student use could also be used to have students engage in argument from their own evidence. For example, the graphs might show that students who had large carbon footprints had a huge contribution from transportation while students with small footprints used little energy for transportation.
Obtaining, evaluating, and communicating information	The visual display communicates the information.

Dig into Gardening Using NGSS Science Practices and Crosscutting Concepts

by Jody Harrington, E.L. Johnson Nature Center, Birmingham, Michigan

You can study plants outside with your students AND complete Science Grade Level Content Expectations using the new Science Practices and Crosscutting Concepts of the Next Generation Science Standards This article demonstrates how you can accomplish all of this while "Digging in the Garden". Included are several elementary GLCEs and Disciplinary Core Concepts of the NGSS and activities from some of the best Environmental Curriculum Guides and Activities involving Garden and Plant Activities.

Teaching in a Garden involves new avenues of learning. You are all set to dig in if you have a rain garden, butterfly garden or farm garden on your school property. If not, find a sunny patch, place railroad ties around the perimeter, fill the space with soil, plant wild flowers or vegetable seeds and get ready to watch them grow and study them. Students will relish studying in a new place. Learning will be remembered when students participate and DO LEARNING! Leave the classroom and go outside where the air is fresh and invigorating.

Here are some tips to help you get started with trips outside. Introduce students to garden trips gradually. Take them out 5 minutes at first. Prepare students for the topic prior to your garden tour. Gradually increase your time in the garden and observe growth in detail. 1/2 of the class can be working in the garden and the other 1/2 reading or journal writing. Have them notice the following:

- Why are plant sprouting up? Were seeds planted?
- Why do some plants look differently than others?
- What do these plants need to grow?

Use data sheets and clip boards to collect information. Pick a favorite plant, draw and measure it. Periodically return outdoors to monitor the growth of the garden plants.

Below are 4 GLCEs that can be accomplished using a Garden. Some excellent activities are included that can be used as whole classroom activities to teach biological concepts or to demonstrate whole class experiments. These activities can also continue this outdoor learning with plant experiments and activities inside the classroom. The activities are listed by GLCEs and ,in parenthesis, the new NGSS Disciplinary Core Concepts with the new grade level that will soon be adopted .

1st Grade

E.ES.01.12 Demonstrate the importance of sunlight and warmth in plant growth. (K-LS1-1 Use observations to describe patterns of what plants need to survive.)

1. "A Plant Begins" , ***AIM Primarily Plants,*** p. 18. Observe and record the growth of plants and what they need to survive. Plant the plants in the garden or at home in the spring.
2. Plants and Water", ***AIMS Primarily Plants,*** p. 93. Activities for teaching that sunlight and water are needed for plants.
3. "What Plants Need to Grow", ***AIMS Primarily Plants,*** p. 139. An experiment with variables showing 4 requirements that plants need to grow.Records growth of plants.

4. Study wildflowers, draw and measure their growth.
5. "Just a Little Sprout", *AIMS Cycles of Knowing and Growing,* p. 40, Growing a pumpkin plant from seed to fruit.
6. Take a tour of the garden and point out that some plants thrive in the sun and others need shade.

2nd Grade

L.OL.02.14 Identify the needs of plants. (2-LS2-1. Plan and conduct an investigation to determine if plants need sunlight and water to grow.)

1. Use the 6 activities above.
2. "Signs of Fall", PLT, p. 337. Students look for signs of fall. An experiment demonstrates the presence of chlorophyll in leaves and explains its absence in leaves that have turned fall colors.
3. "Sunlight and Shades of Green", *PLT*, p. 182. This activity uses an experiment to introduce students to photosynthesis and sunlight used to manufacture food for plants.

3rd Grade

L.OL.03.31 Determine the functions of plant parts: flowers produce fruit and attract pollinators, stems, roots, leaves. (2-LS2-2 Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.)

1. "What do Plants Need to Grow", AIMS Primarily Plants, p. 139. Experiment with all 4 requirements that plants need. Record the growth of the plants.
2. "Signs of Fall", PLT, p. 337. Students look for signs of fall. An experiment demonstrates the presence of chlorophyll in leaves and explains its absence in leaves that have turned fall colors.
3. "Sunlight and Shades of Green", *PLT*, p. 182. This activity uses an experiment to introduce students to photosynthesis" and sunlight used to manufacture food for plants
4. "Plant Parts", *AIMS, Primarily Plants*, p. 173. A student reading about all parts of a plant, including the flower and fruit.
5. "Seeds Travel", *AIMS, Primarily Plants*, p. 79. The life cycle visible in fall is seed production. Observe and compare a milkweed seed and wild flower seed. Take apart the flower heads and use a hand lens to observe seeds. Discuss dispersal, birds' eating seeds, or seeds falling near plants.
6. "Have Seeds Will Travel, *PLT*, p. 185. Students analyze various types of seed dispersal and the advantages for survival of each type. Milkweed seeds can be collected from the garden. Many wildflowers have tiny seeds on their heads that can be seen with a magnifying glass. Several flowers have larger seeds that can be investigated. Use recording page from "Seeds Travel".
7. "Flower Power and Pollination", Use the data sheet to draw and write about the growth of the buds of trees growing on the school grounds. As the flowers open up, the flower parts needed for pollination can be identified. Students can go out on successive days and watch/draw as the seeds begin to form. Find another flowering tree to compare the formation of buds, flowers and seeds.
8. "Pollination Partners", National Wildlife Federation, Butterfly Activity Guide, p. 8. (Explains animal/insect adaptations and their role in the pollination of plants). Excellent diagram of a flower's pollination parts and a worksheet for students to use in their flower parts identification.
9. In a tour of the garden notice bees and butterflies drinking nectar from flowers and subsequently pollinating other flowers.
10. Here is an example of a modeling technique. Use stems of fake flowers with a bee on a stick darting between the 2 to demonstrate pollination. Use stuffed animals to demonstrate how animal fur picks up seeds that stick and drops the seeds in another location. Use a small fan to demonstrate how fluffy flower seeds or milk weed seeds are dispersed in the wind.

4th Grade

L.OL.04.15 Determine that plants require air, water, light, and a source of energy and building material for growth and repair. (5-LSI-1 Support an argument that plants get the materials they need for growth chiefly from air and water.)

1. Use # 1,2, and 3 from the 3rd Grade GLCEs. (E.SE.03.13 Recognize and describe different types of earth materials (rock, clay, sand, soil).
2. *"Soil Stories"* PLT, *p. 54.* Different types of soil are examined and students discuss what the differences mean to plants and people. A soil test is presented.
3. "*Which Soil Works Best*", AIMS, Primarily Plants, p. 103.

Below are examples of how you can use the 8 NGSS Science and Engineering Practices and several Crosscutting Concepts now, with the above GLCEs in a Garden. You will already be proficient in these NGSS Practices and Concepts when the "Michigan Science Standards" are implemented in the near future.

1. Students begin their study by asking a key question. How can we test this out? Does anyone have an idea what questions we can ask to answer this question? Let's formulate a question that needs investigation here.
2. Carlos' group decides that they can grow bean plants and place the plants in various positions of sunlight and decide which group grows the best. This group spends time designing their experiment. They decide that 2 plants would be outside in the garden in the sun, 2 would be placed near a window inside the classroom, and 2 would be placed in the back of the classroom. Other student groups in the class decide to use different plants. Sophie's group chooses to investigate the amount of water bean plants need to grow. They plan 3 conditions with specific amounts of water every other day. All the plants are placed outside in the garden. Once each group has submitted their plans their teacher wants each group to design the method they will use to document each condition. Each group formulates a graph to keep track of their experiments. They predict what they think will happen during their project and what will occur. (A soil testing experiment can be conducted in a similar manner with plants for the 4th grade GLCE.)
3. Once the plants have emerged, the conditions are set up and each experiment is begun. Time is spent every other day measuring the plants (and watering them). After 6 weeks the experiments are concluded. All groups compute the totals of the heights of their plants under their varying conditions. Pictures are drawn or photos taken with the heights listed every 5 days during the experiment. Height graphs are standardized for each group.
4. The data is totaled using mathematical calculations. Carlos, Sophie, and all of the other groups discuss and contribute ideas to interpretation of the results. They use their graphs to help them decide what they have learned. "Why did we get the results we did?" "Were there any inconsistencies?" "What were the problems encountered during our experiment?" " What might we have to change to clarify our results?"
5. Each group works together to construct an explanation for their results.

6. Each group present their reasoning to the class and arguments to prove the answer to their question. They explain their procedure for how to decide to test it and their results showing the data they collected using their graphs and their drawings. They argue how and why the results do or do not answer their questions. The groups present inconsistencies in their procedures and results.
7. Carlos and and all of the groups working with plants met and analyzed their data to look for patterns in the growth of the variety of plants under the different conditions. New data sheets are compiled for the plants over time and patterns of growth discovered. They discussed the reasons for their results. The same is done with Sophie and the other groups investigating water requirements.

A Garden can be used to teach science concepts in a new and fun manner. The GLCEs can be accomplished for each grade level and the new NGSS Science Practices and Crosscutting Concepts can be used during the plant experiments. Get busy digging in the dirt and get ready for NGSS!

Bibliography:

AIMS Education Foundation, *Cycles of Knowing and Growing,* Fresno, 2005

AIMS Education Foundation, *Primarily Plants,* Fresno, 2005.

American Forest Foundation, Environmental Education Activity Guide, PLT, Project Learning Tree: PreK-8, 2008.

National Wildlife Federations, Butterfly Activity Guide, p. 8.

How to Integrate Social Studies and Science Content

By Scott L. Roberts, Central Michigan University, Jim McDonald, Central Michigan University, Teacher Education and Professional Development

Thousands of elementary level teachers across the country can attest to the lack of attention the disciplines of social studies and science received during the No Child Left Behind era as reading and mathematics dominated the elementary level curriculum (Bailey, Shaw Jr., Hollifield, 2006; Griffin & Scharmann, 2008; Jennings & Stark, 2006; VanFossen, 2005). In 2010, the Common Core standards were released. These new standards, along with federal waivers and the Race to the Top program, essentially put an end to the No Child Left Behind legislation (Common Core Standards Initiative, 2011; Hefling & Feller, 2012; U.S. Department of Education, 2012). Though the skills suggested by the standards were open-ended allowing teachers to incorporate social studies and science content, the primary focus of the elementary level standards, due to testing, were once again Language Arts and mathematics.

Members of both the social studies and science education communities insisted that there was a need to develop their own subject specific frameworks and standards that incorporated the higher level learning skills found in the Common Core but focused specifically on important themes and content for each discipline. In 2013, the National Science Teachers Association (NSTA), the American Association of the Advancement of Science (AAAS), Achieve, and the National Research Council released the "Next Generation Science Standards" (NGSS). In the same year, the National Council for the Social Studies in partnership with a number of discipline specific organization followed suite with the release of the "C3 frameworks" (Achieve, Inc., 2014; National Council for the Social Studies, 2013).

While the debate about the merits of all three sets of standards continues, as teachers and educators it is important that we keep these new standards and frameworks in mind as we prepare the current and next generation of teachers to enter the field. Teachers in those states that have adopted these standards will be required to know and develop lessons based on them. This is especially true for those who aspire to teach at the elementary level. Since these teachers are generalists they will need to be familiar with the standards and frameworks in all core discipline areas. With that said, what can teacher educators specializing in different disciples do to prepare our students to meet these challenges of the modern standards based educational environment?

The Introduction of Integrated Units

The primary goal of our collaboration is to help our preservice education students and current teachers develop an understanding for creating inter-disciplinary units that incorporated elements from the Common Core, NGSS and C3 frameworks. Both authors brought different backgrounds, strengths, talents, and interest to the collaborative process. Scott Roberts taught 8th grade social studies and served as a staff developer for his district. At the beginning of the collaboration he was in his first year an elementary social studies methods professor. Jim McDonald taught at the elementary and middle school level for 10 years before becoming an elementary science methods professor and is one of 55 NGSS@NSTA Curators (experts on NGSS). They are colleagues at Central Michigan University working in Department of Teacher Education and Professional Development.

Our collaboration for a partnership and the goals we had for collaboration began with what we saw in the classrooms that we visit. Both authors witnessed the marginalization of their respective discipline in the schools of their state since the No Child Left Behind Act and sought ways to teach their students how to integrate subject matter content with the Common Core standards. Some studies report that science and social studies is taught only one semester or the other but not both semesters. Other reports say that science is only taught an average of 9 minutes per week in the elementary grades similar timeframes in Social Studies (Bailey, Shaw Jr., & Hollifield, 2006; Griffin & Scharmann, 2008; VanFossen, 2005). As both authors taught their specific subject methods classes to students in the same educational cohort in both an on campus and off campus program (two separate groups of students) for their institution they sought ways to not only combine their specific subject matter to the Common Core standards but also how to combine the frameworks and standards of science and social studies in order to find creative ways to present these subjects to elementary students.

Many often see the commonalties between science, mathematics and Language Arts,

For example, the National Association of Gifted Students discussed the commonalities between the Common Core Math and ELA Standards and the NGSS:

The developers of the CCSS and NGSS have acknowledged individual differences of students noting that some students will master many aspects of the standards before grade 12, and that it is up to educators to extend the learning goals and objectives beyond the standards to meet their needs. This acknowledgement means that effective implementation of the standards requires specific instructional strategies and curricular materials, including modified formative and summative assessments, for all students whose levels of learning exceed grade-level expectations. Effective instruction using CCSS and NGSS for students will require extensive professional development on the standards and the assessment systems, sufficient materials and personnel resources to support implementation, and reasonable expectations regarding the time required for learning new instructional practices. In addition, effective and comprehensive implementation of the content standards requires systematic attention to the growth of each learner. For all learners, such opportunities for growth will require concerted efforts from states, school districts, and building leaders to support the implementation of curricula that are sufficiently advanced.

In turn, the commonalities between the Common Core Math and ELA Standards, C3, and the NGSS tell us that integration of these disciplines is an excellent way to provide the support called for in the NAGT statement.

However, we have found that history and science fit well together as well. While, there is a general consensus that the ELA focused Common Core Standards correspond to both disciplines, we found that there are many examples where social studies frameworks and science standards correlate. An example can be found in the K-2 standards for both as the NGSS and C3. When an elementary educator teaches NGSS standard ESS3.C: Human Impacts on Earth Systems he or she can incorporate several C3 frameworks focusing on economics including “D2. Eco.1.K-2: Explain how scarcity necessitates decision making” and “D2.Eco.2.K-2. Identify the benefits and costs of making various personal decisions” (Achieve, Inc., 2014; NCSS, 2013). However, we have found that analysis of the commonalties between the NGSS and the C3 is currently limited in the literature. See Figure 1 for a sample of NGSS and Michigan Social Studies GLCE standards that could be combined to create an integrated unit.

As we worked together we were able to take many of the commonalities between the NGSS and C3 and develop lesson ideas and assessments for our shared elementary education students. For example we concluded that scientific innovation has been a driving force in societal change. One approach for putting this idea in perspective for students is to have them consider what life would be like without the Internet, phones or electricity. What it would be like to look up at the stars and not know what they are?

If you’re teaching an historical time period, you can focus on scientific discoveries and technological advances during that time. Have students create a presentation that highlights one or more scientific innovations and how they affected society (both then and now). Combining social and science is an opportune time to discuss the history and nature of science. Many years ago there was a Science, Technology, Society portion of the science standards and is still part of the National Council for the Social Studies 10 themes of social studies education. Tying these aspects of history and science together help build the science and historical literacy of your students Along with the discussing the past, current events, such as tracking the activities of the Mars Rover and its historic mission, can also be studied in an integrated science and social studies lesson. Check out video of Curiosity’s landing on our neighboring planet.

Hints for Teaching a Successful Integrated Unit

Based on our experience of working with our students as they develop the units and observing them teach the units in the classroom, there are a number of features that you should include to make your integrated unit successful. We offer a few suggestions.

Formative Assessment. You need to know what your students know. There is no better way to do that for science and social studies than by accessing students’ prior knowledge. At the beginning of your unit, and throughout your unit, you should embed formative assessments to make sure you have a handle on how well students understand the key portions of your instruction. Build in checkpoints where you give formative assessments to your students such as exit tickets, pre and post assessments, formative assessment probes (see the work of Page Keeley), and others so that you can adjust your teaching depending on how your students are dealing with the material.

Choosing a Common Core ELA Standard. Choose an English and Language Arts standard that fits into to your unit. If you wish to use children’s literature, have the students practice writing skills, or want students to write out explanations there are many possibilities that you can use with your students. What do you want to emphasize? What skills do you want the students to practice? Let these questions guide you as you pick the standards for your ELA work with students.

Active Learning Strategies. Engaged minds often go along with getting students up and moving. There are many active learning strategies that can be combined with Page Keeley’s Formative Assessment Classroom Techniques (FACTS) that will allow active learning to take place at the same time as formative assessment. Change it up every now and then and you will see the results.

Science, Socail Studies, and Common Core Practices Overlap. There are many overlaps between the practices of the NGSS, C3 Framework, and the CCSS practices that can be incorporated into an integrated unit. Some of these include:

E2 (ELA): Build a strong base of knowledge through content rich texts

E5 (ELA): Read, write, and speak grounded in evidence

M3 & M4 (Math): Construct viable arguments and critique reasoning of others

S7 (Science): Engage in argument from evidence

For example, Inquiry based lessons are important in standards and frameworks of all three disciplines. Developing active, hands-on investigations are valuable in content integration. Getting students to provide evidence in their explanations, arguments, writing, and reasoning is something that can be built into your integrated unit in a variety of ways.

Conclusion

We wrote this article with three goals in mind. First, we hoped to show the commonalities between the NGSS and C3 standards. Second, we want to showcase the excellent lessons ideas that can be developed when teachers, preservice teachers, and college professors from different disciplines work collaboratively using these new standards as a guide. Third, and most importantly, we want to add to the literature providing examples of how teacher educators from different disciplines can develop long term collaborative opportunities based on the common interest of offering their students the best educational opportunities possible.

Figure 1: Sample NGSS and Michigan Social Studies GLCE that can be integrated.

Kindergarten: LS1.C – NGSS: Organization for Matter and Energy Flow in Organisms: All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow

KG5.D.1 – Describe ways people use the environment to meet human needs and wants (e.g. food, shelter, clothing)

1st grade: LS1.B – NGSS: Growth and Development of Organisms: Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

1G5.0.1 – Describe ways in which people modify (e.g. cutting down trees, building roads) and adapt to the environment (e.g. clothing, housing, transportation)

2nd grade: LS2.A – NGSS: LS4.D: Biodiversity and Humans. There are many different kinds of living things in any area, and they exist in different places on land and in water.

2G5.0.2 – Distinguish between personal and civic responsibilities and explain why they are important in community life.

3rd grade: LS4.D – NGSS: Biodiversity and Humans: Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

3G5.0.2 – Describe how people adapt to, use, and modify the natural resources of Michigan.

4th grade: ESS3.A – NGSS: Natural Resources: Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

4.G5.0.1 – Assess the positive and negative effects of human activities on the physical environment of the United States.

References

Achieve, Inc. (2014). ***Next Generation Science Standards: Frequently Asked Questions.*** Retrieved from http://www.nextgenscience.org/

Bailey, G., Shaw Jr., E. L., Hollifield, D. (2006). The devaluation of social studies in the elementary grades. ***Journal of Social Studies Research, 30***(2), 18-29.

Common Core State Standards Initiative. (2011). ***Common Standards***. Retrieved from http://www.corestandards.org/

Griffin, G., & Scharmann, L. (2008). Initial impacts of No Child Left Behind on elementary science education. ***The Journal of Elementary Science Education, 20***(3), 35-48.

Hefling, K. & Feller, B. (2012). ***No child left behind: 10 states receive waiver from education law's sweeping requirements***. Retrieved from http://www.huffingtonpost.com/2012/02/09/no-child-left-behind-waivers_n_1264872.html

Jennings, J., & Rentner, D. S. (2006). Ten big effects of the No Child Left Behind Act on public schools. ***Phi Delta Kappan, 88***(2), 110-113.

National Association for Gifted Children. (2014). Position Statement on Common Core and Next Generation Science Standards for Gifted and Talented Students. Retrieved from http://www.nagc.org/sites/default/files/Position%20Statement/Common%20Core%20and%20Next%20Generation%20Science%20Standards.pdf

National Council for the Social Studies (2013). ***College, Career, and Civic Life (C3) framework for social studies state standards***. Retrieved from http://www.socialstudies.org/c3

National Research Council. (2013). ***Next Generation Science Standards: For states, by states.*** Washington, D.C.: The National Academies Press.

U.S. Department of Education (2012). ***Race to the Top fund***. Retrieved from http://www2.ed.gov/programs/racetothetop/index.html

VanFossen, P. J. (2005). "Reading and Math take so much of the time...:" An overview of social studies instruction in elementary classrooms in Indiana. ***Theory and Research in Social Education, 33***(3): 376-403.

Speed-Reading: Techniques to Improve Reading Speeds for Scientific Literature

By Laura Kaye Harris, Davenport University, Science Laboratory Coordinator

Abstract

The ability to read faster increases both instructor and student productivity. Instructors can more efficiently use their preparation and grading time while students have an easier time learning and retaining new information with less frustration. This paper discusses techniques such as scanning, skimming, hand motions, and summarization taught by Evelyn Wood and used by speed-readers. Practice these techniques to decrease your course preparation and grading times and share them with your students to improve reading speed and comprehension of scientific literature.

Since math and science standards have increased over the past few decades to meet rising international competition in these areas, so have high school dropout rates (Dryden, 2014). One reason is that reading scientific text requires a slower reading rate, prolonging study time for students as well as course preparation and grading time for instructors. Timothy Rasinski discussed how student reading rates are predictive indicator of academic performance since academically challenged students read less due increases in frustration and poor comprehension (Rasinski, 2000). Brett Nelson of Forbes Magazine online cites a speed-reading test performed by Staples that found the average adult reads around 300 words per minute (wpm), twice as fast as third grade students do. At 300 wpm, Nelson calculates nearly 14 hours of reading every week for the average adult among all the newspapers, blogs, magazines, books, emails, and texts. Time spent reading would increase for students, particularly those studying science. Fortunately, speed-readers in the Staples study read at an average 1,500 wpm, allowing them to cover more than four times the material read in the same 14 hours a week (Staples, 2015). Nelson suggests that high level executive and college professors are successful because of their above average reading speeds, 575 and 675 wpm, respectively (Nelson, 2012). So how can you and your students learn to get through text faster?

Scanning

The first step in speed-reading does not involve reading specifically. Scanning is lets your eyes quickly run over several lines of print at a time without acquiring much detail. If the text is new to you, begin by scanning the entire document, paying particular attention to title, headings, figures, and tables. If there are subheadings, read each one and think of possible relationships among them (AACC, 2015). These features provide an overview of the important concepts covered in the text. Scanning is meant to prime your brain to receive more details on the information you are about to read.

Scanning also allows for a fact or piece of information to be located within a large amount of material quickly. The average scan is around 1,500 wpm, though this requires the reader to skip large sections of information without comprehension (AACC, 2015). The hardest part of scanning is remembering what you are looking for, so be sure to hold an image of the idea in your mind. It is also helpful to anticipate the format the information will likely appear in, such as names or numbers. Doing this helps the idea stand out from its surrounding words. Depending on the length of the document, you may have to scan the headings first to determine which section to scan in more detail to find the specific information needed.

Skimming

Once you have the conceptual scaffolding of the text from scanning, you can skim to get an overview of the text. The purpose of skimming is to get main ideas, so it is useful when previewing a document for a more detailed read later, reviewing text already read, or reviewing material quickly that does not need attention that is more detailed (AACC, 2015). This technique is excellent for grading student work, particularly papers and essay exams, since skimming rates average about 1,000 wpm.

If the work has an introduction, read it. Read the first paragraph entirely then read the first sentence of each remaining paragraph. In the English language, paragraph design designates the first sentence as the topic sentence, housing the main idea of the paragraph, and the last sentence being a summarization of the paragraph or a transition of ideas into the next paragraph. Reading the first sentence gives an overview of the main points in the work, though sometimes the last sentence can be more valuable if the author has an anecdotal writing style (AACC, 2015). The same thing applies to the conclusion when you get to it. Be sure to read each paragraph's topic and transitional sentences in the conclusion and read the last paragraph entirely.

Evelyn Wood's Speed Reading workshops recommend looking for key words while skimming text in order to understand the content and better remember details. For example, ignore small, common words: the, a, an, to, and, that, but. These words along with several other smaller words make up the majority of the English language but do not provide significant conceptual value to the text (Dictionary.com, 2015). Save your eyes and brain processing time by skipping over these words while reading to increase your reading rate.

Furthermore, focusing on font changes in the text allows retention to details while skimming, increasing reading speeds. Look for clue words that address who, what, when, why, and how. Focus on proper nouns, enumerations, unusual words, especially if capitalized, and any typographical cues in the text such as italics, underlining, font style changes, boldface and asterisk (AACC, 2015). Also noting any qualifying adjectives just as most, best, or worst is helpful in understand details from context (AACC, 2015).

Hand Techniques in Reading

The use of hands during reading increases concentration and prevents you from losing your place in larger paragraphs. If you are using hard copy material, the best is to use your finger to trace under the words as you read along. This underlining technique enhances concentration on the context and prevents going back over already read material (Frank, 1994). Practice keeping an even pace with the finger and continue moving it even if you stall on a particular phrase. Your eyes will catch up to your figure once your brain processes the troublesome phrase. This method will slow your reading rate initially but I have found it personally accelerates it with practice. Use it consistently to avoid another learning curve. After several decades of practice, my finger is now slower than my eyes can read! If your text is in an electronic format, use your mouse to highlight or underline text as you read each line. You can also hold your finger up to the screen as you would a hard copy text, though this does not work well on touch screens and may injure your arm. One variation to this technique is the horn (Frank, 1994). Use the index and little fingers of your hand to form a horn shape then focus on the words between your fingers as you read.

Evelyn Wood identified other hand motion patterns to accelerate reading. Rather than underline every word with your finger, starting at the beginning of the text, use a broad, reverse sweeping, S motion with your finger to scan a page in 2-4 seconds (Frank, 1994). This is particularly handy in books where text is one column per page. The trick to this technique is that your eyes do not follow the tips of your finger as they do in the underlining or horn motions, though they should move down the page at the same pace as the finger. The goal here is to see as many words as possible with one look rather than focusing on phrases. You may prefer to use a question mark motion instead of an S motion for the same purposes (Frank, 1994).

For scanning text presented in columnar form, such as newspapers, magazines, or some journal articles, an X motion is suggested (Frank, 1994). This technique can be done using one finger, or more efficiently two fingers, though the latter is more difficult to coordinate and will take practice to get used to. The idea is to survey several lines of text in one diagonal sweep of your finger. Starting at the beginning of the text, move your index finger diagonally down and right across the page until the finger reaches the other side of the page about five lines down from where you started. Switch to the middle finger and move it up two lines of text from your current position, still along the right hand side of the print. Repeat the five line downward diagonal movement with the middle finger toward the left side of the page. Switch back to your index finger, move up two lines of text, and begin again until the page is completed. This X pattern covers eight lines of text with each completion. This is a quick motion, so do not linger over any word or line. You can use the same technique in a loop or cursive L shaped hand motion as well.

The brush hand motion technique is recommended for students, particularly during exams or while reading in distracting or high stress environments (Frank, 1994). This technique starts with the back of the hand and brushes the hand across the page moving downward. This is a great way to survey questions on a timed test to determine which the student can answer quickly. Unfortunately, this technique works best on paper tests.

There are horseshoe, crawl, half moon, U, and other hand motion patterns to increase reading speeds (Frank, 1994). Every reader will have a preference to particular hand motion patterns. You should try several patterns to figure out which you prefer then practice those particular hand motions that fit you best. Do not be afraid to invent your own hand motion pattern! Using your hands during reading takes some getting used to, and once mastered is effective at increasing reading speeds.

General Reading Tips

Another technique is paragraph summarization. The idea is to capture the main point of each paragraph in one sentence that scanning techniques can use later to find specific details faster. Furthermore, writing out these summary sentences solidifies the details of the text in your mind and improves long-term retention of the material. This is especially useful when analyzing textbooks or other large amounts of technical information.

Depending on how you process information, you may have developed an internal voice that allows you to hear the words as you read them in your head. You may even read them aloud or mouth them silently as you read for increased comprehension. While this does work, particularly for auditory learners or those new to reading, you are now involving the auditory portions of your brain for a non-reading related task, increasing your overall processing time, since the average person speaks at a rate of 250 wpm (Noah, 2000). Your reading speed decreases further with this method, particularly if you stumble on the pronunciation of new words, which is a common mistake. Limiting these vocalizations and learning to gloss over the pronunciation of complex words increases reading speeds though it may not be helpful if you will have to use these complicated terms verbally later.

Any technique that improves reading speed without significantly sacrificing comprehension can help student and instructor productivity. Practice scanning, skimming, and other general speed-reading techniques regularly to improve your reading speed. This will save valuable instructor preparation and grading time and if students utilize these techniques, they will experience less frustration studying, less time on assignments, and increase their chances for academic success.

References

Anne Arundel Community College Reading and Study Skills Lab. ***Skimming and Scanning***. https://www.aacc.edu/tutoring/file/skimming.pdf

Dictionary.com. (2015). ***What are the 100 most commonly used words in English?*** http://dictionary.reference.com/help/faq/language/t14.html

Dryden, J. (2014). ***Unintended consequences: More high school math, science linked to more dropouts.*** http://news.wustl.edu/news/Pages/27132.aspx

Evelyn Wood's Weekend Speed-Reading Workshop. (1997). Personal experience. http://www.ewrd.com/

Frank, S. (1994). ***Evelyn Wood Seven-Day Speed Reading and Learning Program.*** http://cdn.preterhuman.net/texts/thought_and_writing/language/The.Evelyn.Wood.Seven.Day.Speed.Reading.and.Learning.Program.pdf

Nelson,B. (2012). ***Do You Read Fast Enough To Be Successful?*** Forbes. http://www.forbes.com/sites/brettnelson/2012/06/04/do-you-read-fast-enough-to-be-successful/

Noah, T. (2000). ***The 1,000-Word Dash***. Slate. http://www.slate.com/articles/briefing/articles/2000/02/the_1000word_dash.html

Rasinski, T. (2000). ***Speed does matter in reading***. The Reading Teacher, 54:146-151.

Staples. (2015). http://www.staples.com/sbd/cre/marketing/technology-research-centers/ereaders/speed-reader/

Water Quality Monitoring: Lesson Plan for Exploring Time-Series Data

By Janet Vail, Grand Valley State University Annis Water Resources Institute (GVSU-AWRI), Ashley Meyer, Hamilton Middle School, Anthony Weinke, GVSU-AWRI, and Bopi Biddanda, GVSU-AWRI

Ceaselessly cycling through the biosphere, water touches every aspect of our lives. Therefore, water monitoring is an engaging way for students to link chemical, biological, and physical measurements with everyday environmental conditions. More often than not, monitoring of rivers, streams, or lakes happens only one or two times a year so students do not get a sense of the variability in water quality over the course of a day, season or year. Just as long-term data sets are important for defining trends in climate, continuous high-frequency data are critical to understanding a body of water that is changing. “Real world” scientists and resource managers are not content with one-shot fair-weather measurements. They need multiple and continuous measurements over time (time-series data) to test hypotheses and make informed decisions. Modern observatories provide novel opportunities for educators to explore rich time-series environmental data sets and introduce concepts like ecosystem dynamics in the classroom.

Background

The world around us is in constant change. Observatories are situated all around the world in various ecosystems to track this change by collecting real-time data. For example, the now famous Mauna Loa Observatory in Hawaii has been continuously tracking the build-up of atmospheric carbon dioxide for over half a century (www.esrl.noaa.gov/gmd/obop/mlo/), and the South Pole Observatory located in the geographic South Pole has been keeping watch over the southern continent since 1957 (www.esrl.noaa.gov/gmd/obop/spo/). Scientists can use such long-term time-series data archives to track past changes in ecosystems and to predict future changes. It is important to work with time-series data because if one can’t understand the yearly variability of ecosystem data within days and seasons for example, it would be impossible to track and explain the variability of data over years, decades, centuries, and millennia. Fortunately, many modern instrumented field-deployable sensor-equipped observatories are continuously gathering the pulse of the world’s ecosystems.

Analyzing and recording time-series data in lakes can be helpful as scientists begin to look to lakes to predict effects of anthropogenic activity on ecosystems and climate change. Lakes act as sentinels of climate change, in fact, freshwater systems like lakes are one of Earth’s most valuable resources that are susceptible to and influenced by climate change (Williamson et al, 2009). Because lakes integrate signals from their entire watersheds and have a worldwide distribution, they can serve as the “canary in the coal mine” for ecological and climatic change (Biddanda, 2012). Therefore, it is important for scientists to monitor daily, seasonal, and yearly changes in efforts to slow down, mitigate or reduce the effects of lowered water quality from anthropogenic effects, as well as, reduce the effects of climate change on lake dynamics and ecosystems. Data records from lakes and other inland bodies of water may provide important insight to address both potential impacts from climate change as well as the increased human footprint (Williamson et al, 2009)

The Muskegon Lake Observatory

With the assistance of federal grants and other funding, the Grand Valley State University Annis Water Resources Institute (AWRI) has deployed a multi-sensor buoy that has tracked physical, chemical, and biological changes in Muskegon Lake since 2011 (Biddanda, 2014). Due to historical **environmental degradation,** Muskegon Lake has been designated as an Area of Concern by the Environmental Protection Agency and work is progressing to restore the lake (MDEQ, 2011).

The Muskegon Lake Observatory sensors collect real-time meteorological data (every 5 minutes) and water data (every 15 minutes) during the field season by transmitting a signal from the buoy to an on shore site at AWRI. Data are backed up on a separate server in addition to being uploaded to a real-time data website (www.gvsu.edu/buoy). Data are then shared on databases that include information from other observatory networks such as the Great Lakes Observing System (GLOS; www.glos.us/). GLOS is the regional node of the larger global program: Integrated Ocean Observing System (IOOS; www.ioos.noaa.gov/).

Data collected from the buoy deployed on Muskegon Lake includes: wind speed/direction, air temperature, barometric pressure, precipitation, humidity, dissolved oxygen, conductivity, water temperature, pH, turbidity, photosynthetically active radiation (PAR), nitrates, Chlorophyll a, phycocyanin, colored dissolved organic matter (CDOM), and water velocity/direction (Biddanda 2012, 2014). All of these variables are important in determining productivity and ecosystem health. A specially designed graphical interface allows for easy retrieval of data and there is online graphing capability.

The following inquiry-based 5E middle or high school lesson explores time-series data using the Muskegon Lake Observatory's online **Interactive Data Plotting Tool**.

Lesson Plan: What can time-series lake data tell us about seasonal ecosystem dynamics and upstream influences?

Objectives

- Upon completion of this lesson, students will be able to
- Explain the advantages of using times-series data sets for water monitoring versus single (one time) measurements.
- Construct and interpret graphs of real-time environmental data.
- Formulate a question about water quality and select the appropriate data to answer the question.
- Explore patterns as well as cause and effect relationships.

Engage

1. If possible, take the students outdoors to observe a body of water and the surrounding landscape. Encourage students to generate questions about the water body. For example, What is the quality of the water? What is the temperature of the water? How does shade affect the water? What might be living in the water? Are there excess nutrients in the water? Will weather conditions affect water quality measurements? Is the water flowing or still? How does the surrounding land use affect the water body? Then have them list what they would like to monitor in their water body.
2. Back in the classroom, review some of the commonly measured water quality parameters as they relate to land use (Table 1). Nonpoint source pollution includes runoff from both agricultural and urban areas and is considered the greatest threat to overall water quality. How does Table 1 compare to what the students have listed?

Table 1. **Sources and associated pollutants**

Source	Common Associated Pollutants
Cropland	Turbidity, phosphorus, nitrates, temperature, total solids
Forestry harvest	Turbidity, temperature, total solids
Grazing land	Fecal bacteria, turbidity, phosphorus, nitrates, temperature
Industrial discharge	Temperature, conductivity, total solids, toxics, pH
Mining	pH, alkalinity, total dissolved solids
Septic systems	Fecal bacteria (i.e., Escherichia coli), nitrates, phosphorus, dissolved oxygen/biochemical oxygen demand, conductivity, temperature
Sewage treatment plants	Dissolved oxygen and biochemical oxygen demand, turbidity, conductivity, Phosphorus, nitrates, fecal bacteria, temperature, total solids, pH
Construction	Turbidity, temperature, dissolved oxygen and biochemical oxygen demand, total solids, and toxics
Urban runoff	Turbidity, phosphorus, nitrates, temperature, conductivity, dissolved oxygen and biochemical oxygen demand

U.S. EPA, 2015

Explore

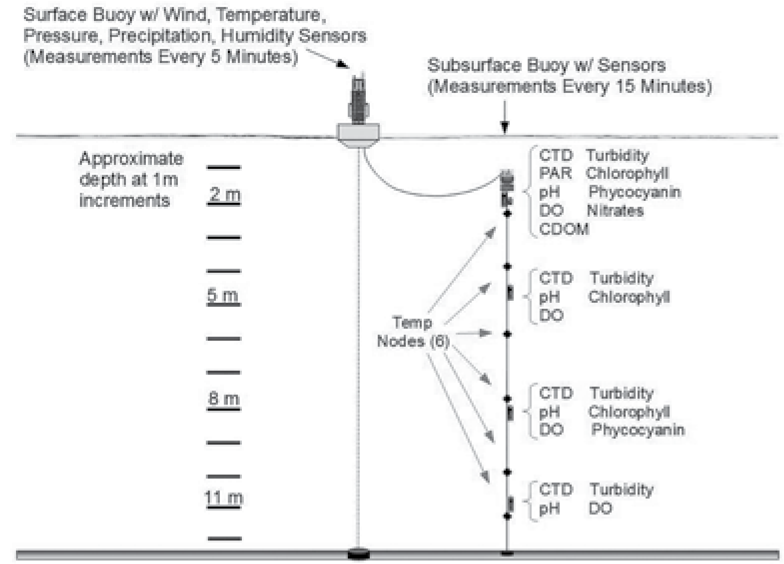
1. In this phase of the lesson, students are introduced to the time-series data found at the Muskegon Lake Observatory. Demonstrate features of the buoy website before letting students explore the site.

Access **www.gvsu.edu/buoy** online. Use the left hand menu to show the whole class the **Buoy Location** in Muskegon Lake (Figure 1). Muskegon Lake is a drowned river mouth that flows into Lake Michigan. Water from the Muskegon River watershed flows through Muskegon Lake. Why is the buoy located where it is?

Figure 1. **Location of the Muskegon Lake Buoy Observatory**

Also usIng the left hand menu, explore the **Buoy Drawings** (Figure 2).The buoy system will typically be deployed on the lake from April to November, and some sensors may be in the lake year round. Water sensors have measured over 13 parameters including temperature, oxygen, nutrients, light, pH, conductivity, algal pigments, bacterial pigments, and current speed and direction. Air sensors measured 8 parameters including temperature, wind, humidity, and precipitation.

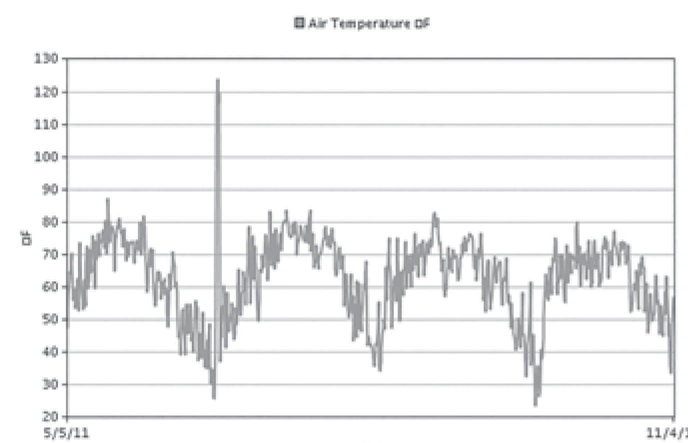
Figure 2. **Components of the Muskegon Lake Observatory**



From the left hand menu, select the **Interactive Data Plotting Tool**. Review the four main parts: X Variable (usually the date is used), Y Variable(s), Date/Time Filters, Advanced Options. Illustrate how a graph is produced by using the following settings: X Variable = *date*, Y Variable = *air temperature*, Date/Time Filters = *all dates*, Advanced Options = *line graph*.

Use "Plot the Data" to generate a graph (Figure 3). Ask students to point out and explain trends in the data. Is the highest data point legitimate? Note that this is an uncensored data set so occasionally there will be anomalies and other issues.

Figure 3. **Air Temperature at the Muskegon Lake Observatory**



2. Present the students with the following situation: suppose each year a class can do one day of water monitoring. When should the monitoring be done? If we compare the data from one year to the next, how can we know that any trends are meaningful? How will we know if things have changed or remained the same? Would more data give a different story about the water body?

3. Provide an opportunity for the students to answer the above questions by exploring the **Interactive Data Plotting Tool**. They can use the sequence in Table 1 to reinforce the idea that a single data point provides limited information about a site. Be sure to click on "Reset" before creating each new graph.

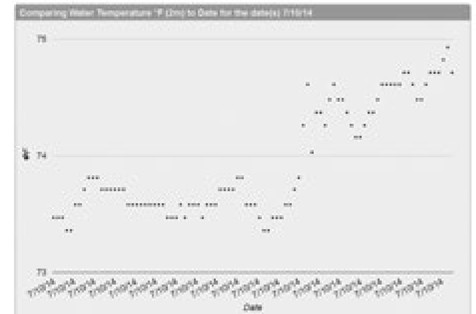
Table 2. Exploring water temperature

Water Quality Parameter	Date	Observations
a. Water temperature at 2 M (specific date, every X minutes)	7/10/14	
b. Water temperature at 2 M (specific date, all day)	7/10/14	
c. Water temperature at 2 M (range of dates for 1 month)	7/10/14 through 8/10/14	
d. Water temperature at 2 M (range of dates for 5 months)	5/10/14 through 10/10/14	
e. Water temperature at 2 M and Water temperature at 11 M (range of dates for 5 months)	5/10/14 through 10/10/14	

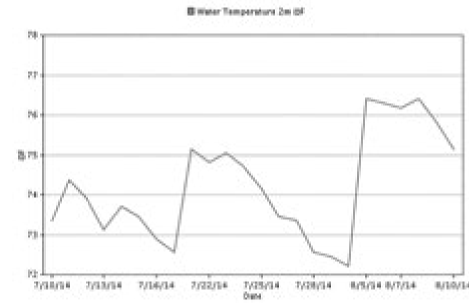
Table 2 Answers:

a. There is a single point on the graph, which is the mean temperature, about 73.4 F.

b. Single day at 2 M

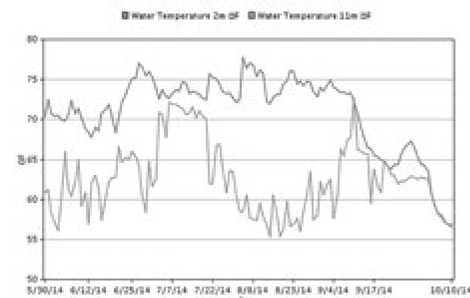


c. Range of dates at 2 M = 1 month



d. Range of dates at 2 M = 5 months

d. Range of dates at 2 M and 5 M = 5 months



4. After the students are comfortable using the **Interactive Data Plotting Tool**, they should continue their exploration by choosing a time scale to place on the x-axis of their graph (year? season? month? daily?).Then they should also select a lake parameter to investigate as they create a graph from the menu of choices. It is recommended that students use dissolved oxygen, water temperature and chlorophyll readings from 5m as 5m in this particular lake can give students a good reading on the "pulse" of the lake. Once students have chosen their criteria, prior to plotting the data, they should predict what they believe their particular graph will look like, and sketch the trend they expect to see. Students should be able to explain why they predicted the trend they sketched in terms of changing weather, day/night period, or season.

After making a prediction about the trend their data should show as well as giving an explanation as to why they predicted that way, student should plot their data, and make an accurate sketch of the trend that they see.

Optional: this exercise could be done by downloading data in an XLS file and plotting graphs in Excel. The advantage to this would be that anomalous data could be removed prior to plotting the graphs.

Explain

After students have plotted the desired data, they should analyze what the data are telling them. Students could be prompted with the following questions:

- What trends do the data show?
- Why do the data show those trends?
- Is the trend different or the same than you predicted? If it's the same, justify. If it's different, justify why?

Students should then put their findings for their prediction/explanation and plotted graph/explanation together and report to the class.

Elaborate

Time-series data are useful for exploring crosscutting concepts as articulated in the Next Generation Science Standards. In independent or group projects using the buoy data, have students formulate and answer questions such as the following:

1. ***Patterns***:

a. Are there seasonal patterns in water temperature? Does water temperature vary with depth? In what way? Why?

b. Are there relationships between dissolved oxygen and water temperature? Or air temperature? What explains any patterns that you see?

c. How do water quality parameters compare at different depths? Depths of sensor clusters are listed in Table 3 along with example inquiries that may be carried out at each depth. The underwater measurements are gathered at various depths by the buoy (2m, 5m, 8m, 11m). The 2 meter dynamics are highly influenced by wind, and other weather conditions impacting mixing, thus this zone may a good measure of maximum dynamics in the lake. At 5 meters, there may be an integrated signal as to what is happening in the lake that is not impacted by other variables as much as in the surface or bottom layers. At 8m, it is below the point where light is going to reach, thus photosynthetic organisms are not likely to be occurring in great number there - except during mixing events. With a lake depth of 13m at the buoy site and mean depth of 7m throughout the lake, the 11 meter data set proves to be impacted by sediment re-suspension and benthic organisms – it also may be a significant zone for tracking the evolution of bottom water hypoxia.

Table 3. **Depths of Muskegon Lake Observatory sensor clusters**

~Buoy Depth (with sensor cluster)	Sample Student Investigations
2 meters	There is a high amount of variability of data at this depth. What might the variability be correlated to? Solar heating? Storm events? Boating/summer events? Shipping channels? River flow?
5 meters	Does water temperature/DO/chlorophyll/etc. mirror daily, seasonal or yearly patterns? What are the anomalies in the data and why might this occur?
8 meters	When looking at temperature and dissolved oxygen across a season, what patterns are there? Is there a significant correlation between storm events and dissolved oxygen at 8 meters?
11 meters	When looking at temperature and dissolved oxygen across a season, what patterns are there? Is there a significant correlation between storm events and dissolved oxygen at 11 meters?

2. ***Cause and Effect:***

a. Given that Muskegon Lake is a drowned river mouth, what could be the connection between its water quality and activities upstream? In looking at the pollutants in Table 1, is there evidence that human impacts may affect the water quality of Muskegon Lake? How could these human impacts be reduced? Specifically, look at flow, water temperature, dissolved oxygen, conductivity, nitrates, and turbidity. Note: the Muskegon River Watershed is about 25.5% agricultural land, 7.5% developed areas, and 55.2% forest.

b. Is there any correlation of the presence of algal blooms as noted by spikes in Chlorophyll a and harmful algal blooms as noted by spikes in phycocyanin with any other parameters?

c. What would be a model for the expected air temperature and the lake temperatures at various depths during the spring, summer, fall and winter? Include energy concepts and properties of matter in the model. Note: Muskegon Lake usually totally freezes during the winter.

- After students have presented their findings and evidence to the class, the instructor can facilitate a discussion talking about how inter-annual and daily cycles within a lake are important to the bigger picture of human impacts and climate change.
- What do the daily, seasonal, and yearly trends of Muskegon Lake show in long terms of human impact and climate?
- How can monitoring of lake dynamics help to predict climate change or monitor environmental quality?

Evaluate
Students should be able to answer the original questions with a greater degree of sophistication based on data:

- Suppose each year a class can do one day of water monitoring. When should the monitoring be done?
- If we compare the data from one year to the next, how can we know that any trends are meaningful?
- How will we know if things have changed or remained the same?
- How can human activities impact the aquatic environment and what evidence do we have (or require) to evaluate and mitigate that impact?

Availability of Other Data Sets
Over 156,000 students, teachers, and others have experienced hands-on science on the Grand Valley State University Annis Water Resources Institute's research and education vessels as they monitor water quality in Lake Michigan and its connecting waterways. Students in grade 4 and above have an opportunity to participate in these educational trips that have been offered since 1986 (www.gvsu.edu/wri/education). The Muskegon Lake Observatory is highlighted on trips on the Muskegon Lake trips. Student-generated data sets for Lake Michigan, Spring Lake and Muskegon Lake have been compiled. Also, GVSU-AWRI scientists conduct water monitoring in Muskegon Lake using more sophisticated instruments than are used in the education program.

Water quality and other data sets can be readily procured from a variety of government agencies, non-profit organizations, and universities (Table 4). The quality and coverage of these data sets and their ease of retrieval varies greatly but they can serve as sources of data sets for further analysis.

Next Generation Science Standards Connections

Using authentic data helps students to identify patterns, change through time, and cause and effect. The lesson sequence above follows the science and engineering practices of asking questions, defining problems, analyzing and interpreting data, constructing explanations, and engaging in argument from evidence.

Lessons involving time-series data from robust data sets can be used to support the Next Generation Science Standards performance expectations. Key performance expectations are:

- MS-ESS3-2 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- HS-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.
- HS-ESS3-1 Evaluate or refine a technological solution that reduces the impacts of human activities on natural systems.
- HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how these relationships are being modified due to human activity.

Table 4. **Online Great Lakes and water quality data sets**

Data Source	Description
Great Lakes Observing System (GLOS) Data Portal (www.glos.us/)	Near-real-time and archived observations including lake conditions, water levels, wave heights, air and water temperatures, and forecasts.
Integrated Ocean Observing System (www.ioos.noaa.gov/)	Students can explore and track conditions over different parts of the world ocean, coastal waters and the Great Lakes
United States Geological Survey (USGS) (waterdata.usgs.gov/mi/nwis/rt)	Real-time data for stream flow and other parameters. Time-series graphs and data sets can be generated online
Teaching Great Lakes Science (www.miseagrant.umich.edu/lessons/	This website features a suite of lessons, activities and data sets focused on the Great Lakes.
Great Lakes Monitoring (greatlakesmonitoring.org/)	Easy access to long-term, environmental monitoring data collected throughout the Great Lakes. There are a range of environmental parameters to choose from such as nutrients, contaminants and physical properties of water.
Michigan Surface Water Information Management System (MiSWIMS) (www.mcgi.state.mi.us/miswims/)	The application on the website is an interactive map-based system that allows users to view information about Michigan's surface water.
Cooperative Lakes Monitoring Program (MI Corps) (www.micorps.net/lakeoverview.html)	An online data set is searchable for lakes and streams in Michigan.
Wastewater and Water Treatment Plants Example: Grand Rapids (grcity.us/enterprise-services/Water-System/).	The City of Grand Rapids has monitored the Grand River and selected tributaries with data going back several decades
World Water Monitoring Challenge™ (WWMC) (www.worldwatermonitoringday.org)	WWMC provides a venue for students to use simple test kits to monitor water quality and their results can be posted online.
Global Learning and Observations to Benefit the Environment (GLOBE) (www.globe.gov)	A world-wide environmental monitoring program where students at GLOBE schools follow standardized monitoring protocols and post their results online. Data sets can be retrieved and analyzed with graphical visualization capability.
Great Lakes Fieldscope (greatlakes.fieldscope.org)	Students can explore maps and graphs and contribute water quality data from across the Great Lakes watershed region.

Other performance expectation examples that could be supported by time-series data are:

- MS-LS1-6 Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.
- MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by the energy of the sun and the force of gravity.

- MS-ESS2-6 Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.
- MS- LS2-3 Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem.
- HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's system result in changes in climate.
- HS-ESS3-5 Analyze geoscience data and the results from global climate change models to make an evidence-based forecast of the current rate of global or regional climate change and the associated future impacts to Earth's systems.

Data can be used in the classroom for varying topics including climate change, photosynthesis, carbon cycling, ecology, human impacts and others. Showing students data from their local ecosystem shows them relevance to topics that happen locally.

Acknowledgements
An EPA-Great Lakes Restoration Initiative grant (2010-2014), and a joint NOAA-Great Lakes Environmental Research Laboratory and University of Michigan-Cooperative Institute for Limnology and Ecosystem Research grant (2015-2016) supports the Muskegon Lake Observatory. Funding from the National Science Foundation for the Target Inquiry Program at GVSU provided a teacher-internship to Ashley Meyer at the AWRI during 2013.

Literature Cited
Biddanda, B. A. 2012. Lake Sentinel: Observatory for Ecosystem Changes in Muskegon Lake. InterChange, Newsletter of the Regional Math and Science Center, Grand Valley state University. May 2012 http://www.gvsu.edu/rmsc/interchange/2012-may-connections-awri-651.htm

Biddanda, B. A. 2014. Observatory for Ecosystem Changes in Muskegon Lake Area of Concern. Final Project Report submitted to US EPA Great Lakes National Program Office, Chicago, December 2014.

Great Lakes Literacy Principles. 2013. http://www.greatlakesliteracy.net/.

Michigan Department of Environmental Quality (MDEQ). 2011.Stage 2 Remedial Action Plan Muskegon Lake Area of Concern.

NGSS Lead States. 2013. *Next Generation Science Standards: For States, By State*s. Washington, DC: The National Academies Press.

Williamson, C. E., Saros, J. E., Vincent, W. F., and J. P. Smol. 2009. Lakes and reservoirs as sentinels, integrators, and regulators of climate change. Limnology and Oceanography. 54: 2273-2282.

Using Extreme Weather Events to Quantify the Hydrologic Cycle

By Steve Mattox, Professor of Geology, Grand Valley State University and Kimberly Jenerou, Science Teacher, Innovation Central High School, Grand Rapids Public Schools

Introduction
Teachers commonly present the water cycle to the students at multiple grade levels (Ben-zvi-Assarf and Orion, 2005). By the end of middle school, most students can draw the water cycle, label the processes that transfer water, and identified the different reservoirs. Water also poses a hazard with flooding or drought. In this lesson we show a quantitative approach to the water cycle using an example of a single flooding event. Students calculate the volume of water that falls in a watershed, the volume flowing out through a major river, and the response of the water table. Evapotranspiration is estimated using published data. Although our example is focused in Kalamazoo, Michigan, the format serves as a template for modifying the lesson to your city and watershed.

We begin with a simple pretest to assess prior knowledge on water volumes and flooding (Figure 1). The pretest hints at the content and calculations to come. Our goal is provoking student thinking and having the correct answers is not important as we begin. We collect the pretests and do not reveal the correct answers. For our pretest, the answers are 1c, 2c, 3b, 4d, 5 answers will vary but should sum to 100, 6 true, 7 60 million if discharge is 700 cfs, 8 false, 9 true, 10 answers will vary, 11 true. .

We engage the students by sharing photographs and stories from the September 2008 Kalamazoo Flood (Ruhf, 2008; Killian, 2008). The headlines are dramatic. If your students don't remember the event, they can ask their parents. The key point is that floods do impact their community, even in the recent past. A simple question to ask your students is "what do you think created such intense rainfall that made the city flood?"

The remnants of Hurricane Ike left the Gulf of Mexico on September 13, 2008 and tracked to the northeast, crossing in to Michigan on September 14 (see map and data at National Weather Service, 2014). Print each student a North Atlantic Hurricane Tracking Chart from the National Hurricane Center (see http://www.nhc.noaa.gov/). Table 1 is the location of the hurricane from its development to demise. Although Michigan does not experience hurricanes directly, their low pressure systems, under the right conditions, pass over the state. They move to the north-northeast (think Coriolis Effect) causing large rainfall events and in some cases, flooding. This simple plotting exercise connects a major atmospheric occurrence that starts in the North Atlantic to flooding in Michigan.

Rainfall
How much water is added to your watershed in a large rainfall event? Figure 2 guides students through a series of calculations that carry them from their basic, qualitative understanding of "precipitation" as part of the water cycle to quantitatively estimating water transferred from the atmosphere to the surface. Students have the opportunity to think of water in square miles, square inches, cubic feet per second, and gallons. Large rainfall events commonly impact the entire watershed. The area of the watershed can be estimated from a map or looked up on the U.S. Geological Survey website (http://waterdata.usgs.gov/nwis/rt). Our students' math abilities vary and some quickly complete the calculations

while others struggle. Many students forget to square the number of feet to determine the number of feet in a square mile or the number of inches to determine the number of inches in a square foot (see Part 1 Figure 2). Because we are converting a large area of the watershed to very small units(square inches) the solution is a very large number.

The next step is to estimate the amount of rainfall. Two online sources provide historical climate data. For the rainfall associated with the remnants of Hurricane Ike, the National Weather Service (NWS) issued a cumulative report (National Weather Service, 2008). Students can locate their area on the map and use the legend to estimate cumulative rainfall. Alternatively, students can visit NWS historical climate data for their city (F6 data) and obtain daily rainfall amounts, which they can then sum.

The third step is to multiply watershed area by rainfall amount, to obtain volume in cubic inches. This large number is not very meaningful, so students can then covert their value to gallons. The large volume, 132 billion gallons, tends to surprise students, which is one of our objectives.

River flow

Where does the water go? The students are quick to tell us that the water flows away in rivers or infiltrates the ground. Many students overlook evaporation/evapotranspiration. Remember the pretest asked the students to estimate, by percent, where the water goes within the cycle.

The rainfall from the hurricane movement was a discreet event; it had not rained for several days before September 13 and it did not rain for many weeks after the two days of intense rain. The U.S. Geological Survey real-time water data (see http://waterdata.usgs.gov/nwis/rt) reports the discharge of major rivers. Data for the Kalamazoo River was measured at Comstock Park, upstream from the city of Kalamazoo. The hydrograph (see Figure 2, Part 2) shows the sharp increase in discharge as the hurricane remnant passed over. Peak discharge, about 5,800 cubic feet/second (cfs), lasted for a few days. After about a week, this caused major flooding in Kalamazoo. Students can calculate the volume of water associated with the storm in many ways. They need to estimate the area under the discharge curve. We found that the easiest method is to estimate the discharge (in cubic feet/second) for each one week period and then sum the volumes (Figure 2, Table 2). We guide the students through the unit conversion (Figure 2, Part 2) from cubic feet/second, to cubic feet/week, and finally gallons/week, which they then sum (Table 2). We use a series of questions to assess understanding and measure students' thinking (Figure 2). The rainfall of the 2008 flood was about 132 billion gallons; the resulting slug of water that flowed out the Kalamazoo River was about 54.9 billion gallons (about 41.6 %, connect back to their estimates in the the pretest). Although there was rainfall in only two intense days, it crested 4.5 days later and stayed high for weeks. Not only are students gaining a quantitative perspective of the hydrologic cycle, they are beginning to appreciate the different rates that water moves through the parts of the cycle.

The numbers do make sense. The river outflow should be less than the rainfall. The "missing" volume of water, nearly 75 billion gallons, may have seeped into the ground or evaporated in to the atmosphere. We'll need more data to completely quantify this single event in the water cycle.

Additions to Groundwater

Did the rainfall event change the amount of groundwater? We have some data on this part of the cycle, but it is more general and less quantitative. The U.S. Geological Survey has real-time data for a water well in northern Indiana, about 45 miles south of Kalamazoo (see http://waterdata.usgs.gov/in/nwis/gw, Site Number: 414318085200601). The well is in glacial sand and gravel. Data for July through November 2008 is shown in Figure 2, Part 3.We present the graph to the students and guide them toward interpretation. Time in months is on the x-axis. The y-axis shows the depth BELOW the land surface (left side) or in absolute elevation about a specific datum (right side). For most of July, there is a gradual decline. For August and early September, the rate of decline is much faster and the water table drops nearly three feet. In mid-September the water table rose quickly, amounting to 1.25 feet in a few days. For October and November, the height of the water table slowly decreased. Clearly the intense rainfall caused the water table rise.

A rainfall of 7.5 inches, causing the water table to rise over 13 inches, might confuse some students. The water is not filling open space. It is filling the open **pore space** between glacial sand and gravel. Because most of the volume is already filled with solid material, an inch of rain might fill many open pores. (Note: If your students have clean gravel, add one inch of water from a same-size beaker and measure the change in height).

Evaporation, Back to the Atmosphere and Synthesizing the Data

What about evaporation and transpiration (ET)? The students are advancing their depth of understanding, but there are some gaps. Data from several published sources can help. Table 3 provides a national and local perspective on the water cycle, which can be used as a culminating exercise. We commonly provide a few of the numbers, about one in each column, and ask the students to speculate on the other values (they made an estimate in Figure 1). Alternatively, the teacher can reveal one row at a time, with or without some values, and discuss the water cycle. The first row is U.S. national average for where rainfall goes. ET dominates the cycle and a small percent recharges groundwater. How does Michigan compare? Mattox and King (2006) compiled data from a variety of sources, and the upper Muskegon River watershed can be used to approximate the state (at least west Michigan if not the lower peninsula). ET is about half the national average, a reflection of our northern latitude and cooler temps. The surface water outflow is at 31%, comparable to our calculations value of 42% for the Kalamazoo flooding event. Our groundwater recharge rate is a whopping 15 times the national average! This is amazing. Perhaps our motto should be changed to the "groundwater state." You might ask your students why they might think this is the case. Our glacial history left a surface layer of abundant porous and permeable outwash. This sand and gravel makes ideal aquifers. It also provides an efficient pathway to our bedrock aquifers of limestone and sandstone. The rows switch from percent to inches and looks at the water cycle over one year, not just the flood event in Kalamazoo. The average rainfall over a year in the upper Muskegon River watershed is about 34.59 inches, lower than the 38.18 inches that fall in Kalamazoo in an average year.

Our study allowed us to quantify the amount of precipitation and surface water outflow (Table 3). We can use these numbers to calculate the percent of surface water outflow (42% or 3.15 in of the precipitation that fell). To make estimates of ET and groundwater recharge simple we can split the remaining 58% of the water cycle equally. This yields an estimate of 29% or 2.18 inches of the water that returned to the atmosphere of added to the groundwater.

Lastly, connect back to where we started. The remnants of a hurricane passed over Michigan and dropped over 7 inches of rain; in a typical year we have 38 inches of rain. These rare events cause flooding and hardship, but they also boost our absolute rainfall and add extra water to our groundwater resources that can be extracted over months and years.

Extensions

Although our lessons provide concrete data on many aspects of the water cycle, we hope it prompts many questions from your students. We supply these potential areas of additional investigation for your curious students:

- Frequency and impacts of other hurricane remnants
- Major flood events in your city, e.g., Grand Rapids in 2013 or Detroit in 2014
- Hydrologic impacts of a big snow storm v. a spring rain storm
- Factors that influence evapotranspiraton and absolute rates of evaporation
- The role of large rainfall events in supplying groundwater for agriculture

Conclusion

The impact of a high rainfall event, here caused by a remnant of a hurricane, is not unique to Kalamazoo. We have modified this lesson for Jackson and Grand Rapids. Alternatively, your community might have been flooded by a slow-moving summer thunderstorm or rapid spring thaw from the winter snow. We are happy to share a text-file of the lesson so you can modify the examples/events to be more relevant to your students.

Answer Key to Figure 2:

Part 1. Area is 4,054,634,496,000 in^2 or about 4 trillion square inches. Rainfall is a total of 7.54 in. Volume of rainfall is 30,571,944,099,840 in^3 or about 30.5 trillion cubic inches which converts to 132,346,078,384 gallons or about 132.3 billion gallons of water. Part 2. See Table 2.

References

Ben-zvi-Assarf, O. and Orion, N. 2005, **A Study of Junior High Students' Perceptions of the Water Cycle**, Journal of Geoscience Education, v. 53, n. 4, September, 2005, p. 366-373.

Hanson, R.L., 1991, Evapotranspiration and Droughts, in Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., Compilers, National Water Summary 1988-89--Hydrologic Events and Floods and Droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 99-104. (available at geochange.er.usgs.gov/sw/changes/natural/et/)

Holtschlag, D.J., 1996, A generalized estimate of ground-water recharge rates in the Lower Peninsula of Michigan: U.S. Geological Survey Open-file report No. OF 96-0593, 37 p.

Killian, C., 2008, An 'incredible' rain: severe flooding causes damage to Kalamazoo businesses, disrupts traffic at http://www.mlive.com/news/kalamazoo/index.ssf/2008/09/sundays_rain_bring_flooding_to.html. Accessed August 31, 2014.

Mattox, S.R., and King, K., 2006, Perspectives on Water Usage in Michigan and the Geology of the Ice Mountain Site, Michigan Science Teachers Association Journal, v. 51, p. 51-60.

National Weather Service, 2008 Atlantic Hurricane Season. Accessed August 31, 2014.

Ruhf, R., 2008 Photo Galleries of the September 2008 Flood in Kalamazoo, Michigan at http://www.x98ruhf.net/kalamazoo_flood.html. Accessed August 31, 2014.

Figure 1. Pretest for Students' Prior Knowledge.

Floods in Your Community   Initials:

1. Hurricanes that originate in the Atlantic can ultimately influence the weather in Michigan.

a. never   b. almost every year   c. at least once per decade

2. On average my school receives about ___ inches of precipitation per year.

a. 0-10   b. 10-20   c. 20-30   d. 30-40 e. 40-50

3. A major flood would occur in my town when a minimum of _______ inches of rain fall.

a. 0-3   b. 3-6   c. 6-9   d. 9-12   e. 12-15

4. During a rare, major rainfall event _____ of gallons of rain will fall in my watershed.

a. tens of thousands   b. hundreds of thousands   c. millions
d. billions   e. trillions

5. If 10 inches of rain falls in my town: ...write number of inches out of 10 by each ...

a. it flows away in creeks and rivers   _____ inches

b. recharges groundwater   _____ inches

c. is stored in plants   _____ inches

d. evaporates back into the atmosphere   _____ inches

e. consumed by people and industry   _____ inches

6. Human activities have modified the flood frequency and severity in my community.

a. true   b. false

7. About ___ gallons of water flow down the Kalamazoo River each day.
assuming ~700 cubic feet of water per second

a. 60 thousand b. 600 thousand c. 6 million d. 60 million
e. 6 billion

8. The water in Lake Michigan is from the melting of glaciers.

a. true b. false

9. Flood plan insurance should be required for all homes and businesses on the 100-year floodplain.

a. true b. false

10. My home is on the 100-year floodplain.

a. true b. false c. don't know

11. All children should learn the basics about floods.

a. true b. false

Table 1. Tracking data from Hurricane Ike.

Date	Time	Category	Location	Latitude	Longitude
Sept 3	11 a.m.	Tropical storm	Atlantic	20.8 N	51.2 W
4	11 a.m.	H4	Atlantic	23.2	57.0
5	11 a.m.	H3	Atlantic	23.2	62.7
6	11 a.m.	H2	Atlantic	21.9	68.8
7	11 a.m.	H4	North of Haiti	21.0	73.4
8	11 a.m.	H2	Central Cuba	21.1	78.5
9	11 a.m.	H1	West Cuba	22.6	83.0
10	11 a.m.	H1	Gulf of Mexico	23.9	85.3
11	11 a.m.	H2	Gulf of Mexico	25.5	88.4
12	11 a.m.	H2	Gulf of Mexico	27.2	92.6
13	11 a.m.	H1	Houston, TX	31.0	95.3
14	5 a.m.	Tropical depression	Arkansas/Missouri	36.4	92.5
15	5 a.m.	Low pressure	Ontario	43.4	81.5

Figure 2. Student Worksheet for Balancing the H2O Budget in Kalamazoo

In this activity you will use simple math to take a closer look at the water cycle during a major event, the September 2008 rain and flood. The activity moves through several steps:

Part 1. How much water was added to the watershed?

Let's look at the Kalamazoo watershed. The area of the Kalamazoo River watershed above the city of Kalamazoo (as measured at Comstock Park) is 1,010 mi^2.

Convert the area of the watershed from square miles to square inches. Remember there are 5,280 feet in one mile and 12 inches in one foot.

For the area of the Kalamazoo River watershed above Kalamazoo in in^2,

$$1{,}010\ mi^2 \times \frac{(5280\ ft)^2}{1\ mi^2} = \_\_\_\_\_\_\_\_\_\_\ ft^2 \times \frac{(12\ in)^2}{1ft^2} = \_\_\_\_\_\_\ in^2$$, about __________ square in.

Calculate the **amount of rainfall** in inches for **Kalamazoo:**

Date	Rainfall (inches)
9-12	0.74
9-13	3.4
9-14	3.38
9-15	0.02
9-16	0
9-17	0
Total =	

Calculate the volume of rainfall in cubic inches and convert to gallons.

________________ in^2 x _____ in = ____________ in^3,

about ___________ in^3 of water.

To convert to gallons, 1 cubic inch = 0.00432900433 US gallons,

__________ in^3 x $\frac{0.00432900433 \text{ gallons}}{1 \text{ in}^3}$ = __________gallons or _________ gallons of water

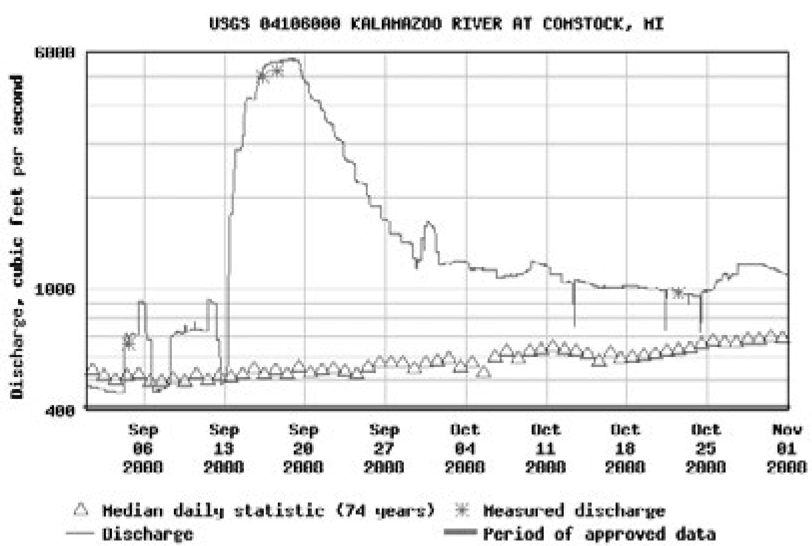
To summarize:

	Area (mi^2)	Rainfall (in)	Volume (gallons)
Kalamazoo	1,010		

Part 2. How much water flowed out of the watershed?

Calculate the amount of water flowing down a river and convert to gallons.

The volume of water flowing through the Kalamazoo River in Kalamazoo in cubic feet per second can be estimated using data from U.S. Geological Survey real-time water data for the station at Comstock Park (USGS 04106000). The curve is shown below.



Estimate an average value for each week and then convert ft^3/s to ft^3/d. The conversion is:

$$1\,\frac{ft^3}{s} \times \frac{60\,s}{1\,min} \times \frac{60\,min}{1\,hr} \times \frac{24\,hr}{1\,d} \times 7\text{ days} = 604{,}800\,\frac{ft^3}{week}$$

Estimated, from the hydrograph above, the weekly average discharge values in ft^3/s and then convert to gallons, 1 cubic foot = 7.48 US gallons. Some values are provided to help keep you on track.

Week of	**Discharge, ft3/s, Kalamazoo River**	**Volume of water per week, ft3/week**	**Gallons of water per week**
Sept 13-20			
20-27			11,309,760,000
27-Oct 4	1,500		
Oct 4-11			
11-18		635,040,000	
18-25			
Total			

What volume of water fell as rainfall to cause the 2008 flood? ____________ gallons. (Part 1).

What volume of water flowed down the Kalamazoo R. to cause the 2008 flood?

__________ gallons.

Describe the duration of the rainfall event relative to the onset and duration of the flooding.

Based on your knowledge of the water cycle, do these volumes make sense? Is there extra or missing water? What volume? Where could other water be located?

What additional evidence might support your hypotheses for where the water might be located?

Part 3. How much water infiltrated the ground?

The U.S. Geological Survey has real-time data for a water well in northern Indiana, about 45 miles south of Kalamazoo (see Site Number: 414318085200601). The well is in glacial sand and gravel. Data for July through November 2008 is shown below.

Did the depth to groundwater change in response to the September 2008 rainfall event? If so, by how much did it change?

Based on your knowledge of the water cycle, do these volumes make sense? Is there extra or missing water? What volume? Where could it be other water be located?

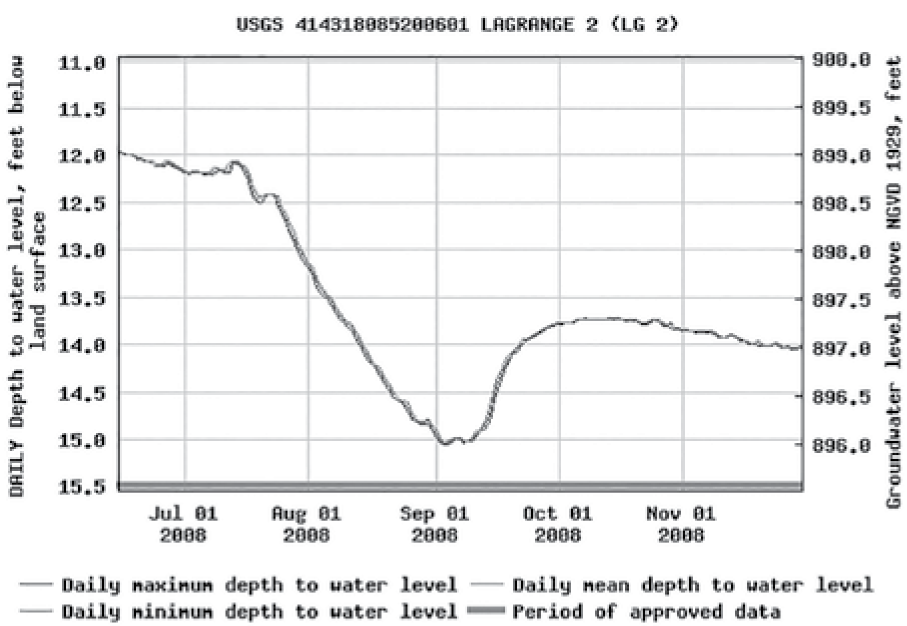


Table 2. Estimates of weekly river discharge.

Week of	**Discharge, ft³/s, Kalamazoo River**	**Volume of water per week, ft³/week**	**Gallons of water per week**
Sept 13-20	5,000	3,024,000,000	22,619,520,000
20-27	2,500	1,512,000,000	11,309,760,000
27-Oct 4	1,500	907,200,000	6,785,856,000
Oct 4-11	1,100	665,280,000	4,976,294,400
11-18	1.050	635,040,000	4,750,099,200
18-25	1,000	604,800,000	4,523,904,000
Total?			54,965,433,600

Table 3. Distribution of water within the water cycle of the United States, the upper Muskegon River watershed (gray shading), and related to the 2008 flooding event.

	+ precipitation	–evaporation/ transpiration	- surface water outflow	– ground water recharge	– consumed
U.S.G.S. national average[a]		67%	29%	2%	2%
Percents for upper Muskegon River watershed		37.54%	31%[b]	30.4%	0.8%[d]
Water budget for watershed (in/yr)	+34.59	-13[a]	-10.72	-10.5[c]	-0.27
Water budget for watershed (gallons/yr)	1.390×10^{12}	5.22×10^{11}	4.31×10^{11}	4.23×10^{11}	1.11×10^{10}
Approximately (gallons/yr)	1.39 trillion	522 billion	431 billion	423 billion	11 billion
Water budget for Ike event (in/yr)	+7.54	29% or 2.18 in	42% or 3.15 in	29% or 2.18 in	
Water budget for Ike event (gallons)	131 billion	~38 billion	54.9 billion	~38 billion	

Consumed means the water is used by people, animals, plants, and industrial and commercial processes. Sources of data: a = Hanson (1991), b = U.S.G.S. online historical data for the Muskegon River at Croton, MI, c = Holtschlag (1996) for Morley, MI, d = U.S. E.P.A. online data for Muskegon River watershed, data for 1990. Bold numbers for the Muskegon watershed were the published or estimated values used to approximate the water budget. Bold numbers for the Ike event were directly measured.

Michigan High School Content Expectations

E1.1 Scientific Inquiry
E1.1D Identify patterns in data and relate them to theoretical models.

E1.2 Scientific Reflection and Social Implications
E1.2C Develop an understanding of a scientific concept by accessing information from multiple sources. Evaluate the scientific accuracy and significance of the information.

E2.1 Earth Systems Overview
E2.1B Analyze the interactions between the major systems (geosphere, atmosphere, hydrosphere, biosphere)that make up the Earth.
E2.1C Explain, using specific examples, how a change in one system affects other Earth systems.

E4.1 Hydrogeology
E4.1A Compare and contrast surface water systems (lakes, rivers, streams, wetlands) and groundwater in regard to their relative sizes as Earth's freshwater reservoirs and the dynamics of water movement (inputs and outputs, residence times, sustainability).

E4.3 Severe Weather
E4.3A Describe the various conditions of formation associated with severe weather (thunderstorms, tornadoes, hurricanes, floods, waves, and drought).
E4.3B Describe the damage resulting from, and the social impact of thunderstorms, tornadoes, hurricanes, and floods.

E4.3C Describe severe weather and flood safety and mitigation.
E4.3D Describe the seasonal variations in severe weather.
E4.3E Describe conditions associated with frontal boundaries that result in severe weather (thunderstorms, tornadoes, and hurricanes).

Next Generation Science Standards

ESS2.A: Earth's Materials and Systems
- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)

ESS2.C: The Roles of Water in Earth's Surface Processes
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)
- The complex patterns of the changes and the movement of water in the atmosphere, determined by winds, landforms, and ocean temperatures and currents, are major determinants of local weather patterns. (MS-ESS2-5)
- Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

ESS2.D: Weather and Climate
- Weather and climate are influenced by interactions involving sunlight, the ocean, the atmosphere, ice, landforms, and living things. These interactions vary with latitude, altitude, and local and regional geography, all of which can affect oceanic and atmospheric flow patterns. (MS-ESS2-6)
- Because these patterns are so complex, weather can only be predicted probabilistically. (MS-ESS2-5)
- The ocean exerts a major influence on weather and climate by absorbing energy from the sun, releasing it over time, and globally redistributing it through ocean currents. (MS-ESS2-6)

Connecting a Classroom Model for Glaciers to the Quaternary Map of Michigan

By Greg Wilson, Geology Lab Supervisor, Department of Geology, Padnos Hall of Science, Grand Valley State University and Steve Mattox, Professor of Geology, Grand Valley State University

Connecting a Classroom Model for Glaciers to the Quaternary Map of Michigan

Michigan's landscape was sculpted and shaped by glaciers tens of thousands of years ago. The resulting deposits and features are the basis for our agriculture, tourism, and abundant surface and groundwater resources.

Although glaciers seem common in our thoughts it is rare to have a student that has seen or walked on one. In many ways glaciers are abstract, distant in time and space. Most students do not understand the different aspects of glacial systems, how glaciers operate, or the streams and lakes associated with them. They also have little understanding of the differences between glacial and water laid deposits. We expect our students to make the intellectual leap to connect our landscape to the processes that formed it.

In this activity students use common, low-cost materials to construct a simple model of glaciers in their classroom. As students observe the model change over a series of days they record their observations and construct a scale map. The activity concludes with students connecting the model to the Quaternary Map of Michigan (Farrand, 1982).

Materials Needed and Setup

A trip to the local department store will be required. The materials for one demonstration or for each group of students are:

1. a large ~9.25 gallon, ~17 ¾ x 33 ½ x 6 inch clear, flat bottomed plastic tub (storage box) common at Meijer or similar stores
2. rubber stoppers, such as a chemist might use in a test tube, about 0.5 inch diameter
3. two smaller plastic containers, ~ 2 quart, for a glacier mold and a second larger ~ 4 quart container for mixing crushed ice or snow
4. ~ 1 quart of sediment: clay, silt, sand, and gravel (beach sand, aquarium gravel, etc…)
5. Quaternary Map of Michigan (Farrand, 1982) or online at Michigan Department of Natural Resources (http://www.dnr.state.mi.us/spatialdatalibrary/PDF_Maps/Geology/Quaternary_Geology_Map.pdf)

The longer the plastic tub, the better. Ideally, the tub should have a completely flat bottom. Drill a drainage hole equal to the minimum diameter of the rubber stopper along the bottom edge of one of the short ends of the plastic tub. We commonly use a pocket knife to carve out the hole. Place the stopper in the hole; it should be water tight. Using a ruler and permanent marker, draw a grid pattern on the bottom of the container matching the grid pattern on Figure 1. The grid system will be used to aid students in drawing their map and determining the scale of the model.

In general, we have 4-6 students work with each tub. We commonly do this lab as a classroom exercise and read the steps below out to the entire class (see Figure 1). Alternatively, you could print the steps and have the groups work independently. Each group records their observations on the base map (Figure 1) or each student could record her/his observations on their own base map.

Stop. Please read all the steps before you begin. Reread each step before you take any action.

STEP 1 – CREATE A LAKE

a. Arrange the tub in a location where it can remain undisturbed for several days, such as lab tables or lab benches. The tub should be positioned so that the water can be drained without moving the tub; this is easy if the edge of the stopper is about an inch past the end of the lab table. The plug should be snuggly fitted into the hole from the outside pushed inward, so that it can later be removed.

b. Elevate one end of the tub so that it is at a slight angle. (The lower the angle of the tub the more the shoreline will shift.) We find that approximately 4 inches (two or three text books) at one end of the tub is about right. Too steep an angle can cause the glacier to move (a key characteristic of real glaciers that we don't want in our models). Create a lake by very gently pouring a quart of water into the low end of the tub. The lake should fill from the bottom upwards, and taking care not to splash into the upper portion of the tub. Sprinkle sediment (fine sand works best) into the lake and spread it around to evenly cover the entire lake bottom. This sediment will mark the position of the original (older) lake.

STEP 2 – MIX UP A GLACIER

a. Fill a 2-quart container with crushed ice to be used as glacier. Overfill the container by ½ to 1 inch, as the ice will compact.

b. Dump ice into a second larger ~ 4-quart plastic container used for mixing.

c. Add a mix of about 1-2 cups of clay, silt, sand, and gravel. The finer sediment (clay and silt) are the key ingredients. If students are making more than one glacier try to vary the proportions of sediment, or the color of the fine sediment.

d. Mix the ice and sediment by hand, and then compact the mixture into the glacier mold.

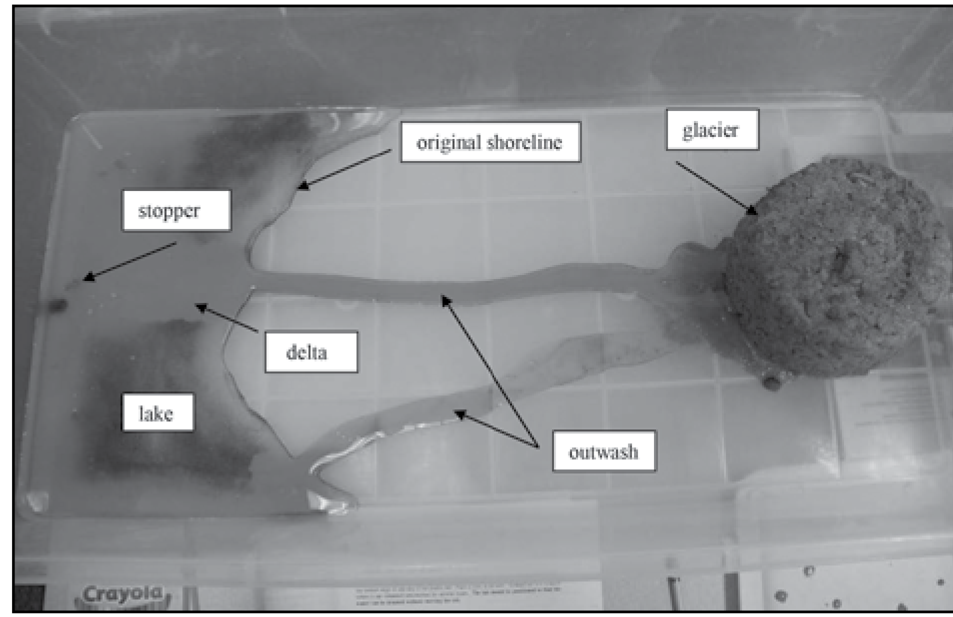
e. Sprinkle a thin layer of sand onto the ice at the top of the mold (the sand will help reduce sliding).

STEP 3 – ADD GLACIER TO MODEL

a. Carefully invert the glacier mold near the top of the slope. Place the glacier far enough to the high end of the model to allow for the rise in the water level of the lake at the low end (Figure 2). Gently pour a few cups of warm water through the ice to start the melting and establish streams. Be sure students are able to observe the meltwater entering and dispersing into the lake.

b. Consider leaving room in the model for adding a second glacier.

Figure 2. A mixture of ice and sediment have been compacted in a container and "flipped" near the top of an inclined shallow, plastic tub (storage container) to model the melting of glaciers. Warm water poured through the "glacier" has established "outwash" streams that selectively removed finer sediment and transport it towards a lake. Note the rubber stopper at the far left of the model that allows the water to drain. The model is resting on two books on the right side.



STEP 4 – OBSERVATIONS OF PROCESSES

a. Observe changes over time. Melting usually takes hours, depending on the size of the glacier. Pouring water onto the ice will increase melting (simulating seasonal and climatic warming). Adding water also increases the sediment flushed from the glacier.

b. Note changes in the water level of the lake as the ice is melting.

c. Note the development of a stream system from the melting ice. What determines where the channel flows? What material is deposited by this system? How is the sediment from the meltwater stream different from the glacial sediment?

d. After the glacier has completely melted and the sediment in the lake water has had time to settle, drain the lake. The model will be very sensitive to bumping once the lake has formed, and it may be advantageous to drain the lake as soon as convenient. Gently pull the plug from the outside and let the water drain into an available container. After the majority of the lake has drained, place the empty 2 quart container beneath the end of the model to catch remaining drips that may fall as the model is allowed to dry.

e. If time or interest allows, after the first glacier has melted, drain the lake, then add a second glacier that has a different composition (proportions or color of sediment). Overlap the second glacier on the deposits left by the first glacier.

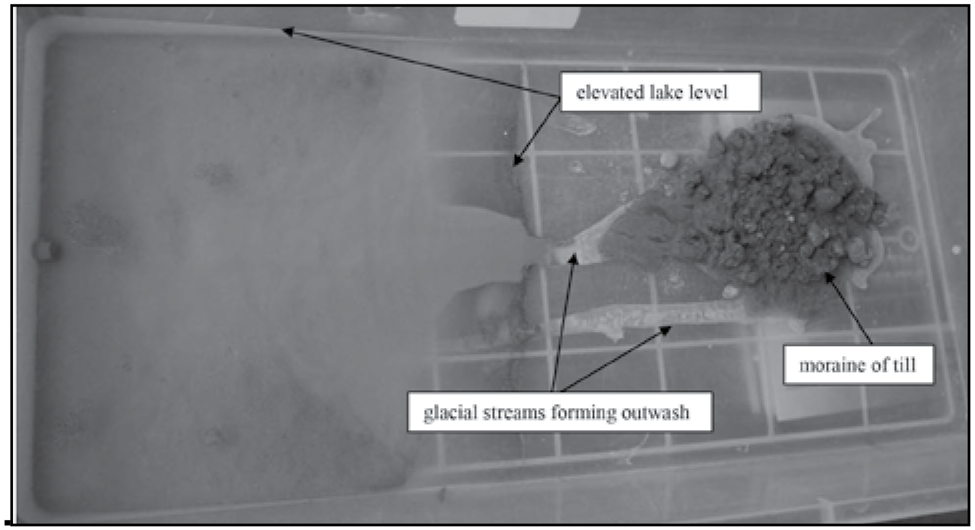


Figure 3. After melting, poorly sorted material that was in contact with the ice (till as a moraine) is revealed. Melt water has caused the lake level to rise and shift the shoreline to higher elevation. Fine sediment will mark the position of the high lake level on the sides and bottom of the container.

STEP 5 – POST MELTING ACTIVITIES

a. Discuss variations in deposits (Figure 3). What are the differences between the deposits left by the glacier, the glacial meltwater stream, and the lake deposits?

b. Have students determine the scale of their map.

c. On the grid paper provided (Figure 1) sketch a geologic map of the deposits. Use the following color combinations for Figure 1, green for the area of glacial deposits, pink for glacial outwash, and blue for areas covered by lake deposits. Also have the students mark on the map in red the locations of the original shoreline and high lake level shoreline. These colors are used so that they match the corresponding deposits on the Quaternary Map of Michigan by Farrand (1982) (Figure 5). Figure 4 shows a completed student map.

d. What was the relationship between the glacier and the shoreline? How might this relate to the real world?

e. Have students write out a history of the events depicted in the model. Discuss the principles used to determine sequence of events based upon the characteristics of the deposits. Adding a second glacier can add to the complexity of this discussion, and provide opportunities for discussion of relative age dating and basic stratigraphic principles.

f. Have students discuss differences between the model and real glaciers (Figure 5). They might contrast the scale of the model to real glaciers. We determine the sediment mixtures (% gravel, sand, clay, types and colors) for the model - What determines the characteristics of sediment in various tills? What factors influence melting?

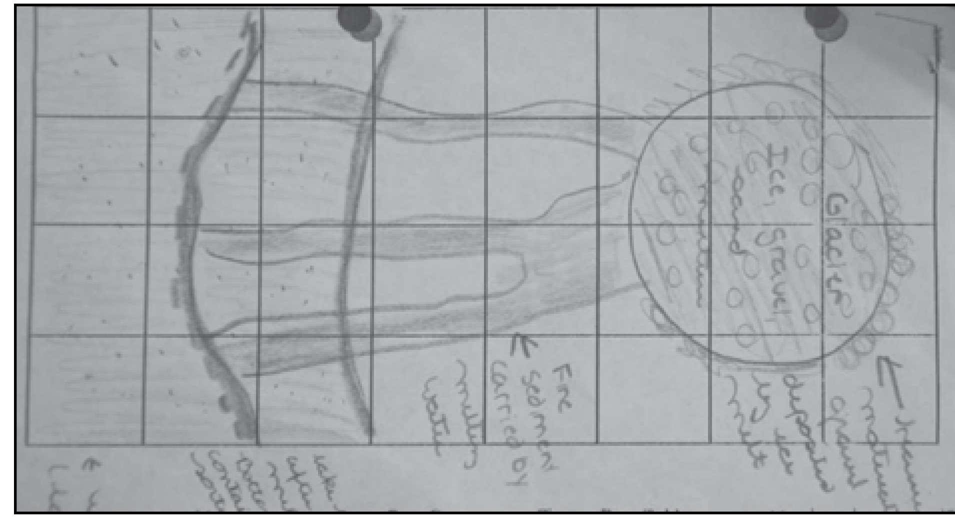


Figure 4. Example of a student map of the distribution and characteristics of ice contact glacial moraine, outwash streams, and shifted lake levels.

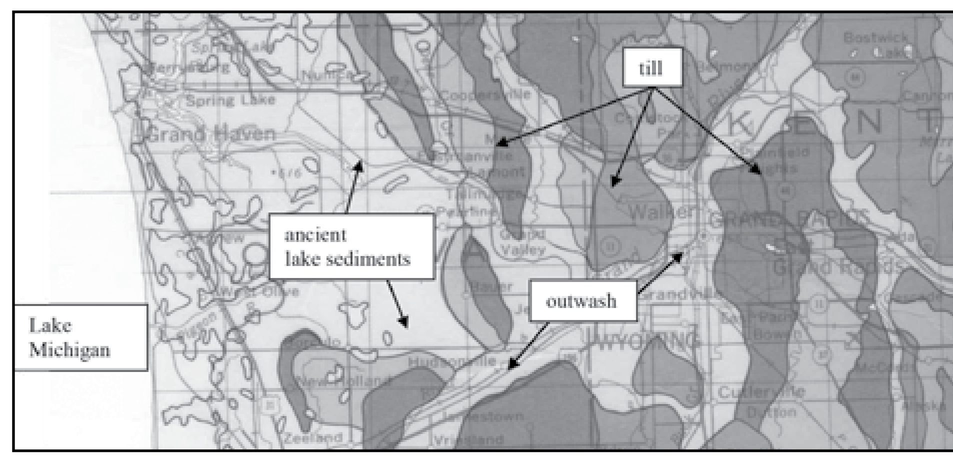
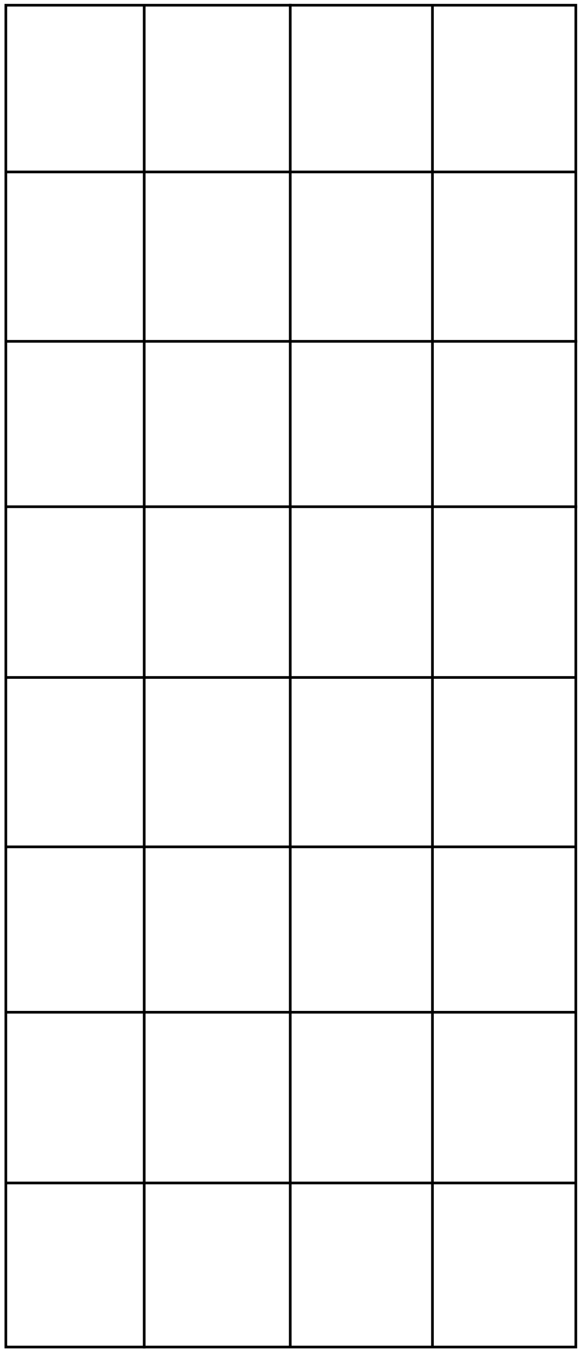


Figure 5. Geologic map of part of west Michigan's lower peninsula. Tills are in shades of green, outwash is in pink, sediment from high lakes levels are in blue, red lines mark positions of former shorelines, and sand dunes are in yellow. Students can compare their map of their glacial model to the real world. From Farrand (1982),

Figure 1. Geologic map of the model glacier.



Names ______________________

____

____

1. Determine the scale of the map—
   R.F.--_____________________
2. Sketch the positions of the following, and shade those areas with the suggested colors.
   a. Glacial Deposits (green) – Material deposited directly by the glacier.
   b. Stream Deposits (pink) – Material deposited by meltwater flowing away from the glacier
      *outline and label a delta
   c. Lake Deposits (blue)
   d. Shorelines (red lines) – identify any recognizable shorelines
      1. Original shoreline – (preglacial) (mark with a dashed red line)
      2. Glacial lakes – high lake level (mark with solid red line)
3. Describe a variation you would add to this experimental model.

STEP 6 – COMPARISON OF THE STUDENT MAPS TO THE ACTUAL QUATERNARY MAP OF MICHIGAN

The term Quaternary refers to a span of geologic time and associated materials that began about 1.8 million year ago and continues to the present day.

The map shows the distribution of materials formed directly and indirectly by the lobes of glaciers (Figure 5). The green colors show poorly sorted sediment deposited directly by the ice (called till) to form landscape features called moraines (darker shades of green). The pink color shows well sorted sand and gravel (called outwash) washed out of glaciers by streams. The blue color shows well sorted lake deposits (lacustrine deposits) that settled to the bottom of high stands of the early Great Lakes. Dark blue represents areas covered by fine sediments (clay and silt), and the lighter shades of blue represent areas covered by sorted sands and occasional gravels. Red lines mark the positions of former shorelines identified by the presence of features also found at modern shorelines such as wave-cut bluffs, dunes or beach ridges.

Reference

Farrand, W.R., 1982, Quaternary Geology of Michigan, State of Michigan, Department of Natural Resources Geological Survey two sheets, 1:500,000.

Should the Substance *Di-Hydrogen Monoxide* be Banned?
A Middle-School Problem-based Learning (PBL) and Evaluation of Resources Activity

By Sandra Yarema

A recent advertisement mocked the gullibility of people who believe in the authority of the internet as a resource. This activity helps students to be more skeptical of information as presented on the internet. This activity will also provide students with the opportunity to derive a chemical formula from a chemical name, to discuss the biological importance of water, identify sources of bias in science, and to discuss the importance of critical thinking in science while they synthesize a conceptual connection between science and society.

Goals/Objectives

NGSS/Frameworks

Disciplinary Core Ideas:

PS1.A: ***Structure and Properties of Matter***
MS-PS1-1: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.

Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.

PS1.B: ***Chemical Reactions***
Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.

ESS3.C: ***Human Impacts on Earth Systems***
Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.

Science and Engineering Practices:

Analyzing and Interpreting Data:
Modeling in 6-8 builds on K-5 experiences and progresses to analyze data in order to derive meaning.

Engaging in Argument from Evidence
Argumentation in 6-8 builds on k-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).

Compare and critique two arguments on the same topic and analyze whether they emphasize similar or different evidence and/or interpretations of facts.

Respectfully provide and receive critiques about one's explanations, procedures, models and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.

Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

Obtaining, Evaluating, and Communicating Information
Obtaining, evaluating, and communicating information in 6-8 builds on K-5 experiences and progresses to evaluating the merit and validity of ideas and methods.

Gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication and methods used, and describe how they are supported or not supported by evidence.

Cross Cutting Concepts:

Cause and Effect
Cause and effect relationships may be used to predict phenomena in natural or designed systems.

Influence of Science, Engineering, and Technology on Society and the Natural World
All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.

Materials

- Student Computers with Internet Access to www.dhmo.org
- Student Worksheets with instruction related to learning about a chemical.
- A copy of the Periodic Table of Elements
- 3" x 5" notecards
- A timer or clock for timed debate

Activity Directions

1. Ask students if they know of any problems with pollutants that have recently been in the news. (You may want to include recent local news clips or videos from recent headlines) Be sure to define *toxic substances*, and how these relate to public health and safety, particularly regarding water, soil, and air quality.
2. Announce to students that they will be investigating a chemical that some believe is dangerous and should be banned.

3. Distribute the worksheet.
4. Have students work on researching DHMO (20 minutes) using the website: http://www.dhmo.org and complete the worksheet. They may NOT access any other websites.
5. Assign students to small groups (3-5 students) to develop arguments to support banning DHMO and others to argue against banning DHMO. Each group must elect a spokesperson who will have a 2 minute limit to present their position to the rest of the class. Collect the worksheets when each group has prepared their position statements and written them on 3 x 5" notecards.
6. Conduct a timed debate, (20 minutes total) with each group allowed 2 minutes to present a concise, logical argument to support their position for or against banning DHMO. Schedule the groups that support banning DHMO to speak first. You may allow 30 second rebuttals if time permits.
7. If no-one has yet recognized that DHMO is water, discuss the meanings of the prefixes "di" and "mono", and use the periodic table to identify the chemical symbols for the elements hydrogen and oxygen.
8. Conduct a "de-briefing" discussion. Remind students that it is important to think critically, and that sources must be checked for accuracy. Discuss the validity of internet sites, how science can easily be manipulated to persuade, especially in political arenas (e.g., global warming: debate or fact), and their familiarity with "scientific language" and terms used in chemistry.

Worksheet: Dihydrogen monoxide (DHMO)

Name: ____Class period: ________

I would like you to be aware of a substance that most are not familiar with:

Visit the following website: www.dhmo.org

1. Read about Dihydrogen Monoxide by scrolling through the pages tabbed in the left-hand margin:
   - Click on "Dihydrogen Monoxide FAQ"
   - Click on "MSDS for DHMO"
2. Based on what you have read, complete the acrostic worksheet.
   - Write a factual statement about dihydrogen monoxide that starts with each letter of the chemical. The statement you write must be a complete sentence, and facts may not be repeated. Online abbreviations and non-standard phrasing are acceptable.

Acrostic: Dihydrogen monoxide

D ____

I ____

H ____

Y ____

D ____

R ____

O ____

G ____

E ____

N ____

M ____

O ____

N ____

O ____

X ____

I ____

D ____

E ____

Questions to answer:

1. Would you support a ban on dihydrogen monoxide? Why or why not?
2. Explain the dangers of dihydrogen monoxide to a family member. Would he or she support a ban on dihydrogen monoxide? Why or why not?

Reading Beyond the Textbook

By Christopher Chopp and Cheryl Hach, Kalamazoo Area Math and Science Center (KAMSC) and Otto Kailing, Junior at KAMSC, and Kalamazoo Central High School, Elizabeth Stout first year student at KAMSC and Gull Lake High School

To enrich and extend learning in middle and high school science classes, opportunities should be provided to allow students to delve into nonfiction text and reflect on what they have read. Attached is a list of 103 books with biological themes that students can read and enrich their understanding of the nature of scientific thought. Also included is a sample of a student book review written by Otto K. an 11th grade student at the Kalamazoo Area Math and Science Center. He read, The Making of the Fittest: DNA & the Ultimate Forensic Record of Evolution by Sean B. Carroll.

Excerpt from APPENDIX H – Understanding the Scientific Enterprise: The Nature of Science in the Next Generation Science Standards

The nature of science (NOS) is included in the Next Generation Science Standards. The NOS Matrix. The basic understandings about the nature of science are:

- Scientific Investigations Use a Variety of Methods
- Scientific Knowledge is Based on Empirical Evidence
- Scientific Knowledge is Open to Revision in Light of New Evidence
- Scientific Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
- Science is a Way of Knowing
- Scientific Knowledge Assumes an Order and Consistency in Natural Systems
- Science is a Human Endeavor
- Science Addresses Questions About the Natural and Material World

The first four of these understandings are closely associated with practices and the second four with crosscutting concepts. The NOS Matrix presents specific content for K- 2, 3-5, middle school and high school. Appropriate learning outcomes for the nature of science are expressed in the performance expectations, and presented in either the foundations column for practices or crosscutting concepts of the DCI standard pages.

Again, one should note that the inclusion of nature of science in NGSS does not constitute a fourth dimension of standards. Rather, the grade level representations of the eight understandings have been incorporated in the practices and crosscutting concepts. [1]

1 http://www.nextgenscience.org/sites/ngss/files/Appendix%20H%20-%20The%20Nature%20of%20Science%20in%20the%20Next%20Generation%20Science%20Standards%204.15.13.pdf

READING BEYOND THE TEXTBOOK

To work toward your highest potential as scholars and citizens, your teachers believe that you must discover the nature of scientific thought. Although you must be familiar with recent discoveries and new technologies, it is more important that you understand how science works, how the different sciences have been interpreted by great thinkers, and how we may use and misuse scientific thought. One way to do this is to read books about science.

The following is an acceptable list of books in science that may be read. If you wish, select one of them to read for extra credit in biology. Upon returning from the holiday vacation, you will be asked to answer a few questions about the book that you have read. This list is NOT complete. It surely reflects some of my own interests and favorite authors. There are more books published every year. There are many more books that would be acceptable, but they must be non-fiction and concerned with biological topics. Please ask me about others that you find and would like to read. Happy Reading!!

1. A Brief History of Nearly Everything by Bill Bryson
2. A Brief History of Time by Stephen Hawking
3. A Field Guide to Bacteria by Betsey Dexter Dyer
4. A Walk into the Woods by Bill Bryson
5. Anatomy of a Scientific Discovery by Jeff Goldberg
6. And No Birds Sing by Mark Jaffe
7. Awakenings by Oliver Sacks
8. Before the Dawn by Nicholas Wade
9. Broca's Brain by Carl Sagan
10. Bully for Brontosaurus by Stephen J. Gould
11. Cats Are Not Peas by Laura Gould
12. Anatomy of an Illness by Norman Cousins
13. Chromosome 6 by Robin Cook
14. Darwin's Blind Spot: Evolution Beyond Natural Selection by Frank Ryan
15. Dead Men Do Tell Tales by William R. Maples
16. Deadly Feasts by Richard Rhodes
17. Deadly Medicine by Thomas J. Moore
18. Hot Zone by Richard Preston
19. Demon in the Freezer by Richard Preston
20. Deep Survival by Laurence Gonzales
21. Doubt is their Product: by David Michaels
22. Earth's First Steps by Jerry McDonald
23. Earthly Pleasures by Roger Swain
24. Eighth Day of Creation by Horace Freeland Judson
25. Endless Forms Most Beautiful: The New Science of Evo Devo by Sean Carroll
26. Eve's Rib by Robert Pool
27. Ever Since Darwin by Stephen J. Gould
28. Field Days by Roger Swain

29. Full House by Stephen Jay Gould
30. Genome by Matt Ridley
31. Good Germs, Bad Germs by Jessica Snyder
32. How the Leopard Changed its Spots by Brian Goodwin
33. In Defense of Food: An Eater's Manifesto by Michael Pollan
34. In Search of the Double Helix by John Gibbon
35. In the Shadow of Man by Jane Goodall
36. Into the Woods by Jon Krakauer
37. Island of the Colorblind by Oliver Sacks
38. Lives of a Cell by Lewis Thomas
39. Mapping Fate by Alice Wexler
40. Men and Microbes by Arno Karlen
41. Monkey Girl by Edward Humes
42. Moral Minds: by Marc Hauser
43. Musicophilia by Oliver Sacks
44. Natural History of the Senses by Diane Ackerman
45. Number: The Language of Science by Tobias Dantzig
46. Of Moths and Men by Judith Hooper
47. On Human Nature by E.O. Wilson
48. On Methuselah's Trail by Peter Douglas Ward
49. One Renegade Cell by Robert Weinberg
50. Proust was a Neuroscientist by Jonah Lehrer
51. Reflections on Mahler's Ninth Symphony by Lewis Thomas
52. Refuge by Terry Tempest Williams
53. Relics of Eden by Daniel J. Fairbanks
54. Rosalind Franklin and DNA by Anne Sayre
55. Rosalind Franklin: The Dark Lady of DNA by Brenda Maddox
56. Sastun by Rosita Arvigo
57. Science and Human Values by Jacob Bronowski
58. Second Nature: A Gardener's Education by Michael Pollan
59. Silent Spring by Rachel Carson
60. Skeleton in the Darkroom by Gilbert Shapiro
61. Sociobiology by E.O. Wilson
62. Spoiled by Nicols Fox
63. Symbiosis in Cell Evolution by Lynn Margulis
64. The Astonishing Hypothesis by Francis Crick
65. The Beak of the Finch by Jonathan Weiner
66. The Blooding by Joseph Wambaugh
67. The Botany of Desire by Michael Pollan
68. The Demon in the Freezer by Richard Preston
69. The Diversity of Life by Edward O. Wilson
70. The Double Helix by James D. Watson
71. The Essential Darwin by Robert Jastrow
72. The Growth of Biological Thought by Ernst Mayr
73. The Man Who Mistook His Wife for a Hat by Oliver Sacks
74. The Medusa and the Snail by Lewis Thomas
75. The Microbe Hunters by Paul DeKruif
76. The Miner's Canary by Niles Eldredge
77. Games of Life by Karl Sigmund
78. The Mismeasure of Man by Stephen J. Gould
79. The Mortal Animal by Robert Wright
80. The Omnivore's Dilemma by Michael Pollan
81. The Origin of Species by Charles Darwin
82. The Panda's Thumb by Stephen J. Gould
83. The Population Bomb by Paul Ehrlich
84. The Red Queen by Matt Ridley
85. The Sand County Almanac by Aldo Leopold
86. The Secret Language and Remarkable Behavior of Animals by Janice Benyus
87. The Selfish Gene by Richard Dawkins
88. The Sports Gene: Inside the Science of Extraordinary Athletic Performance by David Epstein
89. The Structure of Scientific Revolutions by Thomas S. Kuhn
90. The Stuff of Thought: Language as a Window into Human Nature by Steven Pinker
91. The Third Chimpanzee by Jared M. Diamond
92. The Third Man of the Double Helix by Maurice Wilkins
93. The Two Cultures by C.P. Snow
94. The World Without Us by Alan Weisman
95. Voyage of the H.M.S. Beagle by Charles Darwin
96. King Solomon's Ring by Konrad Lorenz
97. What a Mad Pursuit by Francis Crick
98. What Evolution is by Ernst Mayr
99. What is Life? by E. Schrodinger
100. Why Zebras Don't Get Ulcers by Robert Sapolsky
101. Words for the Wild Ann Ronald
102. Year of the Gorilla Dian Fosse
103. Your Inner Fish by Neil Shubin

Book Review Form

Your Name: _____________________________ Date:________________________

Title of the book: ____

Author of the book:____

How would you rate this book?

_____ 1= terrible

_____ 2 = poor

_____ 3 = average

_____ 4 = above average

_____ 5 = excellent

What was one of your favorite scenes from the book? (Briefly describe and explain why it is your favorite.)

What biology theme is explored in this book?

What message does the author make about this biology theme?

Describe how you agree with the author's message:

Describe how you disagree with the author's message:

What are your impressions of this book?

Below, please list FIVE quotes or small passages (paragraph at most) from the book and explain what this means to you as the reader.

1.

2.

3.

4.

5.

Otto Kailing 11th grade Kalamazoo Area Math and Science Center and Kalamazoo Central
Submitted for AP Biology

The Making of the Fittest: DNA & the Ultimate Forensic Record of Evolution by Sean B. Carroll

Rating: 5 – Excellent

What was one of your favorite scenes from the book? (Briefly describe and explain why it is your favorite.)

It's a long one, but I was struck by the historical events centered around Trofim Denisovich Lysenko, who was a prominent "biologist" in the USSR who, under Stalin, led a move against genetics and towards a false "Lamarckian" (222) viewpoint. To me, this illustrates the importance of sound science, as opposed to T. D. Lysenko's softer science in the form of his agricultural "experiments." It also showed the result of political ideology interfering with science.

What biology theme is explored in this book?

Broadly speaking, evolution; specifically, how various DNA evidence shows that a) evolution is possible and b) happened and is happening, as a result of the methods by which DNA is known to work. This is done by exploring different processes and phenomena chapter-by-chapter.

What message does the author make about this biology theme?

Carroll's goal, as he says it, is "to describe [the DNA record] throughout this book, and its place in the larger picture of the evolutionary process…" (27). Additionally, he seeks to convince readers of the truth of evolution through his portrayal of the ideas in the context of forensic DNA evidence. Carroll desired this book to be read by a wide audience.

Describe how you agree with the author's message:

As Carroll points out, we take things like DNA evidence in crimes for granted without the belief in evolution that must go along with it. I believe that wider circulation of this book would be very beneficial to everyone, both those who question evolution, and those who (like me, before this book) used to accept evolution more as a dogma than because of the reasoning and scientific evidence. Carroll's additional chapters are also insightful regarding other locations in society where ignorance and dogma can be found.

Describe how you disagree with the author's message:

Given its date of publication (2006), I have very little criticism. If this book were reprinted, I would like to see an addendum with a short inclusion of epigenetics—how it works and how it relates to DNA evidence, etc.

What are your impressions of this book?

In a simple sense, my impressions are very positive. While it is not riveting entertainment, it isn't meant to be—although Carroll employs several well-placed anecdotes throughout. Instead, it is possibly the most successfully informative 268 pages I've read, in that I now have more of an understanding of the mechanisms of evolution. Also, Carroll's warnings in the last chapter—about management of our world and its fisheries—are very important (though he did not mention ocean acidification).

Below, please list five quotes or small passages (paragraph at most) from the book and explain what this means to you as a reader.

1. "… when a trait is no longer under selection … the genes that were essential in one lifestyle can become dispensable, and mutations can accumulate in them. Use it or lose it." (123)

   This was a very effective description to me of how fossilized genes/ "junk DNA," while unexplainable in creationism, do occur under the theory of evolution.

2. "… the eukaryote genome is the product of a fusion between a relative of a type of archaean and a type of bacterium." (88)

   This wasn't in the textbook! This struck me, as a reader, as a new possibility that, if not already proven, should be further investigated. Way cool, too.

3. "… the history of eye evolution now appears to be one of the repeated evolution of more complex eyes from simpler proto-eyes." (199)

   2 reasons: 1) No, creationists, our eyes didn't just "evolve" into place… 2) Different solutions to the same problem… this is cool!

4. "For more than twenty-five years, T. D. Lysenko reigned over Soviet biology, agriculture, and medicine. And he destroyed it." (219)

   This showed me the importance of having 1) sound and 2) peer-reviewed science, rather than always agreeing with one celebrity scientist.

5. "When the scientific process is abandoned, the lesson throughout history is failure or outright disaster in human affairs." (247)

   2 things here: 1) Good, but I'd like to see more evidence. 2) An excellent warning to some in Congress…

Your Name: Elizabeth Stout   Date: 1/4/15

Title of the book: ***The Botany of Desire***

Author of the book: Michael Pollan

How would you rate this book?

_____ 1= terrible

_____ 2 = poor

_____ 3 = average

_____ 4 = above average

__X__ 5 = excellent

What was one of your favorite scenes from the book? (Briefly describe and explain why it is your favorite.)

I really enjoyed the scene in the marijuana section where the author visits a modern marijuana farm in Amsterdam. The room where it is in smells like sulfur and rotting flesh, and there is so much light that it feels like he is looking into the sun. This passage was one of my favorites, as it made me reconsider how much drugs must really mean to the people who grow the, whether for the effects or the money. The whole house was affected and smelled, and the process itself was tedious. This helped me realize just how much the people growing them are willing to go through in order to get the money from them. Also, Pollan was shocked by the scent and the overall appearance of the garden, and really wanted to leave but couldn't, this part was rather funny.

What biology theme is explored in this book?

Many themes of biology are explored in this book, including human desires, the nature of plants, natural selection, artificial selection, evolution, and agriculture.

What message does the author make about this biology theme?

The author makes a very convincing message: that humans are subject to the same basic desires as plants, that we are not really in control of everything, and we will never be able to control some things, such as nature. It also displays that plants are much more advanced than we often believe, and have developed many of their characteristics to suit our own needs.

Describe how you agree with the author's message:

I agree greatly with the author's message. He provides good strong scientific evidence, and it all makes a lot of sense to me. I have always believed that humans are animals, maybe more advanced than basic creatures such as bacteria, but we are animals nonetheless. It is a strong reality check, that we are not really the controllers of the world.

Describe how you disagree with the author's message:

I do have slightly different feelings about the nature of drugs, and in particular marijuana. My experience with people on marijuana is strictly negative, and I believe that the war on marijuana is a positive and necessary thing. Whereas Pollan pretty much believed that drugs are ok, as long as used properly, and that there is no need to ban marijuana.

What are your impressions of this book.

This book left me understanding that there is much more going on in the world than just humans. Overall it left me with a very positive impression, it helped me to understand some of the basic concepts of plants and biology. It also provided me with history lessons, and information about these four particular plants and what they truly are and mean to humans.

Below, please list FIVE quotes or small passages (paragraph at most) from the book and explain what this means to you as the reader.

1. "If not for grafting—the ancient technique of cloning trees—every apple in the world would be its own distinct variety, and it would be impossible to keep a good one going beyond the life span of that particular tree." (page 10) I had never realized this, I assumed apples were naturally kept in a couple particular species. I could barely believe that I was eating cloned apples; it was amazing to realize I didn't know something that is such a part of my life.
2. "Three and a half centuries earlier, the tulip, still fairly new to the West, unleashed a brief, collective madness that shook a whole nation and nearly brought its economy to ruin." (page 62-63) The whole concept of tulipomania, how crazy the Dutch went for tulips, is seemingly ridiculous. I myself love flowers, but it's hard to believe that tulip bulbs were treated like gold or diamonds, and dominated the economy and lives of almost a whole country. It shows just how much of a grasp plants truly have on us, they control us more than we like to believe.
3. "One of the things certain drugs do to our perceptions is to distance or estrange the objects around us, aestheticizing the most commonplace things until they appear as ideal version of themselves." (page 147) This is a very interesting aspect of marijuana, and one that I had never heard of before. It is something that is useful in life in many ways, sometimes we take for granted everything around us, especially everyday objects. So when something like a table seems magnificent it helps people understand just how amazing life is. For me, this is what my faith helps me with, so in many ways faith can produce some of the same effects as drugs, which I find interesting.
4. "Even after people recognized that this peculiar new plant (potatoes) could produce more food on les sland than any other crop, most of European culture remained inhospitable to the potato. Why? Europeans hadn't eaten tubers before; the potato was a member of the nightshade family; potatoes were thought to cause leprosy and immorality; potatoes were mentioned nowhere in the Bible; potatoes came from America, where they were the staple of an uncivilized and conquered race." (page 199) Refusing to eat potatoes was a silly thing to do, especially since it was based upon far from logical reasons. I would like to believe that humans are above using such illogical reasoning,

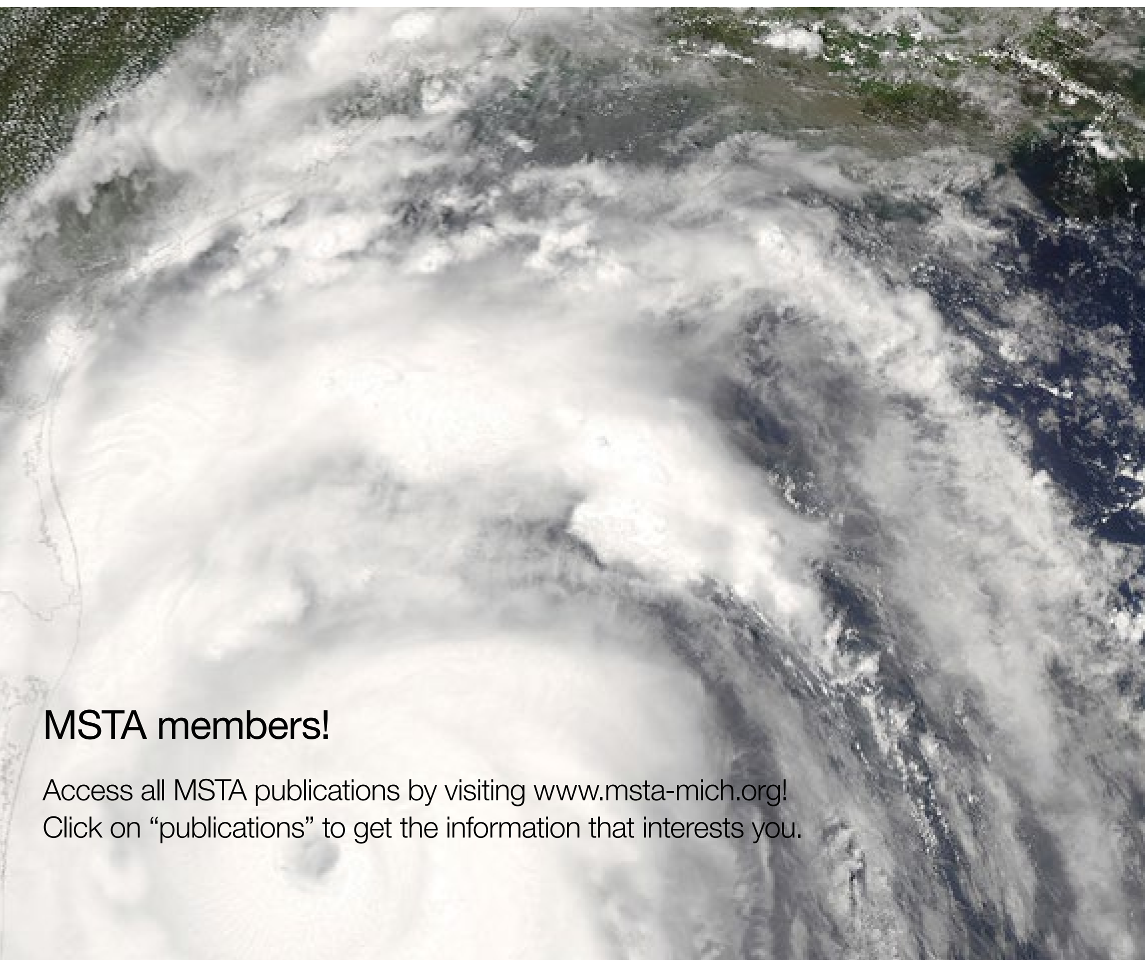
but it happens all the time. This is just proof that though humans are considered more advanced than other species, we are also often more silly and juvenile in our reasoning, putting personal preferences in front of food and life.

5. “There was an old tradition in northern Europe linking the grape, which flourished all through Latin Christendom, with the corruptions of the Catholic Church, while casting the apple as the wholesome fruit of Protestantism. Wine figured in the Eucharist; also, the Old Testament warned against the temptation of the grape. But the Bible didn’t have a bad word to say about the apple or even the strong drink that could be made from it.” (page 20-21) I found this very interesting, as an Episcopalian I consume communion most week, but had never really thought about the mention of grapes in the bible or that they could be considered negative. I never realized that plants could play such a large role in religion into reading the section about the apple. But after thinking about it, they have a lot larger place in weekly services than I realized.

NOTES:

Michigan Science Teachers Association
1390 Eisenhower Place
Ann Arbor, Michigan 48108

NON-PROFIT ORG.
U.S. Postage
PAID
Ypsilanti, MI
Permit No. 863



MSTA members!

Access all MSTA publications by visiting www.msta-mich.org!
Click on “publications” to get the information that interests you.