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Experiments, laboratory activities, demonstrations, and other descriptions of the use of chemicals, apparatus, and instruments are illustrative and directed at qualified teachers. Teachers planning to use materials from MSTA Journal should consider procedures for laboratory and classroom safety to meet their local needs and situation. MSTA Journal cannot assume responsibility for uses made of its published material.
Partnership to Promote Interest in STEM Among Underrepresented k-12 Students in Southeast Michigan

By Sandra Yarema, Ph.D.

The U.S. Army Educational Outreach Program (AEOP) is investigating new and innovative ways to form mutually beneficial relationships with like-minded organizations and technical associations that have similar STEM goals, specifically serving students from underserved populations and military dependents. Through its programs, AEOP focuses on three primary goals:

- **STEM Literate Citizenry** – Broaden, deepen and diversify the pool of STEM talent in support of our defense industry base.
- **STEM Savvy Educators** – Support and empower educators with unique Army research and technology resources.
- **Sustainable Infrastructure** – Develop and implement a cohesive, coordinated, and sustainable STEM education outreach infrastructure across the Army.

AEOP’s portfolio of opportunities include *Gains in the Education of Mathematics and Science* (GEMS), summer STEM enrichment at participating Army Research Laboratories; *Camp Invention*, (CI) a weeklong summer day camp for elementary students to develop critical thinking and STEM skills; *Junior Solar Sprint* (JSS) a competition for middle schoolers to create solar vehicles; *e-Cybermission*, a web-based STEM competition for middle schoolers; and the *Junior Science and Humanities Symposium* (JSHS), an opportunity for high school students to present STEM research projects in competition for scholarships.

In collaboration with community and institutional partners, by sharing information, leveraging strong STEM networks, and building on already existing relationships, AEOP intends to promote its programs to better meet objectives, maximize impact, and provide more enriching STEM opportunities for students, such as enabling more AEOP program participants to engage in scientific meetings and technical symposia to showcase their STEM achievements.

One such partnership was established at Wayne State University (WSU), to promote increased participation of underrepresented high school students in the South East Michigan regional JSHS, an existing AEOP program, housed at WSU, to showcase high school students’ STEM research. This partnership engaged 40 students, participating in WSU’s College of Education Upward Bound Program (COE UB), a federally funded program. All COE UB participants qualify as underserved and underrepresented in multiple categories. Students come from families with low income, according to the federal poverty guidelines, where neither parent has earned a college degree. Many students qualify as second language learners. The COE UB program serves two high schools, located in the state’s largest city. Both high schools ranked in the lowest 21% of performing schools in the state. Both schools serve a large number of LatinX and English Language Learner students (more than 50%). Both schools lack resources to prepare students to participate in basic STEM investigations.
While the broad focus of JSHS is to give high-achieving students the opportunity to present their long-term research project to STEM professionals and their peers, the Strategic Outreach Partnership between AEOP’s JSHS and the COE UB program focused on connecting high school students with research mentors and promoting opportunities for the students to engage in authentic research. After participating in COE UB, these students were well-prepared to begin their research with the aim of presenting at the final showcase, the regional JSHS in March of 2019. Developing contacts with students earlier in their research process led to a stronger commitment to the JSHS program by the student participants over time.

In addition to preparing their research projects and presentations for the Southeastern Michigan Regional Junior Science and Humanities Symposium (JSHS), high school students in the Wayne State College of Education Upward Bound Program (COE UB) spent their summer learning about a variety of STEM careers available right in their own backyard. WSU’s COE UB program is a rigorous, pre-college academic preparation program that serves high school students who meet the federal guidelines for being underserved and underrepresented.

In July of 2018, students toured Wayne State University’s Mortuary Science Laboratory to hear about careers in mortuary sciences. They got out of the lab and into the field for biodiversity data collection at Lake Muskegon in Belle Isle State Park, learning how to collect algae to view under a microscope. Students learned about pollinators from Bees in the D, urban beekeepers. They learned how scientists measure drinking water quality at the Regional Detroit Water Treatment facility. They visited the WSU Planetarium and chemistry laboratories, and the Meteorology laboratory and Wind Tunnel Research facility at the University of Michigan.

Through these activities, students were exposed to a variety of STEM career paths and had the opportunity to ask questions about the day-to-day work life and the academic background to prepare for that profession. Students were able to network with potential STEM mentors and cultivate their curiosity as they prepared a research project for the next JSHS. Fifty three percent of the students who participated in the summer program also attended a pre-symposium research workshop. STEM professionals from the community, including Army personnel and WSU faculty, attended and assisted students in preparing their research for presentation.

Wayne State University was the proud host of the Southeastern Michigan Regional JSHS for the 55th year, on March 8, 2019. JSHS is a program supported by AEOP, and administered by the National Science Teachers Association (NSTA). Seventeen students from the COE UB, along with sixteen other students from across Michigan presented their research projects at the JSHS on March 8. Nine additional COE UB students attended as observers. Total participation in JSHS was 30 of the 40 students, or 75%. This partnership between the JSHS and COE UB was extremely successful at engaging underrepresented and underserved students in comparison with the previous year’s regional JSHS. No students who presented in 2018 qualified as underserved, and there was a 43.5% increase from 23 student presenters in 2018, to 33 in student presenters for the regional JSHS 2019.
STUDENT POSTER PRESENTATIONS (ALL POSTERS WERE CREATED BY COE UB STUDENTS):

- The sweet life of Honey bees
- Bees Around Us
- Reviving Detroit Urban Space
- Effects of Turbidity
- Comparing Water Samples: Testing a Store Bought Water Filter, a Home-made Water Filter, and a Naturally Occurring Filter from a Local Creek
- All About Water
- Little Creators
- Does It Bounce and Why
- Bee Aware
- My Day with the Dead
- The Meaning of Water

ADJUDICATED POSTER SESSION (CASH PRIZES: $250, $150, $100):

- 1st Place: Reviving Detroit Urban Space, Deisi Bartolon, Western International H.S.
- 2nd Place: Comparing Water Samples: Testing a Store Bought Water Filter, a Home-made Water Filter, and a Naturally Occurring Filter from a Local Creek, Julian Brammer-Gonzales, Home-School
- 3rd Place: Does It Bounce and Why, Kevin Mendez, Cesar Chavez Academy

PEER-RATED POSTER AWARDS (GIFT CERTIFICATES FOR BARNES & NOBLE):

- “Best in Show”: Comparing Water Samples: Testing a Store Bought Water Filter, a Home-made Water Filter, and a Naturally Occurring Filter from a Local Creek
- “Most Innovative ‘Out of the Box’ Project”: Reviving Detroit Urban Space
- “The Next ‘Steve Jobs’”: The sweet life of Honey bees

STUDENT ORAL PRESENTATIONS (6 COE UB STUDENTS PRESENTED THEIR RESEARCH ORALLY):

- Noise Exposure in the Neonatal Intensive Care Unit
- What the App?!
- Modeling the Mechanisms of Mycophenolate Mofetil (MMF) during active HIV Infection for Potential Cure
- What Do Insects Prefer to Land In?
- Synthesis and Purification of 6-Hydroxy-2-(2-Phenylethyl) Chromones
- Active Learning over DNN: Automated Engineering Design Optimization for Fluid Dynamics Based on Self-Simulated Dataset
- Alternative Filtration Methods and Free Radicals in Hurricane Wastewater
The top 3 Regional finalists were awarded scholarships: $2,000 for 1st place, $1,500 for 2nd place, and $1,000 for 3rd place. The teacher of the 1st place finalist is also awarded $500 for their school.

**TEACHER AWARD**: MS. REBECCA BREWER, TROY HIGH SCHOOL

The Finalists were:

- **1st Place**: Effectiveness of Radiation via Tumor Interstitial Fluid Pressure and Analysis of Correlation with CD44, Cancer Stem Cell Marker, Astha Dalal, Troy High School
- **2nd Place**: Preparation of cationized dialdehyde cellulose from bamboo pulp for anionic dye adsorption, Akash Rathod, Okemos High School
- **3rd Place**: Synthesis and Purification of 6-Hydroxy-2-(2-Phenylethyl) Chromones, Daniel Calco, Kalamazoo Area Math & Science Center
- **4th Place**: Deep Learning-based Context-Aware Super-Resolution for Medical Imaging, Matthew Dong, Troy High School
- **4th Place**: The Effect of Post Transitional Modifications of the Amino Acids of Cytochrome C on Mitochondrial Respiration Activity, Nikhil Mantena, Detroit Country Day School

These finalists will compete at National JSHS, April 24 – 27, in Albuquerque, NM, all expenses paid. First and Second Place will present their research orally, additional scholarship prizes
will be awarded at National JSHS, in each STEM category: $12,000 for 1st place, $8,000 for 2nd place, and $4,000 for 3rd place. 3rd – 5th place finalists will present posters, scholarship or cash prizes in each STEM category will be awarded.

This partnership is anticipated to continue for the next year, with the addition of a residential research internship for participating rising twelfth graders, who will be paired with WSU STEM faculty mentors to work in the faculty’s laboratories to develop individual research projects eligible for regional JSHS competition.

This program is supported by funds from Battelle Memorial Institute, through a competitive partnership, **AEOP Strategic Outreach Initiatives**, from May 1, 2018 through April 30, 2019.

**RESOURCES**

- Army Educational Outreach Program (2019). [https://www.usaeop.com/about/](https://www.usaeop.com/about/)

**REFERENCES**

- Michigan State University (n.d.). Lesson One of Virtual and Place-Based Educational Opportunities with Sturgeon. Retrieved from chrome-extension://bpmcpldpdmajfjgchkefoigmkfalc/views/app.html
- Bay City Times article by Dave Rogers, published April 25, 2013 **STURGEON HERE? Scientists Study Lake Sturgeon Spawning in Saginaw River** Giant Prehistoric Fish Reproduce Every Decade April-June; Is This The Year?

**SUPPLEMENTARY MATERIALS**

Research Experiences for Teachers: Promoting Learning About Computational Tools and Environment (RET:PLACE), accessed at [https://sites.google.com/a/mtu.edu/ret-place/](https://sites.google.com/a/mtu.edu/ret-place/)

Unit Poster: **Sturgeon Stewardship in Saginaw Bay**

Unit overview and lesson plans are available at [https://sites.google.com/a/mtu.edu/ret-place/lesson-plan-units/2017---2018](https://sites.google.com/a/mtu.edu/ret-place/lesson-plan-units/2017---2018) via the “Sturgeon Stewardship in Saginaw Bay—Let’s Bring ‘Em Back, Baby” portal. If you would like the original files, we will be happy to provide them.
As science teachers strive to integrate important NGSS Science and Engineering practices (NGSS Lead States, 2013) into their lessons and curricula, there can be a tendency to skip over helping children understand the “why” behind these practices. That is, curriculum and lesson development might easily become a process of: “Engaging phenomenon? Check!”; “Modeling? Check!”, or “Engaging in Argumentation? Check!” Ensuring that inclusion of science and engineering practices is grounded on students’ clear understanding of the nature of science (Appendix H, NGSS Lead States, 2013) is an important role every teacher plays in developing their students’ scientific literacy and how their students’ view themselves as scientists. Explicit connections to why we engage in science practices provides students with a strong foundation for learning. Student understanding of “WHY” they do various practices may be the most important concept they develop as they engage in science.

Criticism of science and scientific findings seems to be running rampant, in part because many citizens do not have a full understanding the nature of science. That is, if science is simply considered to be a body of unchanging facts to be uncovered, and one really believes this, then it is incredibly disconcerting to have those facts change - even in light of new evidence. For example: “What! Pluto isn’t a planet? Is coffee good or bad for you? The news stories keep changing!” When students understand the underlying tenets related to the nature of science, these will serve as a foundation to the science and engineering practices as they develop scientific literacy and make sense of these otherwise confusing developments as our understanding of phenomena changes.

So what is the classroom teacher’s role in addressing these criticisms? Decades of research have produced a wide-ranging body of information on the Nature of Science, scientific Habits of Mind, and how specific tenets of this work are included in the NGSS and international standards. The NSTA Position Paper on the Nature of Science (National Science Teachers Association, 2000) outlines many of these tenets as does the Next Generation Science Standards. While there is not complete agreement within this lengthy body of research, there are some common ideas that are more generally accepted. When students are engaged in science practices related to the nature of science from the earliest grades, they will be more apt to understand the value, relevance, and complexity of science.

First, what is science? Many sources begin describing the work of science as helping us to explain and understand through specific ways of knowing. Some examples of this include: science is “a way of a way of explaining the natural world” (Appendix H, NGSS, 2013), “science is an attempt to explain phenomena” (McComas and Olson, 2002), or “the principal product of science is knowledge in the form of naturalistic concepts and the laws and theories related to those concepts” (National Science Teachers Association, 2000). To teachers of science these ideas may be clearly understood and implicit, but this is probably not true for students. I recall
asking my son, a first grader at the time, “What is science?” I asked because I knew his teacher was engaging her students in studying natural phenomena, collecting data, conducting investigations, and assisting her students in learning how to answer their own questions about the world around them. His response? He stated, “Well, it’s like what you read in the big books.” He was referring to the large textbooks his older brothers and sisters routinely brought home to study. You might imagine that he and I subsequently had lots of discussions about science and what “doing science” means! As I read his weekly journal, I witnessed that our discussions resulted in changes in his ideas about the science he was learning in his first grade classroom (Figure A).

Consider the description of science as “an attempt to explain phenomena” (McComas & Olson, 2002). This description makes it more clear why we might launch a unit or lesson by using scientific phenomena. Of course, there will also be many other considerations with respect to choosing appropriate phenomena (McKenna, T.J. & Zieminski C., Phenomena for NGSS). When a teacher launches a discussion about phenomena with a clear explicit statement related to the nature of science, the important language s/he chooses will reinforce the connection between classroom work and the nature of science. For example, “We understand that scientists attempt to explain the natural world and in our science unit we are going to attempt to explain….” This type of statement seems so basic and explicit, and yet it is something that is often missing as we engage students in science and engineering practices.

We could think of the nature of science and the work of scientists as consisting of a set of disciplinary norms. Many of these norms are implicit to us and, hence, the word “norm” makes sense as it represents a widely shared “normal” way we engage in science. This requires that we, as teachers, make these norms explicit to our students, because they are likely not normal at all with respect to how our students think about science or scientific work. Alongside these norms are disciplinary routines through which we engage in the norms. Within the work of teaching any subject area, not only science, teachers strive to help students understand the norms and routines of each disciplinary area. For example, what does it
mean to be an author, an artist, a reader, a citizen, or a scientist? How does the work in these fields mirror what we are doing in class? “Implementing norms and routines” is one high-leverage teaching practice that is described as part of a set of high-leverage teaching practices (University of Michigan, 2016) involving the work that teachers do to help students understand these connections:

Implementing norms and routines for classroom discourse and work: Each discipline has norms and routines that reflect the ways in which people in the field construct and share knowledge. These norms and routines vary across subjects but often include establishing hypotheses, providing evidence for claims, and showing one’s thinking in detail. Teaching students what they are, why they are important, and how to use them is crucial to building understanding and capability in a given subject. Teachers may use explicit explanation, modeling, and repeated practice to do this. *(High Leverage Practices, 2016)*

Considering the norms of science in the context of the nature of science and the NGSS science and engineering practices, it becomes clearer why we engage students in various kinds of work such as investigations, modeling, or argumentation. Routines, such as specific NGSS practices, can support students as they learn to enact science and engineering norms. To assist teachers in making these connections, some examples, along with language suggestions are found in Table 1.

<table>
<thead>
<tr>
<th>Some Generally Agreed-Upon Science Norms</th>
<th>Associated NGSS Science and Engineering Practices</th>
<th>Teaching Language for Younger Students to Support Why we Engage with this Practice</th>
<th>Teaching Language for Older Students to Support Why we Engage with this Practice</th>
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</thead>
</table>
| Science is our attempt to understand and explain the natural and materialistic world | Asking Questions and Defining Problems | Scientists work to develop explanations for what might be happening.  
*What would be a good way to phrase the question we are trying to answer? How can our question lead us to an investigation?* | Scientists ask questions that are generated from observations or arise from empirical evidence.  
*How can the questions we have listed be refined to show relationships among variables and help us understand phenomena?* |
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| Constructing Explanations and Designing Solutions | Remember, scientists work to provide explanations. We have done a lot of work and research to figure out some possible answers to what is happening for our question.  

*Now it is time for you to think about all of this work, and the evidence, to develop your explanation. What is your claim? What evidence from your investigation can you use to support your claim?*  

Scientists use scientific evidence to provide explanations.  

*Now you are going to use evidence from your research or investigation to provide an explanation to the question.*  

*Your goal is to use scientific reasoning to show relationships you find between your evidence and your explanations.* |
| Obtaining, Evaluating, and Communicating Information | Even when scientists have strong evidence to support their ideas, if they communicate it in ways that are not logical or do not make sense, then others may not understand.  

*So when you communicate think about how you can best help others understand what your evidence is, what you believe it means, and what you want others to understand about your work.*  

Scientists obtain and evaluate information from text and other media to support conclusions and findings.  

*When you write or talk about your conclusions, it is important to discuss the sources you used to support your ideas.*  

Scientists communicate their ideas or technical information to address a question or solve a problem.  

*Think about how you can organize your findings so that they can be understood easily by others.* |
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</table>
| Science is a creative endeavor           | Developing and Using Models                      | Science is a creative process. Sometimes we need to creatively think about what might be happening even when we can’t observe it directly. Doing science requires that you think deeply and creatively about what might be happening based on your observations and what you are thinking.  
*When you develop your model, I want you to do this – base your model on your observations, and your creative thinking.* | Scientists develop and use models to help explain a phenomenon or a scientific principle. Models often are used to describe unobservable components or predict phenomena.  
*Creating a model is your license to be creative - to take the ideas you have in your head and make them visible and understandable to others.* |
| Scientific knowledge and claims are supported by empirical evidence | Analyzing and Interpreting Data                  | In science, claims must be supported by evidence.  
*Look carefully at your data. How does the data you collected provide the evidence to answer our question?* | In science, data is organized and interpreted so that it can be used as evidence. As scientists analyze data they look for patterns as well as causal and correlational relationships.  
*Look at your data carefully. How can you use the data you collected to make sense of this phenomena?* |
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</tr>
</thead>
<tbody>
<tr>
<td>Planning and Carrying Out Investigations</td>
<td>Scientists use evidence to make claims.</td>
<td>Scientists conduct investigations to gather data to be used as evidence to support claims about phenomena.</td>
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<tr>
<td></td>
<td><em>We need figure out how to investigate our question to get information, or evidence, that will help us to make claims about the answer to our question. How can we make this a fair test so that we find out more about our question?</em></td>
<td><em>Think about how you can control variables. What are the best and most appropriate tools to use for your investigation? Will your method and data collection process allow you to collect evidence that will answer the question and support your subsequent claims?</em></td>
<td><em>Think about how you can control variables. What are the best and most appropriate tools to use for your investigation? Will your method and data collection process allow you to collect evidence that will answer the question and support your subsequent claims?</em></td>
</tr>
<tr>
<td>Using Mathematics and Computational Thinking</td>
<td>Scientists support their explanations with observations and evidence. Sometimes they use mathematics as a tool to make sense of their observations</td>
<td>Scientists use mathematical tools to help analyze and interpret data.</td>
<td>Scientists use mathematical tools to help analyze and interpret data.</td>
</tr>
<tr>
<td></td>
<td><em>Math is a great tool for scientists. We will be using mathematics to make sense of our observations.</em></td>
<td><em>How will you use mathematics to support your conclusions? Look for patterns? or solve the problem?</em></td>
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| Science knowledge is tentative and is open to revision in light of new evidence | Engaging in Argument from Evidence | The science we know from scientists is based on lots and lots of convincing evidence. However, rarely, new strong evidence is found and then knowledge changes.  
When we discuss [...] and we think about what we believe, let’s be sure to support our claims with evidence but also be open to other ways of thinking about what we believe when we hear other evidence. | Scientists use and compare evidence to support their claims. They provide and accept critiques about explanations or models to refine conclusions. Are you ready to support your claims with evidence? Are you ready to listen to critiques and questions that others may have about your work? Are you ready to consider evidence that others have found that might be different than your own? |

Each and every one of us plays an important role in ensuring scientific literacy and appreciation for science in future generations. Connecting our classroom work with students directly and explicitly to the work of scientists helps to answer the questions students have related to “why” we engage in science practices. When they learn that Pluto is no longer a planet, they may seek to find out more about what new evidence has emerged. When attempting to understand whether a food product such as coffee is good or bad for you, they will take a deeper dive into the scientific study, the evidence, and the argument in the context of other studies. The connections teachers make during science teaching helps students to see themselves as scientists and scientifically literate citizens who can continue to evaluate claims, argue with evidence, make their conclusions public, and seek to understand the world around them.

REFERENCES:


Gifted Education in the Science Classroom

By Emily Kwon, 8th Grade Physical Science Teacher, Emerson School, Ann Arbor, MI

ABSTRACT:
The purpose of this exposition is to portray the importance of nurturing a gifted learner’s need to explore, analyze and develop critical thinking skills in the science classroom. Research that illustrates the importance of proper curriculum is portrayed, and reasoning for its importance is provided. The focus of this account works the reader through the 7E pedagogical method, and how it is utilized in a gifted science classroom. It is based on a unit of study of physical and chemical changes, and how it applies to the Law of Conservation of Mass, supporting Next Generation Science Standards MS-PS1-2 and MS-PS1-5. The unit being portrayed is geared towards a gifted 8th grade physical science classroom in a K-8 Independent School for Gifted Students.

INTRODUCTION:
"What we want to see is the child in pursuit of knowledge, and not knowledge in pursuit of the child." (George Bernard Shaw.) What this quote suggests is that educators should inspire an embrace of the learning process, and not merely meet students at their performance levels. This especially holds true for gifted and talented students. Gifted learners should be offered the opportunity to learn in a way that goes beyond acquiring information in a fundamental manner. Presenting these learners with the task of generating ideas, finding solutions, and producing results allows them to not only obtain knowledge but also advance their cognitive development. Oftentimes, there is a lack of general educators’ training in gifted education, coupled with the pressure to raise the test scores of struggling students. This could be doing a disservice to higher level learners. The science classroom is the perfect opportunity to provide gifted students an environment with which they can flourish. Teachers seek strategies that aim to engage students, motivate them to learn, and guide them toward skill development.

One of the ways to do that is by incorporating inquiry-based approaches like the 7E (expanded 5E) model, which is grounded in active learning. Educators J. Myron Atkin and Robert Karplus argued in 1962 that there is a learning cycle that facilitates learning in a set order of events. Three key elements: exploration, introduction to vocabulary, and concept application allowed learners to become interested in the subject, raise questions, and identify points of dissatisfaction with their current understanding. The findings of Atkin and Karplus inspired the creation of the 7E model, which focuses on allowing students to understand a concept over time through a series of established steps, or phases. These phases include Elicit/Engage, Explore, Explain, Elaborate and Evaluate/Extend. [6] This written report will portray a unit of study, “Physical and Chemical Changes”, which takes students on a journey through the 7E pedagogical approach. It will emphasize the importance of offering gifted learners the opportunity to explore, analyze, and develop critical thinking skills.
RESEARCH:
Gifted students face a number of challenges in the field of education, although they play an important role in the development of societies. Gifted students are the most neglected group of children with special needs. Educational programs designed for students with normal development do not address gifted students, and educational programs specific to gifted students do not apply to formal public schools. Gifted students need gifted programming in many cases because the “general education program is not yet ready to meet the needs of gifted students” due to lack of general educators’ training in gifted education and the pressure classroom teachers face to raise the performance of their struggling students. Gifted and talented students, and those with high abilities, need gifted education programs that will challenge them in regular classroom settings and enrichment in accelerated programs to enable them to make continuous progress in school. According to the Next Generation Science Standards (NGSS) gifted and talented students may have unique characteristics such as intense interests, rapid learning, motivation and commitment, curiosity, and questioning skills. Teachers can employ effective differentiation strategies to promote science learning of gifted and talented students in four domains: (1) fast pacing, (2) level of challenge, including differentiation of content, (3) opportunities for self-direction, and (4) strategic grouping. Gifted programming positively influences students’ futures. Several longitudinal studies have shown that gifted programs have a positive effect on students’ post-secondary plans. For example, studies found that 320 gifted students identified during adolescence who received services through the secondary level pursued doctoral degrees at more than 50X the base rate expectations. In a follow-up report on the same study participants at age 38, 203 participants, or 63%, reported holding advanced terminal degrees (master’s and above). Of these, 142 (44%) held doctoral degrees and 8 of these 142 had more than one doctoral degree. As a benchmark for this accomplishment, the authors of this study compared these rates to the general U.S. population, noting that only approximately 2% of the general population held a doctoral degree according to the 2010 U.S. Census. While some commonalities exist across giftedness, one size does not fit all. Gifted learners exhibit different characteristics, traits, and ways to express their giftedness. Various issues must be considered for identification: Giftedness is dynamic, not static. Giftedness is represented through all racial, ethnic, income levels, and exceptionality groups. Giftedness may be exhibited within a specific interest or category—and even a specific interest within that category. Early identification in school improves the likelihood that gifts will be developed into talents. Differentiation as a response to student readiness is acknowledged by Bransford, Brown, and Cocks (1999) and Vygotsky (1978, 1986), who support the perspective on teaching and learning that a “teacher’s job is to push the child into his or her zone of proximal development, coach for success with a task slightly more complex than the child can manage alone and, thus, push forward the area of independence”. If instruction is presented at or below the child’s level of understanding, there will be no growth in learning. As stated by Byrnes (1996), “instruction should always ‘be in advance’ of a child’s current level of mastery.” Differentiation of curriculum and instruction as a response to student interest is linked to motivation, short- and long-term impacts on learning, productivity, achievement, creativity, student autonomy, acceptance of challenge, and persistence with tasks.
### 7E LEARNING CYCLE

Table 1: The 7E Learning Cycle, incorporating a description of each phase through the unit of study, and expected outcomes.

<table>
<thead>
<tr>
<th>Cycle Phase</th>
<th>Description</th>
<th>Outcome</th>
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</thead>
<tbody>
<tr>
<td>Elicit</td>
<td>Determine prior knowledge of content through a small group card sort.</td>
<td>Results of the card sort will display their current understanding of vocabulary terms and content.</td>
</tr>
<tr>
<td>Engage</td>
<td>Pique student interest and curiosity through the small group card sort.</td>
<td>Students will become curious about the new unit, and wonder whether the results of their card sort were correct. The correct answers are not divulged until later.</td>
</tr>
<tr>
<td>Explore</td>
<td>Investigate content by completing the “Cotton Candy Exploration”</td>
<td>Students will identify and describe physical and chemical changes through exploration.</td>
</tr>
<tr>
<td>Explain</td>
<td>Address misconceptions through analyzing the content, and organizing information into a Venn Diagram and “Comparing Concepts Chart” using classroom curriculum as a guide.</td>
<td>Physical vs. Chemical Properties of Matter Venn Diagram will help clarify their understanding of content, and a “Comparing Concepts” diagram will require them to synthesize how this relates to the Law of Conservation of Mass.</td>
</tr>
<tr>
<td>Elaborate</td>
<td>Solidify understanding through a creative Comic Strip Activity.</td>
<td>Physical and Chemical Changes Comic Strip Activity will demonstrate their synthesis of the information into a creative and artistic comic strip.</td>
</tr>
<tr>
<td>Evaluate</td>
<td>Formative and summative assessments.</td>
<td>To assess their understanding of the content through formative assessments during the full duration of the unit, concluding with a summative assessment.</td>
</tr>
<tr>
<td>Extend</td>
<td>Demonstrate understanding of content by designing a lab.</td>
<td>Experimental Design Lab will demonstrate the Law of Conservation of Mass.</td>
</tr>
</tbody>
</table>

### 7E FLOW CHART GRAPHIC:

Table 2: The 7E flow chart graphic, created to show the continuous flow throughout the cycle.
ALIGNMENT WITH NGSS:

Table 3: Alignment with NGSS

<table>
<thead>
<tr>
<th>MS-PS1-2 Matter and its Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.”</td>
</tr>
<tr>
<td>Science and Engineering Practices:</td>
</tr>
<tr>
<td>“Analyze data in 6-8 builds on K-5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.</td>
</tr>
<tr>
<td>• Explore Phase: Students will identify and describe physical and chemical changes through Cotton Candy Exploration.</td>
</tr>
<tr>
<td>Disciplinary Core Ideas:</td>
</tr>
<tr>
<td>PS1.A: Structure and Properties of Matter: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.</td>
</tr>
<tr>
<td>PS1.B: Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants.</td>
</tr>
<tr>
<td>• Explore Phase: Students will identify and describe physical and chemical characteristics through Cotton Candy Exploration, that in a chemical process the atoms that make up the original substances are regrouped into different molecules.</td>
</tr>
<tr>
<td>Crosscutting Concepts:</td>
</tr>
<tr>
<td>Macroscopic patterns are related to the nature of microscopic and atomic-level structure.</td>
</tr>
<tr>
<td>• Extend Phase: Students will observe macroscopic patterns related to microscopic atomic patterns through the demonstration of the Law of Conservation of Mass.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>MS-PS1-5 Matter and its Interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Develop and use a model to describe how the total number of atoms does not change in a chemical reaction and thus mass is conserved.”</td>
</tr>
<tr>
<td>Science and Engineering Practices:</td>
</tr>
<tr>
<td>Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems.</td>
</tr>
<tr>
<td>• Extend Phase: Students will develop, use, and revise a lab demonstration to describe, test, and predict abstract phenomena of the Law of Conservation of Mass.</td>
</tr>
<tr>
<td>Disciplinary Core Ideas:</td>
</tr>
<tr>
<td>Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change.</td>
</tr>
<tr>
<td>• Extend Phase: Experimental Design Lab will demonstrate the Law of Conservation of Mass, the total number of each type of atom is conserved, and thus the mass does not change.</td>
</tr>
<tr>
<td>Crosscutting Concepts:</td>
</tr>
<tr>
<td>Matter is conserved because atoms are conserved in physical and chemical processes.</td>
</tr>
<tr>
<td>• Extend Phase: Students will observe that matter is conserved in physical and chemical processes through the Experimental Design Lab, which demonstrates the Law of Conservation of Mass.</td>
</tr>
</tbody>
</table>

ELICIT/ENGAGE PHASE:
The 5E pedagogical model suggests instruction should include the following methods: Engage, Explore, Explain, Elaborate, and Evaluate. The proposed 7E model expands the ‘Engage’ element into two components; both ‘Elicit’ and ‘Engage’. Research in cognitive science has shown that eliciting students’ prior knowledge is an essential part of the learning and teaching process. [5] Formatively assessing students’ prior knowledge allows an educator to appropriately structure lessons that are tailored to the needs of the individual students. This step is crucial in a gifted classroom, because the ultimate goal of the teacher is to meet
the students where they are at academically, and take them to the next level. In this unit of study, the students were introduced to the essential question, “What are physical and chemical properties of matter, and how do they apply to the Law of Conservation of Mass?” Prior knowledge and understanding of this subject matter was elicited through a small group card sort activity. Groups of approximately 2-3 students were given an envelope with strips of paper that included phrases and images. They were assigned the task of sorting the phrases and images into two categories: Physical versus Chemical. By circling amongst the groups, listening to conversations, asking guiding questions, and viewing their results, some insight into their prior knowledge is formatively gained. Noting misconceptions, as well as accurate results, provides the teacher with an understanding as to how to build lessons appropriate to the students. This is coupled with the Engage phase of the 7E model, because as students are reading and manipulating the cards which will portray their prior knowledge, they are also starting to ponder and question the new concepts at hand. They were given the opportunity to engage with a small group of peers to pique their curiosity of the subject matter. Upon the completion of the card sort, students were instructed to carefully relocate their set to a safe place on the table. The answers were not going to be immediately divulged, but discovered throughout the remainder of the day’s work. The outcome of the card sort displayed evidence of previous knowledge from various students; however, there were also a variety of mistakes evident. This card sort activity alluded to misconceptions, or lack of knowledge of content. Figure 1 displays a copy of the card sort, which was cut into strips and placed into an envelope for each group.

Figure 1: Physical and chemical properties of matter, a small group card sort activity presented during the Elicit/Engage phase of the 7E pedagogical model.

<table>
<thead>
<tr>
<th>Chemical</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silver necklaces tarnish and turn black.</td>
<td>Copper conducts electricity</td>
</tr>
<tr>
<td>Helium does not react with any other element.</td>
<td>Some magnetic attractions can work at a distance.</td>
</tr>
<tr>
<td>Acid in tomato sauce can corrode aluminum foil.</td>
<td>Barium melts at 725°C</td>
</tr>
<tr>
<td>A piece of charcoal, which is mostly the substance carbon, glows red, gives off heat, and becomes a gray ash.</td>
<td>A bar of lead is more malleable than a bar of aluminum of the same size.</td>
</tr>
<tr>
<td>Gold is nonflammable</td>
<td>The sugar fully dissolved in the water, and the water became oversaturated.</td>
</tr>
<tr>
<td>Alka-Seltzer tablets react with water to produce gas.</td>
<td>A frozen ice cube melts into liquid water, which later evaporates into a gas.</td>
</tr>
</tbody>
</table>

https://www.pexels.com/royalty-free-images/
EXPLORE PHASE:
The Explore phase of the 7E model allows students to investigate the content. The teacher guides students toward coherent and consistent generalizations, helps students with distinct scientific vocabulary, and provides questions that help students use vocabulary to accurately explain the results of their explorations. The distinction between the Explore and Explain components ensures that concepts precede terminology. In this unit, students were involved in a Cotton Candy Demonstration which took the students through the process of predicting, testing, and identifying physical and chemical properties of matter. This aligns the MS-PS1-2 Matter and its Interactions Science and Engineering Practices: “Analyze data in 6-8 builds on K-5 and progresses to extending quantitative analysis to investigations, distinguishing between correlation and causation, and basic statistical techniques of data and error analysis.” Disciplinary Core Ideas: PS1.A: Structure and Properties of Matter: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it. PS1.B: Chemical Reactions: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. While the students may not have been able to identify and describe appropriate vocabulary terms, they are delved into the exploration as small groups. Included in this exploration, as seen in the handout provided to the students in Figure 2, students were able to categorize phrases as either physical or chemical properties of matter. With their lab partner they observed the physical properties of cotton candy including color, texture, luster, malleability and solubility. Reactivity through cooking in a pot using a hot plate, as well as direct contact with an open flame testing for flammability tested chemical properties. Gas production as a result of the combination of warm water and yeast in an Erlenmeyer flask with balloon also demonstrated reactivity. Safety precautions described the importance of not consuming any of the demonstration supplies, using caution around open flames as well as a burner, using hand protection, as well as tying back long hair and loose clothing. Goggles were also worn during this exploration. Directions given were purposefully vague in nature, which then allowed students freedom in their inquiry and investigation. Following the explorations, students were instructed to independently reflect on their current understanding by answering concluding questions. Figure 2 on the subsequent page presents the handout students completed while exploring physical and chemical properties of matter.
COTTON CANDY EXPLORATION
“WHAT ARE PHYSICAL AND CHEMICAL PROPERTIES OF MATTER?”

Purpose: To identify and describe the physical and

Directions: Observe the sample of cotton candy, and determine the physical and chemical properties listed in the table below using materials provided.

<table>
<thead>
<tr>
<th>Property</th>
<th>Prediction</th>
<th>Observations</th>
<th>Physical</th>
<th>Chemical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color/ Texture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Luster</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Malleability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Solubility</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reactivity when heat is applied</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flammability</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gas Production</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Analysis:
1. How do you determine whether a change is chemical or physical?

2. How would understanding the properties of matter be helpful in other fields of study besides chemistry?

EXPLAIN PHASE:
The Explain phase is oftentimes led by the teacher, and provides the students opportunity to synthesize new knowledge and clarify misunderstandings or misinterpretations gained during the Explore phase. Oftentimes, teachers might utilize a text, video, computer software, or other aides to boost understanding. [6] During this unit of study, the students were offered the opportunity to elucidate misinterpretations or confusions through the class
Students are instructed to create a Venn Diagram along with a digital lesson in order to organize their thoughts. The Venn Diagram was labeled as a comparison and contrast of the terms Physical versus Chemical Properties of Matter. In one section of the Venn Diagram, students synthesized information about physical properties of matter including, but not limited to: density, conductivity, solubility, magnetism, melting point, boiling point, malleability, and state of matter. The same process was performed for chemical properties, including concepts such as reactivity and flammability. The students record information acquired, and prior knowledge is confirmed. Students were then asked to reflect on their learning and apply it towards the completion of the center portion of the Venn Diagram. Students were required to generate ideas to create a comparison of the concepts discussed. The outcome resulted with many students describing intrinsic properties of matter in the center part of the Diagram, representing a similarity between physical and chemical properties. It was described that intrinsic properties do not vary with the amount or form of a substance. In another Explain phase activity, students were given the task of creating a direct comparison between physical and chemical changes, and how they relate to the Law of Conservation of Mass by completing a “Comparing Concepts” Diagram. Students answered the questions “How do you know when a physical change has occurred?” “How do you know when a chemical change has occurred?” Upon answering these questions with definitions and examples, they directly related this to the concept of Conservation of Mass. They recognize that regardless if a change has occurred, matter cannot be created nor destroyed only rearranged. To conclude the Explain phase, students were tasked with a wrap up activity that required them to identify a physical or chemical change in diagrams depicting particles undergoing a change. Students should identify individual atoms and recognize if they underwent a physical or chemical change based on the arrangement of the particles. A formative analysis of the students work performed by the teacher, along with strategic questioning and group discussion allows the teacher insight into their level of understanding. Misunderstandings should be addressed and clarified prior to moving towards the next phase. Figure 3a below shows a student sample of a Venn Diagram completed by an 8th grade student in the gifted program. Figure 3b shows a student sample of “Comparing Concepts” in which students related the Law of Conservation of Mass to physical and chemical changes. Figure 3c portrays the physical or chemical change wrap up activity.

Figure 3a: Student sample of Physical vs. Chemical Properties Venn Diagram
Comparing Concepts

“What are physical and chemical changes of matter?”

How do you know when a physical change has occurred?

A physical change is a change that affects one or more physical properties of a substance. You know when a physical change occurs when the identity of the substance has not changed.

How do you know when a chemical change has occurred?

A chemical change occurs when a substance changes into a new substance with different properties. You know that a chemical change has occurred if it changes the identity of the substance. Chemical changes aren’t always easy to see, signs of chemical changes are color, odor, precipitate, etc.

How do these relate to the Law of Conservation of Mass?

It doesn’t matter if a substance has a physical change or a chemical change, the Law of Conservation of Mass states that the changes can’t create or destroy mass.
The Elaborate phase of the 7E model focuses on giving students the opportunity to apply what they’ve learned, which facilitates a deeper understanding. This phase allows students to cement their knowledge of the content before they are evaluated. [6] The Elaborate phase provides the opportunity to apply their knowledge, which also might raise new questions and concepts to investigate. In this unit, students were challenged with a comic strip assignment. Students were instructed to create and design a comic strip that would demonstrate their understanding of physical and chemical changes, as well as incorporate their creativity and imagination into their portrayal. The grading rubric, as shown in Figure 4a, required students to include an appropriate amount of content into illustrated scenes. Dialogue included should present a storyline, while labeling of physical and chemical changes exemplified their understanding of the content. Creativity and neatness were also considered in the assessment of this assignment. The outcome of the comic strip activity, overall, yielded a successful demonstration of their knowledge of content, while stimulating their creativity. Figure 4a contains the Comic Strip Grading Rubric, while Figure 4b represents one student sample of an 8th grade gifted student’s submission.
### Comic Strip Grading Rubric

<table>
<thead>
<tr>
<th>Requirements</th>
<th>Point Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content:</td>
<td>10 points</td>
</tr>
<tr>
<td>✓ The comic strip should contain two examples of physical changes and two examples of chemical changes</td>
<td></td>
</tr>
<tr>
<td>Illustrated Scenes:</td>
<td>10 points</td>
</tr>
<tr>
<td>✓ Color should be utilized, and appropriately detailed illustrations created.</td>
<td></td>
</tr>
<tr>
<td>Dialogue:</td>
<td>5 points</td>
</tr>
<tr>
<td>✓ The comic contains a story, or dialogue, that presents a storyline.</td>
<td></td>
</tr>
<tr>
<td>Labeling:</td>
<td>5 points</td>
</tr>
<tr>
<td>✓ Chemical and physical changes are defined and labeled. It is clear to understand.</td>
<td></td>
</tr>
<tr>
<td>Creativity:</td>
<td>5 points</td>
</tr>
<tr>
<td>✓ Appropriate amount of creativity is obvious, and the comic style story line is evident.</td>
<td></td>
</tr>
<tr>
<td>Neatness:</td>
<td>5 points</td>
</tr>
<tr>
<td>✓ Obvious care went towards being neat.</td>
<td></td>
</tr>
<tr>
<td><strong>Total Possible</strong></td>
<td><strong>40 points</strong></td>
</tr>
</tbody>
</table>
Figure 4b represents one student sample of an 8th grade gifted student’s submission.
EVALUATE PHASE:

While formative assessments are being performed by the educator throughout the entirety of the 7E process, the Evaluate phase implies educators perform both summative as well as formative assessments. It should be determined whether or not the students have a complete grasp of the core concepts throughout the entirety of the 7E process. It is also helpful to note whether students approach problems in a different way based on what they learned. [6] In a gifted classroom, it is imperative to offer opportunities for higher level questioning during the Evaluate phase. With reference to Bloom’s Taxonomic Levels of Questioning, [11] there are a variety of leveled questions to offer. Evaluation should require gifted students to not only portray memory of previously learned material, but also present and defend ideas, make judgments about information, compile information in new patterns, synthesize solutions, make inferences, and solve problems in new situations by applying acquired knowledge in a different or new way. During the unit of study being portrayed in this report, there was a plethora of questioning techniques provided. For example, multiple-choice requires students to recall facts in order to apply this information to new situations. Identification of physical versus chemical changes based on a statement is also a comprehension style of questioning that was provided. Students were required to synthesize a new situation when asked to relate the Law of Conservation of Mass to the act of dry ice converting into carbon dioxide gas through sublimation. The average of all 41 eighth graders who took this summative assessment was calculated as 90.3%. This demonstrates an appropriately rigorous assessment, and students who were well prepared for success. During a summative assessment, gifted students should be accustomed to the exposure to a variety of styles of questions requiring both recollection of knowledge as well as the application of analysis to new situations. What is crucial for educators to remember, however, is that formative evaluation must take place during all interactions with students throughout the entirety of the 7E process. Figure 6 shows an excerpt from the summative assessment given based on this described unit of physical and chemical properties of matter, which includes a variety of levels of questioning techniques.
“Properties of Matter” Quiz

1. A student measured the mass of ice in a glass container with a tight lid. He allowed the ice to melt and then found the mass of the container, its lid, and its contents again. What conclusion could he draw based on the masses he measured?
   a. No matter how tight the lid is, some mass is lost when a solid melts.
   b. The liquid formed from a melted solid has less mass than the solid has.
   c. The liquid formed from a melted solid has the same mass as the solid has.
   d. The liquid formed from a melted solid has a greater mass than the solid has.

2. The law of conservation of mass states that mass cannot be created or destroyed. To what type of change does this law apply?
   a. Physical changes only
   b. Chemical changes only
   c. Both physical and chemical changes.
   d. Only mass that is not undergoing change.

3. How could you break down the compound calcium carbonate into the elements that make it up?
   a. By melting
   b. By crushing
   c. With a filter
   d. With chemical changes

4. Magnetism, solubility, and malleability are physical properties of matter. What makes these properties different from chemical properties?
   a. Physical properties relate to elements rather than compounds
   b. Physical properties appear only after a chemical change occurs.
   c. Physical properties can be observed without attempting to change the identity of the substance.
   d. Physical properties describe elements in the solid state rather than liquid or gas.

**Short Answer:**

5. Compare the original mass of dry ice with the mass of carbon dioxide gas that forms through sublimation. Explain how you arrived at your answer. (2 pts.)

6. An unknown substance has a volume of 2 cm$^3$ and a mass of 38.6 grams. What is the density of the sample? ________________

<table>
<thead>
<tr>
<th>Material</th>
<th>Density (g/cm$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>1.0</td>
</tr>
<tr>
<td>Aluminum</td>
<td>2.7</td>
</tr>
</tbody>
</table>

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Iron</td>
<td>7.9</td>
</tr>
<tr>
<td>Silver</td>
<td>10.5</td>
</tr>
<tr>
<td>Gold</td>
<td>19.3</td>
</tr>
</tbody>
</table>

a. Use the chart to find the identity of the unknown sample.

b. List three other physical properties that could be used to identify this sample.
EXTEND PHASE:
The Extend phase is intended to explicitly remind educators of the importance for students to practice the transfer of learning. Teachers need to make sure that knowledge is applied in a new context and is not limited to simple elaboration. This phase fully supports a gifted student’s opportunity to present their level of comprehension through student-led exhibitions. The Extend portion of this unit of study incorporates a Science Olympiad event, called “Experimental Design.” It aligns with MS-PS1-5 Matter and its Interactions Science and Engineering Practices: Modeling in 6-8 builds on K-5 and progresses to developing, using and revising models to describe, test, and predict more abstract phenomena and design systems. The students will develop, use, and revise a lab demonstration to describe, test, and predict abstract phenomena of the Law of Conservation of Mass. Disciplinary Core Ideas: Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. The total number of each type of atom is conserved, and thus the mass does not change. The Experimental Design Lab demonstrates the Law of Conservation of Mass, which states that the total number of each type of atom is conserved, and thus the mass does not change. Crosscutting Concepts: Matter is conserved because atoms are conserved in physical and chemical processes. The students will observe that matter is conserved in physical and chemical processes through the Experimental Design Lab, which demonstrates the Law of Conservation of Mass. The students apply their understanding of physical and chemical changes by designing their own experiment that demonstrates the Law of Conservation of Mass. This demonstrates that on an atomic level, matter cannot be created nor destroyed, only rearranged. Students were introduced to this activity by reading through the Experimental Design Proposal. This proposal takes the students on a journey through the scientific method. They are tasked with the responsibility of designing a statement of purpose, which is the question their experiment is attempting to answer. They provide a brief description as to why their question is scientifically important, and relate their purpose to the Law of Conservation of Mass. Their hypothesis is then created to predict the outcome of their experiment, stated in the future tense using an “If…then…because…” statement. Students also identify their independent and dependent variables in their experiment. For example, what will be purposefully manipulated in the experiment, and what will be measured as a result of those changes are to be recognized and described. Constants, or items in the testing environment that will stay the same throughout their experiment, will also be identified. A materials list will be planned and created. Students then are ready to design their procedures. Using numerical steps, they write detailed procedures for conducting their experiment that will demonstrate the Law of Conservation of Mass. They write their procedures visualizing it as though someone will be performing their experiment for the first time. The students will also take into consideration how many trials will be necessary, as well as where and how their data will be appropriately and efficiently collected into data tables. Lastly, safety precautions are considered and identified. Before students are free to begin their experimental, they must go through both a peer, as well as a teacher review. Any errors or confusions will be rectified through the editing process. When their design has passed peer and teacher review, students are ready to begin performing their experiment. With materials gathered, and their designed procedural steps being followed, they delve into experimentation. Whatever reasonable amount of time the students need to complete their experimental trials, they are allotted during class
time. Following the experiment, students are provided with the opportunity to communicate their results to the class by presenting their findings, as well as a set of reflective concluding questions to consider. Reflective queries include, but are not limited to, questions that require reflection of their design as well as tying their experimental findings to the content. Images represented in Figure 5 include the student procedures for this activity, as well as a student sample that exemplify this Experimental Design process from the start through to the conclusion of the experience.

*Figure 5a: Procedures for Experimental Design Extend phase activity*

**EXPERIMENTAL DESIGN PROPOSAL**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Statement of Purpose</strong></td>
<td>What is the question that the experiment is trying to answer, or the problem it is trying to solve? Give a brief description of why the question is scientifically important (what is the purpose of research relating to Conservation of Mass?).</td>
</tr>
<tr>
<td><strong>2. Hypothesis:</strong></td>
<td>What is your prediction about the outcome of the experiment, or possible answer to the problem/question? This statement should be written in future tense using an “If…then…because…” statement.</td>
</tr>
<tr>
<td><strong>3. Independent Variable:</strong></td>
<td>What will be manipulated, or purposely changed in the experiment?</td>
</tr>
<tr>
<td><strong>4. Dependent Variable:</strong></td>
<td>What will be measured? (What “depends” on the independent variable?) Include what instrument or tool will be used, and in what metric units.</td>
</tr>
<tr>
<td><strong>5. Constants:</strong></td>
<td>What things in the testing environment will stay the same for all parts of the experiment?</td>
</tr>
<tr>
<td><strong>6. Materials:</strong></td>
<td>List all materials and equipment needed to conduct this experiment.</td>
</tr>
<tr>
<td><strong>7. Procedures:</strong></td>
<td>Using numerical steps, write detailed procedures for conducting this experiment. Try to write the procedure as though someone was going to perform this experiment for the first time. Consider how many trials will be conducted during this experiment.</td>
</tr>
<tr>
<td><strong>8. Safety Precautions:</strong></td>
<td>List any safety issues that should be considered when conducting this experiment.</td>
</tr>
<tr>
<td><strong>9. Data:</strong></td>
<td>Construct a data table in which you would record measurements collected during the experiment. Include title for table, Y and X axes. Consider how many trials will be conducted, where they all are recorded? Where will observations made during the experiment be recorded?</td>
</tr>
<tr>
<td><strong>10. Conclusion:</strong></td>
<td>&quot;Reflecting conclusion questions will be provided to you.&quot;</td>
</tr>
</tbody>
</table>
EXPERIMENTAL DESIGN REVIEW

*The following items will be checked during the peer review process. The scores WILL NOT OFFICALLY be added into the gradebook, and are used ONLY as a TOOL to help GUIDE you in creating an efficient experiment! *

<table>
<thead>
<tr>
<th>Category:</th>
<th>Peer Review (2 pts each)</th>
<th>Teacher Review (2 pts each)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statement of Purpose</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Hypothesis</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Independent Variable</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Dependent Variable</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Constants</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Materials</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Procedures</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Safety Precautions</td>
<td>__/2pts, Notes:</td>
<td>__/2pts, Notes:</td>
</tr>
<tr>
<td>Data</td>
<td>__/2pts, Notes:</td>
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</tr>
<tr>
<td><strong>Total:</strong></td>
<td>__/20pts, Notes:</td>
<td>__/20pts, Notes:</td>
</tr>
</tbody>
</table>
Statement of Purpose:
What effect does melting chocolate have on the substance’s mass? How does state of matter change the mass of a substance? Does the law of conservation of mass always apply?

Hypothesis:
If a substance changes its state of matter, in this case, changes from a solid to a liquid and then back to a solid, the mass will not change. Seeing as the amount of matter does not change, there is no reason the mass should change, for the same amount of matter still remains, and that is what the measure of mass is based off of. This will prove the Law of Conservation of Mass, because the amount of matter will not change, nor will the mass, only the state of matter.

Independent Variable: The variable that will be purposefully changed will be the Chocolate’s temperature, state of matter, and form.

Dependent Variable: The dependent variable will be the mass in grams at the end of the experiment.

Constants: The same Hershey’s chocolate, the same mold, the same temperature melting the chocolate, the same amount of time heating.

Materials: Material used include: triple beam balance, candy molds, Hershey’s Chocolate, heating plate, parchment paper, baking pan, tin foil

Procedures:
1. Begin by finding the mass of the original chocolate using a triple beam balance
2. Weigh mold on a triple beam balance
3. Break each chocolate bar into 12 equal pieces
4. Weigh individual chocolate piece on a triple beam balance
5. Place one chocolate piece inside each individual mold
6. Turn on the heating plate
7. Pour water into baking pan
8. Using rolled up tin foil, place on the bottom of candy mold
9. Make sure tin foil wraps around pan (MOLD MUST TOUCH WATER)
10. Place pan atop the heating table
11. Watch carefully and record melting point, and time taken to melt
12. Turn off the heating table
13. Add this data to your data table
14. With oven mitts carefully place the molds into the freezer
15. Wait 24 hours
16. After 24 hour wait carefully take the molds out of the freezer and place on table
17. Pop chocolate from the molds and onto the parchment paper
18. Weigh the molten chocolate on a triple beam balance
19. Observe and compare the mass of chocolate before and after

Figure 5B: Student sample of Extend phase
Lab Activity Reflection

Reflect on the lab activity you performed in class by responding to all of the following questions.

1. Why did we do this? (Relate to the Essential Question)
2. Discuss the relationship between physical and chemical changes with the Law of Conservation of Mass.
3. Did the results of your experiment support your hypothesis? Why/why not?
4. Were changes from your original set of procedures necessary throughout the experiment? What/Why?
5. What would you recommend to someone who wants to design their own lab?
6. What did you learn about yourself during this process?

1. We chose to do this experiment to show that the Law of Conservation of Mass always applies even after a physical change.
2. The Law of Conservation of Mass states that in ordinary chemical and physical changes, mass is not created or destroyed, but is transformed into different substances.
3. Our hypothesis was correct when we conducted our experiment in the microwave. The reason we did not get the same results for the first experiment is because we used different triple beam balances to measure the mass. Therefore, our hypothesis not only proves the mass always stays the same, but also proves the Law of Conservation of Mass always applies.
4. Yes, we had to heat the chocolate in a microwave rather than using a heating pan.
5. I would recommend you always use the same triple beam balance and follow the steps chronologically.
6. I learned that I have to be more observant and always use the same materials so you don’t mess up the results for the experiment.
CONCLUSION:
“I never teach my pupils. I only attempt to provide conditions in which they can learn.” (Albert Einstein.) This quote can be explained well by Roger Lewin, who said that too often we give kids answers to remember, rather than problems to solve. While any student would benefit from this style of education, it is even more relevant to approach gifted education in such a manner. The 7E pedagogical method is an advantageous approach to educating the creative gifted thinkers in the classroom. It is more than just giving students a challenge in the classroom. The process of eliciting their prior knowledge to meet them where they stand, engaging your audience's attention, allowing for digging in through exploration, explaining and elucidating misunderstandings along the way, providing opportunities to elaborate and extend their understanding of the material all while evaluating the students creates an education experience that pushes them to the next level. The goal of an educator is to guide students toward reaching their full potential. The science classroom provides the perfect opportunity to encourage gifted students in an environment with which they can flourish.

ACKNOWLEDGEMENT:
I would like to acknowledge and thank Professor Lawrence Kolopajlo, Ph.D. for his expert advice and guidance throughout the process of this publication.

REFERENCES:
Three tools that helped make the shift to NGSS (A first-grade teacher’s journey)

By Marie Woodman and Julia Alder

Marie Woodman teaches first grade at Morse Elementary School where she collaborates with colleagues to make changes to how science is taught and learned. This year, Marie joined teacher leaders in Troy Schools to collaborate and provide support for the 2019-2020 new science materials implementation. She is also part of the Morse Elementary School team that provides before and after school parent and staff learning sessions in science.

As a Troy science leader Marie attended NGSX learning, piloted and reviewed new science units, and is now part of an early adopter curriculum team for her grade level. As part of the leadership team, she and others learn and implement science using strategies, tools, and new science units. They also focus on the eight Science and Engineering Practices with a particular emphasis on creating driving question boards, creating summary tables, modeling, and engaging in argument from evidence with their students.

MAKING SHIFTS IN SCIENCE LEARNING

The journey begins with a paradigm shift where the teacher is no longer the keeper of facts and figures. The standards expect students to shift from learning about science to a place where students wonder and figure-out the natural world by engaging phenomena about the world. This shift may feel uncomfortable for elementary teachers who don’t have science backgrounds or are new to NGSS. A key benefit is that the teacher no longer must feel responsible as the keeper of science knowledge, but rather teacher and students are embarking on learning cycles where together they make observations, pick-up evidence, and make sense of the experiences over time.

Teachers and students don’t need to be experts in science to learn and observe the natural world, but they do have to observe, wonder, question, listen, investigate, and revise their ideas together. The Michigan Science Standards bring challenges and wonderful opportunities for teachers to facilitate learning with students. To meet the challenges, Marie has combined the use of three powerful tools to ensure learning in science.
THREE POWERFUL TOOLS

KLEWS bulletin board, Investigation Notebooks, and Talk Moves are used to scaffold and support both student and teacher learning. KLEWS bulletin boards are used in conjunction with whole group Talk Moves to help students share their individual thinking that is captured in investigation notebooks based on observations of phenomena or investigations.

A LITTLE ABOUT KLEWS

KLEWS boards are posted and available for students to see and interact with at all times during the unit. The board is developed as a whole class and is continually updated as students investigate science ideas during the learning cycle. This is the class public space, and it highlights student questions, thoughts, what they investigated, what they figured out, and how the learning relates to the science concepts or phenomena of the unit. It is basically a working, class summary board that changes as the class learns more about each big unit idea.
The board begins empty and it is constantly added to, revised, and visited throughout the unit.

This idea of a “blank space” can be intimidating at first but once teachers practice working with a KLEWS board, the freedom this allows is compelling!

“The components of the KLEW(S) chart are used to document the following:

*K—What do we think we know?
*L—What are we learning? [claims]
*E—What is our evidence?
*W—What do we still wonder about?
*S—What scientific principles/vocabulary help explain the phenomena?” (Hershverger, Zembal-Saul, 2015)

**A BIT ABOUT INVESTIGATION NOTEBOOKS**

Based on inquiry, students use the notebooks to collect and organize observations, questions, and revisions. They also provide formative information that is used by teachers to drive instruction based on individual student ideas. Using individual investigation notebooks is important because they are a space to capture individual thought. Marie provides students time to think individually before recording whole-class ideas that may be posted on the KLEWS board. Sometimes students free-write and other times students use scaffolds to record information or their ideas about a topic. T-Charts, Venn diagrams, pictures, and sentence stems are often used in the beginning of the year.
**STUDENTS IN MARIE’S CLASS USE THEIR NOTEBOOKS IN SEVERAL WAYS:**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Image</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write down thoughts about their scientific observations</td>
<td><img src="image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Draw and describe models of phenomena</td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Record data</td>
<td><img src="image3.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Write questions</td>
<td><img src="image4.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Look at their science learning over time</td>
<td><img src="image5.jpg" alt="Image" /></td>
</tr>
<tr>
<td>Make revisions</td>
<td><img src="image6.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>
Individual student notebooks are a key aspect of learning science because they follow the iterative learning process of science where the students and teachers in Marie’s class ask questions, collect data, revise and reflect on that data, and draw conclusions about their learning. The notebooks range from extremely detailed to difficult to decode in a single classroom; yet, they are a true picture of a student’s ability. The most important aspect of an investigation notebook is that the student can go back, find their previous work, build upon ideas and take ownership of their learning.

Both the teacher and the student can utilize the notebook at any time to reflect on evidence and concepts that the students have investigated during the school year.

POWERFUL TALK MOVES USED IN MARIE’S FIRST GRADE CLASS

Using Talk Moves during discussions that are based on common experiences provides the teacher opportunities to strengthen communication between students.

Marie, and other teachers at Morse Elementary, utilize Talk Moves to help students listen and express their ideas from first draft thinking to final draft thoughts. Engaging in this type of discussion works well because it follows important inquiry experiences. For example, Marie’s students experienced how their shadows change during the day by going outside and observing changes. The students were able to talk about what they saw, and why they think the shadow behaved in that way with great detail and enthusiasm because they had first hand observations and experiences to draw upon.

Without phenomenal experiences, opportunities to think individually first, and the teacher’s Talk Moves used to focus students’ reasoning, productive talk is difficult to achieve.

Here are some powerful sentence stems and routines used in Marie’s class from the Talk Science Primer.
These Talk Moves are essential for creating a safe collaborative space for students to share partially developed ideas about the natural world.

**PUTTING ALL THREE TOOLS TOGETHER**

The crucial element of the KLEWS board, Investigation Notebook, and Talk Moves as tools in an elementary classroom is that they cannot be used in isolation. The Investigation Notebook is where individual students start. Their own learning is documented, revised, and expanded upon in drawing and writing. The students then use their notebook to help launch conversation through Talk Moves with partners, small groups, and eventually the whole class. The teacher then facilitates group discussions which result in additions to the KLEWS board. It is the ability of these three tools to work in harmony which provides rich science learning for all learners in the classroom.

**MAKING IT WORK IN AN ELEMENTARY SCHOOL**

One of the biggest barriers to successful science teaching in the elementary school is that many elementary teachers do not consider themselves “science people.” They are afraid of getting the answer “wrong” or that they will teach the “wrong thing” to their students. Most elementary teachers feel very comfortable teaching reading and writing but get nervous when it comes to tackling the seemingly daunting subject of science. A second great barrier is time. With so much emphasis on reading, writing, and math, teachers often feel overwhelmed that they do not have enough time in their day to teach science well. One solution to these barriers is getting teachers excited and motivated about using these tools. Marie and her colleagues have had the benefit of time in their school to provide professional development for the teachers in their building. She has shown her hesitant colleagues that it is okay to make mistakes with these tools and that there is no precise “right way” to use a KLEWS board or an investigation notebook. They have also learned that if you can try to use these tools to launch a new unit, it can be fun and much less intimidating than they imagined. The most helpful practice has been to see these three tools in action, observed in a
classroom, and modeled by a teacher. Once teachers see how these tools can be used for science, the possibilities of transdisciplinary units become evident and real. Teachers see that when they put a KLEWS board front and center in their room, their students refer to it, they want to read about science, they want to write about science, and they want to talk about science. The opportunities to use books from science for writing and reading are plenty – teachers need the push and the freedom to take them!

These three tools have provided support and opportunities for Marie and the Morse team to develop stronger science experiences.

REFERENCES


Service-learning: Its Role in Science Teaching

By James T. McDonald, Professor of Science Education, Central Michigan University

In a previous issue (McDonald & Kromer, 2005) we examined service-learning as a viable teaching method for teaching science. Veteran teachers have always understood the need and efficacy of applying science concepts as a means of helping students learn. Service-learning will be shown to be an excellent pedagogical tool that teachers can use to engage their students in the learning process.

But new teachers need to be taught the importance of applying science concepts and learn the skills needed to apply the science concepts taught in their classrooms. Helping preservice and new teachers to use service-learning activities during their teacher preparation program or early in their teaching career through professional development programs are great ways to help them apply science concepts outside of the classroom.

Service-learning is not a new idea. John Dewey (1938) wrote that actions directed toward the welfare of others stimulate academic and social development. William Kirkpatrick in support of the “project method” in 1918 argued that learning should take place in a setting outside of school and involve efforts to meet real community needs. Both were early proponents of service-learning. More recently (Glasser, 1993) indicates that community service should be a part of every quality school program.

Teachers frequently “discover” service-learning as they work with children in their classrooms. Perhaps elementary children notice that the playground is becoming littered and want to remedy the situation. The playground clean-up activity becomes integrated in classroom study of the environment or recycling. A teacher in a science classes may discover that younger students need tutoring and has his class provide it on a volunteer basis. This “old, tried and true” method of combining service and learning may be quite familiar to veteran teachers who have discovered it through serendipity. It is likely to be much less familiar to inexperienced teachers who have not yet discovered the value of combining service and learning activities.

In more recent years several authors have proposed including service-learning in teacher training programs (Sullivan, 1991; Moon & Root, 1993, Anderson & Pickeral, 2000). One rationale for this suggestion is that participation in service-learning can prepare teachers to include service-learning activities in their own classrooms. Several authors (Gomez, et al., 1990; Moon & Root, 1993) have noted the consistency between practices recommended in recent calls for education reform and the goals and pedagogy of service-learning. For example, service-learning activities offer an opportunity for students with diverse learning styles, with special needs and sociocultural backgrounds to experience success (Karayan & Gathercoal, 2003). Learning in conjunction with
service is more apt to be “authentic, in-depth” learning that students perceive as real, and thus it provides motivation to the students. Service-learning activities in which students identify community problems and potential solutions can engage the types of higher order thinking skills which educators agree students will need in an information and technologically-based age (Lanier & Sedlak, 1989). Finally, the problem-solving approach frequently employed in service-learning naturally and comfortably allows students and teachers to focus all of their knowledge base on the problem and thus integrated learning and teaching frequently result (Brandell, et al., 1994).

In addition to preparing prospective and current teachers to achieve the goals of education reform, service-learning can also help them prepare their students to function as contributing members of a participatory democracy. Aronowitz and Giroux (1990) argue that teachers need to be “transformative intellectuals” who teach their students to be critical thinkers and active, informed citizens. Their views are echoed by Strike (1990) and Root (1997) who point out that the ethical aims of teaching are grounded in the requirements of a liberal democratic society for a citizenry with a capacity for self-governance, the ability to work within democratic institutions, and the opportunity to implement its own conceptions of what comprises the “good life”. Studies indicate that service-learning is an effective method for fostering these capacities of democratic citizenship and is linked to increases in open mindedness and tolerance, political efficacy, and social and personal responsibility in students (Wilson, 1974; Luchs, 1981; Conrad & Hedin, 1982; Hamilton & Fenzel, 1988). In essence, service-learning projects raise the awareness of young people about the problems facing their communities and demonstrate that, through their participation in organized projects, they can have a positive impact on these problems. They also learn about community organization, leadership and the agencies that provide services to the members of a community.

In the preceding portion of this paper the focus has been primarily on the benefits derived by the learner who has been involved with service-learning. Cairn and Kielsmeier (1991) suggest that the implementation of service-learning has beneficial outcomes for schools and the community as well. The school has engaged learners who are motivated and responsible for their own learning. Collegiality develops as staff, students and the community interact as partners. Educational excellence is achieved because of the enhanced learning climate, the enriched curriculum and through the use of authentic performance-based assessment. The community benefits by having its unmet needs addressed, often in unique ways, and students become active stakeholders, now and in the future.

Service-learning is a teaching method that is relatively easy to convey to preservice and inservice teachers. The concept is a simple one, and a good deal of information and support is now available from the National Youth Leadership Council, from regional K-12 Service-learning Centers and from various colleges and universities who have been involved in the implementation process in their own teacher education programs. A list of Service-learning resources can be found later in the body of this paper.

One group of 18 student teachers at Central Michigan University summed up their initial involvement with implementing service-learning during their student teaching experience as follows (Hitch & Kromer, 1993):
1. Projects were rooted in the existing curriculum. The service-learning units were not in addition to but a part of the subject matter that would normally have been taught. Little extra time was needed for planning or implementing the service-learning unit.

2. The service-learning unit provided an opportunity for thematic teaching. The integration of various subjects in the learning process seemed natural and comfortable.

3. Student teachers enjoyed the service unit because they were directly involved in an active learning environment that dealt with a real problem. The students in their classes liked the cooperative group planning and the fact that genuine problem-solving skills were used.

4. The K-12 students felt like they had made a contribution. Given an opportunity to reflect on what they had done, the students felt good about themselves and what they had been able to accomplish.

5. The student teachers would incorporate service units in their teaching when they obtained their first job.

Specifically, the following comments came from reflections of student teacher’s service-learning projects:

The impact that participating in this service-learning project has had on me was huge. I have learned that with a little bit of thought and planning, the students can take part in lessons that reach out to the local community. They are able to do things to help others while still completing the necessary work as required by the state curriculum. There are many different ways that we can incorporate community service into the curriculum. This was just one example. It has really prompted me to explore different ways that I can include the students in more activities. The students are so excited about helping and it may encourage them to develop life long habits of community service. I firmly believe that giving service is something that we need to teach our children. By the time children come to school, they are ready to begin learning that lesson. That is evident in the character programs that are being taught in the schools today. This Service-learning Program is an extension of this character education.

Kathleen, first grade

Students truly can learn through service. No matter what their age, they can be active participants and physically involved in the learning process. They enjoy being involved and receiving positive feedback. Many students wanted to create more than one placemat and card. They also wanted to create projects for other important individuals that they knew. They enjoyed seeing what they had created being appreciated and displayed where all types of people could see their accomplishments. They were active and energetic and eager to participate in all aspects of the lessons. They enjoyed listening to the stories, recreating acts through dramatic play, creating the projects, discussing actions and affects, and being challenged to continue their good deeds. Some students met the challenge
of continuing their kindness by showing appropriate behaviors in the classroom and on the playground. These students were also rewarded with WOW coupons to be redeemed at the school store.

My participation in the service-learning project has given me a better understanding of what service-learning is all about. It has shown me that students enjoy the involvement and can come away from the project with a deeper connection to the learning outcomes. The type and complexity of service-learning is dependent upon the age of the students involved. With older students you could complete more complex tasks and involve the students even more with the service-learning process. They could assist with the development, teaching, and evaluating processes.

Karen, Kindergarten

I firmly believe in the use of service-learning projects in the classroom. Service-learning allows students to connect with the community and the community to connect with the students. I would definitely use this service-learning project again in my classes, as well as others. They sky is the limit. Young adolescents have amazing, wonderful ideas and it is their school, their community, given the chance, they will not disappoint.

When the project was done I had the students do a reflection. I was completely blown away by what the students said about the experience. At the bottom of the page I had the students write the ONE word they would use to describe their experience. Mine would be Amazing!

Kellie, middle school

Due to the almost magical level of student motivation I observed during this project, I am certain I will continue to use service-learning in my future classroom. There are plenty of small and simple service projects that require a minimal amount of additional effort to incorporate into the curriculum. However, I am impressed enough to plan ambitious projects in the future. I’ve learned almost everything I know by assisting others in some form or another and I would not want to deny my students the same avenue of learning.

Jeremy, 4th grade

As indicated above, service-learning can have far-reaching effects as a teaching strategy. Its contribution to many of the desired student outcomes in public schools makes it a strategy worth considering in many situations. A more systematic approach to helping preservice and inservice teachers learn how to use this strategy seems appropriate. Effective teaching practices should be a part of every teacher’s background of knowledge, skills and beliefs and service-learning should be included in this background to ensure that all teacher have the competencies that are needed in today’s complex society. Fifteen years experience of integrating service-learning into the student teaching program at Central Michigan University has given us some insights.

The case has been made above about the effect that service-learning has on teachers. Service-learning naturally lends itself to science teaching. There are many ways in
which service-learning can be integrated with science standards and environmental education standards (see below). When choosing ideas for a service-learning project, local issues work best.

GLOBAL VS. LOCAL ISSUES

Studying issues connected to the natural environment provides rich and varied service-learning experiences. These experiences can be easily connected to the Guidelines for Learning established for environmental education by the North American Alliance for Environmental Education (Table 1) (NAAEE, 2000). The purpose of some service-learning projects is to get children connected to their local environments. In urban settings these might be schoolyards or local parks, or issues dealing with local air quality or land use. In rural settings the choices may also include more natural environments such as state forests or parks.

It is important to remember that the service-learning in science is student-driven with the teacher acting as a facilitator. Student selection of the issue they will become involved with increases their feelings of ownership and personal investment. In the elementary grades, students need to become aware of and make connections with their local environment before tackling global issues. Sobel (1995) believes that if children only study global environmental problems they will begin to disassociate themselves from the natural world because they believe the problems are overwhelming. Rather than learning about far away rainforests and endangered animals, children should be examining the trees in the park down the street and understanding the complex society of ants in their schoolyard. As children get more information from electronic media, they spend more time indoors, out of the rain, mud, and dirt - losing a vital connection to the natural world around them. The science and service-learning combination not only increases students’ knowledge and skills to deal with environmental issues, but also opens the classroom door to the outside world.

The process of taking action on an environmental issue as a service-learning project involves gaining knowledge, making informed decisions, and developing and using skills to solve a problem. It is through the use of knowledge to facilitate engagement with an issue that helps students to internalize their knowledge and enable them to use it in a meaningful way. Students may gain knowledge about a particular issue through research, investigation, and evaluation of information. They then identify ways to take action on the issue, develop an action plan, and implement the plan with facilitation from the teacher.

Partnering with the Community: Community resource people within local agencies or businesses can often help students identify important issues, contribute to background research, and may even provide resources and contacts. An important component of service-learning is community involvement. Students can be encouraged to contact local agencies for information, invite them into the classroom for presentations, or set-up field trips to investigate problems first hand. Local environmental issues concern the entire community. Any actions that are taken to resolve a problem will have consequences that may be both negative and positive. Well-balanced environmental education activities are non-biased and assist students in investigating all sides of
TABLE 1: SERVICE-LEARNING CORRELATIONS TO THE NAAEE EXCELLENCE IN ENVIRONMENTAL EDUCATION: GUIDELINES FOR LEARNING (K-12)

Strand 1--Questioning and Analysis Skills
A) Questioning--Learners are able to develop questions that help them learn about the environment and do simple investigations.

B) Designing investigations--Learners are able to design simple investigations.

C) Collecting information--Learners are able to locate and collect information about the environment and environmental topics.

D) Evaluating accuracy and reliability--Learners understand the need to use reliable information to answer their questions. They are familiar with some basic factors to consider in judging the merits of information.

Strand 2.3--Humans and Their Societies
A) Individuals and groups--Learners understand that people act as individuals and as group members and that groups can influence individual actions.

B) Culture--Learners understand that experiences and places may be interpreted differently by people with different cultural backgrounds, at different times, or with other frames of reference.

Strand 2.4--Environment and Society
A) Human/environment interactions--Learners understand that people depend on, change, and are affected by the environment.

Strand 3–Understanding and Addressing Environmental Issues
3.1 – Skills for analyzing and investigating environmental issues;

3.2 – Decision-making and citizenship skills

Strand 4-Personal and Civic Responsibility
A) application and development of concept-based learning

B) skills for inquiry, analysis, and action

C) understand that individuals and groups can make a difference
Service-learning projects can integrate many different subjects and be an important part of meeting state and national science education standards (Table 2). As part of the project, students may present oral and written progress reports; an oral poster presentation; a final, written report; or even a video of their project. An individual reflection paper, using guiding questions completed at the end of the project, is a critical component of service-learning. The reflective opportunities allow students to write across the curriculum, presentations let students develop speech skills, and conducting research connects students with history and assists them with internalizing the process of doing science.

**TABLE 2: SERVICE-LEARNING CORRELATIONS TO SCIENCE TEACHING**

**Science Teaching Best Practices**

- Develop a framework of yearlong and short-term goals for students.
- Select science content and adapt and design curricula to meet the interests, knowledge, understanding, abilities, and experiences of students.
- Select teaching and assessment strategies that support the development of student understanding and nurture a community of science learners.
- Challenge students to accept and share responsibility for their own learning.

**CONCLUSION**

Service-learning provides for the completion of not only science benchmarks but also fits most state’s benchmarks that call for active involvement with the community. Service-learning is a win-win situation. Using service-learning allows both the community and the learner to benefit from the experience.

**REFERENCES**


RESOURCES FOR MORE INFORMATION:

National Service-learning Partnership http://www.service-learningpartnership.org/

National Commission on Service-learning http://servicelearningcommission.org/slcommission/
National Youth Leadership Council http://www.nylc.org/index.cfm


Find the following service-learning resources on-line at: Campus Compact (www.compact.org):


Fundamentals of Service-Learning Course Construction. (2001)


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Developing Classroom Discussions from the Inside Out: Developing Science Language Skills

By Jim McDonald, Professor of Science Education, Central Michigan University, Department of Teacher Education and Professional Development

The direct and engaging experiences of hands-on, inquiry-based science draw out students’ sense of wonder, and readily lend themselves to conversation. Students are excited by their discoveries, motivating them to share, discuss, and debate their ideas with others. Science talk is an instructional discourse practice that capitalizes on this enthusiasm and gives students regular and deliberate opportunities to process their thinking and communicate about what they have seen and done. Through exchanging views with others, students develop their understanding of the science beyond what could be achieved individually.

I have been in many classrooms watching preservice and in-service teachers lead a discussion to explore science concepts. Immediately these educators facilitate a whole class discussion where students are asked to share their understandings and thoughts without having the opportunity to think about them. Students are caught cold by this approach and therefore a lot of them do not have much to contribute.

Instead of taking this approach, do the opposite. Start with the individual, then to pairs or groups, and then have discussion with the entire class. Here are some reasons that you need to provide time for students to think about the topic of the discussion prior to doing it with the whole class:

1. Start with the individual: Pose a question or a couple of questions and let the students think about their response. Let them write notes, find relevant support for their answers from informational text, and get their thoughts together.

2. Think-Pair-Share: After students have had individual think time, let each student pair up in a think-pair-share or small group to discuss the same questions and learn from one another. They can add on to their own notes and thoughts and enhance their own responses to the questions.

3. Whole class discussion: Using the same questions to discuss, you will get many more responses since students have a chance to get their own thoughts together, acknowledge the contributions of others, and refine their explanations.

Discussions are an integral part of doing science. When students have conversations in which they share their observations, interpret evidence, and explain their findings, they support one another in making connections, refining ideas, and developing new perspectives. The student-to-student and student-to-teacher interactions that take place during science talk not only support science learning, but also lead to the development of language.
ADVANTAGES OF THINK-PAIR-SHARE:

- Instructors find they can have a format change during lecture that only takes a small amount of class time. Preparation is generally easy and takes a short amount of time.
- The personal interaction motivates students who might not generally be interested in the discipline.
- You can ask different kinds and levels of questions.
- It engages the entire class and allows quiet students to answer questions without having to stand out from their classmates.
- You can assess student understanding by listening in on several groups during the activity, and by collecting responses at the end.
- The fluid nature of group formation makes this technique very effective and popular for use by instructors of large classes.
- Full class discussion is generally more fruitful after a think-pair-share and throughout the semester as the frequent use of such activities generally improves student comfort levels and willingness to participate throughout a class period.

STEPS AND TIPS FOR USING THINK-PAIR-SHARE

1. Ask a question. Be aware that open-ended questions are more likely to generate more discussion and higher order thinking. A think-pair-share can take as little as three minutes or can be longer, depending on the question or task and the class size.

2. Give students a minute to two (longer for more complicated questions) to discuss the question and work out an answer.

3. Ask students to get together in pairs or at most, groups with three or four students. If need be, have some of the students move. If the instructor definitely wants to stick with pairs of students, but have an odd number of students, then allow one group of three. It’s important to have small groups so that each student can talk.

4. Ask for responses from some or all of the pairs or small groups. Include time to discuss as a class as well as time for student pairs to address the question.

SCIENCE TALK SUPPORTS SCIENCE LEARNING BY:

- Providing opportunities to clarify thoughts, generate conclusions, develop theories, and ask new questions
- Exposing learners to new ideas and perspectives, thereby encouraging the growth of new understanding
- Connecting what students already know from their prior experiences to what they are being asked to learn
- Acknowledging the value of students’ own ideas and empowering them to gradually take more responsibility for their learning
- Building an understanding of the collaborative nature of doing science
- Privileging the expression of personally meaningful ideas and the use of everyday language rather than focusing on the correct answers and the use of perfect language
SCIENCE TALK SUPPORTS LANGUAGE DEVELOPMENT BY:

- Providing a context for language use in association with phenomena that all students have experienced
- Placing a higher cognitive demand on learners than more conventional monologic forms of classroom interaction, such as IRE (Initiation/Response/Evaluation), where the teacher initiates the request for a response, the student provides the response, and the teacher evaluates the response; interaction between students to build on their thinking requires more elaboration, revisiting ideas, and clarification of meaning
- Connecting talk to other language-rich classroom practices (science writing, reading, etc.)
- Allowing students to learn from each other’s examples; it enables students of varying language proficiencies to produce and listen to a greater variety of language, because they express similar ideas in different ways
- Establishing norms that ease students’ inhibitions, motivate sharing, and promote respectful communication
- Valuing cultural differences and encouraging students to use the language they have in order to communicate their ideas

Science talk can take on many different forms, but in all cases, it relies on the establishment of a welcoming environment where all students feel respected and comfortable taking risks. It requires conscious effort and patience on the part of the teacher to set the conditions that address its inherent language demands (i.e., the language needed to express one’s ideas and understand those of others) and provide the supports necessary for students of all language proficiencies to participate. Creating a culture of talk is a purposeful process; it takes time for both teachers and students to develop the skills that support productive conversations.

CLASSROOMS WITH SUCCESSFUL CULTURES OF TALK TEND TO SHARE CERTAIN FEATURES AND PRACTICES:

- Science talk is a regular occurrence woven into classroom activities, not an isolated exercise.
- Students are paired or grouped strategically by the teacher to maximize productive interaction between students of varying English language proficiencies.
- Students are encouraged and supported to talk but are not forced to talk.
- In a whole-group setting, the teacher takes on the role of a facilitator, refocusing the group when necessary and encouraging a natural flow to the conversation where students respond to each other’s ideas and no one person, including the teacher, dominates.
- Students are encouraged to use the language they have to express their ideas (e.g., everyday language, imperfect English, native language).
- Scientifically inaccurate ideas are not dismissed; open discussion and further investigation are relied on to help students construct ideas that support them to progress in their scientific understanding.
- The teacher uses carefully constructed focus questions to frame pair, small-group, and whole-group discussions.
• Guidelines for behavior during talk are explicit, mutually agreed upon, and frequently reviewed. The following list of science talk norms was created by a fourth-grade class.
  • Listen carefully to each other.
  • Take turns talking.
  • Speak one at a time, without interrupting.
  • Politely agree or disagree and explain why.
  • If confused, ask questions.
  • Stay focused on the discussion topic.
  • Respond to one another.

• The teacher provides scaffolds that allow students of different language proficiencies to be able to participate in talks (e.g., prompts are tailored to students’ varying needs; students are grouped strategically; examples of environmental print, including charts, posters, word walls and thinking maps, are abundant in the classroom).

Science talk can be used for various purposes, all of which can be productive to students’ meaning making. Talks can be conducted to elicit students’ prior knowledge, gather initial ideas about an investigation, generate questions, plan investigations, make meaning of data, and draw conclusions. Science talk gives teachers a window into students’ thinking, which helps them make decisions about how to support students as they progress in their language development and science understanding.

The purpose of a science talk can guide the teacher in determining its timing and format. Science talks can take on many different participant structures (pair share, small-group, whole-group, etc.); they can be brief or extended, and they can occur at different stages in an investigation. For example, a teacher may initiate a science talk between pairs of students to allow them to summarize their observations before sharing them aloud or recording them on a class chart. A small-group discussion can be a good way to give students opportunities to share and discuss their ideas informally before creating a more formal presentation to the group. A whole-group discussion can support students working together at the end of a unit to make meaning of a series of experiences.

There is a strong reciprocal relationship between science talk and science writing. Talking can be a precursor to writing, and writing can be a precursor to talking. For instance, students can have a science talk before writing so they can listen to others and rehearse their own language and ideas before committing them to print. Writing in their notebooks, in turn, can give students a reference to draw upon when sharing out in a whole-group science talk. The combination of science talk and science writing supports the learning of science ideas and, in the process, helps students develop the language to express these ideas.

RESOURCES FOR LEADING SCIENCE DISCUSSIONS:


Science Talks in Pre-K. Retrieved at: https://scienceinprek.si.edu/science-talks


Expanding the Lead-Tin Eutectic Lab: Connecting Science and Art

By Maryam Yousif and Mark Benvenuto, Department of Chemistry & Biochemistry, University of Detroit Mercy, Detroit, MI 48221-3038

ABSTRACT
What is traditionally called the lead-tin eutectic lab, in which students produce alloys by melting and mixing the two elemental metals, has a long history. The experiment gives students the experience of working with metals in the melt, and exposes them to the idea of a eutectic – an alloy that melts at a much lower temperature than either component. We have expanded this experiment to incorporate an arts component, the creation of medals. By using a graphite block as both mold and heat sink, students can use the metal alloy made in the experiment as the material for an art medal.

INTRODUCTION
The concept of “gluing” two metals together using a solder has a truly ancient history, reaching back at least to the Roman Empire. Their use of lead was extensive, and indeed, the words, “plumbing” and “plumber,” have their roots in the Latin (as does the elemental symbol ‘Pb’). But the idea of making alloys with known mass percentages of each element in the alloy has a much shorter history; and the many alloys we use today may only trace back to the Second or the First World Wars.

The idea of making lead-tin alloys and seeing the low melting point, called the eutectic point, that exists roughly at the half-way mark, is one that appears to have enjoyed some popularity in trade schools and technical schools in the past, but that seems to have disappeared from high school and college or university laboratories in the past forty years. Yet this is an experiment that produces alloys at low temperatures – such as those temperatures generated by a hot plate – and that shows a behavior of metals that is not often seen.

EXPERIMENTAL
The steps in this experiment are both simple and straightforward. On a hotplate, in a crucible:
1. Melt a weighed amount of tin in the crucible
2. Add a weighed amount of lead to the molten tin
3. Ensure the alloy is entirely melted
4. Quench by pouring the alloy into cold water (the alloy will sizzle and spit)
5. Dry the alloy chunks
6. Replace the chunks into the crucible
7. Place a thermometer or thermocouple amidst chunks, not touching the bottom of the crucible. The thermometer or thermocouple should be nestled among the solid metal chunks, and be close to the bottom of the crucible, but not touching it.

8. Melt the alloy.

9. Take a temperature reading immediately as melting of the alloy begins.

10. Add a further weighed amount of lead to the molten alloy.

11. Ensure the new alloy is entirely molten.

12. Repeat 4 – 11 as many times as needed.

13. This will provide data points across a wide range, from 0–100% lead (or 10 –0% tin)

Steps 4 through 11 can be repeated as many times as desired, but we have found that using the known melting point of tin, and that of lead from any reference source, as well as just four alloys can routinely give a good lead-tin eutectic graph.(1)

SAFETY AND CAUTIONS ABOUT USING LEAD

Unfortunately, the term “lead poisoning” appears to have taken on some new and untrue connections. Lead can poison a person through ingestion of lead salts, such as the lead oxides that were formerly used as whiteners in paints. It can also be caused through inhalation of vapors. Simple skin contact with lead metal or the melting of small amounts of it into lead-tin alloys is neither ingestion nor inhalation. When this lab is performed with proper ventilation there should be no problems associated with the use of lead metal.

The major safety concern in this experiment is the possibility of a person burning themselves with hot, molten metal. Assuming no spills, the level of concern is no greater than boiling water for any experiment. Should a spill occur, advise students before beginning the lab simply to let the metal flow until it stops, then scrape it back up. The metal cools very quickly on a benchtop or on a floor, and can be re-used by crushing the inadvertently formed foil back into a small enough shape to fit into a crucible.

If there is still concern about the use of lead metal, the amount of it can be minimized by following the instructions in the experimental section, but starting with lead and constantly adding tin. Thus, the end result will include far more tin in the alloy than lead.

DISCUSSION

The production of a good lead-tin alloy graph, inclusive of a good approximation of the eutectic point, is dependent upon proper measurement of the masses of each metal, and keeping a close eye on the melting of the metal. The first moment when melting is evident needs to be noted. Unlike water, which has what can be called a temperature plateau while ice is melting to liquid, metal shows no such behavior. This is because water has a hydrogen bonding network, while metals show no intermolecular forces at all.

Students who use known values for the melting points of lead and of tin, and who produce a minimum of four alloys, can often produce a good graph that shows the pronounced dip, the eutectic, at approximately 55% by mass of tin (although a difference of 5% in either direction is not bad). The melting point of tin is 232°C,
while that of lead is 328°C. The eutectic point of the alloys is published as 176°C – although we will mention that when mildly impure lead is used in the experiment – for example, lead from old roofing projects – the melting point of the eutectic can drop to below 100°C, effectively producing an alloy that can melt in boiling water. Should this happen, students often find it enlightening to boil water, then immerse the alloy in it, to prove to themselves that it will melt at this low a temperature.(1,2)

ART AND SCIENCE, MAKING MEDALS

The production of metal alloys means that at the end of the experiment, a significant amount of lead-tin metal exists. While this could be discarded, we have found that this can also be the raw material for an arts project, one in which students make medals. The steps in making a medal require only graphite blocks and the leftover metal. We have found the following to be useful and reproducible:

1. Use a 3” graphite cube (companies selling graphite can be found on-line)
2. If desired, carve a circular groove in one side of the graphite block
3. Draw a desired design on a piece of paper
4. Using wood carving tools, or any other carving tools made of metal, carve the design into the block, keeping in mind that letters will have to be carved in reverse
5. If desired, make a modeling clay dam around the circle and design, so that when poured, any excess metal is kept in the design frame of the medal
6. Melt a quantity of metal
7. Pour the metal into the carved graphite mold

This procedure results in what is called a uniface medal; and the graphite mold can be re-used numerous times.(3)

The use of graphite, as opposed to sand or jeweler’s pastes, is beneficial because the graphite is excellent at transferring the heat from the molten metal to the graphite block. Typically, a medal that has been poured can be removed from the mold in minutes, just by turning the mold on its side and tapping it on a tabletop. If there is concern that the newly-made medal is still hot, it can be picked up with tongs and dropped into cold water. After this dunking, the medal will be cold enough to handle. Depending on the simplicity of a design, a student can carve, melt, and cast a medal in a typical classroom period. Complex designs may take longer to carve. Figures 1, 2, and 3 show examples of the blocks and medals.
Figure 1: (a) Medal carving, and (b) Medal before removal from mold.

Figure 2: Medals after removal from mold.

Figure 3: Additional examples of students’ work utilizing the prepared Sn-Pb alloy.
CONCLUSIONS

The lead-tin eutectic lab is an old and established one, but one that has fallen out of favor in many science labs or lab courses. We have found that it remains an excellent learning experience for students. Advantages it brings to a lab course include:

1. Use of molten metals. This is routinely the first time students have made and seen molten metal. The fact that these alloys can be made at relatively low temperatures means that the phenomenon can be seen safely and easily.

2. Computing percentages. This experiment provides a good reinforcement of computing percentages based on mass, and thus utilizes basic math skills in a real world scenario.

3. Physical properties. This experiment demonstrates how the physical properties (melting point, luster, and color) of a pure metal can be modified by mixing it with different metal to form an alloy.

4. Data analysis. This experiment permits students to use computer software (like Excel) to present their data in a graphical format and make interpretations based on the obtained diagram. Graphs are excellent way to establish visual images of collected data and provide the students with the ability to predict outcomes.

5. Heat transfer. This experiment is valuable in illustrating how heat is transferred from one material, a metal alloy, into another, a graphite block. The discussion is qualitative, but still useful.

6. A science-to-art connection. The connection is that the students begin with a science experiment, determining metal compositions and melting temperatures, but end with an arts project, in which they carve an art medal.

Ultimately, this experiment is an example of learning in both science and art that has proven to be fun for the students. Indeed, this has proven for one of the two authors to be the only experiment for which students have asked in the following year if they could return to pour medals again!

REFERENCES


Exploring and Teaching the Sedimentary Rocks of Michigan

By Steve Mattox, Grand Valley State University and Christina Giovanni, Middle School Science and Technology Teacher, St. Fabian Catholic School, Farmington Hills

Think of the sedimentary rocks you use to teach your students. Where and how did you collect them? How are they organized? If you are like us, you collected your teaching samples while on geologic field trips, family vacations, or the occasional stop at a road cut or quarry. We feel lucky when we find a good sample of shale or limestone to share with our students.

As we teach rock types, the students open a literal “box of rocks” to examine the composition and texture of each specimen, leading students to placing samples within a group (clastic, chemical, biogenic), to infer an environment of deposition, and, ultimately, identification and assigning a name.

Although our samples might be perfect for teaching lithology, they commonly were collected from scattered locations, often across the nation, and randomly over geologic time. We here describe our Michigan-focused approach to teach sedimentary rocks than span the geologic history and the distribution of lithologies across our state.

This lesson is most closely aligned with two topics in the new Michigan Science Standards. MS-ESS3-1: Construct a scientific explanation based on evidence for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes. By identifying the environments of formation of Michigan’s sedimentary rocks and their spatial distribution we can identify the unequal distribution of aquifers, oil and natural gas, limestone and sandstone (building materials), salt, gypsum, coal, and sand and gravel. MS-ESS1-4: Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth’s 4.6-billion-year-old history. As students construct their knowledge and synthesize their thinking they can apply basic geologic principles (original horizontality, superposition) to reconstruct changes over the last 1.8 billion years. Note: This lesson specifically addresses the state’s requirement to “Allow for local, regional, or Michigan specific contexts or examples in teaching and assessment”.

Depending on your background you may want to review some geology. Voice (2016) and Harrison (2016) provide short, online descriptions on Michigan’s geology. For more depth see LoDuca (2009) and Grammer and others (2018).

Our Approach
We learn Michigan geology across our careers. During our undergraduate training we relished field trips to classic locales such as the Pennsylvania sedimentary rocks at Grand Ledge, the Devonian reef limestone at the quarries in Alpena, or the Precambrian Kona Dolomite at Lindberg Quarry near Marquette. After graduation you might have visited the...
Proterozoic clastic rocks of the Jacobsville Sandstone (along the Lake Superior coast) or the Copper Harbor Conglomerate. Many of us join professional organizations that offer guided field trips to different sites each year, such as Michigan Earth Science Teachers Association (https://www.mestarocks.org), Michigan Basin Geological Society (https://www.mbgs.org/), and the Michigan section of the American Institute of Professional Geologists (http://mi.aipg.org/). Lastly, we might search a database of past field trips to locate a new place of interest (Voice, 2019). All of these opportunities allow us to add samples to our teaching collections. As we looked at our personal rock collections, built over 20 years in Michigan, we realized we had excellent samples of clastic, chemical, and biogenic rocks. These served as the basis of our new lab.

Figure 1 shows the standardized format of our lab. Students gather data from hand samples, Google Earth, the Bedrock Geologic Map of Michigan (Michigan Department of Natural Resources, 1999), and selected internet sites. The series of questions are designed to guide students towards key observations: general character of the rock, texture, composition, tentative identification, and a possible environment of formation. By plotting the latitude and longitude of the sample in Google Earth students can see the nature of the sample location (quarry, beach, road cut). Next, students transfer the location to the geologic map. From the geologic map they can use the map legend to determine the stratigraphic/rock unit of the sample and its geologic age/period (Devonian, etc.). Each page ends with a link to a website that shows a modern equivalent to the ancient depositional environment.

The lab is not taught in isolation. Sedimentary rocks are introduced with a lecture that presents major rock types (clastic, chemical, biogenic) with examples and depositional environments. We laminate and share classification and identification keys from published lab manuals to help students to construct their mental framework; keys from the National Association of Geology Teachers lab manual (Cronin, 2018 or older editions) work well. We conclude the lab with a PowerPoint presentation that provides an opportunity for students to check their answers (see GVSU HSAG at https://gvsuhsag.weebly.com for the complete lab of 20 samples).

Our samples are not organized chronologically in geologic time nor spatially across the state. Our sample numbers were assigned as we added samples to our collection. You might consider placing your samples in geochronologic order (Precambrian, Cambrian, etc), however, realize if you add a new sample (say a Silurian limestone) you would need to renumber all the younger samples and reprint your lab. As your collection grows, you would need to repeat the process every time. Our collection has ten clastic, seven chemical, and three biogenic sedimentary rocks. As we built our lab we purposefully filled gaps. For example, we collected Antrim Shale (our M7), to represent fine-grained clastic rocks, and Ionia Formation (our M20), a friable quartz sandstone, to represent the youngest bedrock unit in Michigan.

**RUNNING THE LAB**

Prior to running the lab we organize print materials, posters, computers, and hand samples. We print the complete lab and place them in binders; this makes them easy to reuse year after year. We make one copy for each pair of students. We also post a laminated copy of the Bedrock Geology of Michigan (Michigan DEQ, 2005) on
the front board or print copies for each student (Figure 2). We also place a poster of the new “Generalized Stratigraphic Column of Michigan Bedrock” (Mattox and others, 2019) on the front board (Figure 3) or the older version of the Stratigraphic Nomenclature of Michigan (Michigan Department of Environmental Quality, 2000). The rock column can also be printed and placed in the binder with the lab. Each pair of students will need a laptop with access to Google Earth. We place the hand samples in trays and arrange them by sample number. We have a total of 40 samples of 20 different rocks; for each location we have one to four samples. This is enough materials to keep our lab of 24 students engaged at all times.

We start as a full class to work through two or three examples, including at least one clastic and one chemical sedimentary rock. This helps to guide the students on how to complete each lab page and it reduces the number of general questions. We demonstrate how to use the identification charts and read the geologic map. Lastly, we show how each page finishes by using a website to visit a present-day location that represents an ancient environment of formation.

Most of the lab time is dedicated to each pair of students constructing their knowledge by exploring the samples on their own. Each pair of students take one sample to their table and start down the list of standard questions. As teachers, we serve as facilitators, circulating in the classroom and answering specific questions. Students frequently get stuck on fine-grained clastic rocks (siltstones and shales) versus some chemical rocks (dolostone) or selecting the exact unit on the geologic map (if needed we add the location on the geologic map to save lab time). We provide an answer key for our samples (see Figure 4 and GVSU HSAG at https://gvsuhsag.weebly.com) to provide teachers with some guidance. We provide a nearly incomplete key that can be used by students to record their observations.

We found it takes about six hours to teach this lesson: a one hour introduction on textures, composition, and environments of formation; four hours with the samples, maps, and websites; and one hour to review and synthesize their results.

Your lab will be a bit different than the model we present here. You probably have some of the same samples and can use the pages we prepared without modification (if you want to use the same sample numbers). You also have samples we don’t; use the blank lab page we provide at GVSU HSAG website to make the lab page you need.

**SYNTHESIS OF THE LAB**

We conclude with a PowerPoint as a class review and as an opportunity for individual students to review their answers. We provide a PowerPoint on the GVSU HSAG weebly (https://gvsuhsag.weebly.com/resources.html) and show an example in Figure 5. We call on students to present their findings for each sample. If answers disagree we can quickly grab the hand sample and clarify any confusion or use the photos in the PowerPoint to discuss depositional environments.
EXTENSIONS

The lesson easily extends to explore the uneven distribution of resources. Four of the sandstones we use have been identified for their economic value (Heinrich, 2001) but in most counties the rock unit is too deep or buried under drift. Our collection also contains salt, gypsum, and coal that were or continue to be mined and carbonates used for cement (Voice, 2016). Our Antrim Shale has been discussed as a potential target for hydraulic fracturing (Dolton and Quinn, 1996). Some of the limestones we collected may be quarried by Greymont Mining and exported to Canada.

Some sedimentary rock units in Michigan host abundant groundwater. Other sedimentary units act as aquicludes. The U.S. Geological Survey’s Groundwater Atlas of the United States (https://pubs.usgs.gov/ha/ha730/ch_j/) provides an excellent overview. Steve Mattox and Brenda Prough wrote a lesson connecting the bedrock units beneath each county to the potential aquifers at depth (see Mattox and Prough Groundwater 2002 in (https://gvsuhsag.weebly.com/resources.html).

REFERENCES CITED


SUPPLEMENTARY MATERIALS

The GVSU HSAG weebly has the complete lab (21 pages plus one blank page), the Mattox and others (2019) Stratigraphic Column of Michigan Bedrock, the complete PowerPoint for 20 common sedimentary rocks in Michigan, the answer key for the lab and a near blank answer key and a copy of Mattox and Prough’s Michigan Groundwater lab.

https://gvsuhsag.weebly.com/resources.html

Figure 1. Example of the design of the lab worksheet for each sedimentary rock. The content and order is consistent for all 20 samples. Photos from left to right: Google Earth view of sample location, geologic map location, and photo of hand sample.

Sample M2:
Google Earth Photo: none
Latitude, Longitude: 42.160, -84.239
Location: Napoleon, Michigan

1. Is this material clastic, chemical, or biogenic?

2. What is the texture of the material? (Circle one)
   a) Pebble  
   b) Silt  
   c) Microcrystalline  
   d) Crystalline  
   e) Sand  
   f) Other

3. Which of the following minerals are present in this sample?
   a) Feldspar  
   b) Calcite  
   c) Halite  
   d) Quartz  
   e) Dolomite  
   f) Crystals are too small to tell

4. What is the material called? Justify your reasoning.

5. Speculate on the material’s environment of formation.

6. What is the map unit?

7. How old is this material?

8. Go to Clearwater, Florida and look for a picture that shows the geologic features of the area. Speculate on the environment of formation.
Figure 2. Location and sample number for samples from the Upper Peninsula and northern Lower Peninsula. The map shows the uneven spatial distribution of rock resources. Providing the locations can save classroom time.

Figures 3. Location and sample number for samples from the younger sedimentary rocks in our collection. Plotting the samples on the Generalized Stratigraphic Column of Michigan Bedrock (Mattox and others, 2019) shows the changes in geologic environment over time. The complete column is 4 by 6 feet. Providing the stratigraphic units of each sample can save classroom time.
Figure 4. Answer key for the sedimentary rocks in our collection. Rocks are arranged from oldest (bottom) to the youngest (top). The key is handy as we guide students in lab.

<table>
<thead>
<tr>
<th>Rock Type</th>
<th>Composition</th>
<th>Minerals</th>
<th>Period</th>
<th>Formation</th>
<th>Ocean/marine</th>
<th>Mudd/bay/estuary</th>
<th>Reef</th>
<th>Evaporating bay</th>
<th>Peat bog/swamp</th>
<th>River</th>
<th>Beach/delta</th>
<th>Alluvial fan</th>
<th>Dune</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 sandstone</td>
<td>clastic</td>
<td>quartz</td>
<td>Jurassic???</td>
<td>Ionia Fm</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 siltstone</td>
<td>clastic (w/fossils)</td>
<td>Mica, quartz</td>
<td>Late Penn.</td>
<td>Grand River Fm</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 coal</td>
<td>biogenic</td>
<td>Pennsylvanian</td>
<td>Pennsylvanian</td>
<td>Saginaw Fm</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19 Pebby sandstone</td>
<td>clastic</td>
<td>Quartz</td>
<td>Early Penn.</td>
<td>Saginaw Fm</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 dolostone</td>
<td>chemical</td>
<td>Dolomite</td>
<td>Late Miss.</td>
<td>Bayport Lss</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 gypsum</td>
<td>chemical</td>
<td>Gypsum</td>
<td>Late Miss.</td>
<td>Michigan Fm</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14 shale</td>
<td>clastic</td>
<td>Late Miss.</td>
<td>Michigan Fm</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 sandstone</td>
<td>Clastic</td>
<td>Quartz</td>
<td>Early Miss.</td>
<td>Marshall Sandstone</td>
<td>X X X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 Antrim shale</td>
<td>clastic</td>
<td>Late Devonian</td>
<td>Antrim</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 Fossiferous</td>
<td>Bio/chemical</td>
<td>Calcite</td>
<td>Mid Devonian</td>
<td>Traverse Limestone</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 dolostone</td>
<td>chemical</td>
<td>Dolomite</td>
<td>Sil.-Devonian</td>
<td>Mackinac Breccia</td>
<td>X</td>
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<td>10 breccia</td>
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<td>Mackinac Breccia</td>
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<td>5 salt</td>
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<td>13 conglomerate</td>
<td>clastic</td>
<td>Granite, quartz</td>
<td>Proterozoic</td>
<td>Copper Harbor</td>
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<td>3 Jacobsville</td>
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<td>1 Kona dolomite</td>
<td>Chemical/bio</td>
<td>Dolomite</td>
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<td>9 banded-iron</td>
<td>chemical</td>
<td>Hemag, quartz</td>
<td>Proterozoic</td>
<td>Naugatuck</td>
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Figure 5. Example of the format of the PowerPoint slides. The slides allow students to check their observations and interpretations for each sample.

M8 Alpena skeletal limestone

Chemical, biogenic
Microcrystalline, mud w/ fossils
calcite
Age: Middle Devonian
marine
Shallow ocean
Invasion Meltdown: A Lesson Meltdown Saved by Invasion-Wise Elementary Students

By Meredith A. Zettlemoyer, Kellogg Biological Station

INTRODUCTION

Invasive species represent a serious threat to the health of our native ecosystems and our daily lives. These non-native plants and animals disrupt food production, agriculture, natural resources, waterways, recreation...the list is endless, and the damage caused can cost billions in time, money, and resources (Padilla and Williams 2004, Pimentel 2009). The impacts reach national scales, but local consequences are already recognized by land managers and educators (Hakam 2016). It is the next generation that will have to take care of our damaged ecosystems, so their decisions, actions, and knowledge will play into the establishment and prevention of invasive species’ spread in the future.

Despite this, many students can neither name an invasive plant or animal in their home state nor the extent of the problem (Hakam 2016). There are hundreds of research articles floating around in the nether of scientific literature, but how can we translate this into secondary school classrooms? McGuire’s (2015) identity-based environmental education model addresses this: we can help students generate environmental identity, and hopefully stewardship, through public education and outreach programs.

The K-12 Partnership at the W.K. Kellogg Biological Station hosts three annual professional development workshops for K-12 STEM educators from across Michigan, where researchers develop classroom activities based on their own work and hot topics in ecology and environmental science. In the evaluation form from one of these workshops, invasive species came up as a suggestion for a future session theme. During the following workshop, I took on an invasive species session, which played out in a tale of the folly of candy, exploding pom-poms, and the power of the Bee Gees’ ‘Stayin’ Alive’.

OUR FIRST RUN AT AN INVASION LESSON: CHAOS ENSUED

In this lesson, we decided to teach about the role invasive species play in native ecosystems, focusing on Michigan’s invasive species, and developed a game where students, playing as invasive and native insects, would compete for resources. After learning about basic invasion biology and seeing some “Most Wanted” profiles of our most prolific local invaders, students would be introduced to some of the adaptations and effects of invasive species, including resource limitation and biodiversity decline. Our goal: drive every single native species extinct.
The first time I presented this lesson was to mostly middle-and high-school science teachers. The teachers split into groups: one person at each table was the emerald ash borer, a voracious wood-eating insect that has decimated ash trees across North America. Everyone else was assigned a native bug of a particular color. They had to compete for food resources in their habitat: M&Ms. We set some basic rules of invasive species’ biology: they are more competitive (could use two hands to collect more ‘food resources’ at a time) and are generalist feeders (can collect any color M&M). Meanwhile, the native species specialized on a particular color M&M and could only collect one at a time. We played in rounds, so everyone had 20 seconds to collect the food they needed to survive. Eventually, your species wouldn’t have any more food available to it and would be “extinct”. Once that happened, you transformed into an emerald ash borer (think of this as rapidly reproducing invasive populations) and played as one of the invaders. After a few rounds, we threw in some jellybeans to represent polluted food resources: native species couldn’t recognize the threat, so if they accidentally collected too many toxic resources, they died. We set everything up with our one goal in mind. What a disaster.

Error #1: candy. We had candy going into people’s mouths, onto the floor, halfway across the room. I was yelling out “Time’s up!” after every round over the resulting hyperactivity.

Error #2: letting people choose whatever native bug most appealed to them. We had so many cute green caterpillars, all the green M&Ms vanished and the caterpillars died within minutes. Meanwhile, our native brown insects survived just fine.

Error #3: not having a minimum amount of food resources needed to survive. Some native insects elected to starve themselves instead of attempt to collect polluted jellybeans. A wise strategy? Yes. A biological suicide mission in a real ecosystem? Definitely.

Needless to say, the feedback from this activity was mixed:

- “Fun and locally relevant.” Check - studies have shown that an understanding of invasive species in people’s own communities are more likely to promote engagement (Hashitomo-Martell and Mcneill 2012).
- “Neat game… not with M&Ms though.” Our opinion too!
- And my personal favorite: a “hot mess.”

TAKE TWO: THE KNOWLEDGE OF SOME INCREDIBLE FOURTH-GRADES

A few months later we had the opportunity to present at Women in Engineering’s Girls’ STEM Day at Michigan State University. We needed a quick lesson, doable in 20-minute shifts. The most rapid-fire lesson plan we had available was the invasion game. But there was no way we could go into a classroom full of 1st-4th grade girls with the chaos that had ensued last time.
We ended up developing the game for groups of 5 students: 1 emerald ash borer and 4 native species of red, yellow, green, and blue. We bought pom-poms in matching colors and made player cards for each student. In order to make it through a round, you had to collect at least 3 pom-poms: if you were an insect and you were out of food, wouldn’t you at least try to eat something else? Finally, to top it off (and entertain the parents in the back of the classroom) in a nod to musical chairs, we blasted “Stayin’ Alive” through each 20-second round so that the girls would freeze as soon as the music stopped. Anyone who was out of food raised their hands so that we could tally who’d died and needed to switch to the ever-growing population of emerald ash borers.

This was without a doubt one of the most successful K-12 lessons I have participated in. The girls were collecting as quickly as possible, scavenging any pom-poms that fell to the floor in an attempt to survive, and carefully tracked their food intake as food got scarcer and scarcer.

We then tossed in some glittery pom-poms as a poisonous little twist. If you accidentally collect this food, you have to keep it: this was the new rule. If you’re out of your healthy food source, what are you going to eat? Different strategies popped up: some collected much slower, avoiding the poison but sometimes not collecting their minimum food requirement as time wore on. Some girls took the dangerous approach and even closed their eyes (“Would they know it was poison?”) and took their chances. By the end of a few rounds, when we asked who was still alive, not a hand raised. When we asked who was playing as an emerald ash borer, two dozen hands with emerald ash borer cards popped up - they’d taken over!

The most rewarding part of this was the follow-up discussion. We didn’t have time to do walk through a complete lesson plan, but we wanted the girls to understand why invasive species are so damaging and link this to species in their own neighborhoods. We started off by having the students name as many invasive species as they could, not expecting more than a vague “ivy” or “snails.” Instead, we got stink-bugs, zebra mussels, Asian carp, emerald ash borers, spotted knapweed, purple loosestrife...all invasive species that have been particularly damaging to Michigan’s native habitats. The highlight was when one girl, in responding to my questions about what an invasive species is and what adaptations make them competitive, proceeded to give me a more thorough answer than some undergraduates would give: “A species that is foreign to an environment and has damaging effects, that can eat anything and grow quickly and has lots of babies.” She even threw in the enemy-release hypothesis, an idea in invasion biology that predicts that invaders spread because they no longer have natural predators or enemies to keep their populations in check, and allelopathy, a plant’s ability to release chemicals that inhibit any nearby germination. These students engaged with a local environmental issue, and actively acquired information through both past knowledge and the game.

CONCLUSIONS

When every single student in the room raised an emerald ash borer at the end of the game, it clicked: invasive species cause the extinction of our native species. We were able to discuss human-caused changes to the environment when they recognized that
pollution caused extinction to happen even more rapidly. This lesson addressed the NGSS standards relating to environmental change (3-LS4-1, LS2.C), cause and effect (3-LS4-2-3), and constructing explanations (3-LS4-2-3). Beyond that, it demonstrated the mechanisms by which invasive species are so competitive and problematic and how humans compound that threat, and engaged the students in how their own homes might be impacted. This last lesson, hopefully, will be the link to place that helps them grow into the environmental stewards of tomorrow.

REFERENCES

SUPPLEMENTARY MATERIALS
The resources for the “Invasion Meltdown!” lesson (lesson plan, PowerPoint, and insects for the game) can be found in the folder at: https://drive.google.com/open?id=1IBj0ro1wHxaM5MqlJ715_ou-MdFey3Ut

FIGURES

M. Zettlemoyer adding toxic plants to the insects’ food supplies at the Girls’ STEM Day (2018 17 November).
Sample pieces for the Invasion Meltdown game, including food resources and playing cards. Each native insect feeds on only one color pom-pom, while the invasive emerald ash borer can feed on yellow, blue, red, or green pom-poms.
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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.