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The NGSS: Application and Inquiry in the Field

Jon Berklich, Andrew de Voest, Isabelle Fleszar, Hendrick Jannenga, Kenzie McLarty, Nova Nietling, Connor Nugent, Tamara Coleman, Ph.D, Lowell High School

Students in an Advanced Placement Biology class were asked by the Land Conservancy of West Michigan to gather and analyze data on a recent prescribed burn at their school’s Agriscience and Environmental Center. In doing so, students applied ecological concepts such as population ecology, abiotic factor influences, and how “invasive” differs from “native”. As a result, these students employed all eight practices of the Next Generation Science Standards, developed college, and workforce training and 21st century skills.

These practices include:

1. Posing questions and defining problems - Why might our data differ from what we expected?
2. Developing and applying models - A way to test the greater ecosystem is to…
3. Designing and conducting an investigation - We can follow up on our question by…
4. Analyzing and interpreting data - But when we look at the data taken by the class, we found…
5. Using mathematics and computational thinking - A graph of our class data shows…
6. Constructing explanations and designing solutions - Our prediction was….but we found…. so let’s try…
7. Engaging in and justifying an argument from evidence - But the trends we found tell us…
8. Obtaining, evaluating, and communicating information - resulting in this work.

The students gathered early in the morning, stayed late, worked with partners, provided alternative explanations, and debated the themes emerging from their research. Additionally, their work paralleled the processes, frustrations, justifications, and teamwork found in conducting and communicating research at the college level.

Below is the written documentation of these practices and their journey, written and submitted by the students, as a reviewed research article.

ABSTRACT

In order to evaluate the effects of controlled burns on the population of invasive species, the number of invasives were counted in thirteen burned and unburned plots at the Wedge Oak Forest in the Wittenbach/Wedge Environmental Center by two groups of students. The species counted were *Rosa multiflora* (multi-floral rose), *Lonicera morowii* (Japanese honeysuckle), *Acer rubrum* (red maple), and *Elaeagnus umbellata* (autumn olive). The burned areas contained a greater amount of *A. rubrum* than the unburned areas, while the unburned contained a greater number of *E. umbellata*, *L. morowii*, and *R. multiflora* than that of the unburned. This suggests the burn was effective in reducing invasive species with a slower growth rate and less woody stems (relative to *A. rubrum*). However, the burned areas were found to have more
INTRODUCTION
Approximately 60 Advanced Placement Biology students participated in an ecological study by conducting a population count of land in a school/community natural area. The location of study, an agriscience and environmental center in rural Michigan “was a pine plantation, but mostly red pine, not white pine. Other parts of the preserve (i.e., the ones currently covered in mature deciduous forest) were not planted in pine, but were cleared and grazed, or selectively logged in the past”(Heslinga).

A prescribed burn was conducted four months prior to the study, in the month of May. While “herbicide treatments are considered the most effective management for multiflora rose, as well as the others…” (Heslinga), this study looked at invasion of burned versus unburned areas. The study took place in the September following the burn.

For this study, four major invasive species were observed and counted: Japanese Honeysuckle, Autumn Olive, and Multiflora Rose are non-native to Michigan, with Red Maple representing a native problem species.

While invasives are, by definition, prolific in disturbed areas, the burn was expected to impact the growth of invasives by allowing them to appear quickly in the newly burned area.

The species of interest include Multiflora Rose, Japanese Honeysuckle, Autumn Olive, and red Maple. Multiflora Rose was introduced in the United States as rootstock to ornamental roses. In the 1930’s it was advertised as an erosion control method and a natural fence for livestock. Later it was planted along roadsides to reduce reflection from car headlights and to serve as crash barriers. Unfortunately, by the time the plant was recognized as a pest, it was widespread. Multiflora Rose is an incredibly hardy plant, and is able to tolerate extreme soil, moisture, and light conditions. Furthermore, one plant can produce up to one million seeds a year, which “remain capable of growth for an additional two decades” (Swearingen).

In the early to mid 1800’s Japanese honeysuckle was a premier plant for immigrants to the region. It was “adaptable to almost any environment, heat tolerant, and nearly indestructible”(Adams, Kristina, Kohl, and Kahn). Additionally, it can photosynthesize without its leaves. Like Multiflora Rose, Japanese Honeysuckle was used for erosion control.

Autumn Olive is a deciduous shrub that can grow up to seven meters annually, and produces appealing berries that vary from a cream to pale pink color. According to nps.gov, “It is drought tolerant and thrives in a variety of soil and moisture conditions. Because Autumn Olive is capable of fixing nitrogen in its roots, it can grow on bare mineral substrates.” This plant was also used for erosion control. However unlike the other species, attempts to burn or cut it down have actually resulted in an increase of the invasive plant (Abrams).

Red Maple is a fast growing, sturdy, woody, broadleaf tree that is native to Michigan, but is still considered a problem. The maple can thrive in sunny or shady, basic or acidic, and dry or moist conditions. However, Red Maple thrives best in moist, acidic environments. The rapid shade than the unburned areas, which may have been in part due to the prevalence of full-grown A. rubrum in the burned areas. This persistent shade may have altered the impact of the burn. Reduction of the canopy cover contributed by A. rubrum may be better pursued by other methods of removal.
growth of the maple is what makes the wood a soft material. The thin bark that encases it is thought to leave the smaller maples susceptible to fire and disease (Abrams).

The purpose of this investigation was to observe the effect of a controlled burn on these invasive species. This was achieved by observing both burned and unburned regions of the agriscience and environmental center for the four aforementioned species of plants. A map of the study area follows (Fig. 1). This map includes 14 burned and 14 unburned sites. Circles indicate areas of high sun exposure. Observations by 60 Advanced Placement Biology students took place over a period of two weeks in the month of September, with a minimum of three visits to the site. The data was then compiled into burned/unburned sets of data and analyzed.

**METHODS**
1. On day one of the study, a learning session was conducted for the students, with an expert to identify the four species of interest.
2. To enhance reliability, identification and counting of the four species of plants was conducted by the students, in 11 (in the first hour) and 14 (in the second hour) groups of two to three students.
3. On day three, students were assigned their plots—one in a burned area, and one in a nearby unburned area. Quadrats were counted in the same regions by each class in order to enhance the study’s reliability.
4. Pacing was used to determine 14 sets of quadrats, each at 10 m X 10 m.
5. On day three, the four species of interest were counted by the two classes of students.
6. Referencing the group’s prediction, data was analyzed by 7 students in a research group, working before school one day a week for two months.
7. The research group traveled back out to the field where they conducted a validation of data, looking for clarification of some of the data shared by their classmates.

The quadrat method has the following assumptions (University of Toronto):

1. The individuals of interest in each quadrat is counted.
2. The size of the quadrat is pre-planned and consistent.
3. The sample quadrats serve as a representative of the study area

**FIGURE 1. ROSE**

**FIGURE 2. AUTUMN OLIVE**

**FIGURE 3. RED MAPLE**

**FIGURE 4. HONEYSUCKLE**
FIGURE 1. MAP OF STUDY AREA
RESULTS

CLASS 1 DATA

<table>
<thead>
<tr>
<th>Burned Area</th>
<th>Rose (Figure 1)</th>
<th>Autumn Olive (Figure 2)</th>
<th>Red Maple (Figure 3)</th>
<th>Honeysuckle (Figure 4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>4</td>
<td>0</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Group 2</td>
<td>0</td>
<td>0</td>
<td>29</td>
<td>0</td>
</tr>
<tr>
<td>Group 3</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Group 4</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Group 5</td>
<td>14</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Group 6</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>Group 7</td>
<td>0</td>
<td>1</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>Group 8</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Group 9</td>
<td>1</td>
<td>2</td>
<td>13</td>
<td>0</td>
</tr>
</tbody>
</table>

CLASS 1 BURNED AREA

![Class Data Burned Area](chart.png)

### Results

**Class 1 Data**

- **Group 1**: Rose (Figure 1) = 4, Autumn Olive (Figure 2) = 0, Red Maple (Figure 3) = 16, Honeysuckle (Figure 4) = 0
- **Group 2**: Rose (Figure 1) = 0, Autumn Olive (Figure 2) = 29, Red Maple (Figure 3) = 0, Honeysuckle (Figure 4) = 0
- **Group 3**: Rose (Figure 1) = 0, Autumn Olive (Figure 2) = 7, Red Maple (Figure 3) = 0, Honeysuckle (Figure 4) = 1
- **Group 4**: Rose (Figure 1) = 6, Autumn Olive (Figure 2) = 1, Red Maple (Figure 3) = 2, Honeysuckle (Figure 4) = 0
- **Group 5**: Rose (Figure 1) = 14, Autumn Olive (Figure 2) = 0, Red Maple (Figure 3) = 1, Honeysuckle (Figure 4) = 2
- **Group 6**: Rose (Figure 1) = 0, Autumn Olive (Figure 2) = 1, Red Maple (Figure 3) = 7, Honeysuckle (Figure 4) = 1
- **Group 7**: Rose (Figure 1) = 0, Autumn Olive (Figure 2) = 1, Red Maple (Figure 3) = 10, Honeysuckle (Figure 4) = 0
- **Group 8**: Rose (Figure 1) = 0, Autumn Olive (Figure 2) = 0, Red Maple (Figure 3) = 1, Honeysuckle (Figure 4) = 0
- **Group 9**: Rose (Figure 1) = 1, Autumn Olive (Figure 2) = 2, Red Maple (Figure 3) = 13, Honeysuckle (Figure 4) = 0
Unburned Area | Rose Figure 1 | Autumn Olive Figure 2 | Red Maple Figure 3 | Honeysuckle Figure 4
---|---|---|---|---
Group 1 | 0 | 0 | 4 | 0
Group 5 | 0 | 17 | 4 | 0
Group 6 | 1 | 0 | 4 | 0
Group 8 | 0 | 16 | 0 | 0
Group 10 | 2 | 2 | 0 | 0
Group 11 | 0 | 1 | 3 | 0
Group 11 (2) | 0 | 2 | 5 | 0
Group 12 | 0 | 0 | 6 | 12
Group 12 (2) | 1 | 0 | 5 | 0
Group 13 | 0 | 1 | 5 | 0
Group 13 (2) | 0 | 4 | 3 | 0
Group 14 | 0 | 0 | 13 | 0
Group 15 | 0 | 6 | 0 | 6

CLASS 2 UNBURNED AREA

![Class Data Unburned Area](image)

DISCUSSION
The burned areas contained, on average, more Red Maple (*A. rubrum*), and more Rose (*R. multiflora*) than the unburned areas. and the unburned areas contained more Autumn Olive (*E. umbellata*) and Silver Honeysuckle (*L. japonica*), and Rose (*R. multiflora*) than the burned areas.

This can be attributed to the burn’s lack of intensity in the areas through which the flame blew but did not catch on much more than the brush, resulting in a smaller, shorter-lived burn with a greater effect on the forest’s brush than the trees themselves. Red Maple’s *A. rubrum’s* ability to survive in a wider range of soil types also would give it a competitive advantage in repopulating...
the burned areas, given that the pine needles fallen from the Red Pine (*Pinus resinosa*) that were cultivated in the Wittenbach/Wege Oak forest would have lowered the soil pH over time, producing a soil less conducive to the growth of other native species. Autumn Olive is by far the hardest of the invasive species. Attempts to burn the plant often fail due to the sheer amount of seeds that each single plant produces. As a result, burns often result in an exponential increase of the plant itself. Autumn Olive is shade tolerant, but thrives best in fields and disturbed areas (AKA sunny environments). The plant survives best in drier environments.

As we examined trends in our data, however, it became apparent that we could not make generalizations regarding the invasive species as we examined the differences in the burned versus the unburned areas. We therefore, investigated the abiotic needs of the four plants, as they respond to shade, or in the case of the Red Maple, provide shade. We found that Red Maples thrive in both sunny and shady environments. Due to the thinness of its bark and the softness of its wood, the Red Maple is not very protected against fire. However, if Red Maple seeds do survive an environmental disruption, they will rapidly overtake the local plants due to their rapid rate of growth. Japanese Honeysuckle is a semi-evergreen plant that can thrive in low temperatures. As a result, the plant requires copious amounts of water to survive. The plant does this by extending complex networks of roots to suck up water. Each root can actually grow into a separate plant if severed for the stem. This is why burns are not effective against this plant. The fire simply cannot destroy the enormous root network the plant creates. The plant can survive in all but the most extreme of light conditions. Multiflora Rose has a wide tolerance for light conditions. Periodic burns during the spring is the most effective management technique for the plant.

Despite having less overall vegetation, more shade existed in the unburned areas. The greater abundance of adult Red Maple (*A. Rubrum*) in the burned areas might contribute to this; as a species requiring a relatively high degree of sun exposure to survive, its canopy is denser relative to other native species, casting more shade. This shade may have also altered the population counts in question.

The burned areas contained, on average, more Red Maple (*A. rubrum*), and more Rose (*R. multiflora*) than the unburned areas. The unburned areas contained more Autumn Olive (*E. umbellata*) and Silver Honeysuckle (*L. japonica*), and Rose (*R. multiflora*) than the burned areas. This can be attributed to the burn’s lack of intensity in the areas where the flames were smaller and shorter-lived, lacking the capacity to clear adult trees but still able to burn through the understory brush (Heslinga). *A. rubrum*’s ability to survive in a wider range of soil types (Abrams 359-62) may have also it a competitive advantage in repopulating the burned areas.

Despite having fewer of the species of interest, we estimated that the burned areas have more shade. The greater abundance of adult Red Maple (*A. rubrum*) in the burned areas may both contribute to this and be caused in part by this; the shade cast by its canopy tends to be denser relative to the shade provided by other native species (Heslinga), and its shade tolerance may make it additionally suited to succeed in these areas (Abrams 359). This shade may have also affected the population counts in question.

**For Classroom Application:**

Conducting authentic research is an integral component of the NGSS standards and provides a bridge to college science classwork. An understanding of students’ abilities to scientifically observe and analyze data followed by explicit science writing is imperative for the facilitator of any students and
such science research in the high school classroom.

Are the students understanding and following protocol?

Are the students given enough practice to feel confident and to be accurate in their observations?

Are they working with experts who can provide such practice, in addition to career examples and skills?

What format is best for the students to use in their writing? (many journals require APA, but many students use MLA format). Furthermore, while many students excel at creative writing, such a skill may not be beneficial in the submission of science research work.

CITATIONS:


Heslinga, Justin, group discussion, 8, September, 2016, & 23 January, 2017


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How to Shift your Literacy Philosophy into Practice in a High School Science Classroom Part 2

by Ellen Karel

In the last winter and spring MSTA journal an introduction to an analytical study which explored to what extent and in what ways a centrally focused program, concentrated on how to teach students to not just write, but how to read, write, and speak about real world problems in a persuasive manner based on multiple sets of data related to science concepts, increased student scientific argumentative writing proficiencies. The outcome of the study showed significant differences in the way students think, write, and speak as measured by pre and post assessments. In this edition, the third of six contributing factors will be discussed. This factor, weak instructional planning and practice, seamlessly ties with the second contributing factor, differences between literacy philosophy and practice. Simply teaching students about claim, evidence, and reason was not sufficient. Understanding how to incorporate data analysis, real world problems along with literacy practices through research based practices such as Gradual Release Instructional Model, Visible Thinking routines, and Backwards Design, QPOE2 investigative plans is fundamentally important to increase students scientific argumentative thinking and writing proficiencies.

Prior to the study: Weak Instructional Planning and Practice

Weak instructional planning and practice is yet another factor that contributes to the problem in this study. Observations of the eight science classrooms at the mid-western high school in this study most often revealed traditional classroom practices; that is, often the methodology modeled had the teacher being the transmitter of new knowledge, which in turn keeps the student in an inactive role. The classroom environment was not skill-based, nor was it based on questions led by the students. Rather, observed was memorization of content, assessed most often in a summative way, with little to no feedback. Again, these characteristics would be defined as a traditional classroom, not conducive to deep scientific analysis (Bybee, 2011). To change instructional practice, the classroom environment must be transformed. Bybee (2011) argued that for science understanding to increase, students must become active in the learning process, which requires instructional plans that are responsive to the learning needs of the students. Students must be given time to co-participate, collaborate, be guided by the teacher, and have discovery experiences clarified by the teacher (Bybee, 2011).

A learning environment that allows for evidence-based practice must include opportunities for students to raise questions, foster respect between and for all learners, and to take risks. The learning environment must also be centered on rich sensory activities focused on the core idea or skill to be learned. Expectations of skill mastery must follow opportunities for students that allow (a) interaction with others in the process of learning, (b) shared control, and (c) opportunities to socially negotiate meaning (Bybee, 2011). For learners in a transformational classroom, an instructional path must be based on the ability to construct and apply new knowledge with a focus on conceptual understanding and logical process skills. Connections about new knowledge and personal knowledge must be forged together through student self-reflection. Instructional leaders in the transformational classroom must intertwine cross cutting concepts, a set of core ideas, and scientific and engineering practices (Bybee, 2011). Hence, instructional practices must shift from “just expect it,” which is traditional in approach, to a transformational instructional model that is based
on intentional evidence-based instruction, centered on questions that engage students in analytical literacy skills, resulting in feedback that can transform the learning environment.

**Putting it into Practice**
The planning protocols associated with backwards design, QPOE2, and the instructional planning template were integrated by design to help plan the integration of cross cutting literacy strategy for scientific discourse with real world problems. This plan was used in two ways. First as a mental outline for the development of lessons and units. As a classroom instructor, one knows that there is not always time to create a formal plan. Therefore, mentally preparing lessons is extremely important when trying to embed scientific thinking into the classroom. Second, this template was used as a record of lesson and unit development. The instructional planning template outlined what worked and did not work related to scientific concepts being taught with the skill. The written record allowed for the development of alternative instructional strategies when lessons provided insight into student understandings and misunderstandings. When students argue like a scientist, misunderstandings become more evident, so instructional mini lessons were developed to help students shift their scientific reasoning. This template is an instructional tool that works in the classroom for practitioners. The planning template is designed to help the instructor to be mindful of the many layers of instruction related to critical thinking.

In the next journal article, further explanation about formative assessment and professional development will be discussed as factors contributing to the problem and the solution for improvement related to students thinking, writing, and speaking.

**Planning towards inquiry based argumentative writing through reflective teacher prompts**
Furthermore, a planning tool that focuses on inquiry based lessons and argumentative writing inclusive of literacy strategies, visible thinking, the gradual release method, assessment, and student reflection was designed and followed to ensure all of the protocols were integrated in the instructional practice. This planning tool integrates with the backwards design template. However, it allows the instructor to reflect about four areas as they plan around a real world, data rich problem or investigation.

1. What evidenced-based analytical literacy skills or visible thinking strategies are you going to use? Will it be thinking, writing, and oral discourse?
2. What level of instructional support will you use on the Gradual Release Model?
3. Will you assess this? How will you assess? What type of feedback will you/peers provide?

This tool will help to scaffold a sound investigation that uses cross cutting analytical thinking and writing skills with best instructional strategies.
Title:

Goal(s) (Include state standards, cross cutting literacy skills (CCSS), habits of mind):

Big Idea (What do you want students to remember 40 years from now?):

Essential Questions:
What are the leading questions that will help students think and produce quality tasks related to the goal? (These questions should be related to STEM.)

Desired Understandings:
What scientific principals or concepts do you want students to think about for their scientific argument? What do you want them to understand and explain in their reasoning?


Key Knowledge
• What vocabulary related to the STEM problem should students know?
• What scientific principles/theories/laws should students know?
• What cross cutting analytical literacy skills and argumentative writing skills should students have?
• What “Visible Thinking Routine” will students be able to use?
• When and how will you share this information with students?
• What habits of mind will students focus on?
• Know: Write as student “I can statement…”
• Do: Write as student “I can statement…”
Assessment Blueprint

Performance Tasks

1. Define the real world problem (STEM) by using a RAFT, or write a problem as an inquiry question.
   - Is it testable in the lab or the field?
   - Does the question have two clear variables?
   - Is it repeatable?
   - Does it result in data?
   - Does the problem result in new knowledge?

2. Determine the level of student inquiry for the investigation and then match the level in the development of your assessment.

   ![Confirm Structure Guide Open]

3. Select the literacy “Anchor” connection to build background knowledge during the knowledge probe. (A journal article, current event, textbook, etc.) Does the literacy “Anchor” help students identify what they need to know? Does the literacy “Anchor” help students identify what they need to be able to do? What literacy strategy will you use to help them extract the information? How will you assess this? What will you do to give feedback? What do you plan to do if students do not extract the background knowledge?

4. Determine what strategy to use to engage students in the development of a hypothesis based on the habit of mind curiosity.

5. Create an investigation or formulate how your students will design an investigation to explore the problem. Keep in mind the QPOE2 model.

6. Determine what type of data (qualitative or quantitative) will be collected to match the learning goals and scientific principles. The data can be real time data collected by students or it can be data that comes from scientific investigations conducted by an outside source.

Then, identify the following evidence based instructional strategies:

7. What habit of mind will students be thinking about?

8. What level of support will you give to students through the Gradual Release of Instruction Model?

9. When will you use formative assessments in the process above? What understandings or goals will be assessed through this task?
10. What type of self-reflection or self-assessment opportunities will you provide for the student? How will you have students rethink about the big ideas or important contents? What instructional practice will you use to have students revise or refine their skills, products, performance, or thinking?

11. Through what scaffolded tasks will students demonstrate understanding? (Writing, or Speaking). These are tasks that will help students build schema for the final argumentative writing.

Culminating Task

12. What final student products and/or performances will provide evidence of the desired understandings? This might be chosen by the teacher or student generated with teacher permission. Will it be oral discourse or written?

13. What qualities must student work demonstrate to signify that standards were met? What rubric will you use? When will you review the rubric with students? What analytical strategy will you use to enhance comprehension of the rubric? Do you have exemplars? What is the plan for using them to enhance student performance?

Unit and Assessment Planning Template

Integrating all three dimensions of NGSS seems daunting, however this template will help you think through all of the steps necessary to incorporate the dimensions in a comprehensive way. This will help to scaffold a sound investigation that uses analytical thinking and writing skills in the assessment.

(The numbers related in the template correspond to the numbers in the previous outline.)
<table>
<thead>
<tr>
<th>Investigation: Problem/Question (1-3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What type of problem statement will you write?</td>
</tr>
<tr>
<td>• Inquiry? Real World? Combination?</td>
</tr>
<tr>
<td>• What type of RAFT will you write?</td>
</tr>
<tr>
<td>• What is the level of inquiry for the investigation?</td>
</tr>
<tr>
<td>• What is the “Anchor” text you will use to help build students background knowledge during the knowledge probe?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis (4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What will students do to generate a prediction?</td>
</tr>
</tbody>
</table>

| What evidence-based analytical literacy skills or visible thinking strategies are you going to use? Will it be thinking, writing, and oral discourse? | What level of instructional support will you use on the Gradual Release Model? | Will you assess this? How will you assess? What type of feedback will you/peers provide? | Will students self-assess/reflect? If so, what will they do and how will they do it? |

<table>
<thead>
<tr>
<th>Investigation: Design (5) QPOE2</th>
</tr>
</thead>
<tbody>
<tr>
<td>• What are the independent variable (cause/manipulated) and the dependent variables (effect or responding)?</td>
</tr>
<tr>
<td>• What step-by-step plan will you provide for your students?</td>
</tr>
<tr>
<td>Question</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>What instructional plan will you use to help students develop their own inquiry investigation?</td>
</tr>
<tr>
<td>What materials are necessary or acceptable?</td>
</tr>
<tr>
<td>How will you engage students in the investigation design or investigation protocols to ensure reliability and repeatability?</td>
</tr>
<tr>
<td>What can you do to provide opportunities for “Messing a bit?”</td>
</tr>
<tr>
<td>What type of observations will students make (qualitative/quantitative)?</td>
</tr>
<tr>
<td>Will the teacher design and explicitly define the type and quantity of the evidence to be collected?</td>
</tr>
<tr>
<td>What type of graphic organizer will the teacher give to the student?</td>
</tr>
<tr>
<td>Or, Will students design and collect their own evidence?</td>
</tr>
<tr>
<td>What process will you use to help students develop a sufficient graphic organizer to collect the evidence?</td>
</tr>
<tr>
<td>What evidence-based analytical literacy skills or visible thinking strategies are you going to use? Will it be thinking, writing, and oral discourse?</td>
</tr>
<tr>
<td>---</td>
</tr>
</tbody>
</table>

### Investigation: Data (6) QPOE<sub>2</sub>

- What is the most convincing piece(s) of evidence?
- What is the least convincing piece(s) of evidence?
- What types of univariant data analysis are you expecting students to make and use?
- Why is this data important?
- What amount of evidence is sufficient?
- What evidence(s) can be used to prove a counter argument?
- What will students do with the evidence?
- Have you zoomed in, out, and in/out?

### Scientific Argument (11-13)

- How are students going to use critical thinking to explain in an argumentative way the findings of the investigation?
**Scientific Argument (11-13) (continued)**

- What are the claim, the evidence, the reasons, and the conclusion with reflection?

- What significant evidence could be used to support the argument?

- What is a sufficient amount of reasoning?

- What connections do you minimally expect back to the scientific understandings, principles, and vocabulary?

- What might be a compelling reason to support this claim and evidence?

- What might be the most compelling evidence to use in a counter argument?
<table>
<thead>
<tr>
<th>Conclusion (11-13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What do you expect in the conclusion?</td>
</tr>
<tr>
<td>Sources of errors</td>
</tr>
<tr>
<td>Confidence of findings</td>
</tr>
<tr>
<td>What do you expect related to fair test comments?</td>
</tr>
<tr>
<td>Surprises?</td>
</tr>
<tr>
<td>Connection to prediction?</td>
</tr>
<tr>
<td>Application to the STEM question in another context?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reflection (10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What type of reflection opportunity will you provide to your students to think about the:</td>
</tr>
<tr>
<td>Experiment</td>
</tr>
<tr>
<td>Learning Experience</td>
</tr>
<tr>
<td>Skills and Behavior</td>
</tr>
</tbody>
</table>


*For transitional phrases and transitional words use the following website https://docs.google.com/a/bcpsk12.net/document/d/1Rmp_trmk/q8Qv0pObmR8JrCggJfGRM3ZP1MY09FK5IM/edit
REFERENCES: (continued)


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Illuminating Conductivity
Larry Kolopajlo, Eastern Michigan University

ABSTRACT

In this lesson, the 7E Learning Cycle (1) is used in conjunction with Modeling pedagogy (2) to advance student understanding of ionization by guiding them through experimental investigations on conductivity. The title, “Illuminating Conductivity,” derives from the use of commercially available LED “ice” cubes (3) as conductivity detectors in both the Engage and Extend phases of the 7E lesson plan. A key objective is for students to construct conceptual models for the ionization of salts, as inferred from experimental evidence. Johnstone’s (4, 5) MPS (macroscopic-particulate-symbolic) theory provides a framework to help students differentiate between the macroscopic (crystals, solutions), particulate (through novel animations, diagrams), and symbolic representations of matter (molecules, ions, and chemical equations). This lesson, presented as a teacher edition, is designed for 11th grade second semester chemistry students to take place over 7 days. However, it is also suitable for a college chemistry classroom. It can be broken up and used as separate modules as well. Since the emphasis is on developing conceptual models, little mathematics is employed. Experimental sections of this lesson plan have been used in college laboratories, in conjunction with a general chemistry laboratory (6), and in labs for preservice elementary education students (7). The animations have been used in general chemistry lecture. In regards to NGSS, this lesson plan includes:

1. Connecting several scientific domains including chemistry/physics, earth science, and engineering technology.
2. A 3D design.
3. Devising a solution to a real-world problem, that of obtaining potable water.

BACKGROUND

The purpose of this lesson plan is to provide a constructionist approach to teaching chemical ionization in aqueous solution. The subject of ionization is very important to general chemistry, and so important in the chemistry curriculum, that failing to understand ionization will limit students’ ability to be successful in other chemistry courses. In order for students to comprehend the subject matter, they must take part in active learning through laboratory work. In addition, they must be exposed to multiple representations such as the particle diagrams, here embodied as particle animations, which could actually be designed by students. The lesson plan follows the 7E model, beginning with a simple laboratory and ending with a engineering application in a real-world context, that of testing for potable water. The 7E Lesson plan is presented as a 7E map in Figure 1, and also described in Table 1 on the next page.
FIGURE 1. 7E FLOW MAP

TABLE 1. 7E LEARNING CYCLE FOR “ILLUMINATING CONDUCTIVITY”

<table>
<thead>
<tr>
<th>Cycle Phase</th>
<th>Description</th>
<th>Time frame (1 period is 50 min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Elicit Teacher determines prior knowledge.</td>
<td>15 minutes</td>
</tr>
<tr>
<td>2</td>
<td>Engage LED cube demo</td>
<td>10 minutes</td>
</tr>
<tr>
<td>3</td>
<td>Explore Conductivity study of NaCl crystals in DI water</td>
<td>1.5 periods</td>
</tr>
<tr>
<td>4</td>
<td>Explain 1. Whiteboard discussion</td>
<td>1 period</td>
</tr>
<tr>
<td></td>
<td>2. Teacher lectures on ionization @ animations</td>
<td>1 period</td>
</tr>
<tr>
<td>5</td>
<td>Elaborate Conductivity investigation extended to other salts, precipitation,</td>
<td>1 period</td>
</tr>
<tr>
<td></td>
<td>and neutralization reactions</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Evaluate 3D formative assessment</td>
<td>1 period</td>
</tr>
<tr>
<td>7</td>
<td>Extend 1. Build and test a simple conductivity detector.</td>
<td>1 period</td>
</tr>
<tr>
<td></td>
<td>2. Reverse-engineer an LED light cube.</td>
<td></td>
</tr>
</tbody>
</table>

LESSON PLAN ALIGNMENT WITH NGSS

Table 2 demonstrates how the 7E learning cycle aligns with NGSS (8). In the alignment table, SEP means science and engineering practices, DCI means disciplinary core ideas, while CC stands for crosscutting concepts. The crosscutting concepts utilized in this lesson and listed in Table 2 link together these domains of science:
chemistry, earth science (minerals have unique crystal structures), physics (electrical circuits), and engineering (building a conductivity detector). There are also connections to NOS: namely through the historical connection to Svante Arrhenius.

**TABLE 2. 7E LESSON PLAN ALIGNMENT WITH NGSS**
ELICIT

In the first phase of the 7E learning cycle, the teacher elicits student prior knowledge regarding these vocabulary terms: solute, solvent, solution, salt, ion, cation, anion, chemical reaction, conductivity, and ionization. Students must also know how to construct the chemical formula of an ionic compound. Students should know the chemical formula for water, that it has a “V” structure, and that the oxygen end has a partial negative charge while the hydrogen end has a positive charge. These vocabulary terms are introduced during the lesson: conductivity, electrolyte, nonelectrolyte, and weak electrolyte, and strong electrolyte. If students are deficient in understanding the above information, then the teacher must set aside time to teach them, or incorporate them into the following parts of the lesson plan.

ENGAGE

After students offer their prior knowledge to the teacher, a demonstration is presented to capture student interest. Students are told to pay attention and observe. Teacher shows two clear containers such as 250 mL beakers, each containing about 50 mL of a
clear liquid. Students aren’t told that the first liquid is tap water, and that the second liquid is mineral oil. The teacher places an ice cube in the container with water, but not in the container with mineral oil. The teacher then places an LED light cube (as from Bigmouth Inc.) in each of the containers. The light cube in the water lights up brightly but the LED light cube in the mineral oil remains unlit, as shown in Figure 2 below. Teacher asks students what they observed, and if they can explain what happened.

Students have been presented with a demonstration. Not having been told anything about the clear liquids, they may assume that both vessels contain the same clear liquid, water, and that the cold temperature is the reason the LED cube lights up in the clear liquid containing water, but not in the second warm clear liquid. Teacher leaves the question as open-ended and tells students that it will be examined again at the end of the lesson, in about a week.

**FIGURE 2. DEMONSTRATION WITH LED CUBES**

![FIGURE 2. DEMONSTRATION WITH LED CUBES](image)

**EXPLORE**

In the third phase of the 7E cycle, students perform an experiment to understand ionization using a conductivity probe. Conductivity refers to the ability of a solution to carry or conduct electricity or electrical current. Students will work in groups of four. The experiment is described below, after some safety considerations are mentioned.

**Safety**

1. Wear eye protection at all times.
2. Wash your hands with soap and water before leaving lab.
3. Dispose of liquid chemicals in the sink.
4. Dispose of solids in appropriate waste containers.

**Objectives**

The purposes of this laboratory experiment are to:

1. determine how conductivity changes when NaCl crystals are placed in water.
2. develop conceptual models to illustrate ionization in solution through macroscopic, particulate, and symbolic representations.

SOLUTIONS

A liquid solution is a homogeneous mixture that contains a solvent, usually water that contains a dissolved substance in lesser quantity called the solute. For example, if we dissolve 1 gram of sugar in water, then the solute is sugar and the solvent is water.

IONIC SUBSTANCES

Ionic substances are compounds that contain a metal and nonmetal. The metal is a positive ion (cation) and the nonmetal is a negative ion (anion). The positive to negative attractive force holds the ionic compound together. Sodium chloride is composed of a sodium ion, and a chloride ion, and these ions are held together by a positive to negative electrostatic force of attraction, called the ionic bond. Ionic substances are often called salts, and generally exist in a crystalline form containing a lattice network in which the ions form a self-repeating pattern. Ionic substances are brittle and dissolve in water.

Under magnification, a NaCl salt crystal is cubic in shape as shown below in Figure 3 below. Photos in the Figure provide a macroscopic representation of NaCl. On the left are shown cubic NaCl crystals (9) that are between 0.1 and 1 mm in size, while that on the right are shown imperfect NaCl crystals, the large ones being about 2 inches in length.

FIGURE 3. NACL SALT CRYSTALS ON THE MACROSCOPIC SCALE

The cubic macroscopic structure means that at the submicroscopic or particulate level, the sodium and chloride ions must also exist in a cubic structure. In Figure 4 below, the “space-filling” particulate model is shown on the left, while on the right, a “ball-and-stick” model shows a better visualization of the NaCl cubic structure. Notice that the sodium and chloride ions seem to occupy definite positions at the corners of a cube.
Students are told that they will perform an experiment with a conductivity probe to construct a conceptual model that explains what happens when NaCl crystals are placed in water. Their model should explain the role of water. For this experiment, students will work in groups of four, and each group will be given one whiteboard and several colored dry erase markers. Each group member will take responsibility for one of the following tasks: 1) experimenter, 2) white-board recorder, 3) presenter, and 4) manager who also assists other group members. Any type of conductivity detector may be used, but for this experiment a Vernier conductivity probe (10) was used. Before use, it must first be rinsed with DI water, and then calibrated. A single point calibration is sufficient, using a known conductivity standard. Vernier Corporation sells a 12,280 μS/cm standard (11). A picture of the conductivity probe setup is shown below. The probe connects to a PC or Mac (not shown):

**FIGURE 5. CONDUCTIVITY PROBE SETUP**

**PROCEDURE**
Vernier (12) and Nord (ibid) have published experimental procedures for using the Vernier conductivity detector. Students are told to follow the following procedure. Record all measurements and observations in the data table shown below, and also on whiteboards. Using a graduated cylinder, measure out 25 mL of DI water into a small beaker or other container. Next mass out 0.3 – 0.4 g of NaCl (rock salt will do). Measure the conductivity of the water and start a recording a conductivity versus time
After about 30 seconds, add the rock salt to the water, and while stirring, keep recording until there is no change in conductivity.

Volume of DI Water: ___________ Mass of NaCl: ____________________

Conductivity of DI Water: _________ Conductivity of Salt + DI Water: __________

Observations

WHITEBOARDS

Students should be told that their whiteboards should contain the following information:

FIGURE 6. STUDENT WHITEBOARD

EXPLAIN

Students gather round in a circle, and sitting, each group takes a turn presenting their findings as recorded on their whiteboards. Students ask the presenters questions, and provide constructive criticism. The teacher facilitates the discussion, and corrects misconceptions, and clarifies key points. A model whiteboard is shown on the next page:
EXPLAIN USING ANIMATIONS AS PARTICLE REPRESENTATIONS

When students have finished whiteboard discussions, the teacher explains what the conductivity experimental data shows by lecturing, and providing particle representations in the form of animations. Two animations that describe the dissolution of NaCl in water will be discussed. The first of two animations was made using Adobe Flash, and offers a two dimensional (2D) view, while the second animation offers a three dimensional (3D) view and was made using Microsoft PowerPoint. After showing the animations, a discussion should ensue in which students are asked to explain what the animations depict, including explaining the role of water. A note about the animations is in order:

1. The animations oversimplify the the dissolution reaction by showing all the water molecules moving simultaneously, but in nature it does not happen that way.

2. One could alternately show only one H in an O-H bond attracting a chloride ion.

The 2D animation begins by showing a simple 2-dimensional NaCl crystal containing just two NaCl molecules, or four ions:

FIGURE 8. NACL MICROCRYSTAL.

The next frame of the animation shows the crystal in water; and to make it simple, only a few water molecules are shown on the next page:
The water molecules will move toward and surround the salt crystal because positive charges attract negative charges. This happens because the water molecule actually contains a negative pole on its oxygen ($\delta^-$) and a positive pole on its hydrogen end ($\delta^+$). Sodium chloride also contains charges in the form of positive sodium ions, and negative chloride ions. Hence the positive sodium ions attract the negative oxygen end of the water molecule while the negative chloride ion attracts the positive hydrogen end of a water molecule. The NaCl crystal becomes surrounded with water molecules as shown in the picture below where $\delta^-$ and $\delta^+$ represent partial charges on the negative and positive electric poles on the water molecule.

As the water molecules jiggle around due to thermal motion, they pull the sodium and chloride ions out of the crystal lattice, and the NaCl crystal has dissolved:
The animation constructs a microscopic or particulate model that explains what happens when students observe the macroscopic process of salt crystals dissolving in water. Because pictures take up a lot of space, chemists simplify particulate models using another symbolic model, an old friend, the chemical equation:

$$\text{NaCl}(s) \rightarrow \text{Na}^+(aq) + \text{Cl}^-(aq)$$

The solvent water need not be shown in the balanced chemical equation because, although it is necessary for the dissolution, it does not undergo a chemical change.

Last of all students should answer the question, is dissolving salt in water a physical or chemical change? Although the salt can be recovered as NaCl(s) by evaporating the water, the right side of the above equation contains products whose chemical formulas are different than the reactant. Hence ionization by dissolution in water is a chemical change.

The second PowerPoint animation attempts to show NaCl dissolution in three dimensions, and the teacher may suggest that artistic students create their own. As shown in Figure 10 below, the teacher should explain that initially, a NaCl crystal is surrounded by water molecules:

Water molecules then move toward the sodium and chloride ions in the crystal lattice, with their negative oxygen ends pointer toward sodium cations, and their positive hydrogen ends pointed toward the chlorine anions. The result is shown on the left side of FIGURE 11: Finally, thermal motion allows the water molecules to rip the sodium
and chloride ions from the lattice, to give a solution in which the cations and anions are mobile, as shown on the right side of FIGURE 11.

**FIGURE 13. NACL MICROCRYSTAL DISSOLVING IN IN WATER**

![Diagram of NaCl microcrystal dissolving in water](image)

**HISTORICAL CONNECTION**

For this lesson plan, Sweden’s very own Svante Arrhenius is the most important figure to mention.

“The Nobel Prize in Chemistry 1903 was awarded to Svante Arrhenius “in recognition of the extraordinary services he has rendered to the advancement of chemistry by his electrolytic theory of dissociation”.

(13)

**FIGURE 14. SVANTE ARRHENIUS (14, WIKICOMMONS)**

![Image of Svante Arrhenius](image)

**ELABORATE**

Solutions can be classified according to their ability to conduct electricity. Electrolytes conduct electricity whereas nonelectrolytes do not. Electrolytes can be further grouped into two types, strong electrolytes that are good conductors of electricity, and weak electrolytes that are poor conductors of electricity. The classification scheme is shown in Figure 15.
In this section, students will transfer their knowledge from the NaCl in water investigation to other chemical substances including Group 1 salts like KCl and LiCl, Group 2 salts like CaCl2, and MgCl2, a strong acid (HCl) and weak acid (CH3COOH), a strong base (NaOH) and weak base (NH3), a neutralization reaction (HCl + NaOH), and a precipitation reaction (CaCl2 and Na2CO3). All solution concentrations are kept constant at 0.050 M.

The procedure entails having students pour about 25 mL of liquid (using a graduated cylinder) into a small vessel, inserting a calibrated conductivity probe into the solution, and recording the measurement, in a table like the one below (students may create their own tables). Between measurements, the conductivity probe must be rinsed with DI water, and carefully dried with an absorbent towel. Students also classify each substance as either a strong-, weak-, or non-electrolyte.

**TABLE 3. EXAMPLE DATA TABLE FOR CONDUCTIVITY MEASUREMENTS**

<table>
<thead>
<tr>
<th>Solution (0.050 M)</th>
<th>Conductivity μS/cm</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>DI water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaCl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KCl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LiCl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CaCl2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na2CO3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Solution (0.050 M)</th>
<th>Conductivity μS/cm</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>HCl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CH3COOH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaOH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NH3 (NH4OH)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HCl + NaOH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CaCl2 + Na2CO3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mineral Oil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the discussion section of this experiment, students write balanced ionization chemical reaction equations for each reaction. Students must be told that if the substance is a nonelectrolyte, then they write “N.R.” for no reaction on the right-side of the arrow. For weak electrolytes, students are told to use the equilibrium double arrow symbol, \( \rightleftharpoons \), instead of the forward arrow. Students should make connections that the neutralization and precipitation reactions remove ions from solution, so conductivity decreases.
EVALUATION
Evaluate: Formative Assessment

1. Which statement is false about water’s role in the ionization of NaCl(s)?
   a) water is the solvent
   b) water is necessary for ionization to occur
   c) water need not be shown in the chemical reaction equation
   d) water must be shown to balance the chemical reaction equation

2. Four beakers contain equal volumes and equal numbers of molecules of LiCl, NaCl, KCl, and CsCl dissolved in water. Ranking them from low to high conductivity gives:
   a) LiCl < NaCl < KCl < CsCl
   b) LiCl = NaCl = KCl = CsCl
   c) CsCl < KCl < NaCl < LiCl
   d) Conductivity data is required before this question can be answered

3. Four beakers contain equal volumes and equal numbers of molecules of NaCl, CaCl2, and FeCl3 dissolved in water. Ranking them from low to high conductivity gives:
   a) NaCl < CaCl2 < FeCl3
   b) NaCl = CaCl2 = FeCl3
   c) FeCl3 < CaCl2 < NaCl
   d) Conductivity data is required before this question can be answered

4. Which of the following choices correctly show the order: nonelectrolyte, weak electrolyte, strong electrolyte?
   a) water, cooking oil, KF(aq)
   b) KF(aq), water, cooking oil
   c) KF(aq), cooking oil, water
   d) cooking oil, water, KF(aq)

5. In aqueous solution, a weak electrolyte:
   a) mainly consists of ions
   b) mainly contains molecules
   c) contains equal numbers of ions and molecules
   d) contains only molecules

6. In aqueous solution, a strong electrolyte:
   a) mainly consists of ions
   b) mainly contains molecules
   c) contains equal numbers of ions and molecules
   d) contains only ions
7. For a solution of NaCl in water:
   a) water is the solute and NaCl is the solvent
   b) NaCl is the solute and water is the solvent
   c) water acts as both solute and solvent
   d) none of the above

8. Write an ionization equation for KF(s) in water.

9. Write an ionization equation for CaF2(s) in water.

10. A crystal containing three molecules of LiCl are placed in water. Draw initial and final state particle diagrams without showing water molecules.

    Initial State (Reactants)                                      Final State (Products)
EXTEND

PART 1
The scarcity of potable water is a global problem. Students will build a detector to test for water salinity in this last phase of the 7E cycle that extends the 3D NGSS lesson plan into the engineering realm in two ways:

1. by constructing a simple conductivity detector and using it to classify common household substances as strong-, weak-, or non-nonelectrolytes.
2. by figuring out that the LED ice cubes used in the Engage phase of this lesson function on the principle of a conductivity detector.

CONDUCTIVITY OF SOLUTIONS

Name __________________________ Day/Date/ __________________________

Time __________________________ Partner __________________________

ACTIVITY 1:
Building a Conductivity Detector to Test Water Salinity

There are some safety considerations for this exercise:

1. Use alkaline batteries, not lithium batteries.
2. When storing the batteries, their positive and negative terminals must be covered to prevent an electrical fire due to a short circuit.

Take a 9 Volt battery and carefully attach a snap-on connector, and to its wire connected to its negative pole, attach and solder (or tape) a 1 kohm resistor and LED (short wire to negative terminal). Tape the assembly to a cardboard strip with the wires dangaling as shown in the picture below, where the left side shows a electrical circuit schematic, and the right side shows a lit conductivity detector.

FIGURE 16. CONDUCTIVITY DETECTOR CIRCUIT AND GADGET
**ACTIVITY 2:**

**Results: Testing the Conductivity of Household Substances**

Immerse the wire ends of the conductivity detector into the solutions to a depth of about 1/2 inch (but do not immerse the battery or LED). Clean several 50 mL beakers or similarly sized containers with DI water. For liquids, pour about 25 mL into the container. Be sure to rinse and wipe dry the free wire ends in between measurements.

The conductivity tester LED may burn out if kept on for a long time; it is meant to be used on a short term basis. So dip both free ends of the wires into a solution, and make observations within a five seconds. Repeat measurements if necessary. A waste beaker is used to collect used substances. Students can make their own data table that should look like the one below. In the data table, students write “bright,” “dim,” or “off” under the column labeled “LED.” Under the column labeled “Classification,” students write “SE” for strong electrolyte, “WE” for weak electrolyte, and “NE” for nonelectrolyte.

**TABLE 4. CONDUCTIVITY RESULTS**

<table>
<thead>
<tr>
<th>Substance</th>
<th>LED</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distilled water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tap water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaCl (s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NaCl (aq)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isopropyl Alcohol (70 - 90%)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Substance</th>
<th>LED</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vinegar</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemon juice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooking oil</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXTEND**

**PART 2:**

This last **Extend** activity connects to the **Engage** activity, and provides closure to the lesson plan. Students will figure out, and reverse-engineer LED “ice” cubes, and relate them to what they have learned about conductivity. Each student group will be given one LED “ice” cube.

1. Examine an LED cube and write down what you see.

Students should notice that the cube contains batteries, a circuit, inside and two small screws on one side on the outside.
2. Place a jumper wire across the two screws, and press down. Describe what happens.

The light cube lights up, brightly. Therefore the two screws are serving as electrodes.

3. Now place the cube (screws down) in small cups containing about 20 mL of mineral oil, DI-water, a NaCl solution, and 91% isopropyl alcohol. Describe what happened.
4. What do your experimental results show about how the light cube works.

The two screws act as electrodes. The battery inside the cube sends a current through one screw. Ions in the liquid conduct the current to the second electrode screw, completing the circuit, and the LED inside the cube lights up.

The LED cube is a conductivity detector, just like the one constructed in part 1 of this activity. A solution that contains many ions like a strong electrolyte will make the LED glow brightly, while DI contains few ions making the LED glow dim. A nonelectrolyte like oil will cause the LED to remain in the off state.

Going back to the Engage Phase activity, temperature is not a factor determining how the LED cubes work, so ice was not required.

However, the LED cubes are too sensitive to differentiate between some weak electrolytes like vinegar and a strong electrolyte.

FUTURE WORK
LED cubes can be made to glow less brightly by soldering resistors to the screws. A digital multimeter could be added to tie conductivity detector to measure electrical current.

REFERENCES:
Integrated Unit for Fourth Grade: Natural Resources and the Effect on the Environment with Human Impact

Natalie Doherty, Ashlee Pietela, Nikki Wiedbush, and James T. McDonald, Central Michigan University

INTRODUCTION
This fourth-grade integrated unit brings math, science, social studies, and literacy together to examine natural resources, the effect on the environment, and human impact. The lesson takes place over 4 one-hour lessons.

We were put into groups of three and were required to design a unit that would integrate science, social studies, and math using the National Council of Social Studies (NCSS) theme, MDE Social Studies Standards, Next Generation Science Standards, and the Common Core State Standards. Using those resources, we decided to teach our lesson about food webs and how the impact of pollution can negatively affect these food webs. The three types of pollution we focused on were air pollution, land pollution, and water pollution. We used formative and summative assessment to gauge our student’s learning, and the lesson was overall very successful. Our students learned a great deal about pollution, and how they can alter slight aspects of their lives to reduce their ecological footprint.

COMMON CORE STANDARDS DESCRIPTION

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Detailed description of each standard you are discussing for Math and Literacy/Reading/Language Arts.</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCSS.ELA-Literacy.SL.5.</td>
<td>Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.</td>
</tr>
<tr>
<td>CCSS.4.OA.C.5</td>
<td>Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.</td>
</tr>
<tr>
<td>CCSS.4.NBT.B.4</td>
<td>Fluently add and subtract multi-digit whole numbers using the standard algorithm.</td>
</tr>
</tbody>
</table>

STATE SOCIAL STUDIES STANDARDS

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Detailed description of each standard you are discussing.</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.G5.0.1</td>
<td>Assess the positive and negative effects of human activities on the physical environment of the United States.</td>
</tr>
</tbody>
</table>

NCSS THEME DESCRIPTION

<table>
<thead>
<tr>
<th>Theme Number</th>
<th>Detailed description of each NCSS theme you are incorporating.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Time, continuity, and change. In this lesson, we will be showing how pollutants can affect water. Students will see how the water changes when pollution enters. They will also see how pollution affects animals, such as polar bears, due to global warming. They will see how the change in temperature in the arctic due to global warming affects the polar bears lives.</td>
</tr>
</tbody>
</table>
NGSS STANDARDS

<table>
<thead>
<tr>
<th>Standard Number</th>
<th>Detailed description of each NGSS standard and practices you are incorporating. Numbers and letters need to be included; write out the entire standard.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance Expectation</td>
<td>Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.</td>
</tr>
<tr>
<td>Disciplinary Core Idea</td>
<td>Natural Resources: Energy and fuels that humans use is derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.</td>
</tr>
<tr>
<td>Science Practices</td>
<td>Engaging in argument with evidence. 1. Obtaining, evaluating, and communicating information. 2. Developing and using models</td>
</tr>
</tbody>
</table>

DAY ONE

On the first day of our unit lesson, we introduced food chains and food webs to the students. We began by showing the class a video about this topic on a website called BrainPop.com. The video was called “Food Webs” and emphasizes some points about how food webs work. The video went on to answer questions, such as: “Are plants always at the bottom of the food chain?” This video provided a good insight to learning about ecosystems to prepare the students for the activity that they would do later in the lesson. The video thoroughly explained how food webs are connected and what they are composed of. Each part of the food web was broken down so it could be better understood. This is how we could introduce all the vocabulary we would be talking about to the students. There was a quiz at the end of the video that we used as a formative assessment to wrap up the lesson to see how much the students had learned that day about food webs. It was very important for students to gain a strong base knowledge of food webs because it was the building block of our whole unit.

Next, we created an anchor chart to get the students familiar with making their own food chain. We started with producers, then primary consumers, and finally secondary consumers. Each student could create their own food chain and then share what they came up with to the class. The food chains the students created consisted of a producer, primary consumer, and secondary consumer of their choice. The creation of their own food chain showed us that they understood the vocabulary terms introduced during the video. Following this activity, we had the students complete a food web worksheet. The worksheet was comprised of six multiple choice questions which focused on the students filling in the correct vocabulary word. This was followed by two short answer questions that asked the students to develop a deeper level of thinking based on the role food webs play in our ecosystem, as well as why they feel it is important to learn about them. After completing the worksheet, the students paired and shared their answers, which then led to a whole class discussion. Once we knew the students had a clear understanding of food webs, we could move on to the yarn activity.

We used this yarn activity to show an interactive visual of a food web. Each student was handed a note card attached to a string, which was worn as a necklace so everyone could know their role in the food web. There was one sun and the sun always started with the yarn. The rest of the students had roles such as grass, rabbits, and bears (representing each role in the food chain). The sun then threw the yarn to a producer, who threw the yarn to a primary consumer, who threw the yarn to a secondary consumer. Once the yarn reached the
secondary consumer, we cut it and then started it back at the sun. We completed this until everyone was holding a yarn strand.

We then had the sun pull on the yarn and instructed students who felt the pull to also pull on their yarn. We asked the students to raise their hand if they felt the pull (all students had their hands raised). We then asked students to explain why they felt the pull. At that point students could visually see that each role in the food web is important and depends on one another for survival. We then had the primary consumers from the food web drop their yarn to show what would happen if that group wasn’t in the food web. The food web immediately collapsed, which showed the students that food webs need all their components to thrive (Adapted from Web of Life on eekwi.org).

To wrap up our lesson, we visually showed the students the quiz on the Smart Board. We asked students to flip over their worksheet and number the blank side one through ten. We then asked students to answer each question, which was followed by a discussion to make sure all students obtaining the correct answers. We then collected the quiz and could see how much the students knew about food webs based on the lesson. The students did very well on the post-quiz, which showed us that we did not need to go over as much of the information on day two.

**DAY TWO**

On the second day of our integrated unit, we focused on water, land, and air pollution. Before we dove into pollution, we reviewed the yarn activity that we facilitated on day one. Our goal was for students to make connections as to why certain groups of organisms can decrease over time. We allowed them time to talk with their table groups, then we opened the discussion to the class. We were looking for pollution as an answer, but we heard various answers before, such as lack of food or water. One of our students did mention pollution so we were able to expand on that, but if a student did not mention pollution then we planned to pose two questions. One being if they knew what pollution was and the other asking if they thought pollution could play a role in the decrease of a certain organism. During our discussion of pollution affecting organisms, we brought it back to the food chains to show how a food chain could be disturbed due to pollution. We then brought the three types of pollution: air, land, and water into the discussion. We asked students what they knew so far about each type of pollution so we could gauge their prior knowledge. We then counted the class off by 3’s and then split the class into three groups based on the number they received. Each of the three groups was responsible for one type of pollution. Group one was assigned water pollution, group two was assigned air pollution, and group three was assigned land pollution. We designated spots in the room for each of the three groups to work in. The students met in their groups and we proceeded to give directions as to what each group was responsible for.

We went on to discuss KWL (know, what to know, and learned) charts and how each group member was going to utilize it to not only gain information on their own assigned topic, but also to learn more from the other groups about their type of pollution. Each group was instructed to fill out the K section, which represents what they already knew about their assigned pollution type. Next, the students were instructed to move to the W section, which represents what they want to know about their assigned pollution type. We instructed the students to wait to fill out L until further instructed to do so. Since we had three teachers, each teacher could work with a group to help them fill out and discuss points made from
the KWL charts. We gave the groups ten minutes to fill out and discuss points made on their KWL charts, then we introduced our next activity.

We explained that each group was going to make an awareness poster to represent their group’s type of pollution. We went on to explain the requirements for the awareness poster, stating that it needed to have the causes of the pollution, how it affects humans/animals, and what people can do to reduce their pollutant. We explained that the KWL chart could be referenced while making the poster and we also encouraged students to refer to their group discussion as well. We allowed the students about ten minutes to create their posters. We then brought the class back together and explained that the students would finally be filling in the L portion of their KWL chart while they listened to the other groups explain their awareness poster. Each group was considered the ‘expert group’ as they shared their poster aloud with the class. The rest of the class had to write new information they learned in the L section of their KWL chart from hearing the expert group share their poster. We did this with all three groups to sum up our lesson on pollution. While we placed importance on the expert group sharing their information to the class, we also emphasized the importance of listening to other groups to gain new knowledge on each type of pollution. This was an interactive way we could get students involved in their own learning. Students were not only able to pose questions and discuss their thoughts on pollution, but they were also able to share their new-found knowledge in a creative way.

**DAY THREE**

On the third day of our unit lesson, we discussed the effects of pollution on The Great Barrier Reef. We began by teaching students about the three most common types of pollution that have impacted the reef; these three pollutants were acidic runoff, coral bleaching and physical pollutants (i.e. plastic). Once students were familiar with each pollutant, we broke them into three different groups and gave them a pollutant and a bin of water. Group one had food coloring added to their water to represent the effects of acidic runoff. Group two had flour added to their water to represent the effects of coral bleaching. Group three had pepper added to their water to represent physical pollutants. Each group was given coffee filters, a strainer, a fork, and they could also use their hands. Their objective was to use their tools to try to rid their water of the pollutant. After five minutes of students trying to get rid of their pollutant, we transitioned into a whole-group discussion where each group was given the opportunity to discuss their findings. The students in group one explained there was no way to get the food coloring out of the water, so they believe acidic runoff causes permanent damage. The students in group two explained that even though they could get some of the flour out, there was still flour remaining and their water turned cloudy, so the effects of coral bleaching were permanent. The students in group three could get some of the pepper out, but as hard as they tried there was still pepper (plastic) left in their water. From this simulation, students could visually see the lasting impact of pollutants on the ocean, and discussed how instead of trying to clean up the mess after it’s made, we should make efforts to end pollution all together.

After the water simulation, we related pollution back to its impact on animals. A food chain was drawn on the board (seaweed to fish to polar bears) and students were asked what would happen to the polar bear population if fish were affected by pollution and why. Students were then instructed to create their own food chain with a partner to show their understanding of a pollutants effect on the food chain. For this activity, we had students
pick a pollutant of their choice to disrupt their food chain. They then had to create a food chain consisting of a producer, primary consumer, and secondary consumer. Based on these two aspects, the students could discuss how pollution can affect a food chain. When students finished their food chain, pairs were picked to present their findings to the class. All food chains were collected at the end of the lesson for the teachers to review for assessment purposes.

**DAY FOUR**

On the fourth and final day of our integrated unit, we focused heavily on developing a summative assessment that would allow us to see how much the students have learned through the course of our unit. Before jumping into our summative assessment, we did a problem of the day. The problem of the day asked students, “As of 2016, the average temperature in the United States has increased 1.7 degrees since 1880. Estimate what the temperature increase will be in 2150. Show your work and explain your reasoning.” We had students work in their table groups to solve the problem while we circulated the class to monitor students’ progress, and assist where needed. We then allowed students to share their work on the visualizer and explain how they got their answer. This led to a whole group discussion of global warming with the class. We gathered the students’ prior knowledge on global warming and connected it to their knowledge on air pollution which we discussed on day two of our lesson. The students had a lot of prior knowledge on air pollution, so we didn’t spend a lot of time discussing what it was. Instead, we moved ahead to the next part of our lesson that showed students the effects of global warming on animals, specifically the polar bear. We showed before and after pictures of glaciers and polar bears and we also shared graphs that focused on the shift in temperature and decline in organisms due to temperature increase. We fostered conversation with students about what they noticed and dug deeper into their knowledge by having them state why this was occurring.

We then shifted into the main summative assessment of our lesson by playing Jeopardy, which covered our unit as whole. We had the students become a team with their table group. The instructions were made clear at the beginning of the game to avoid confusion. We used an online Jeopardy game through a website called JeopardyRocks.com, which kept score for us, so the team’s job was to simply select a new student on their team each round to stand up and raise their hand when their team knew the answer. If that team got the answer wrong, then we would open the question to the rest of the teams to answer and gain those points. We played this game to wrap up our unit to not only see as teachers what the students have learned, but for the students to feel a sense of closure and accomplishments on their own learning during our unit on food webs and pollution.

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*address all correspondence to this author.
REFERENCES:
Jeopardy Rocks Retrieved from https://www.playfactile.com

WORKSHEET USED FOR DURING DAY 1:
Directions: Choose the correct answer for every statement.

1. All producers are
   a. plants   b. animals   c. aquatic

2. The ________________ is the basis of all food chains.
   a. plants   b. grass   c. sun

3. A ________________ shows how food moves through a community.
   a. food web   b. food chain   c. picture

4. Earthworms and bacteria are examples of
   a. producers   b. decomposers   c. consumers

5. Herbivores eat only
   a. meat   b. plants   c. both meat and plants

6. Meat eating animals are called
   a. carnivores   b. producers   c. decomposers

Directions: Answer each question in complete sentences.

1. What do food chains and food webs tell us about life?

2. Why do you think it is important to learn about food chains?
Integrated Unit: Growth and Development of Organisms and How Humans Modify the Environment for Grade 1

Michelle Black, and James T. McDonald, Central Michigan University

BACKGROUND/INTRODUCTION
In my second semester in my education cohorts at Central Michigan University, I was asked to produce a unit plan incorporating Science, Social Studies, English Language Arts, and Mathematics with first grade standards, and therefore created a unit plan that takes two days and hits a variety of different standards in all of these content areas.

STANDARDS CHOSEN

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description of Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common Core, Mathematics: 1.G.A.2</td>
<td>Compose two-dimensional shapes (rectangles, squares, trapezoids, triangles, half-circles, and quarter circles) or three-dimensional shapes (cubes, right rectangular prisms, right circular cones, and right circular cylinders) to create composite shapes, and compose new shapes from that composite shape.</td>
</tr>
<tr>
<td>Common Core, ELA: LITERACY.W.1.3</td>
<td>Write narratives in which they recount two or more appropriately sequenced events, includes some details regarding what happened, use temporal words to signal event order, and provide some sense of closure.</td>
</tr>
<tr>
<td>Common Core, ELA: LITERACY.W.1.8</td>
<td>With guidance and support from adults, recall information from experiences or gather information from provided sources to answer a question.</td>
</tr>
<tr>
<td>MI State Standard, Social Studies: 1G5.0.1</td>
<td>Describe ways in which people modify (e.g. cutting down trees, building roads) and adapt to the environment (e.g. clothing, housing, transportation).</td>
</tr>
<tr>
<td>NCSS Theme Number: 1</td>
<td>Use materials to design a solution to a human problem by mimicking how plants and/or animals use their external parts to help them survive, grow, and meet their needs.</td>
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</tbody>
</table>
DAY 1: SCIENCE

Due to the amount of content and its needs, this unit plan was broken into two days. On the first day, the first lesson the students would embark on would be their science lesson. To begin, the first graders were given photographs of parents and their offspring, and very much like a matching game, they were to wander around the room until they found the parent and young match (e.g., a student with a robin will ideally match with a baby bird). This is a great activity for active learning, as it gets the students up and moving around throughout the classroom and engaging with one another rather than sitting in their seats for the duration of the lesson. This activity allows for the opportunity to discuss with students how parents have offspring. Students were then eased into a lesson through the use of Nearpod, where we talked about adapting and surviving. NearPod is an interactive feature that allows you to display slide presentations while students can interact with it on tablets or computers in front of them. For this piece, interactive activities featured included an easy definition quiz, drawing an animal that they have seen: (both the parent and the offspring), and an area where they can type what humans do to adapt to weather changes. This presentation’s content primarily incorporated a variety of things like useful terminology (parent, offspring, adapt), how offspring grow and change to survive, and examples to help students understand that. An example of a blue jay was used, and how they learn to fly, how their beak helps them peck into nuts to eat, and how their claws help them grip tree branches. To finalize this lesson, we then asked the students to identify how humans adapt to cold weather, expecting answers like blankets, jackets, houses, and heat through the interactive features. By using NearPod rather than PowerPoint, it gives our students the opportunity to interact with the presentation through drawings and questions. If NearPod or PowerPoint presentations are unavailable in the classroom, it is suggested that these questions take the form of classroom discussion rather than worksheets.

This lesson plan is one of the most hands on, and can be used alone or integrated with the remainder of the unit. It begins with relating the idea of adapting and surviving to children on the level of animals, which will get them thinking about things they might not have thought of prior. This can spark a variety of classroom conversations and different branching science topics about various animals, or even different climates that animals use to survive. The science lesson then eases into humans, and what students know they do to keep warm or safe in environments that they are familiar with. Emphasis can also be put on similarities that animals and humans have in common environments by using productive questions (How would your life be different if you didn’t have your parents to help you grow up? How would life be different if we didn’t adapt to the environment? How do parents help their offspring compared to animals? What do they have in common and what is different?). Essentially,
the science aspect of this unit plan is perhaps the most important because it sets the base for everything the students will learn in the remainder of the unit.

**DAY 1: MATHEMATICS**

The second part of day one concludes with the mathematics lesson, in which students are using manipulative shapes (e.g. triangles, squares, rectangles) to build a house that has no gaps, but fits within the outline on a worksheet that we created. First, though, students will go on a shape hunt throughout their classroom, and point out shapes that they recognize. For example, squares in the windows, or circles on the meeting rug. Getting them familiar with the shapes and letting them explore the classroom will help make them more aware when they go to build their own structure.

Manipulatives are important to use in this lesson because it helps get them familiar with shapes they will be using throughout their mathematics career, and it is problem solving: they are responsible for finding their own patterns and possibilities. Students should be reminded why having a house without holes or gaps is important through different weather changes (e.g. blocking out snow or rain, keeping in cool during summer). As stated, the students’ designs should have no gaps or holes. This means that the manipulatives must fit with one another, and must line up exactly right. Discuss with students why those holes must not be there, and how good structures help us survive. A variety of manipulatives should be provided to the students to learn. For example, great shapes for them to use would be: triangles, squares, rectangles, trapezoids, and circles. (Students will certainly realize that circles are not an ideal shape for leaving no gaps).

**DAY 2: SOCIAL STUDIES**

The second day of this lesson begins with the social studies concepts. Students will work with the teacher to complete the K and W portions of a KWL Chart (what I know, what I want to know, what I learned) regarding the topic “what has changed in our world?” Students, in groups, will look at a PowerPoint that shows different changes over time. Things on this PowerPoint can include cars, clothing, roads, houses, etc. (This can also be a good idea for primary and secondary source discussions). Students will make claims as to what they think has been adapted, and then will be asked to identify what has changed between the two pictures. Students can even talk about why they think those changes are important. To finish up this lesson, students will fill out the L portion of the KWL Chart, recalling what they had learned about the adaptations in the world around us. Students can do this in partner pairs, and then come together as a class to evaluate and discuss what they all learned. By doing this, students will be able to hear things they may not have heard prior, and can begin to think about what they know.

**DAY 2: ENGLISH LANGUAGE ARTS**

In the finale of this unit plan, students partake in the ELA lesson, which also serves as the summative assessment. Provide students with materials to be creative in their space. For example, materials such as paper or construction paper are a necessity; markers, pencils, crayons, colored pencils, or paint can be great additions. Using these materials provided, students will make a story book about a person (it can be themselves, if they so wish), or an animal, moving through time. To give a starting point, an example could be a caveman; as the caveman moves through time, the attire of the caveman should change, as should the environment. If there is a student who may decide to do a caveman, it could start out with
the caveman surrounded by lush forests and rocks, and by the end of the book he could be standing in the middle of the city.

The little book should include things that they learned throughout each of their lessons, and should ideally touch on many different things like homes, clothing, transportation, etc. These storybooks help them recall the concepts, and apply them to something of their creation. Writing in the story books may not be necessary: depending on how you gauge your classroom environment, students can either draw the pictures and be able to describe them, or write a few words to go along with the drawings. Below, you will find a sample rubric for grading these pieces:

<table>
<thead>
<tr>
<th></th>
<th>5</th>
<th>4</th>
<th>3</th>
<th>2</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorporating classroom topics.</td>
<td>Includes 5 changes to: homes, clothing, transportation, area around them, changes to weather.</td>
<td>Includes 4 of the 5 changes.</td>
<td>Includes 3 of the 5 changes.</td>
<td>Includes 2 of the 5 changes.</td>
<td>Includes 1 or 0 of the 5 changes.</td>
</tr>
<tr>
<td>Character(s) in the story.</td>
<td>One or more characters; moves from past to present.</td>
<td>One or more characters; moves almost entirely from past to present.</td>
<td>One or more characters; barely leaves past, past is not accurate.</td>
<td>One or more characters; does not get to present, past is not accurate.</td>
<td>No character throughout the piece.</td>
</tr>
<tr>
<td>Storyline (past to present)</td>
<td>Goes entirely from past to present, hitting all main points.</td>
<td>Gets from past to present, few main points missed.</td>
<td>Gets from past to present, many main points missed.</td>
<td>Past to present is there, but inaccurate.</td>
<td>Do not get from past to present, all points missed.</td>
</tr>
</tbody>
</table>

Students should be graded out of 5 points total. For example, a student may get a 5 on incorporating classroom topics, a 3 on character(s) in the story, and a 5 on storyline (past to present), and divided by 3 (the total areas of points) will get them a 4 on the project.

**THE BENEFITS OF THIS UNIT PLAN**

The benefits to a unit plan structured like this are very apparent. There are a variety of formative assessment strategies riddled throughout the lesson so that an educator can evaluate their students as they learn. Each different content area’s lesson is a hands on process, and allows for the students to explore as they learn. This is apparent through hands on PowerPoints and presentations and different activities. It was important that each was hands on because students can learn better when they are working with their learning; when they can work with the standards hands-on in ways that will make the content more understandable to them, then they will remember the content more. This unit plan also incorporates the Five E’s of Science inquiry: Engage, Explore, Explain, Elaborate, and Evaluate.

**CONCLUSION**

In conclusion, this is a great way to get your students involved in classroom activities in ways that are fun and engaging to them. It provides ideas that the students can connect with on personal levels, and gives them a hands on opportunity to work with their classmates around them. This unit plan presents ideas that might have been previously unfamiliar to
students in ways that are easily comprehensible, and allow room for the educator to build on for future lessons. Integrated units, such as this one, are a great way to create a classroom environment that promotes learning and questioning across contents. It gives the students the opportunity to be in charge of their learning, and each lesson adapts well for all of the different types of learning so that each child can be successful. On top of that, each of these lessons—Science, Social Studies, ELA, and Mathematics—can be easily adapted through different grade levels with minor tweaking, and different standards.

REFERENCES


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*contact for more information
Author Guidelines

HOW TO GET PUBLISHED IN THE MSTA JOURNAL
Twice each year in the fall and spring, MSTA publishes a journal that reaches elementary, middle, and secondary classroom teachers, principals, and science educators. Why not share your ideas with your colleagues?

BEFORE YOU BEGIN
Review the current journal to get an idea of the types of articles that are published. We have two sections:

(1) feature articles that deal with research, MEAP topics, or address a learning theory
(2) classroom ideas that give classroom activities, usually in much the same format as the teachers use in their own classroom.

Write clearly and concisely, organize your material logically, and use an active voice and conversational tone. Write about your firsthand experiences or your unique area of expertise and stress classroom applicability.

You must guarantee the originality of your work. Credit any other author’s ideas that you use or build on. Do not copy illustrations from textbooks. All illustrations must be copyright free.

Your manuscript length can be variable. We have published articles that range from 1-16 pages. On the title page provide each author’s name, current position, mailing address, e-mail address, home and work telephone numbers and fax number.

Cite only direct sources, and use the author-date reference style in the text. Bibliographies and resource lists should be alphabetized and limited to current, readily available items. Check the accuracy of your items carefully.

HOW TO SUBMIT
Email your article to Chris at (cchopp@gmail) in Word format. If your article has specific formatting, please mail a printed hardcopy proof of your article to the editor for formatting reference. Note: If you do not supply a printed hardcopy proof for formatting reference, we can’t be held responsible for formatting errors or inconsistencies.

Photographs should be submitted electronically in high-resolution format (4” x 3”, 300 dpi). Students in lab must be shown following appropriate safety guidelines and wearing proper safety attire, including splash-proof goggles. Their faces should be visible, but they should not look directly at the camera. If the photo is used, a signed model release will be required of each student pictured.

CHECKLIST
☐ Author’s name, current position, mailing address, phone numbers are included with article.
☐ Written clearly and concisely with an introduction and conclusion.
☐ Stresses classroom applicability.
☐ References are complete.
☐ Photos show students following appropriate rules of safety.

DEADLINES: SEPTEMBER 13TH FOR THE FALL JOURNAL & MARCH 28TH FOR THE SPRING