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President's Paragraph: Notes from HASTI's President

A Thank You Note to Teachers

Dawn Bick

In each issue of The Hoosier Science Teacher, we invite the president to share some thoughts as an introduction. In this issue, HASTI's current President Dawn Bick offers a word of thanks to Indiana's science teachers.

Welcome to summer! I hope you have been able to sleep in, eat lunch at a restaurant with friends and family, and go to the bathroom when your body wants you to go. Our self-indulgences are small, aren't they? No matter what your role in the educational world, you are in a job that is rewarding in some ways and draining in others. Teaching is hard. Teaching doesn't often give us words of encouragement, actions of appreciation, or feelings of respect. I feel my new role as President of HASTI is to encourage, uplift, and support you, the hardest working people I know.

Thank you! Thank you for working well past the end of the day and the last bell on lesson plans. Thank you for legitimately grading papers according to effort instead of tossing them down the stairs and giving the ones that get to the bottom an A. Thank you for sacrificing your personal time to become a better educator and leader taking professional development and watching videos to sharpen your skills. Thank you for showing up every day with colds and upset stomachs because you know how much harder it is to make sub plans than it is to just show up. Thank you for all you do even when you seldom, if ever, see the results of your efforts.

It happened to me this summer. I happened to be at the high school graduation of a family friend. As I was listening to the names being called, I heard a few familiar ones, my former students, being called forward. I said to my husband, "That one is mine." "And that one is mine." I haven't taught these graduating seniors in 7 years or more, but I still consider them mine. After graduation, we gathered outside and found our family friend. Some of my former students saw me and said my name long before I recalled theirs. They were glad to see me. They hugged me. They wanted to take pictures with me. One of them told me that I inspired her to major in teaching. My heart swelled.

We don't often get thanked as educators. We don't often feel appreciated. We sometimes don't know whether we've made the right choices each day regarding our students.

You are valuable! You are important! Your efforts are making a difference and planting seeds you may never see or experience! Take this "time off" as your time to remind yourself how exceptional you are! You are touching lives and making the future better. Enjoy your summer and recharge! Remember that you've earned the right to sleep in, eat lunch at your favorite restaurant, and go to the bathroom whenever you want!

Full listing of authors and contacts can be found at the end of this article.

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2025 HASTI Conference Update: Embracing the Future Together

Craig Williams

Abstract
2025 HASTI Conference Chairman Craig Williams gives an update on the theme and plans for the next HASTI Conference. This communication announces the theme of the 2025 conference, and answers three questions: Why are we focusing on the future, how will we do it, and how will having the conference at Noblesville High School provide a superior experience for attendees?

As the 2025 Conference Chair, I am excited to announce the Theme of the 2025 HASTI Conference: ***Embracing the Future Together***. In this communication, I would like to answer three questions that might come to mind. Why do we need to embrace the future? How will we embrace the future together? Where will we meet to embrace the future together?

Why do we need to embrace the future? The last few years in education have been a whirlwind of change. As we have recovered and continue to recover from the pandemic, we are hearing about new technologies and AI, and figuring out how to keep our students engaged in learning science. We need to prepare them for the careers and the world of tomorrow. The opportunities are endless, but we need to help each other avoid the pitfalls and overcome challenges. Some of the key themes of this conference: the future of literacy instruction, the future of STEM and engineering, the future of cross-curricular instruction, and the future of life on our planet.

How will we embrace the future together? By doing what we do best: providing quality professional development in the context of a supportive network of peers. While there will be a lot of information presented, one doesn't go to HASTI just for information. One also goes to HASTI to be among other teachers from around the state who are also passionate about their teaching. While we will have the traditional forty-five-minute talks (both lecture and hands-on), we will also have several sessions intentionally designed to allow teachers to network and learn from each other. We are planning unconference sessions, share-a-thons, panel sessions, gatherings for specific grade levels and disciplines, evening socials, and more!

Where will we meet to embrace the future together? As I communicated at the 2024 conference in February, we will have our 2025 conference at Noblesville High School. The members of the HASTI board selected this location because we will be able to provide a superior conference experience and do so in a way that is economical for our members. We will have access to multiple classrooms, including several with science lab space. We are planning for another great exhibit hall, with many opportunities for attendees to interact with and learn about the companies, schools, and organizations represented there. After the daily sessions, we will have social activities in the surrounding community.

The registration fees for the 2025 conference will be released soon. We are excited that the fees will be lower than they have been the last couple of years, primarily due to the fact that we will not be paying for food through a hotel. We hope that this will make it easier for HASTI members to attend the conference and will entice new people to join us!

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For those that have been around awhile, you know that we have switched conference locations a number of times. HASTI originally met in smaller hotels. When our attendance ballooned into the thousands, we began meeting at the Convention Center. This came with a host of costs, many of which were shouldered by attendees, such as parking, meals, and hotels downtown.

For the last several years, we have been meeting in smaller hotels outside of downtown. This has cut down on the extra costs shouldered by attendees, but has added to the cost shouldered by HASTI. Lunches and snacks had to go through the hotel, and this ultimately resulted in higher conference registration fees, as well as adding complexity to the planning.

By meeting at Noblesville High School, we are fully in control of our destiny. We are happy that we will have lower registration fees for the 2025 conference. Attendees will still continue to enjoy free parking, good meals at lunchtime, and will find a range of hotels nearby to suit their needs. This will allow the HASTI board members to focus on the professional development experience and the peer networking experience for the attendees. It allows our organization to put its energy and focus into making these two things the best they can be.

The countdown has begun. I can't wait to see you February 15-17th, 2025 at Noblesville High School!

2025 HASTI Conference

Embracing the Future Together.

February 15-17, 2025

Noblesville High School

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The Art of Science and the Science of Art

Lael Williams

Abstract
If the curriculum and assessment practices in schools focused on developing the thinking processes and skills related to each discipline/ subject, students would see themselves as practitioners of each discipline and develop a continuing understanding of what practitioners in the work force experience in their daily work. To be a practitioner of a discipline, an individual has moved from a novice through competent to practitioner and sometimes an expert. The vocabulary, concepts and processes used by practitioners in the arts and the sciences are critical to develop the thinking skills needed to solve complex problems. Those complex problems involve both the arts and the sciences in their solutions. With a focus on practitioner practices and performance assessment, students would be engaged and encountering satisfying experiences as learners in school.

We think the arts and the sciences are on the opposite ends of the spectrum from each other. What does sculpting and painting have to do with research and experiments? When we look past the subjects/topics in a discipline that are central to problem solving in either the arts or the sciences, we recognize that the cognitive skills of critical and creative thinking to solve those problems are the same. daVinci stated that his four principles of education are: The art of science, the science of art, the development of the senses and the interrelatedness of everything.

When thinking about what makes a discipline, we can think about the multiple intelligences. Each intelligence has a language with a vocabulary, a conceptual framework and an intellectual process. In comparing the arts and the sciences, each discipline detects patterns, uses interpretation and reasoning to solve problems, understands relationships between information and meaning, and creates solutions to problems.

One of the most basic skills in both the arts and the sciences is observation. From observation comes inquiry. Inquiry is used to recognize what's familiar, like patterns, and what's unfamiliar. We use reasoning and interpretation to begin to solve a problem when something is unfamiliar. An example from science is observing something in a petri dish or an x-ray. It is critical for a surgeon or a chemist to see the nuance in what's observed for the success of the outcome. Visual arts education is essential for the scientist to train their eye to observe. The artist's eye sees line, shape, color – hue, value and intensity, pattern/texture and space. To see with an artist's eye is to see the nuance and detail not detected with an eye that typically sees things it can name. An example from the arts is an artist relies on observation in observing whatever interests them in the world to explore and interpret it in their artwork.

Observation is the critical first step for both the artist and scientist. The scientist's major focus becomes critical thinking to solve a scientific problem. The artist's major focus becomes creative thinking to imagine, interpret and express a visual idea. However, with both the scientist and the artist, critical and creative thinking skills are used together in their work.

We are humans who participate in the arts and sciences. As humans, we respond holistically to whatever we are doing. As you think about your work, think about how you respond critically or creatively to each step in the process to solving a problem. As an example, a ceramist begins their work by creating an object out of clay. The ceramist starts by selecting the clay that is appropriate for the size, shape and glazing of the work (art and science). There are many types of clay. The ceramist needs to know the chemical compounds of each clay to select which one that will work for the project (science). If the ceramist is throwing clay on a wheel,

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the ceramist needs to know the physics of motion, speed and pressure to control the clay as it's spinning (science). Then the ceramist can create the clay object and decorate the surface of clay to their liking (art). After the object is complete the drying and firing process takes place. The ceramist must understand the environmental conditions needed for that particular piece to dry as a whole piece without cracks or breaks (science). In the kiln, the piece must be placed and fired at the correct temperature for it' survival (science). After the clay is in its bisque state, glazing begins. The ceramist then becomes the chemist to mix which chemicals will create the glaze color and finish the ceramist desires (science and art).

The ceramist's example illustrates how seamlessly we respond to our work whether we are involved in the arts or the sciences. With a vocabulary, concepts and processes in all of the disciplines used in work and solving problems, we can honor the value of thinking like an artist and a scientist simultaneously.

The assessment processes of both the arts and the sciences are similar. Science uses scientific methods and process skills explain and problem solve: Observe, question, research, hypothesize, experiment, test the hypothesis, draw conclusions and report. In the arts, preparation is defined as a first step of assessment - identifying the goal or issue, gathering input and insight and clarifying the challenge, next is incubation – the mental process of generating ideas and finding solutions, illumination is next – the Aha moment with defining a novel solution with a prototype and strengthening a plan for action, and finally evaluating the solution and analyzing it for it's design feasibility and possibility looking for more ideas. Verification or revision is part of evaluation which is the constant assessment of investigating and assessing the artwork as it's being created. Typically we think of assessment at the end of a process or a finished product. However, assessment is a process that occurs throughout the process of creation in the arts and the sciences.

In a deeper way, finding the beauty in a mathematical problem or the aesthetic in a scientific solution and equally seeing the science in viewing the angles and perception in an artwork draws us to see the inherent value of the art of science and the science of art.

To accomplish all that's been described, performance assessment in schools is central to the work. Performance assessment involves a portfolio of work, presentations of work, and reflection as part of the learning process. A student collects their work in a discipline over time and then presents their work to others illustrating their growth, specific changes they've made (as an artist, scientist, mathematician, etc.), a piece of successful work and a piece of work they struggled with and their goals for the next time period in school. Those presentations are recorded and kept in the student's portfolio. The portfolio begins in kindergarten and goes through grade twelve. Students are given the tools needed for each discipline every year as they become more proficient in each discipline. An example, in kindergarten a student could receive three paint brushes, a ruler and scissors to begin their work as an artist.

Performance assessment provides students with a focus on who they are as artists, scientists, mathematicians, etc. and their journey in school to become more proficient in each discipline. Currently, students study the subject areas. Most students feel something is being "done unto them." Students using performance assessment throughout their education see themselves as participants in disciplines gaining more understanding and skills as they move through the grades. Performance assessment in each discipline is the type of assessment that occurs when people work in the discipline. They reflect, maintain a body of work, describe their work and are assessed on who they are as members of a discipline.

The art of science and the science of art is inherent in all that is studied in school and dealt with in the work place. Subjects in school can emphasize problem solving and the thinking skills at the center or core of each discipline. All educators can use the same thinking skills and problem-solving concepts and vocabulary to reinforce the commonalities between the arts and sciences and support the growth of students as they authentically pursue becoming a scientist, artist, mathematician, musician, athlete and more.

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Column: Elementary Explorations
Linking Art and Science

Kristen Poindexter

Abstract
There are so many ways to bring art into science in the elementary classroom. That can be as simple as sketching a diagram of something a student notices in an outdoor space to designing and building models that show how a science topic works. As you look through the NGSS, there are many examples of this across the K-5 spectrum. Included are examples of NGSS standards that show where opportunities for art can be included along with several classroom examples.

There are many ways to bring art into science in the elementary classroom. It can be as simple as sketching a diagram of something a student notices in an outdoor space to designing and building models that show how a science topic works. As you look through the Next Generation Science Standards (NGSS), there are examples of this across the K-5 grade levels. Scientists, across all disciplines, create models and representations daily in their work. The NGSS were designed for students to engage in the role of being a scientist by creating their own representations.

Model building and design also live outside the Engineering Design standards, so when looking for opportunities to bring in some options for art to your classroom, be sure to look at other areas as well. For example, standard 4-PS4-2 asks students to model light reflecting, you could provide students with opportunities to explore with flashlights and mirrors. Exploring with these items first allows students to give input on how the final model could look. Standard 3-LS1-1 would be an opportunity to give students a variety of materials to build models of organism lifecycles and compare them with their peers. Here are a few examples listed with their grade or grade bands and indicators:

Full listing of authors and contacts can be found at the end of this article.

2-ESS2-2 Earth's Systems
Develop a model to represent the shapes and kinds of land and bodies of water in an area. Grade: K-2, 2

K-2-ETS1-2 Engineering Design
Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem. Grade: K-2, K, 1, 2

3-LS1-1 From molecules to Organisms: Structures and Processes
Develop models to describe that organisms have unique and diverse life cycles, but all have in common birth, growth, reproduction, and death. Grade: 3-5, 3

4-PS4-1 Waves and Their Applications in Technologies for Information Transfer
Develop a model of waves to describe patterns in terms of amplitude and wavelength and that waves can cause objects to move. Grade: 3-5, 4

4-PS4-2 Waves and Their Applications in Technologies for Information Transfer
Develop a model to describe that light reflecting from objects and entering the eye allows objects to be seen. Grade: 3-5, 4

4-LS1-2 From Molecules to Organisms: Structures and Processes
Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways. Grade: 3-5, 4

5-PS1-1 Matter and Its Interactions
Develop a model to describe that matter is made of particles too small to be seen. Grade: 3-5, 5

5-PS3-1 Energy
Use models to describe that energy in animals' food (used for body repair, growth, motion, and to maintain body warmth) was once energy from the sun. Grade: 3-5, 5

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In my classroom, when students studied weather, one student noticed that there usually seemed to be a hexagon in the middle of each snowflake we studied. Students asked if they could use materials from around the classroom to create their own snowflakes! In this case, students used materials from our Loose Parts baskets and mimicked the symmetry they noticed in snowflakes. Even though they noticed the hexagon in the middle of the snowflakes we studied, most students focused on the symmetry and included 7 or more branches in the first models they made of snowflakes. This activity helped us transition into discussing K-ESS3-2, Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to severe weather.

When hovering over the first part of the linked standard (asking questions to obtain information) more information about how this might look or sound pops up (Figure 1). These pop-up areas are some of the most helpful, as they break down what a student might do or how the teacher can respond with an activity that would help students understand.

As I observe students create their own snowflakes, I take observational notes of the design on each snowflake, including the number of branches it has and if it is symmetrical. I am also noting the students' ability to ask questions about the snowflakes; anything that might clue me into what they would like to know more about and what information they already know. This snowflake building opportunity was a way that students could explore the art side of science while still learning about the factual weather content (Figure 2).

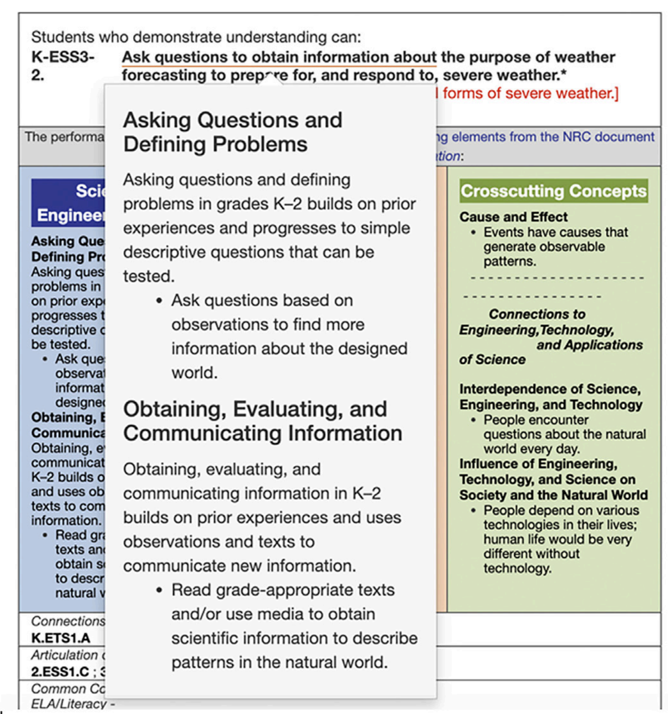

Figure 1. Practices in an NGSS Standard

Figure 2. Snowflake building activity.

In spring, when we studied flowers, seeds, and pollinators, students created representations of flowers that included ways that flowers could disperse seeds or attract pollinators. Several students also included details that showed what needs plants have (sun, water, soil). Most examples included the basic parts of a plant as well. In addition to demonstrating their knowledge, they were also able to engage in creating art using found and recycled objects. The standards listed below, K-ESS3-1 and 2-LS1-2 both allow for art and science to be combined. Students can use art materials to create models of the relationships between plants and animals or use materials to create a model that shows one way seeds are dispersed by animals or how plants are pollinated. Each activity would allow students to be creative in their model making and demonstrate their understanding of how ecosystems work at a developmentally appropriate level. (Figures

K-ESS3-1 Earth and Human Activity
Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live. Grade: K-2, K

2-LS2-2 Ecosystems: Interactions, Energy, and Dynamics
Develop a simple model that mimics the function of an animal in dispersing seeds or pollinating plants.*Grade: K-2, 2

Figure 3. Student representation of flowers

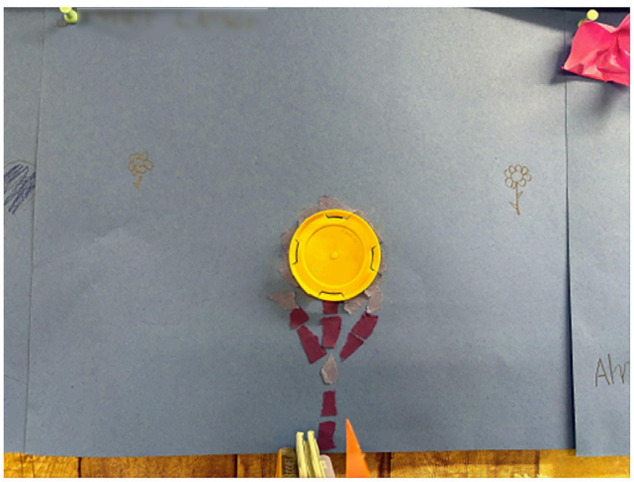

Figure 4. Student representation of flowers

Figure 5. Student representation of flowers

In the older elementary grades, it may prove to be more difficult to make time for extended art projects, however, it is so important that students have the time, when possible, to create models and diagrams so they can further demonstrate their understanding of topics. We have all had students who may not readily volunteer answers in a large or even small group setting, but they shine when given the opportunity to create art or detailed entries in a science notebook. Including sketches and drawings in science notebooks helps students increase their understanding of topics and it gives them a resource to refer to as needed.

Next time you review the science standards, be sure to look for words that invite art in; model, design, build, create, show. We have been given a gift in these standards, the gift to allow our students to replicate the work practicing scientists are doing in their own work. Don't forget to pass on this gift to your students and allow them the time to create art during science!

Kristen Poindexter is a veteran Kindergarten teacher in Indianapolis, Indiana. Her passion is Science and she loves to share that love with her Kindergarten students. Kristen is the recipient of the 2014 National Shell Science Teaching Award and the recipient of the Presidential Award for Excellence in Math and Science Teaching. She is a frequent presenter at district, state, and national conferences and shares how she incorporates Science into her Kindergarten classroom. Kristen uses lots of technology in her classroom and integrates it into all subject areas.

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Featured Article: Enhancing Teaching and Learning: 14 Strategies for Boosting Effectiveness and Joy

Joe Ruhl

Abstract
Educational research along with 42 years of classroom teaching have taught me that establishing meaningful, appropriate relationships with students results in minimized classroom discipline problems, increased student engagement and joy, increased learning, and enhanced job satisfaction, sense of fulfillment, and joy for the teacher! Positive teacher to students relationships are dependent on the teacher being intentional about demonstrating to the students that they are cared for as individuals. This article will summarize 14 ways to demonstrate teacher caring.

What's the most important thing I learned in 42 years of teaching high school students? What's the secret to happiness and fulfillment for the teacher in the classroom? What's the key to effective classroom management, increased student motivation and engagement, and effective learning? Building *relationships*!

Being intentional about building relationships in the classroom is huge, and it's built on a foundation of teacher caring. If the students perceive that we genuinely care about them as individuals, then walls of resistance to learning can crumble, creating positive experiences for the students and the teacher. Those days at school when I was intentional about remembering that "I don't teach biology. I teach *kids* biology," were the days when the students seemed to be most cheerful, most attentive, most engaged, and most on task. So, let's get practical. How can we show students that we care? Here are 14 practices that I have found to be highly effective.

1. Stand by the door and greet the students as they arrive at your classroom.

Beginning about the 6th year of my teaching career I picked up this idea from Harry Wong, an educator and motivational speaker, when I attended one of his workshops at a convention of the *National Science Teachers Association*. On the first day of school, I would stand in the hallway outside of my door and greet the students with a smile, a handshake, and a warm "Hi, I'm Mr. Ruhl!" Thank you for taking my class! I am so excited to have you in my class!" (or some similar greeting). Throughout the school year, this practice can be difficult when we're busy, but taking the time and effort to greet the students as they enter the classroom can pay huge dividends, even if the greeting is no more than a thumbs up or a smile. Researchers have found that greeting "problem" students this way before class can increase their engagement from 45 to 72 percent (Allday & Pakurar, 2007).

2. Be real and smile on the first day of school.

I'll never forget the advice I received from a grizzled old, burned-out veteran teacher who sat down beside me at the table in the teachers' lounge during lunch time on my very first day of school when I was a scared, first year teacher. He told me, "Don't smile until Thanksgiving!" I listened politely, even though I was skeptical because it didn't seem natural and I've learned over four decades, that his suggestion just doesn't work. A smile is a universal, disarming expression of acceptance. Don't be afraid to use it. Be a person!

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3. **Learn the students' names as soon as possible and remember and use them inside and outside of the class. Learn something about their interests outside of your class.**

Since the students were so used to hearing the teacher talk about classroom rules and policies on the first day of school, they usually found this activity to be a welcome and unexpected break in the routine. I decided to wait until the second day of school to go over classroom rules of which I only had one: "Treat others as you would have them treat you." I did of course, elaborate a little bit on specific examples of how someone might mess up and not put that rule into practice. But on that first day, to introduce the get acquainted activity, I always told the students, "Welcome! Thank you for taking my class! (I loved the puzzled looks during this moment.) I love biology and I can't wait to share it with you, but more importantly, you are more than names and student ID numbers on this printout, so I first want to find out who you are as people. Then we'll get into biology." After that brief introduction I would then pull up the slide screen to reveal the following list that I had previously printed on the board:

1. Name
2. Birth date
3. Extracurricular activities
4. Hobbies
5. Part-time job, if any
6. Favorite food
7. Favorite movie
8. What do you want to be when you "grow up?"

Next, I would tell the students to take out a sheet of paper and then find a partner to talk to (*"What? We can talk in here?"*). I would go on to say "Take a few minutes to interview your partner, and to write down the above listed 8 pieces of information about your partner on your paper. After you're finished, your partner will interview you, and write down information about you on their paper. When everyone is finished with their interviews, I'll have you come up to the front of the classroom, one pair at a time, and introduce your partner to the rest of the class." The wide-eyed looks on the faces of some of the students at this time revealed varying levels of anxiety as many teenagers are self-conscious about speaking in front of an audience. I reassured the students and told them that such feelings are normal; everybody has them. I always went on to say something like, "In almost every career or profession that you choose, there will be times when you will have opportunities to speak publicly, so this is a good time to begin practicing!" (*And why not let them share a little bit of the first day of school jitters that this introvert leaning teacher experiences!*) The important unspoken message to the students on this first day of school, was that they could expect this class to be student-centered rather than teacher-centered. The productive buzz that ensued during the next 10 minutes while the students interviewed one another was the kind of low-level classroom noise that teachers love to hear; the sound of students working together with purpose. This activity worked especially well for me because many of the students really did not know each other, since our school where I spent the last 36 years of my 42-year career (*Jefferson High School in Lafayette, Indiana*) is an urban high school of around 2500 students in the upper four grades. After all the interviews were completed, I made my way back to the front of the room and brought the class back together with an announcement something like this: "Before we start the introductions, I think that if I'm having you guys do this, it's only fair that I should go first, so I'll introduce myself!" Introducing myself to the students as I shared the 8 pieces of information about me revealed to the students that I was real and most importantly, approachable.

Before students began introducing their partners to the rest of the class, I had handed out a blank seating chart and told the students to note where they were in the classroom seating arrangement and to print their names on the seating chart (*"You mean we can choose where we want to sit in this class?"*). I also told them that when all the introductions were completed, that I would collect their papers and study them carefully so that I could learn all about who they were as persons. As I sat on a student desk or lab table to the side of the class during the student introductions I took careful notes on each student, noting especially the correct pronunciations of any unusual names. Having the students pronounce their partners' names during the introductions saved me *and* the students the embarrassment of butchering their names. That's not something that should be done to a self-conscious or insecure student on the first day of school. After each pair presented their partner to the class, I was able to interject occasional remarks such as "You're on the softball team? What position do you play? First base? That's what I played on the baseball team when I was in high school back in the Pleistocene when wooly mammoths roamed the frozen tundra!" Or "You're going to try out for the school musicals? I can't wait to see you on the stage!"

This first day of school activity took pretty much the entire class period and I would spend some time during the first couple evenings of that first week, studying the students' papers so that when I would see them in the school hallways, I could address them by name and ask them questions such as, "How's your after school marching band practice going? I've seen you guys out there after school marching under the hot August sun in the school parking lot!" Or "Has that restaurant that you work at given you a raise yet? No? Does Mr. Ruhl need to go in and talk to your boss?" As you can see, from the beginning I was trying to be intentional about establishing those all-important appropriate, firm, friendly, and fair teacher-student relationships. Relationship in the classroom is huge.

Every effective teacher stands on the shoulders of giants (*mentors*). I'll never forget one of those giants. His name was Dr. Sam Postlethwait, the creative innovative pioneer in science education at Purdue University – the father of the student-centered audio-tutorial method of instruction that he used in his freshman biology course, Botany 108. It was early in the fall semester of my freshman year of college. He saw me in the hallway and said, "Hello Joe! How are you?" I was floored and I felt valued! It was only the first week of school. He oversaw a course of hundreds of students and he knew my name! That was probably the best lesson that I learned on my path towards becoming a teacher.

4. **Have a sense of humor. Be able to laugh at yourself.**

It's important to find out and be aware of your own unique style of humor. I'm not a great joke teller, because my attempts at jokes tend to be "Dad jokes" so I will avoid telling jokes. It's just not my style. My humor tends to be a bit daffy, of the self-deprecating kind. This style of humor can show the students that their teacher is human, soften their hearts and help to create a sense of community. Be sure to find out what your style is and use it. Kids respond to humor.

5. **Look prepared and be prepared. Have predictable classroom rituals and routines.**

Being prepared is just basic professionalism. Think about how you have felt if you've ever dined in a fine restaurant. A professionally dressed host or hostess smiles, welcomes you and escorts you to your table. You sit down to a beautifully prepared table complete with pressed white table cloth, flowers, neatly folded cloth napkins, and carefully placed silverware. The presentation of the food, when it arrives, is so immaculate, you may be tempted to take a photograph of your plate and post it on Facebook! You're made to feel like you're the only customer there, and you just know that this restaurant carefully prepared before opening their doors. Contrast that to the way you felt if you've ever pulled up to the speaker in a fast-food drive through lane and heard the employee announce, "Our chocolate shake machine is out of order." It probably says a lot about me, but for me that can be a real letdown, especially on a long road trip. Looking prepared and being prepared is just as important in education.

6. **Be passionate and excited about what you're teaching.**

Margaret McFarland was a child psychologist who happened to be Mr. Fred Rogers' mentor. Here's a quote from her: "Attitudes aren't taught, they're caught. If a teacher has an attitude of enthusiasm for the subject, the student catches that whether the student is in second grade or is in graduate school." (as cited in King, 2018, p. 138). I know we've all experienced this. I'll never forget my third-grade teacher Miss Hershey. She would take 10-15 minutes after lunch to read to us. There she stood at the front of the class each day in her flowered dress where she would read a small portion of The Adventures of Tom Sawyer, to be continued the next day! Now we had entertaining cartoons on our black and white TV at home, but this was different! The Adventures of Tom Sawyer was a riveting adventure! And at the end of each day's reading, I couldn't wait for Miss Hershey to continue the story the next day. It seemed that Tom and his friends were always at a cliff hanger moment when she closed the book for the day! It was obvious to us that Miss Hershey was passionate about reading and loved to read to us! Looking back, I would have to say that she inspired me to be a reader. But Miss Hershey taught in a time before non-educators in state legislatures began mandating state-wide standards and standardized testing, so she, being respected by society for her experience and professional training, was free to teach and inspire.

7. **Allow time for freedom of movement in the classroom along with small group, hands-on work requiring students to *collaborate* and *communicate.***

For the first few years of my teaching career my "go to," comfortable, teaching method was lecturing. After all, that was the predominant method of instruction that I grew up with. I think most of us remember the "teacher-centered" classroom. Right? The teacher was up front and center. The students were in nice neat rows, not allowed to talk to each other and the teacher, the source of authority, downloaded information to the kids who regurgitated it back up on a test designed to measure how much content they could remember. The first few years of my career I was tempted to resort to that comfortable, familiar style, even if it wasn't exactly inspiring for the students or for me!

I'm so thankful that, after several years of teaching, I finally transitioned from a teacher-centered approach to running a student-centered classroom. It takes a great deal of work and preparation on the front end but the rewards are so worth it! I discovered that the kids LIKE learning this way (*"We get to do stuff in here." "We get to work together."*). I remember thinking, no wonder kids like learning this way! That's how our brains are wired. We are a social species. Our brains are wired to collaborate and communicate. I'm convinced that having students sit in nice neat rows where they're not allowed to talk to each other is unnatural and counter-productive. A few years ago, some teachers and administrators who visited and observed my classes were amazed that "100% of the kids were on task 100% of the time in three consecutive 92-minute periods." For me, teaching this way is not only effective but it's fun. Most importantly it allows the teacher opportunities to informally sit down with small groups of students and work eye to eye and shoulder to shoulder, creating opportunities to mentor, nurture, and inspire kids – to work on building those all-important teacher-students relationships.

8. Allow time for project work. Humans enjoy being *creative*.

It takes a bit of courage and trust for the teacher to move off-stage and allow the students time for project work. Creativity is a uniquely human, pleasurable, self-satisfying activity. Since human brains are wired for creativity, students like to be given the opportunity for project work, and they view it as evidence that the teacher cares. Just as important, project work is pedagogically sound because it promotes problem-solving and critical thinking. Project work will involve students not just in basic memorization, or understanding thinking, but will move them up into those higher levels of thinking such as applying, analyzing, evaluating, and ultimately to the pinnacle of higher-order thinking: creating.

In each unit of my 9th grade biology course, I gave students the opportunity to do a project (created mostly outside of class time) if they wanted to earn additional points towards a higher grade for that unit. I allowed them to design a project of their own choosing that would demonstrate in a nontraditional way their understanding of some concept or topic that they had learned about during the unit. One specific example was quite memorable. It was during the first three-week unit of the school year on the nature of science. I'll never forget a group of four girls who decided to write a script for a 15-minute play about the conflict and subsequent trials that Galileo suffered at the hands of church leaders in the 1600s. They then acted out and made a video dramatization of Galileo's discoveries, trial, and sentencing, complete with fake beards and make-shift attempts at period clothing! We watched their entertaining and educational production in class. I really believe that those four girls and their classmates will always remember key aspects of the nature of science taught by Galileo because of this project work. But beyond mere belief, I recall some empirical evidence that project work is effective. A couple of years ago at a high school football game I visited with Tenecia, a former student who is now a 20-year veteran of our town's police force. She hugged me and said, "Mr. Ruhl!" I'll never forget that cell cake I made for your biology class! I still remember that the mitochondrion is the power house of the cell, that the endoplasmic reticulum moves materials throughout the cell, that the nucleus contains the DNA and controls the cell's activities, and that the vacuoles are storage bins in the cell, (*She went on and on, much to my delight!*) . . ." I remember! She had baked a cake at home and decorated it with icing and different sizes and shapes of various candies to represent the different cell parts, creating a 3-D edible model of a cell. When she brought it to school, she gave a 5-minute presentation to the class, pointing out the various cell parts and describing their functions. Even though she and her police department co-workers over the years have likely not talked much in their daily conversations about the importance of mitochondria, the endoplasmic reticulum, the cell nucleus, or vacuoles, she retained that information for all these years thanks to project work!

9. Whenever possible, allow for student choice of learning activities.

Autonomy is a universal human value. Humans seem to like it when they know they have choices. Have you ever noticed people moving through the line in a smorgasbord restaurant, picking and choosing the food items to place on their plates? They usually have smiles on their faces because of the opportunity to make choices! In all aspects of life, humans like having choices, and that includes life in the classroom. The following are a few easy to implement, simple ideas that can be used to allow for student choice in many different grade levels and subject areas. I am certain you have used some of these and that you have other ideas as well. I believe it's important for us to be reminded to implement student choice whenever we can.

1. Allow choices on tests or quizzes. When I was a college student, I took a course in Cell Biology and the professor would often give us essay tests with the following instruction: "Do any three of the following five essay questions."
2. Choose which homework problems to do. When I was a high school student, I remember a math teacher who told us, "For homework, do either the odd or the even-numbered problems at the end of the chapter."
3. "Design and construct a project of your own choosing that would demonstrate in a nontraditional way, your understanding of some concept or topic that you learned about during the unit."
4. "Here are three activities that I have set up at three different learning stations throughout the classroom. When you have completed the work at the three stations, go ahead and hand in your work. You may rotate through the stations in any order you choose."
5. "Here are some practice genetics problems I would like for you to work on. You may either work alone or with a partner."
6. (*on the first day of school*) "You may sit anywhere you want (*I'll assess in a week or two to see if it works out!*), and I'll pass around a blank seating chart for you to print your name on."
7. "For today's group work, you may choose your lab partners."

Kids like a class in which they have choices. If you give them choices, they will believe and know that you care.

10. Recognize students for their accomplishments outside of the classroom.

Human beings have a desire to be successful in whatever passion in life they choose to pursue, and to feel a sense of pride in a job well done. I also believe human beings have an inherent need to feel valued and to be recognized. I have found recognizing students for their accomplishments outside of the classroom to be a powerfully effective way to show the kids that I care, and to strengthen those all-important teacher-student relationships in the classroom. To do this, whenever I had a student recognized in the local newspaper for some accomplishment in an outside activity such as Chess Club, the school play or musical, choir, Robotics Team, 4-H fair queen, Eagle Scout award, or athletics, I always enjoyed cutting out their newspaper article and posting it on the Wall of Fame in my classroom. It was a simple thing to do but so effective! Even if a student never made the newspaper, the unspoken message when they saw the Wall of Fame covered with newspaper articles, was that this teacher cared. I always loved it when a student would make eye contact with me and smile when they recognized their news clipping on the wall. I would normally say something like, "I was so excited to see that in the newspaper this morning! How cool! I'm proud of you! Please take a pen and, sometime this period, sign that newspaper article, because someday when you're famous, I bet your autograph will be worth lots of money and it will help fund my retirement!"

11. Recognize their birthdays.

I've known teachers who have all kinds of creative ways of recognizing students' birthdays. My method was actually very simple. My early morning ritual when I arrived at school included checking to see if any of my students had a birthday that day or, if it was a Friday, if anyone had a birthday during the upcoming weekend. As soon as the bell would ring to start class, after my usual "Happy Monday (or Tuesday, or Wednesday . . .)!" I would say to the student, "Happy Birthday!" and to the class I would announce, "Okay! Let's show (Insert student's name here.) some love! I'll leave the door open so we can rock the hallway on this floor!" The kids enjoyed and appreciated it when I led the class in loud, off-key birthday wishes! Sometimes the littlest gestures can make the biggest difference.

12. Praise students in public, but scold them in private. NEVER yell.

I've never viewed myself as the greatest disciplinarian, so I chose to use what I call preventative discipline. In other words, set up a learning environment that is such an attention grabber, so interesting, so engaging, (*and yes, maybe even fun*) that the students won't have the time or the desire to misbehave (*"Mr. Ruhl, I love biology because we get to do stuff in here!"*). Now, of course, occasionally I would have that kid who would still manage to find a way to act inappropriately. I learned that if I confronted that student in front of the whole class, he felt, knowing that his peers were watching, obliged to "save face" and demonstrate a defiant, argumentative attitude. As a teacher, it's next to impossible to win in that scenario. I found it best to calmly say, without emotion, something very brief and firm such as, "(*Insert name of student here.*), please (*Notice the good manners modeling going on here?*) come and see me when we split up and begin the day's activities after these announcements. I want to chat for a minute." As the students got up from their seats and began moving to their work stations, I would look down at some papers I was holding while the culprit slowly and cautiously (*What's Mr. Ruhl going to do to me?*) walked up towards me. I would look up from that stack of papers and say something like, "Oh. Yes. I just wanted to chat with you for a minute. I know you have a lot of work to do, so it won't take long." We would then step outside the open door of the classroom, out of earshot, with the student out of site of the other kids and positioning myself so I could "keep one eye on the class." In those situations, reminding myself to be firm, friendly, and fair, I found that even the most annoying kid, without an audience, would act like a human being, carry on a respectful conversation with me, and come away knowing, in no uncertain terms, what my expectations were going forward.

13. Say "hello" when you see them outside of class in the hall during passing periods, in the lunchroom, or at after school events. Smile and act like you're genuinely happy to see them.

This one is so easy to do! But, as teachers, in our time-pressured, busy day this gesture sometimes requires us to be intentional about it. As mentioned before, a smile is a universal expression of warmth and acceptance and it can be one of your most effective tools. I've always counseled my young student teachers, "Just be a person." It's amazing how something as simple as a smile can communicate to students that you care.

14. Attend after school extracurricular events.

Whenever possible, this one is a must do! Kids will notice when you show up at their choir or band concerts, musicals or plays, science fairs or athletic events, and when you do, they will perceive that you genuinely care about them. Carving out time for such activities can be extremely difficult, given a teacher's busy professional and personal schedule, but I'm sure you will find that the time invested in attending at least a few of your students' outside of class events will result in increased student motivation and improved behavior in class.

One day not long ago, I had heard that our girls' high school softball team would be having a home game after school so I thought I would go, since several of my students were on the team. I made my way up the bleachers and found a seat above our home team's dugout along the third baseline. It wasn't long before I saw a student's head pop up and look up into the stands and then pop right back down again. A few moments later, I heard a voice in the dugout: "Mr. Ruhl came to our game!" I'm convinced that if you take the time to attend at least a few of their outside of class activities, that it will pay off. Having first-hand experience witnessing their home run, their solo in the school musical, their last second shot in the basketball game, or their march ing band show during halftime of the football game, will give you even more material that you can use when you strike up those short relationship building conversations in the lunchroom, in the hallway, or as the students trickle into your classroom before or shortly after the bell rings.

At about the 15-year mark of my 42-year teaching career, I started experiencing that dreaded teacher burnout. The kids weren't loving biology as much as I did. I'm so thankful that I had that "light bulb" moment in the school hallway during passing period years ago when I realized, "I don't teach biology. I teach **KIDS** – biology." The days when I was intentional about remembering that seemed to be, more often than not, the days when teaching **AND** learning were most effective and most enjoyable. The ideas that I have shared in this article reignited that passion, generating a wave of job satisfaction and joy that I was able to ride all the way through to the end of the last day of year number 42. Relationship building in the classroom is huge, and it's starts with showing the students that you care about them as individuals.

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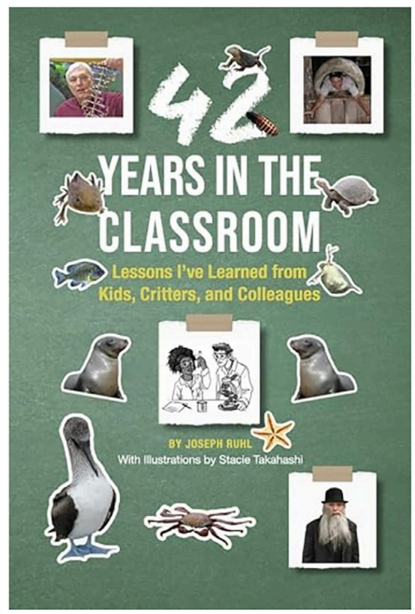
Editors Note:

This article is adaptated from Joe's 2022 book, titled *42 Years in the Classroom: Lessons I've Learned from Kids, Critters, and Colleagues.*



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Assessing Science Learning Objectives with Nature Journals

Brooke Stewart[1] and Kelly Book[2]

Abstract
Nature journals are an easy way to get your students outside and to practice making observations of the real world around them. Teachers can formatively assess their student's understanding of learning objectives with nature journal prompts.

Every teacher has experienced something in their life that has sparked an idea in the classroom. For the authors, that has been the purpose of field notebooks through courses that were taken at Indiana University Southeast. Brooke Stewart, one of the authors and a life science teacher, took a field biology class as an undergraduate with Dr. David Taylor at IU Southeast where she studied abroad for two weeks in Australia and the South Pacific. It was in this course where she was first introduced to field notebooks and where she first felt like an actual field biologist.

For Kelly Book, an earth space science teacher and co-author of this article, she also first experienced field notebooks through IU Southeast. However, her course was as a graduate student with the late Dr. Glenn Mason for a weeklong geology field trip class to the Jurassic Coast of England. This was Kelly's first introduction to field work in general, and she got a taste for what it was like to experience learning outside of a traditional classroom setting. For both authors, the field work has provided inspiration to provide similar opportunities for authentic science activities in the classroom through nature journals. For Brooke, she uses them in her Biology and Environmental Science classes. Kelly uses them in her Earth Space 2 class.

Nature journaling has given us an engaging way to assess our students' understanding of the science concepts they have learned in class and their ability to tie those concepts to the real world. Also, by connecting these concepts to their own local environment and drawing them out, it aids in long-term retention of the information. "Studies have shown that the most effective means of retaining information and memory for the long term is through finding familiarity, relevancy, and meaning in an experience" (Muir Laws et. al., 2020, p. 4). Nature journaling can also be a form of scientific inquiry that gives opportunities to ask questions about the world around them and make hypotheses. Not only does it deepen the students' scientific thinking skills, but this cross-curricular approach also gives teachers the opportunity to highlight the individual strengths and interests of more students (Hobart, 2005).

NGSS emphasizes the integration of science and engineering practices. According to *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (National Research Council, 2011), scientists need to be able to communicate their findings in a scientifically literate manner. The book also states that to practice this, students should be using journals with written text to record observations to improve their ability to think and write like a scientist.

Full listing of authors and contacts can be found at the end of this article.

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Integration of Arts into the Sciences: Putting the A in STEAM

Many people do not realize that creativity is an important component of science; we maintain that this is one of the reasons that the STEM acronym has evolved to STEAM to include the arts. Creative scientists are more able to think outside the box and generate new ideas. Creativity comes in many forms, but the most common is in the form of art. Nature journaling often combines art and science through an open-ended process. They allow students to express themselves artistically through drawing, painting, and sketching, which enhances their creativity and self-expression (Coppens, 2022). When we take students outside into nature, each student has their own unique perspective, and we enjoy seeing students' creativity as they try to convey their own perspectives of nature in their own journals.

Nature journals can also be an opportunity for students to practice writing about something that interests them. After implementing nature journaling into language arts classrooms, McMillan and Wilhem (2007) saw evidence of their students using figurative language beyond their language arts classes. It helps students see the art of writing and making observations as more of an interdisciplinary skill that they should carry throughout their lives.

Psychological Benefits of Nature Journaling

Evidence suggests that if a child spends a lot of their time outside, then not only will they become adults who spend a lot of time outside, but also adults who have more positive attitudes towards their local ecosystems (Bollich, 2023; Wells & Lekies, 2006). Students are more easily able to see their role in nature and how nature impacts their lives. Nature journaling provides so many benefits beyond just allowing us to assess their understanding of NGSS. According to Hammond (2002, p. 35), "research has shown us that drawing and writing about something we have just experienced fixes that experience in long-term memory and stimulates relational thinking." Studies have also shown a decrease in symptoms of both attention deficit disorder (ADD) and depression after children spend time in outdoor settings (Snell et al., 2016). Nature journaling also encourages students to pay more attention to the environment and focus on the details of their surroundings (Bollich, 2023).

Assessment Examples using the IDOE Science Standards

At the beginning of the school year, the authors gave each student a 'Rite in the Rain' notebook. First, students are taught how to properly organize field notebooks using a table of contents and page numbers. It was heavily emphasized to students that they need to write their name on the front cover of their nature journal and that they should not lose it. Students did not get a replacement notebook if they lost it during the school year. It is also explained to students that nature journals are not like other journals because they focus on science rather than their feelings. Students are reminded that this is a scientific tool for learning in the classroom, not a personal diary. The authors appreciated that Hammond (2002) allows his students to create a list of their own rules for their notebooks. With this idea in mind, it would be better practice to create field journal norms with our classes that they will follow throughout the upcoming school year.

Since Kelly and Brooke use the nature journals in different areas of study at different grade levels, they use them in ways that work for them as individuals in their own classrooms. Kelly likes to use her nature journals to emphasize concepts covered in geology, meteorology, and astronomy for her dual credit Earth Space 2 class, which is a junior-senior course. Because this class has no state standards, the "Main Course Learning Objectives" and "Learning Content" from Ivy Tech Community College are used in this course. Brooke uses nature journals in her biology classes, a freshmen course, and her Environmental Science class, which is taught to sophomores through seniors. She has a focus on reinforcing the state standards for both of these courses.

For Brooke, one of the most basic standards to teach in both her Environmental Science and biology courses is the difference between abiotic and biotic factors. For this reason, she found it difficult to get students to engage with the material enough for them to commit the terms to memory. Therefore, she believed that a nature journal entry could be the key. After covering the definitions and doing an in-class activity, she assessed their understanding by taking them outside with their notebooks. They were instructed to look in one direction and draw what they saw like they were looking out a window. Then they were supposed to list

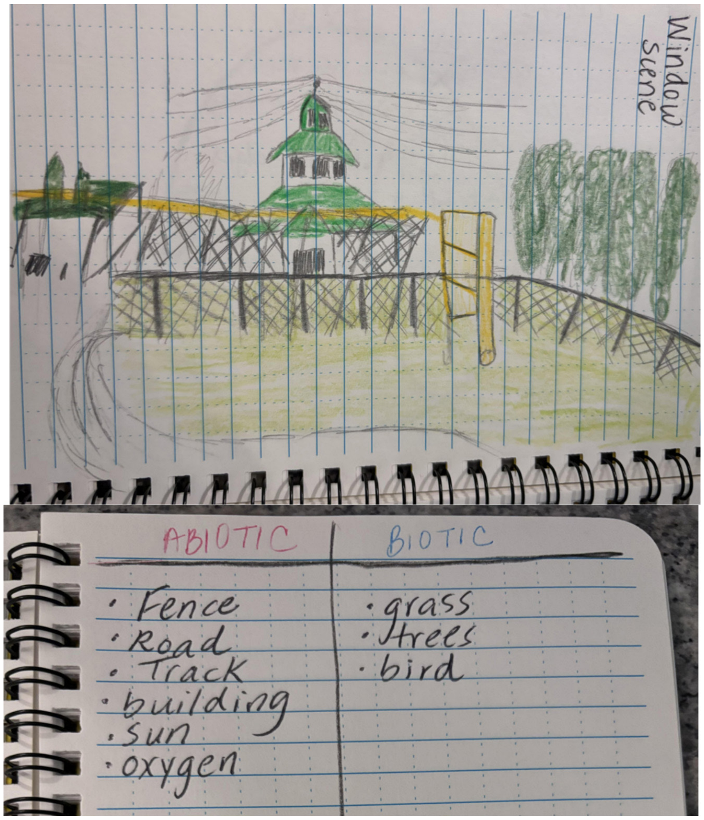

Figure 1. Example from teacher's sample notebook
HS-ENV1-5 *- Evaluate, measure, and communicate biological, chemical, and physical (abiotic and biotic) factors within an ecosystem.*

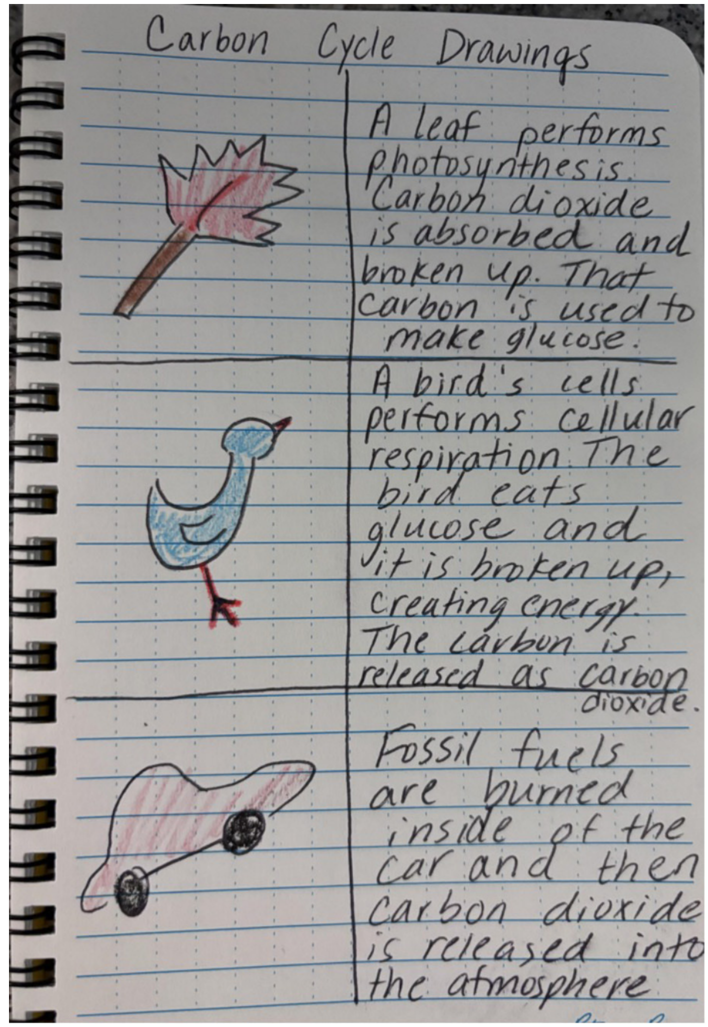

Figure 2. Example from teacher's sample notebook
HS-LS2-5 - *Develop a model to illustrate the role of photosynthesis and cellular respiration in the cycling of carbon among the biosphere, atmosphere, hydrosphere, and geosphere.*

all the abiotic and biotic factors within their view. A representation along with the correlating IDOE standard is shown in Figure 1.

Sometimes students struggle to understand that almost everything around them in the natural world (and a lot of the unnatural parts) are part of the carbon cycle. Brooke wanted to create a nature journal task that would help students connect the dots between the scientific principles they learn in the classroom and the world around them. At the start of the activity, she took students on a short walk outside and had them identify at least three different items that participate in either the long or short carbon cycle. They had to draw the item and then explain how it is part of the carbon cycle. For example, some students drew a car and explained that it burned fossil fuels and released carbon dioxide into the atmosphere (Figure 2). While the class was outside, they were excited about the meaningful conversations that were kindled. Students started to realize almost everything around them was part of the cycle.

This next prompt Brooke gave was part of an introduction to the biodiversity unit. Her goal was for the students to think about local biodiversity before they discussed it on a global scale. Before the class went outside, she had students create a small chart for each of the locations they would be observing (parking lot, forest edge, and crop field). While the class walked through each area, the students marked a tally every time they saw a new type of living species (Figure 3). Then before they moved on to the next area, they wrote a summary of their observations. The last page contained the summary, and the students were instructed to explain which area they thought had the most and least biodiversity. Students were also expected to explain how they thought human intervention affected the biodiversity in each area. One of her students stated, "The field has less biodiversity than the woods because the field is continuously mowed." This led to a conversation about other things the class does at their own homes that can threaten local biodiversity.

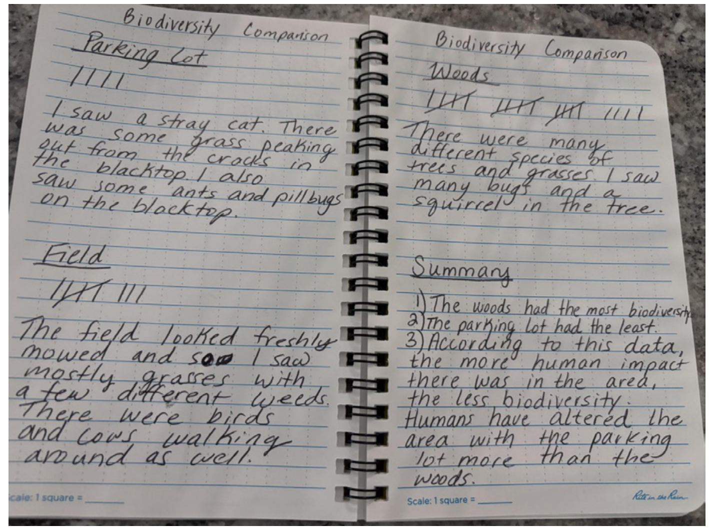

Figure 3. Example from teacher's sample notebook **HS-ENV5-5** - *Identify the indirect and direct threats to biodiversity.*

Kelly kicks off her year in Earth Space 2 by covering meteorology, one of the four main topics covered in any earth science class. By introducing students to the basic concepts of weather, students are then expected to incorporate each new prompt's daily weather conditions for the entire year. The first prompt of the year starts with students taking a walk around the school's campus and recording any weather conditions that they might observe such as cloud coverage, humidity, temperature, and wind speed (Figure 4). Students then come back into the classroom and fill in any missing quantitative data by utilizing local weather reports and websites.

Geology is another core topic of earth science that is also covered in Kelly's Earth Space 2 class. Throughout the year, some of the geology topics the students studied included fossils, minerals, and rocks. Students had already experienced hands-on learning activities with these materials in class, and at this point they are familiar with identifying local specimens. When these nature walks were completed during class time, students would be given instructions to write and draw

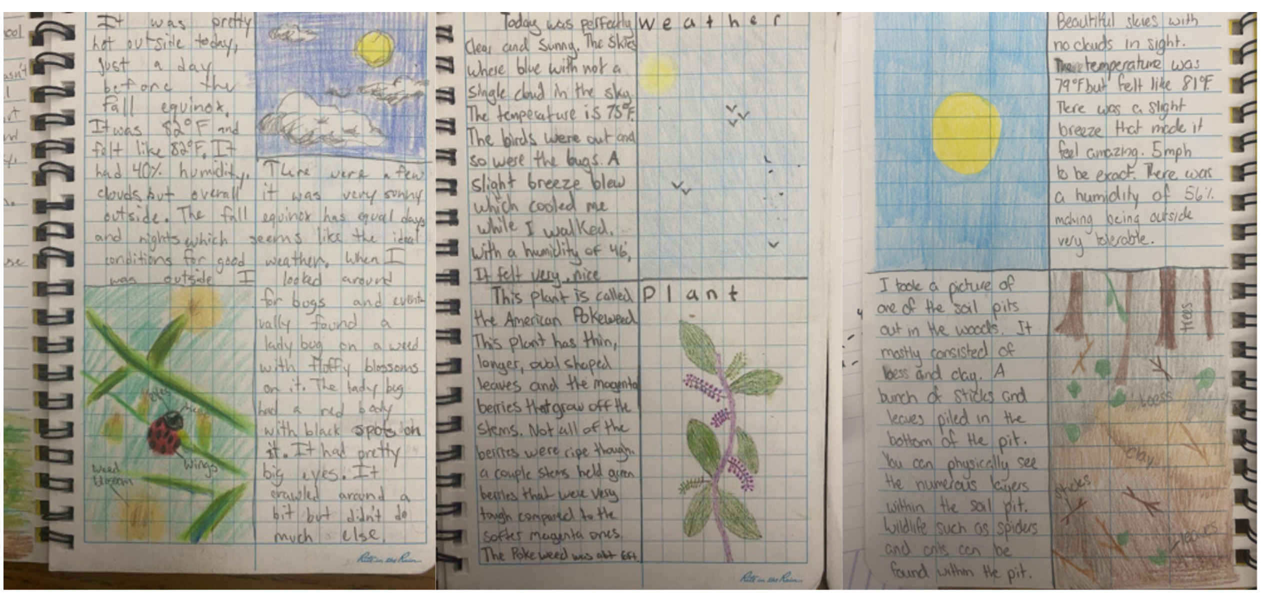

Figure 4. Early examples from student notebooks. ***Ivy Tech Community College SCIN-100 Major Course Learning Objective #12*** - *Discuss concepts related to Meteorology and climate processes.*

about any geologic feature that they come across (Figure 5). They could often be seen picking up rocks to look for embedded mineral crystals or fossilized remains of Southern Indiana's prehistoric past. Students then had to not only identify the substance, but they had to make inferences of how that material ended up in that location and what geologic processes have occurred. The amount of excitement and enthusiasm around finding certain fossils lead to some interesting and purposeful conversations when the class discussed their findings. Making connections to the "real world" has inspired students to view the significance of their education differently, and it has led to many days of class time making great memories together.

Perhaps the most exciting nature journal prompt of the 2023-2024 school year occurred on April 8, 2024, during the Great American Eclipse. After learning all that they could in class about the total solar eclipse, Kelly's Earth Space 2 class came up with their own prompt to fill out in their nature journal on eclipse day. Students were very thorough and included in their prompt the location, percent of totality, shadow observations, weather conditions, animal behavior, contact times, structures of the Sun such as the corona, and so much more. Students were told to write and draw as much as they could observe during the eclipse at their particular location (Figure 6).

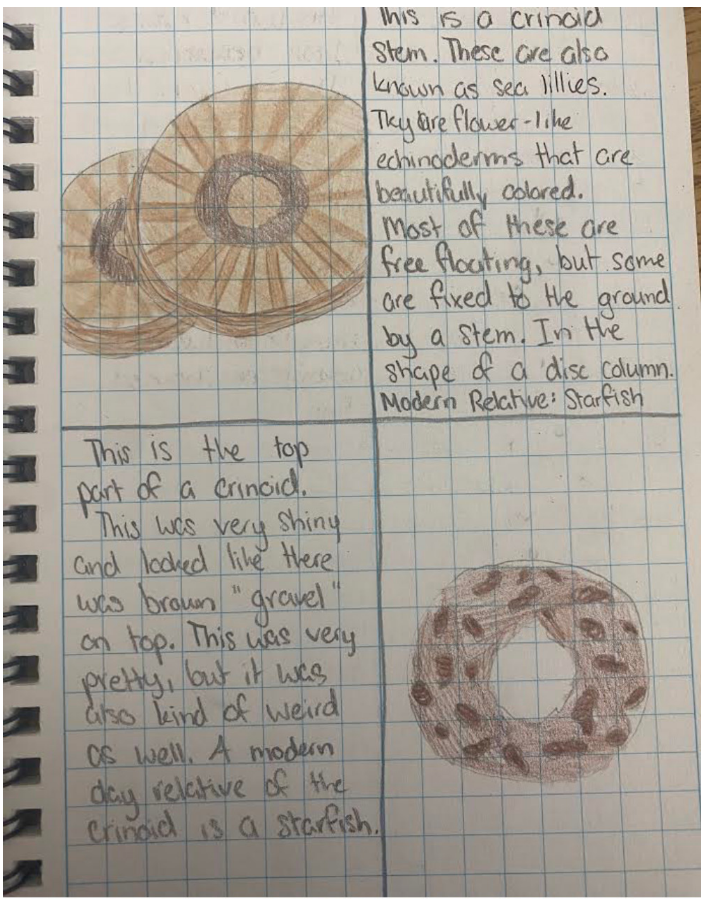

Figure 5. Example from a student notebook introduces concepts of Geologic Time through fossil identification. ***Ivy Tech Community College SCIN-100 Major Course Learning Objective #10*** *- State the age of the earth and explain how earth science measures and organizes the geologic time frame.*

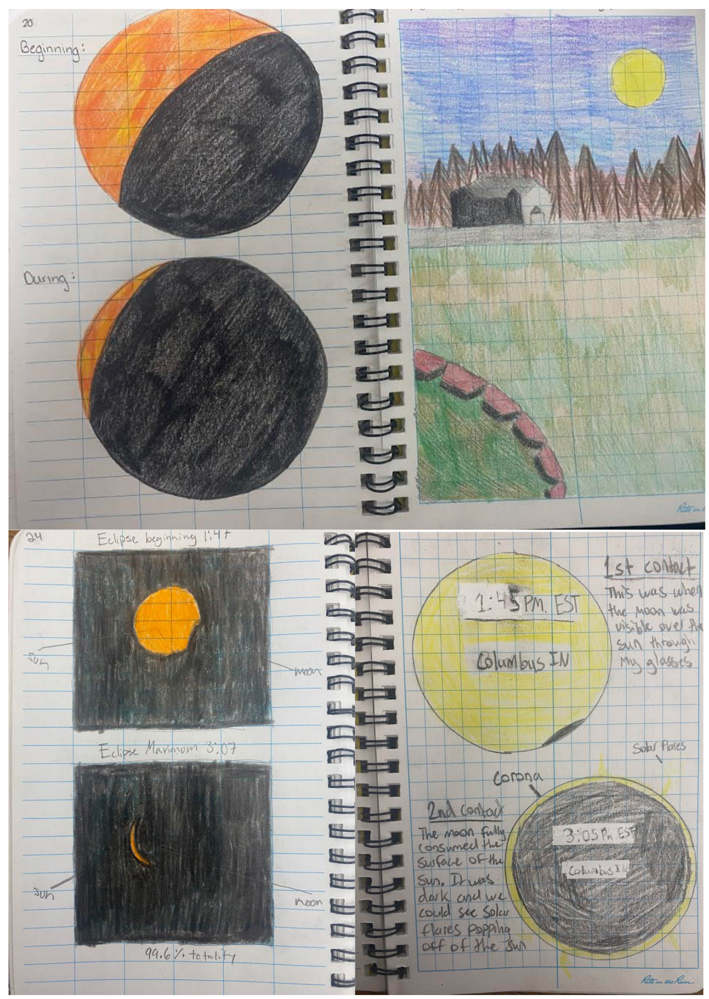

Figure 6. Partial examples from several student notebooks over the total solar eclipse on April 8th, 2024. ***Ivy Tech Community College SCIN-100*** *Course Content - Solar System*.

Technology Integration

Whether we want them to or not, high school students are always trying to find ways to use their cell phones in the classroom. Need a calculator? Get out your cellphone. Need to know the time? Get out your cell phone. We try to occasionally integrate the use of their cell phones for educational, purposeful reasons. Considering this, our classes have integrated the new Look Up iPhone tool, which allows students to take a picture of a plant and reverse image search to identify the plant (see Figure 7). Brooke extended the biodiversity entry mentioned earlier and had students use the Look Up tool to identify a couple of different plants from each of the locations that her class visited. Then when they got back to the classroom, the students were given the opportunity to research the best growth conditions for each plant and learn more about the abiotic components for that area." In their journals, they were instructed to hypothesize the correlation between the plant's requirements and where they were found and then relate that back to the biodiversity of each location.

Kelly also utilized the Look Up tool in her Earth Space 2 classroom for the first couple nature journal prompts of the year. Since earth science was a new topic to many of her students, they were first more comfortable implementing their nature journals with familiar life science topics such as plants. Another app other than the Look Up tool that students were encouraged to use to identify plants was the Indiana Wildflowers app. This app had students identify flowering plants found in Indiana by putting in the plant type, flower color, petals, flower size, leaf arrangement, and habitat. Students had to identify plants using one of these digital tools while on a nature walk. After identifying, they looked up what type of soil and climate those plants grow best to tie the assignment back to geology topics. This also helped familiarize students with identifying unknown objects, which became a required skill with geological samples such as rocks and minerals later in the course.

Figure 7. A student using the Look Up iPhone tool to identify a plant.

Living in a digital world, there are a plethora of other apps available for students to identify living things outside using their phones or computers. A study was done by Unger et al. (2001) in which undergraduate biology students were asked to identify the taxonomic classifications of organisms they saw in the field with the iNaturalist app. According to their results, the iNaturalist app was accurate 92.3%-97.3% of the time. Brooke thought it was cool that her students could have access to technological tools that experienced scientists use in their own research. Kelly found that the idea of integrating technology with nature gave students a truly subversive experience in their learning.

Plants and fossils are not the only things students can identify using apps. Sometimes looking towards the heavens can generate excitement of new possibilities and discoveries. Perhaps one of the most anticipated topics students learned about in Kelly's Earth Space 2 is astronomy. Because the students live in a rural community, they have an ease of access to view a clear sky at night. The best part about viewing the night sky or going along any of these nature walks is that they can often be done for free either at school or at students' homes. As part of Ivy Tech Community College's Course Content requirement for Earth Space 2, students need to learn about the Solar System. What better way than downloading an app and viewing some visible planets firsthand? The Star Chart app is free to use to find and locate planets in the night sky, and as an added bonus, students can learn about different constellations and be able to spot them throughout the seasons.

With the new announcement of Senate Bill 185 recently being passed, many Indiana teachers might be skeptical of instructing their students to time" (A.B. 185, 2024). Cell phones can be productive in the classroom (or in nature) when given an educational purpose.

Differentiation and Inclusivity

Nature journals can appeal to many types of learners because of the mixed media approach. Students can show their understanding through writing, drawing, graphing, etc. Taking students outside in nature provides opportunities for students and the teacher to have deeper conversations about the classroom concepts they have learned. According to Zurek et al. (2013), during outdoor activities such as nature journaling, "teachers can provide feedback, hints, or assistance to scaffold children's learning about their environment".

Nature journal activities can be differentiated by modifying the prompts to require students to perform a higher order thinking. For example, if the goal was to increase the rigor of the carbon cycle activity listed above, students could be challenged to predict the effects on the environment if they removed one of the components of the cycle they drew.

To assist students who struggle with the open-ended prompts, sentence starters can be given as a scaffolding strategy to give them a foundation. John Muir Laws (2020) provides an array of nature journal prompts and sentence starters in his book, *How to Teach Nature Journaling: Curiosity, Wonder, Attention.*

Nature is a global experience shared across many cultures. To incorporate more inclusivity, students could be introduced to underrepresented voices in the scientific community such as BIPOC and/or female scientists. They could next research their contributions to the topic they are currently studying and include that in their nature journal prompt.

Another way of adding cultural awareness could involve students researching how other countries, cultures, and societies utilize certain materials or ideas that they are currently studying. For example, students could study the cultural significance of constellations across different civilizations. Perhaps this could be done by comparing the constellations of the indigenous peoples of the Americas to those of the Ancient Greeks. They could in turn look for these constellations in the night sky as an activity and write and draw about their findings in their nature journal.

Evaluation of Journals

For each entry, a grading rubric (see Table 1) is used that has categories similar to the one presented by Hammond (2002) in his article titled, *The Creative Journal: A Power Tool for Learning*. According to Farnsworth et al. (2014), the rubric should be flexible if the goal is to encourage student engagement and creativity. Nature journals are graded at every midterm and/or at the end of every nine weeks depending on the teacher. It is emphasized that written feedback from the teacher

Table 1. Nature Journal grading rubric

Nature Journal Grading Rubric			**Comments**
Quality	**5** The entry is easy to read, all pages are numbered, all prompts begin on a new page and have a title on the top of the page, and there is a filled out table of contents.	**0-4** The entry lacks readability, pages aren't numbered, titles aren't written on the top of the page of each entry on a new page, and/or the table of contents is not completely filled out.	
Creativity	**5** There is evidence of student effort with detailed and labeled colored drawings.	**0-4** There is little to no evidence of student effort	
Content	**5** Mastery of content and detail are recorded through written text and visual drawings. The prompt was answered fully and completely. (Weather conditions are recorded. - Earth Space 2 class only)	**0-4** The entry lacks written text and/or visual drawings. The prompt is not completely answered and/or misinformation is present. (No weather conditions are recorded. - Earth Space 2 class only)	

into the nature journals should be taken into consideration, and improvements to future entries are expected with each round of grading. Written feedback for the authors is typically written directly onto the pages of the student work in red ink that stands out on the page for easy viewing. Typically, a few sentences are written on a page after the latest student entry that highlights the successes and improvements of each student, the date that it was graded, and the final score. In the authors' classrooms, nature journals are used as a formative assessment that helps students improve their understanding of the standards and/or learning outcomes before a final summative assessment.

Limitations and Expectations

One of the biggest benefits of nature journaling is that it gets students outside and interacting with nature. Depending on your location, this can be difficult during certain seasons of the year. In Indiana, it is sometimes too cold throughout the second and third quarters of the school year to take students outside. Brooke tried to combat this issue by utilizing a variety of websites with live nature recordings. For example, the website for the National Park Services has hundreds of live video cameras that are located all around the country. She's found several videos that are close enough to her location that allowed students to study their local ecosystems.

Kelly had a somewhat different approach to battling the cold months in Indiana by setting out samples of different fossils, minerals, rocks, etc. that students were currently learning about. They were then given a prompt over these to journal about including identification, formation, and composition. She required the use of stereomicroscopes for most of these prompts so students could see samples at a deeper level. The idea was to view these items at the microscopic scale before observing them at the macroscopic scale. The overall goal for students was to take their knowledge that they learned in class and eventually identify many of these fossils, minerals, and rock samples in a field setting during the warmer spring months.

Regardless of what time of year or what the prompt involves, safety should always be stressed throughout the entire year. When students can go outside during school time, it is always important to emphasize with students how long they are expected to be outside, what time and where they should meet up with the teacher, what items they are allowed to collect and bring back to the classroom, and what boundaries and trails on their school campus they should stay within. Have students set an alarm on their phones to know when they should head to the meeting spot, and have students travel in groups of at least two to three. The teacher should also be walking around during this time and meeting up with various groups ofstudents to offer instructional assistance and to keep an eye on behavior. Informing the office of where the class will be located and providing them with the teacher's cell phone information is also important in case there is an emergency, or a student is called to the office for various reasons.

Students should also know what their behavior expectations are, and what the consequences are for not following those expectations. Not following expectations typically results in a loss of one or more students going outside, messages sent home to guardians, and consequences with administration.

Conclusion

With the NGSS standards being phenomena-based, it can be a struggle for science educators to find phenomena that are cognizant of where the students live and their backgrounds (Sharma et al., 2023). As stated by Lee (2020), "using local phenomena is critical when working with students who have not experienced science and engineering as real or relevant to their lives for future careers". Through nature journaling, students can develop a personal connection to their local environment and can also form an appreciation for its ecological history.

In the future, it would be beneficial to give our students more opportunities to share their nature journals with their peers. Not only is it an empowering experience for them, but it helps them think in new or different ways. Inviting students to voluntarily share their journals with others will also make their journals feel more valuable (Farnsworth et al., 2014).

Nature journals can be empowering and a source of pride for students because it gives them the opportunity to be an author (Hammond, 2002). They can be a cheap and engaging way to enrich your current curriculum. They can also make for a nice memento for graduating seniors who complete a nature journal for a class. Several graduated students have given feedback to Kelly saying they sometimes look back at their field notebook and have great memories of the class, which is something every teacher wants to hear. The authors believe that science education is most effective when students are doing the same practices as what scientists are doing in the field. Nature journals are an easy way to get your students outside and to practice making observations. As science teachers we have the unique opportunity to take our classroom outdoors and let it enrich our curriculum (Cormell & Ivey, 2012).

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Birdwatching: A Field-Based Unit or Short Course

Donald Winslow

Abstract
I taught Birdwatching for the Indiana Academy's 2023 May Term. The latitude and flexibility of a standalone course provided opportunities for creative student expression. The focus was on recreational observation of birds with a modest introduction to the science of ornithology. Students gained skills in bird identification, interpretation of behavioral observations, and ecological study design. The only textbook was a field guide. Students were instructed to install and use the free mobile app Merlin. We met each morning for a total of 10 class sessions, each 3-4 hours long. Topics included binocular use, bird identification by sight and sound, the eBird project, avian physiology, note-taking, bird behavior, study design, North American birds, distribution ranges, bird nests, habitat, and subspecies. We took field excursions every morning, usually on foot but with two trips by van to nearby birding hotspots. Students demonstrated their identification skills every morning in field quizzes. Each student kept a journal of field observations. Students worked in pairs to design a study on behavior and one on ecology. The instructor developed a list of questions of interest, and students collected data to answer them by observing birds in the field. Each student wrote two research reports presenting the results of these investigations. On the last day, students completed a final examination. Scores on these assessments indicated that the student learning outcomes were achieved by most students. This course could be adapted as a unit at the end of a spring semester course in biology or zoology.

I just saw a hawk alight on a branch in the woods in back of our house. The breast was light-colored, and the wings and back were darker. The relatively short tail indicated that it was a *Buteo* rather than an *Accipiter* (Peterson, 2020). The overcast sky made it difficult for me to resolve a lot of detail, but the light speckles spread uniformly across the wings revealed it to be a Red-shouldered Hawk (*Buteo lineatus*). Songbirds started mobbing the hawk. When it flew, the striped tail confirmed the identification (Figure 1).

Teachers are always looking for lessons that will inspire students (Dajani, 2013), experiences that will spark their own interest and lead them to further discovery. Birdwatching is an enjoyable pastime that provides opportunities for learning about biology and the natural world (Paige *et al.*, 2010). Spring is an excellent time to introduce students to birding.

The Indiana Academy for Science, Mathematics, and Humanities is a high school for high-ability students in grades 10-12 (Indiana Academy, 2024). The school is located on the Ball State University (BSU) campus and is considered a department within the BSU

Figure 1. Red-shouldered Hawk (Buteo lineatus) perched on a branch in a tree. Photo by Donald Winslow.

Full listing of authors and contacts can be found at the end of this article.

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Teacher's College. Most of the students are residential, although some students commute. The Indiana Academy offers college-level courses and opportunities for creative exploration (Gooding, 1996). In addition to fall and spring academic terms, the Academy also conducts a two-week May Term at the end of the school year. During May Term, each student is enrolled in one course.

During May Term 2023, I taught a course in Birdwatching. There were no prerequisites for this course, and it fulfilled no requirements beyond an elective. This self-contained nature afforded flexibility and latitude and provided opportunities for students to express their creativity.

The content of the course included recreational observation of birds along with a modest introduction to the science of ornithology. Topics in ornithology included fundamentals of ornithology, avian systematics, classification of birds by order and family, subspecies, morphology, physiology, behavior, observation of bird behavior, taking field notes, ecology, habitat, distribution ranges, bird nests, and design of behavioral and ecological studies. Birding topics included binocular use, the Merlin app (Cornell Lab of Ornithology, 2024a), and identification by sight and sound. A couple of topics, North American birds and the eBird Project (Cornell Lab of Ornithology, 2024b), pertained both to ornithology and to recreational birding.

Class met each weekday morning for a total of 10 class meetings. Class sessions were 3-4 hours long and included lectures, labs, and field trips. Most classes lasted from 8-11 AM, but the two Thursday classes were scheduled from 8 AM-12 PM to allow for longer field trips by van. The drive to the furthest field site took about 30 minutes. During lectures we discussed birds and birding. In lab we examined bird study skins and mounted specimens.

The Academy has a small teaching collection of bird specimens that were donated by the Smithsonian Institution some years ago. It is worth noting that most bird species are protected under the Migratory Bird Treaty between Canada, the United States, and Mexico. The U.S. Migratory Bird Treaty Act prohibits the possession of most wild birds or their parts without a permit (Migratory Bird Permits, 1974). In Indiana, permits should be obtained from the U.S. Fish and Wildlife Service (U.S. Fish and Wildlife Service, 2024) and the Indiana Department of Natural Resources (DNR) to possess feathers and dead bird skins for educational purposes. Museums occasionally have excess specimens to donate to educational institutions, or an instructor can apply for a salvage permit from the DNR to collect road killed birds and feathers.

Course materials included a field guide (Peterson, 2020), the Bushnell All-Purpose Binoculars (Bushnell, n.d.), a field and lab notebook, and the Merlin (Cornell Lab of Ornithology, 2024a) and eBird (Cornell Lab of Ornithology, 2023) mobile apps. Students' lab fees paid for the field guides and binoculars, so they were able to keep these after the course. Recent changes in state law may prevent schools from charging students for books in future courses, but these materials were chosen to be relatively inexpensive yet high in quality. The mobile apps, both developed by the Cornell Lab of Ornithology, are free to download and install.

We went outside every day to observe birds (Figure 2). On a typical day, we would spend one or two hours in the field and the remaining time in the classroom (which is a biology laboratory) discussing topics and/or examining bird specimens. On field trips, students learned to identify local birds by sight and sound. Students practiced using binoculars effectively. Students observed the behavior of wild birds and collected data to answer questions on behavior and ecology. Each student kept a journal of lab and field observations. Students were instructed to record the date, times of observations, location of field site, weather conditions, bird species encountered, and behavioral observations in their journals. Students worked in pairs to design two studies, one on the behavior of birds and one on ecology.

Figure 2. The Birdwatching class in Christy Woods on the Ball State University campus, May 2023. Photo by Kendall Harris.

Most field excursions were on foot. Our class met just across the street from Christy Woods on the Ball State University campus, and there were other nice birding locations within walking distance. We took two longer trips by van to nearby birding hotspots, one to Prairie Creek Reservoir and the other to Province Pond. Every morning, we conducted field quizzes in which I pointed out birds for the students to identify. This provided opportunities for learners to demonstrate the bird identification skills they were acquiring. I continued to quiz them on birds until every student had an opportunity to identify a bird, with students who had already identified one ineligible to answer subsequent queries. Unfortunately, I underestimated the capability of the Merlin app, which will indicate the identity of a bird that is singing from the audio recorded by the microphone. Regardless, most students gained skill in the identification of local birds, and Merlin is a useful tool for developing that capability. The daily bird quiz typically took 15-20 minutes of class time. The schedule of topics and activities for the two-week course taught in 2023 is shown in Table 1.

On the second day, the students learned to use eBird to report bird observations. Although the eBird mobile app can be used to record observations in the field in real time, my preference is to make a list on paper and enter them later on the eBird website (Cornell Laboratory of Ornithology, 2024b). We surveyed Christy Woods and entered our list on the website when we returned to lab. I used my eBird account to do so; when there are multiple observers on an excursion, it is advisable for only one to enter data. The eBird interface presents a map to locate the site of the observation and also asks for other general information before allowing the observer to enter data on bird species detected.

During lab sessions, students worked in pairs or alone to examine study skins. I instructed students to draw pictures in their journals. Students wrote the species name (common and scientific) next to each drawing, indicating important field marks with arrows. Attention was given to differences in plumage between sexes, ages, and seasons.

For the field studies, the instructor developed a list of behavior and ecology questions. Each student pair chose one behavior and one ecology question from the list. Student pairs collected data to answer questions by watching birds in the field.

Behavior questions posed by the instructor included the following: What are the boundaries of a bird's territory? How much time does a breeding bird spend in various behaviors? How does a bird interact with other birds of the same species? How frequently does a bird feed its nestlings? How much time does an incubating bird stay on the nest? What habitat do birds of a particular species choose for nesting, feeding, etc.? How many individual songs does a bird have in its repertoire?

Ecological questions posed by the instructor included the following: How many birds of a particular species are found in a certain area? How many breeding territories for a species are found in an area? How many bird species are found in a certain area? How

Table 1. Schedule of topics and activities for the two-week Birdwatching course.

Date	Activities
15 May 2023	Introduction to class, fundamentals of ornithology, avian systematics, binoculars, Merlin
16 May 2023	Walking excursion to Christy Woods, avian morphology, identification by sight, eBird
17 May 2023	Walking excursion to White River, avian physiology, identification by sound, field notes
18 May 2023	Trip to Prairie Creek reservoir, bird identification, classification of birds by Order, quiz
19 May 2023	Discuss bird behavior and examine study skins, birds of Muncie area, bird Families, quiz
22 May 2023	Avian ecology, design behavioral and ecological studies, North American birds, quiz
23 May 2023	Observation of bird behavior, field quiz, distribution ranges, bird nests, habitat
24 May 2023	Collection of ecological field data, interpret behavioral and ecological data, field quiz
25 May 2023	Trip to Province Pond Wetland Conservation Area, field quiz, behavior report due
26 May 2023	Subspecies, field quiz, lab practical, final exam, ecology report due, field journal due

many breeding bird species are found in a certain area? How many migrating birds are found in a certain area? What are the locations of the nesting territories of one or more species? How do habitat characteristics affect the abundance of birds? How do habitat characteristics affect the bird species present?

The students conducted their research studies during the second week of class. I found that it worked fairly well for the student pairs to devise methods to answer their research questions with minimal intervention by the instructor. However, it may be advisable to provide some introduction to the scientific method. Each pair of students took about an hour during the first class meeting of the second week to design both studies. Observations for the behavioral study were made the next morning, and observations for the ecological study were made the morning after that. Later in the same morning, student pairs were given about an hour to analyze and interpret the results of their studies. Each student wrote two reports presenting the results of their investigations. A research report rubric is shown in Table 2.

Safety Guidelines

In the lab, safety protocols specific to the laboratory room should be followed. No food, gum, or drinks should be allowed in the lab. Each student's workspace should be kept clear and free of clutter besides necessary materials (pens/pencils, notebooks, etc.). Any hazardous materials (such as debris from specimens that have been chemically preserved) should be disposed of according to site-specific protocols. Students should promptly notify the instructor about any glassware breakage or equipment problems so that proper safety and equipment protocols are followed.

In the field, students should wear sturdy shoes and protective clothing. Students should stay near the group. When there are pairs of students working on specific projects, the teams may be a bit dispersed, and the instructor should circulate among the teams to help the students and keep track of them. Students should be instructed to watch their step and to watch for moving vehicles. After field excursions, each student should check themselves thoroughly for ticks. Any student bitten by a tick should visit the nurse.

In terms of field conduct, students should be instructed to remain quiet and focused on observing birds, be considerate of classmates, and keep device notifications silenced. Students should be instructed not to engage in conversations that are not relevant to the task at hand; more birds will be seen that way.

Table 2. A rubric for the behavior and ecology research reports. (25 points available)

Criterion	Ratings	Points
Report is in research report format (Objectives, Methods, Results, Discussion, etc.)	1 or 0	1 point
Objectives section is present.	1 or 0	1 point
Objectives are stated.	1 or 0	1 point
Research questions are expressed.	1 or 0	1 point
Methods section is present.	1 or 0	1 point
Methods are in past tense.	1 or 0	1 point
Sufficient detail is included for someone else to repeat the study.	1 or 0	1 point
Results section is present.	1 or 0	1 point
Results are stated in the text of the Results section.	1 or 0	1 point
Text refers to tables by number.	1 or 0	1 point
Tables are present.	1 or 0	1 point
Table numbers are present with each table.	1 or 0	1 point
Table captions are present.	1 or 0	1 point
A map is included.	1 or 0	1 point
A graph or photo is included.	1 or 0	1 point
The map is labeled as a figure.	1 or 0	1 point
At least one graph or photo is labeled as a figure.	1 or 0	1 point
Figure numbers are present.	1 or 0	1 point
Figure captions (legends) are present.	1 or 0	1 point
Findings are stated in the Results section.	1 or 0	1 point
Discussion section is present.	1 or 0	1 point
Findings are interpreted in the Discussion section.	1 or 0	1 point
Figures are referenced in the text.	1 or 0	1 point
Findings are related to stated objectives.	1 or 0	1 point
Suggestions for future research projects are given.	1 or 0	1 point

Techniques for Teaching Bird Identification

When a student spots a bird, it becomes that student's own discovery. The ability to quickly raise the binoculars to obtain a good view of the creature enables the learner to take control of the subject matter. The student can use field marks to identify the bird and then observe its behavior to see what it is doing.

Students can learn to identify birds by sight and sound. One skill that is important is effective binocular use. When a bird is spotted, the student should look at the bird while moving the binoculars in front of their eyes. This will place the bird image in the field of view of the binoculars. The binoculars can be focused with the central knob, and the viewer can adjust for differences between the eyes with a focus knob on one ocular.

To identify birds, one should learn the field marks of birds that are commonly seen in the area. A field mark is a shape, marking, or plumage pattern that is characteristic of a particular bird species. A field guide will often indicate these field marks with arrows, facilitating learning.

One can learn bird songs and other vocalizations of particular species by listening to audio recordings. There are collections of recordings available online, but the easiest way to learn bird calls is with the Merlin app (Cornell Lab of Ornithology, 2024a). Merlin provides recordings of each species to listen to on demand. In addition, Merlin will identify the birds itself as it records sounds in the surroundings. By looking at the names of species Merlin associates with the sounds it detects, the student can learn to recognize bird calls without the aid. It should be stressed that Merlin should be regarded not as a means of identification but as an aid to identification, just as a binocular and a field guide are aids to identification. It is quite accurate but does make mistakes.

Course Outcomes

Student learning outcomes included identification of spring birds of the Muncie area by sight and sound, classification of bird species by order and family, the ability to describe avian morphology and physiology, interpretation of behavioral observations, and design of studies on ecological interactions involving birds.

On the last day of class, we took one more bird walk, we had one last field quiz, the students took a written examination and completed a lab practical examination, and the students turned in their journals. The written examination consisted of multiple choice and short free response questions on paper. For the practical examination, I set bird specimens out at stations with questions at each station, and students circulated among the stations to answer the questions. I graded the journals while they were taking exams so that I could return the journals to them promptly.

Final grades were based on the field quizzes, final exam, lab practical, lab/field journal, and participation (Table 3). Scores on these assessments indicated that the student learning outcomes were achieved by most students. A straight grading scale was used, although a C is required to pass a course at the Indiana Academy (Table 4). Final grades were pleasantly high, despite so much of the assessment occurring toward the end of the brief term.

Table 3. Points awarded for assignments.

Assignment	Points
Field quizzes	100
Final exam	100
Lab practical	50
Lab reports	50
Lab/field journal	50
Participation	50
Total	400

Table 4. Grading scale for Birdwatching course.

Points	Letter grade
360-400	A
320-360	B
280-320	C
0-280	D*

*A C is required to pass a course at the Indiana Academy.

May is the perfect time for birding, and I truly enjoyed teaching this standalone course. Students also had a good time. Although not all schools will be able to offer a full course in birdwatching, this course could be adapted as a unit at the end of a spring semester course in biology or zoology. Many schools are situated in landscapes that will attract lots of bird species, especially in May when many songbirds are migrating. Birdwatching provides an ideal opportunity for an immersive active learning experience in a natural setting.

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Play-Doh Volumes: An Experience in Science/Math Lesson Integration

Shelly Engle[1] and Patrick Eggleton[2]

Abstract
This article demonstrates integration of mathematics and science lessons for 5th grade students with preservice teachers. The article shares a lesson where mathematics and science content are fully integrated, allowing students to make sense of conceptual understandings in both subject areas and the lesson also allows students to view mathematics and science as tools to question, analyze, represent, and communicate findings. The lesson is one the authors used in Spring 2022 and Spring 2023 with preservice elementary teachers. The description of the lesson includes lesson objectives and connections to relevant science, math, and cross-cutting concepts for 5th grade (although it could be adapted for various grade levels).

"Where did the science go?" I asked myself as I dug deeply into an inherited syllabus where preservice teachers were expected to teach science lessons to each other in class as an assignment instead of in their practicums. It seemed that preservice teachers could not teach science in their placements because science was not being taught in every classroom, thus the assignment could not often be fulfilled in elementary classrooms.

No science in many schools was a startling thought and one that I could not accept. Somehow in the last seven years, science has exited the elementary classroom. I immediately knew that if science was not explicitly being taught in the classroom, I was going to have to teach my preservice teachers how to sneak it in. This would have to become a course objective.

As I drove to work that next morning, my thoughts were swirling about how I could do this. It led me to stash my stuff in my office, find out who the math methods professor was, and head up to his office unannounced. I introduced myself and asked if he wanted to partner to model for preservice teachers how we could integrate science content into math content because elementary students deserved to learn science in school too, even though many schools stopped explicitly teaching it. After he likely got over the thought of, "Who is this lady and why is she so caffeinated," we jumped in feet first discussing how we could combine two subjects of content and what could be a starting place.

The idea of integrating content or subject areas is not new and even seems like common sense to educators in the field (Czerniak, Weber, Sandmann, & Ahern, 2010). Life is not separated into different content areas, and neither is learning. Students typically ask the question, "Will I even use this in real life?" Integration of content areas allows students to see how different content areas naturally connect and overlap as they maneuver problems at work, in their homes, and in society. Educators know and tell students this, but students fail to take teachers at face value and only believe what they experience, so educators need to provide experiences where students can see the connection of ideas and subjects.

As teacher educators we need to support our future teachers by identifying and implementing effective strategies to meaningfully and purposefully integrate mathematics and science. While we communicate the

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value of this integration, we must also model it within our classes. One of the best ways to model this integration is by combining the science and mathematics classes as they pursue a common objective.

For the past three years we have done this at our school by combining our science and mathematics methods classes in a lesson on conservation of mass that corresponds with a lesson on the volume formulas of solids. As one student commented, "Integrating science concepts like scientific method is helpful when exploring the origin of math equations and concepts. Science topics, like the conservation of mass, can also be defined and explained in math which was seen today. The other subject adds a whole new layer of depth to the understanding of the topic in another subject." The National Council of Teachers of Mathematics (NCTM) and the National Science Teaching Association (NSTA) concur with this student's observations and have demonstrated that by recent entire publications dedicated to the integration of mathematics and science (NCTM, 2024; NSTA, 2024).

It is our goal that lessons like "Play-Doh Volumes" inspire future teachers to explore science and math topics together. Beck and Park (2011) conclude that students exposed to integrative approaches such as math and science demonstrated greater achievement in STEM subjects.

When approached to consider a math/science integrated lesson I loved the idea, but, like many teachers, I wondered if I had enough scientific background to develop a lesson that would authentically integrate the two subjects. In a survey of 221 in-service and preservice teachers, Lehman (1994) reported that less than 50% felt they had sufficient knowledge to integrate mathematics and science. Working with a colleague who can provide support in the other content area is a great way to get these lessons started. Looking through my lessons I noted that I taught a lesson on finding the volume of solids that needed an opportunity for students to actively find volumes of different solids. It would also be good for students to create prisms, pyramids, cones, cylinders, and spheres, forcing them to connect the abstract attributes and definitions with actual solids. I loved the activities where you could pour water or sand from a pyramid into a prism with the same base and height to see that it takes three pyramids to equal the prism, but that didn't seem to capture an authentic scientific principle. I then recalled how students often struggle with the concept of conservation of mass when the mass changes shape. Checking with my science colleague reinforced that this was an important concept and fit well with the science standards. The lesson on Play-Doh volumes started taking shape!

Play-Doh Volumes

Objectives:

- Students will explore volume and develop the general formulas for prisms, cylinders, pyramids, cones, and spheres making models of each shape to plan and carry out their investigation.
- Students will use the volume formulas to calculate the volume of a set amount of play doh in various solid shapes – hoping to get the same volume each time.
- Students will create a claim based on evidence collected in their investigation.

Materials:

- 1 can of Play-Doh (various colors).
- 1 ruler.
- 1 set of calipers (optional).
- 1 measuring tape (optional).
- 1 worksheet packet.
- 1 set of pencils and erasers.
- 1 container or bag for storing Play-Doh.
- 1 set of hand sanitizer or soap and water access.

Play-Doh Volumes

Classroom Management and Safety Considerations:

- Clear and explicit instructions
- Model each step- there are many steps to perform in this activity
- Remind students of formulas and how to use the tools
- Monitor student performance and work
- Set the rules for Play-Doh and tool use- no eating of the Play-Doh
- Keep hands clean

Inclusivity, Grouping, and Accommodations:

- Multimodal instructions, practical examples of volume
- Interest-based grouping, knowledge or ability grouping, heterogeneous grouping across ability levels (suggested by authors)
- Scaffolds such as adaptive or digital tools, sentence starters, calculators

Related Fifth Grade Curricular Standards:

From the NGSS Science:

5-PS1-2. *Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.*

From the Common Core Math:

5.MD.C.5 *Relate volume to the operations of multiplication and addition and solve real world and mathematical problems involving volume.*

(b.) Apply the formulas $V = l \times w \times h$ and $V = b \times h$ for rectangular prisms to find volumes of right rectangular prisms with whole-number edge lengths in the context of solving real world and mathematical problems.

From NGSS Crosscutting Concepts

CC.3: Scale, Proportion, and Quantity *- In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.*

From NGSS Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.

From NGSS Science and Engineering Principles

- *Developing and Using Models*
- *Planning and Carrying Out Investigations*
- *Using Mathematics and Computational Thinking*
- *Engaging in Argument from Evidence*

As this was a lesson for preservice teachers, we provided a quick overview of how to develop volume formulas for solids with students. A "bell ringer" puzzle that scaffolded the concept of finding the volume of a rectangular prism by first counting identifiable cubes, to illustrations of prisms with the grids removed, to just the quantities provided for length, width and height provided a starting point that develops the concept of volume as recommended by the common core standards (Marcy & Marcy, 1978).

We showed students prisms with different bases to note that the volume could always be found by multiplying the area of the base shape to the height of the prism. This was even extended to cylinders. Next, students observed videos where pyramids were used to fill prisms of the same base shape and height with water to note that pyramids have 1/3 the volume of a prism with the same base shape and height. This was also extended to cones being compared to cylinders. (YouTube Video #1) Finally, we watched a quick video that demonstrated how a cone and a sphere with the same radius (the cone having the height of the diameter of the sphere) could be used to show the development of the formula for the volume of a sphere. (It takes 2 of these cones to fill the sphere.) (YouTube Video #2)

Quickly supplied with these different volume formulas, students were tasked with using a set amount of playdoh to create solids of different shapes. They were then to take measurements to find the volume of each solid. Prior to engaging with the task, they were to create a hypothesis regarding what would happen to the volume as it was transformed into the different solids. (see Figure 1) Something we plan to include with future opportunities to teach this lesson is to have the students weigh each solid after it has been formed. We also plan to dive deeper into the science concept of conservation of mass and matter as a result of our claims backed by evidence and supported by reasoning.

Figure 1
With your clump of Play-Doh, create each of the given solids. Draw a diagram of each solid with the appropriate measurements and then calculate the volume of each solid.

Create a hypothesis that relates volume and the different types of solids.

My hypothesis:
____
____
____

Solid	Diagram with Needed Measurements	Volume
Cube		
Triangular Prism		
Square Pyramid		

Solid	Diagram with Needed Measurements	Volume
Cylinder		
Cone		
Sphere		

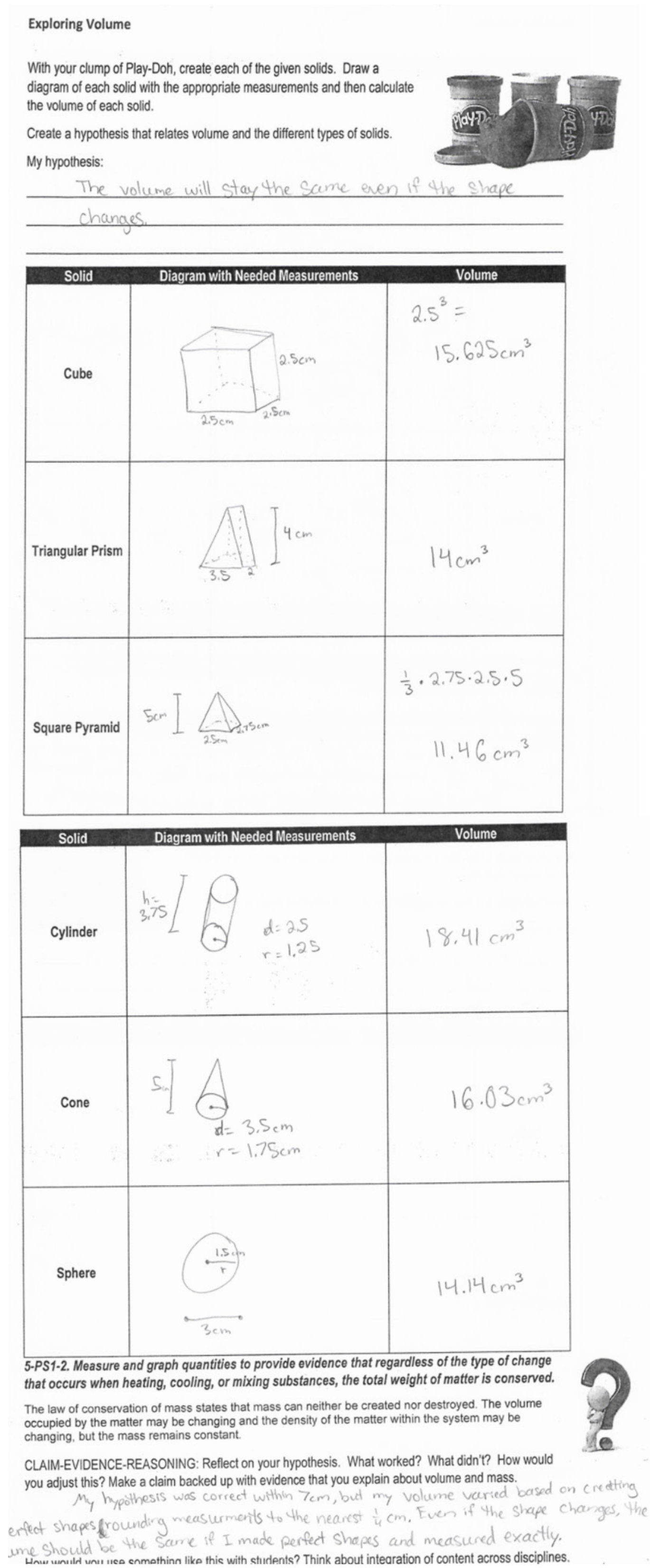
5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.
The law of conservation of mass states that mass can neither be created nor destroyed. The volume occupied by the matter may be changing and the density of the matter within the system may be changing, but the mass remains constant.

CLAIM-EVIDENCE-REASONING: Reflect on your hypothesis. What worked? What didn't? How would you adjust this? Make a claim backed up with evidence that you explain about volume and mass.

Figure 1. Student handout for activity.

Upon debrief at the end of the activity, students were asked to “think like a scientist” and discuss the effect of changing shapes and volume as well as conservation of mass during the changes. They then reflected on their hypothesis and made a claim backed up with evidence that explained their observations about volume and mass. Students applied the Claim, Evidence, Reasoning (CER) principle that they had frequently used after making observations and participating in a discovery activity.

Many students made solid connections between conservation of volume and matter as well as demonstrated understanding of the concepts individually. Students experienced irregularities because of measurement and concise shape creation. This led to additional observations and discussion to determine what should have happened and conclusions that should be drawn. The results of one of our students is shared (see Figure 2). Note how she effectively provided several representations of her volumes (both in pictures and through symbolic representations), she looked for regularity in her data, and she drew a conclusion based on her original hypothesis.



Exploring Volume

With your clump of Play-Doh, create each of the given solids. Draw a diagram of each solid with the appropriate measurements and then calculate the volume of each solid.

Create a hypothesis that relates volume and the different types of solids.

My hypothesis:

The volume will stay the same even if the shape changes.

Solid	Diagram with Needed Measurements	Volume
Cube	2.5cm, 2.5cm, 2.5cm	$2.5^3 =$ $15.625 cm^3$
Triangular Prism	4 cm, 3.5, 2	$14 cm^3$
Square Pyramid	5cm, 2.5cm, 2.75cm	$\frac{1}{3} \cdot 2.75 \cdot 2.5 \cdot 5$ $11.46 cm^3$
Cylinder	h = 3.75, d = 2.5, r = 1.25	$18.41 cm^3$
Cone	5cm, d = 3.5cm, r = 1.75cm	$16.03 cm^3$
Sphere	1.5cm r, 3cm	$14.14 cm^3$

5-PS1-2. Measure and graph quantities to provide evidence that regardless of the type of change that occurs when heating, cooling, or mixing substances, the total weight of matter is conserved.

The law of conservation of mass states that mass can neither be created nor destroyed. The volume occupied by the matter may be changing and the density of the matter within the system may be changing, but the mass remains constant.

CLAIM-EVIDENCE-REASONING: Reflect on your hypothesis. What worked? What didn't? How would you adjust this? Make a claim backed up with evidence that you explain about volume and mass.

My hypothesis was correct within 7cm, but my volume varied based on creating perfect shapes, rounding measurements to the nearest 1/4 cm. Even if the shape changes, the volume should be the same if I made perfect shapes and measured exactly.

How would you use something like this with students? Think about integration of content across disciplines.

Figure 2. Sample of student observations and data.

We followed the activity by getting survey responses from the preservice teachers regarding how they might integrate content across disciplines and how authentically math and science were connected in the Play-Doh volume lessons. All the students who responded (n=29) stated that the concepts were moderately or very well connected. One student shared,

"In my future teaching, I would like to also integrate the subjects of science and math because they go hand-in-hand so well, with minimal extra effort on the teacher's part. I can see myself creating projects for my students that integrate many domains of learning into a culminating piece. This allows students to see more purpose and value in their learning because application is present in the classroom, not just a faraway potential."

Another student stated, "I would love to integrate subjects as much as I can. … Science really helps to bring math alive especially when doing lots of measurements and experiments."

While we did not use a rubric to grade these responses and simply used it as a formative in-class activity, a rubric like the one below could be used to score preservice teachers or fifth-grade students (OpenAI, 2024). (See figure 3)

Rubric for Play-Doh Volume Assignment

Criteria	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)	Points
Hypothesis	Clearly stated, relevant, and testable hypothesis.	Clearly stated but somewhat general hypothesis.	Hypothesis is unclear or partially irrelevant.	Hypothesis is missing or completely irrelevant.	
Diagrams and Measurements	Diagrams are accurate, detailed, and correctly labeled with appropriate measurements.	Diagrams are mostly accurate with minor errors in detail or labeling.	Diagrams are somewhat accurate but lack detail or correct labeling.	Diagrams are inaccurate or missing, with incorrect or missing measurements.	
Volume Calculations	Volume calculations are accurate and correctly shown for all solids.	Volume calculations are mostly accurate with minor errors in calculation.	Volume calculations have several errors or are incomplete.	Volume calculations are incorrect or missing.	
Application of Law of Conservation of Mass	Clearly demonstrates understanding of the law with accurate reasoning in reflection.	Shows understanding of the law with mostly accurate reasoning.	Shows partial understanding of the law with some reasoning errors.	Shows little to no understanding of the law with incorrect or missing reasoning.	
Claim-Evidence-Reasoning	Claim is clearly stated, evidence is relevant and well-explained, reasoning is logical and thorough.	Claim is clear, evidence is mostly relevant and explained, reasoning is generally logical.	Claim is somewhat clear, evidence is partially relevant, reasoning is somewhat logical.	Claim is unclear, evidence is irrelevant or missing, reasoning is flawed or missing.	
Neatness and Organization	Work is neat, well-organized, and easy to follow.	Work is mostly neat and organized with minor issues.	Work is somewhat organized but may be difficult to follow.	Work is disorganized and difficult to follow.	

Total Points: ______ / 24

Additional Comments:

- **Strengths:**
- **Areas for Improvement:**

Figure 3. Rubric for assessing responses

Conclusion

Whether you are teaching preservice teachers or a teacher in the classroom P-12, integration across disciplines and within content areas allows students to make authentic connections to real world learning. Czerniak, Weber, Sandmann, & Ahern (2010) recommend that preservice teachers receive instruction on the integration of mathematics and science and experience the teaming process of content with experienced teachers. While this advice focuses on preservice educators, the same advice can still be applied to current classroom teachers.

Take a risk and partner with an experienced teacher in science or mathematics and put together one lesson that seems to make sense. This is exactly what we did, and we saw great success with students. Had we taught this lesson to fifth grade, we predict we would have achieved great success in the classroom as well. In fact, many preservice teachers, our students who will be out in the classroom within a year, stated that they would likely use this exact lesson with their students.

The hands-on element of this lesson also allowed students to experience different solids, the measurements associated with volume, and exploration of a hypothesis. This solidifies the mathematical and scientific concepts for their learning. In the follow up survey one student commented, "[Integrating subjects] shows how to apply learning to life … that life is not divided into subjects. We use the knowledge from ALL the different subjects to work together in our lives." We never want even a hint that science is lacking in the curriculum. If we need to sneak it in, mathematics seems like a natural path.

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Incorporating Climate Engineering into Secondary Education: A New Direction for Indiana's Science Classrooms

Paul B. Goddard[1], Ben Kravitz[2], Adam Scribner[3], Kirstin Milks[4], and Catherine Peterson[5]

Abstract

Climate change represents a significant existential challenge in modern times, with widespread anxiety over its impacts. There's a growing desire among students to explore climate solutions and identify personal actions to address climate change. Despite mitigation efforts, current greenhouse gas emission reduction measures are insufficient, and development of negative emission technologies is slow and costly. Consequently, the past two decades have witnessed an escalating interest in alternative strategies to temporarily and intentionally cool the planet. Collectively known as climate engineering or geoengineering, these approaches could serve as a temporary shield against the most severe outcomes of climate change, buying time while efforts to mitigate emissions and enhance carbon sequestration reach the required scale.

In line with the Indiana state science standards (HS-ESS3-4), this article presents the Climate Engineering Teaching Module (CETM) and recounts firsthand experiences from its application in high school settings. Launched over three years ago, the CETM has been effectively integrated into fifteen Indiana classrooms. As the future citizens and leaders of Indiana, it is crucial that students are well-informed on climate engineering. Educating them about the scientific, ethical, political, and economic facets of climate engineering is imperative for fostering responsible decision-making. By examining the trade-offs associated with climate engineering and encouraging students to conceptualize ways to implement these technologies beneficially while minimizing risks, the CETM offers an innovative and practical approach to teaching climate change and engineering design. This method not only prepares students for active engagement in future discussions on climate engineering but also equips them with a comprehensive understanding of its complexities.

Introduction/Motivation

Climate change is one of the greatest existential threats of the modern age (Ripple et al., 2023), and anxiety about its consequences is pervasive (Crandon et al., 2022). There is increasing demand by students to figure out what can be done about climate change (Hickman et al., 2021). The only permanent solution to preventing further climate change is to reduce greenhouse gas emissions (Solomon et al., 2009; IPCC, 2023), potentially supplemented with negative emissions technologies (NRC, 2015a). However, these are both slow and expensive prospects (NASEM, 2019) and currently inadequate to match society's greenhouse gas emissions (Martin-Roberts et al., 2021). Adaptation to climate change will be necessary in the meantime (IPCC, 2022), but there are legitimate concerns that the increasingly harmful effects of climate change outpace humanity's ability to adapt (Costello et al., 2023). As the world approaches 1.5°C of global warming in the next decade or so (Matthews and Wynes, 2022; Diffenbaugh and Barnes, 2023), there is increasing discussion around alternative options to temporarily, deliberately modify the climate to prevent some of the worst effects of climate change while more permanent solutions are implemented (Shepherd et al., 2009). Technologies to cool the planet, like injecting large amounts of reflective particles into the stratosphere or brightening low clouds over the oceans, are part of a larger umbrella that we term *climate engineering*.

As a research field, climate engineering, also called

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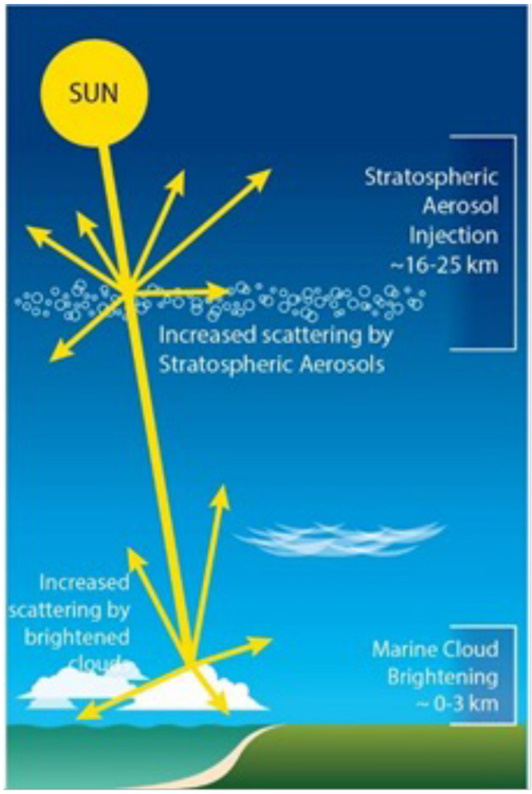

Figure 1. Schematic of Stratospheric Aerosol Injection and Marine Cloud Brightening. Modified from NASEM (2021).

geoengineering, has been gaining momentum over the past two decades (Boettcher and Schäfer, 2017). Computer modeling studies show that climate engineering, such as Stratospheric Aerosol Injection or Marine Cloud Brightening (Figure 1), can effectively cool the planet, offsetting warming from greenhouse gas emissions (Kravitz et al., 2013). This could prevent climate tipping points such as the loss of the Greenland (Moore et al., 2019) and Antarctic ice sheets (Goddard et al., 2023), melting of boreal permafrost, disappearance of Arctic Sea ice, and large-scale die-off of low-latitude coral reefs; for a summary of climate tipping points and how climate engineering may mitigate some of these tipping points, see McKay et al. (2022) and Hirasawa et al. (2023). It could also reduce the magnitude of and consequences of extreme heat and precipitation events (e.g., Tye et al., 2022).

Conversely, climate engineering also poses many risks (Robock, 2008), such as altering regional weather and climate patterns impacting agriculture, water availability, and ecosystems. Climate engineering may also result in slower carbon emission mitigation efforts (Reynolds, 2015) incurring a large risk of dangerous rapid warming if the deployment is abruptly halted (Jones et al., 2013). Climate engineering deployment raises potential geopolitical conflicts regarding who controls the technology and who pays for both deployment and negative consequences (Dalby, 2015). Understanding the tradeoffs of doing or not doing climate engineering has been the subject of several completed and ongoing federal efforts (NRC, 2015b; NASEM, 2021; OSTP, 2023). Nevertheless, decisions about whether and how climate engineering might be deployed in the future will need to be made in the absence of complete certainty.

Indiana's students are tomorrow's citizens and leaders. Our best shot at a responsible decision about climate engineering is to ensure that our teachers are prepared to teach our students about scientific, ethical, political, and economic implications. Exploring these various tradeoffs, as well as envisioning (in a classroom setting) ways of deploying climate engineering that maximize benefits and minimize risks is a novel and effective way of teaching both climate change and engineering design, while simultaneously preparing K-12 students to be knowledgeable and active participants in the climate engineering discourse ahead. Recognizing this imperative, the Next Generation Science Standards (NGSS) and the Indiana State Science Standards include climate engineering as an important learning outcome (NGSS Lead States, 2013; HS-ESS3-4).

Teacher Support

Our project team was formed under Indiana University's (IU) Educating for Environmental Change (EfEC) program, led by co-author Scribner, to support K-12 educators in teaching the science and policy of climate change through professional development. EfEC partners K-12 teachers with IU scientists to co-design classroom-ready lessons and activities based on the scientific research conducted at IU. In 2021, the EfEC team co-designed a new module on climate engineering, led by co-authors Goddard and Kravitz, IU climate scientists who study climate engineering. The Climate Engineering Teaching Module (CETM) was developed to help middle and high school students understand climate engineering solutions by applying critical thinking and problem-solving skills.

Since 2021, the CETM has been featured in four full-day and four half-day EfEC workshops, reaching over fifty K-12 educators, including co-authors Milks and Peterson. These workshops aim to enhance teachers' pedagogical content knowledge and teaching efficacy in the area of climate engineering. The project team helps to establish these essential skills and expertise through workshop sessions focused on in-depth exploration of climate engineering-related topics. These include:

1. Discussing strategies for mitigating climate change, enhancing community resilience, understanding negative emissions technologies, and introducing climate engineering.
2. Exploring the role of climate engineering as a complementary approach to emission mitigation efforts, and its potential for educational purposes, engaging in engineering design processes, and evaluating proposed climate engineering solutions.
3. Delving into the social, political, ethical, and economic dimensions of climate engineering, with a focus on fostering optimism among students when confronting environmental challenges.

The project team recognizes that teaching climate engineering is particularly challenging because climate engineering is, comparatively, quite a new field and has not fully entered the public sphere. To address these concerns, the project team created an introductory video (~20 min) on climate engineering and organized a continually updated list of content-relevant websites that teachers can view to help prepare them to teach this unit. To supplement this, Lesson 5 (described in more detail below) allows the classrooms to interact with climate engineering and climate change exerts. These interactions could easily involve a question-and-answer session, so teachers have an additional resource and do not feel that they have to know everything. This can also serve as an opportunity for teachers to gain more knowledge about this field, leading to greater confidence with the lessons. Nevertheless, providing the "right" amount of background is challenging, and we are constantly updating and improving the materials we provide.

Lessons

The five lessons of the CETM, detailed below, were initially developed by Goddard, Kravitz, and Scribner. After each workshop, the lessons are updated to reflect the ideas and concerns of the participants. Additionally, the CETM has been implemented at Bloomington High School South by teachers Milks and Peterson in their Earth and Space sciences courses. Their feedback has contributed to the ongoing collaborative design of each lesson, resulting in lesson plans that have been tested and refined for the classroom.

These lessons are aligned with NGSS and Indiana Science and Social Studies Standards (Table 1). PowerPoint presentations, instructional resources and videos, and all the necessary materials to conduct the activities are provided.

Table 1. Alignment of lessons with NGSS and Indiana Social Studies Standards (denoted by a leading "IN-").

HS-ESS2-2 Earth's Systems	Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.	2,4,5
HS-ESS2-4 Earth's Systems	Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.	2,5
HS-ESS3-4 Earth and Human Activity	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.**	1-5
HS-ESS3-5 Earth and Human Activity	Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.	2,4,5
HS-ESS3-6 Earth and Human Activity	Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.	2,5
HS-ETS1-1 Engineering Design	Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	1,3,4
HS-ETS1-2 Engineering Design	Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	1,2,3
HS-ETS1-3 Engineering Design	Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	3,4,5
IN-WH.7.6 World History	Formulate and present a position or course of action on an issue by examining the underlying factors contributing to that issue, and support that position.	4, 5
IN-WG.5.2 World Geography	Identify solutions to problems caused by environmental changes brought on by human activity.	1,5
IN-S.8.11 Sociology	Evaluate a current issue that has resulted from scientific discoveries and/or technological innovations.	4

The module provides background information on the scientific and engineering principles underlying climate engineering and places a special focus on three critical STEM practices frequently neglected in climate change and engineering education: (1) the communication of results and ideas, (2) engagement in scientific and engineering debates, and (3) examination of the societal, political, and economic contexts surrounding these topics (e.g., Ford, 2008; Berland and Reiser, 2009; Chin and Osborne, 2010; Dawson, 2012; Herman et al., 2017). Moreover, grounded in problem-based learning (Hmelo-Silver, 2004), the lessons engage students by tasking them to collaboratively work through the engineering design process to help solve climate challenges. Through this process, students work together to develop climate engineering technologies aimed at slowing global warming and mitigating the adverse effects of climate change. At the conclusion of the module, we anticipate that students will have developed the skills to participate in informed argumentation and make informed decisions regarding climate engineering.

Lesson 1: ***Climate Engineering Concept Generation***

Building on previous lessons about climate change, the initial lesson encourages students to brainstorm innovative technological solutions to mitigate global warming and its adverse effects. To begin, students work individually to conceive ideas, with an emphasis on creative, out-of-the-box thinking regarding potential technologies and their functionalities. They jot down these ideas on different-colored sticky notes (using different colors allows teachers to view everyone's individual ideas). Throughout this process, teachers encourage their students to go for quantity, generate wild ideas, build on previous ideas, and defer judgment. Subsequently, in small groups, students collaborate to generate additional ideas and organize their sticky notes into categories. These categories, forming each group's "Mind Map" (Edwards and Cooper, 2010), might include "Sunlight Reflection," "Carbon Uptake," "Emission Reduction," and "Miscellaneous" (Figure 2).

Figure 2. Student group's Mind Map, brainstorming climate engineering ideas.

Next, each student picks three climate engineering concepts to illustrate in three different sketches. These sketches are then circulated to group members who add details or commentary to the initial sketch. Each sketch is passed amongst group members until every sketch has feedback from 3 to 4 group members. We term this process concept sketching.

By the end of Lesson 1, each student will have developed three climate engineering designs enriched with collaborative input and ideas from their peers. It is expected that many of the students' ideas may not be feasible in the real world, but as they work through the brainstorming → mind mapping → concept sketching process, they begin to understand what a climate engineering technology may look like - and possibly, what they still need to learn to inform the next steps in the engineering design process (selecting a design, refining and testing the design, and finalizing and sharing the design, as shown in Figure 3).

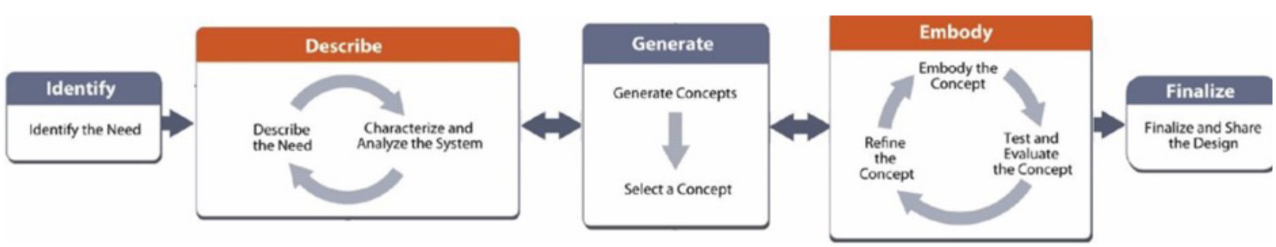

Figure 3. An engineering design process emphasizing concept generation, modified from Guerra et al. (2012).

This initial lesson was designed for the ABC, Activity Before Content (Cavanagh, 2007), approach to effectively elevate students' understanding of climate engineering to the creation of three distinct technological solutions addressing global warming and climate change. We also want to note here that the "wild ideas" that the students come up with during this lesson are probably all ideas that climate engineers are actually looking into - like this idea to have a giant umbrella in space.

Lesson 2: Marine Cloud Brightening Experiment

Lesson 2 challenges the students with designing and conducting an experiment to brighten clouds. This lesson is based on the real-world climate engineering science of co-authors Goddard and Kravitz (e.g., Goddard et al., 2022). Continuing the ABC (Cavanagh, 2007) and problem-based learning (Hmelo-Silver, 2004) approaches, teachers refrain from providing specific details about the climate engineering technology that the lesson models (marine cloud brightening) in favor of student discovery. To scaffold this task, teachers guide students by revisiting the composition of clouds (including cloud condensation nuclei), clarifying the concept of albedo, and demonstrating how to create a cloud inside a plastic bottle. Following this, teachers assist students in developing a research protocol that involves comparing the brightness of clouds formed in environments with high aerosol levels to those in environments with low aerosol levels.

The subsequent lesson amplifies the classic "cloud-in-a-bottle" experiment and reveals to the students the relationship between the number of cloud droplets and the cloud's reflective properties (Figure 4). In turn, students are primed to apply this knowledge towards understanding marine cloud brightening as a potential climate engineering solution. This climate engineering technology proposes to spray sea salt particles into low level clouds to increase the cloud droplet number and, ultimately, the cloud's albedo.

During the lesson, students will measure the reflectance of clouds created in environments with low and high aerosol concentrations. We have found that the clouds resulting from this protocol are impressive to students, especially when higher concentrations of aerosols are present. The data collected will be pooled across the classroom, and students will conduct statistical analyses, including calculations of the mean, median, mode, and range of the reflectance. To further scale up this analysis and student understanding for more

Figure 4. Student group measuring cloud reflectance, Tri-North Middle School, Bloomington, IN.

advanced learners, students can calculate a T-test statistic to determine if the difference in mean reflectance between the two experiments is statistically significant. Instructions for conducting these statistics are provided in the lesson materials.

Lesson 2 highlights the significance of developing an engineering prototype that enables testing and iterative refinement of technology on a small scale, which assists in decision-making for large-scale deployment. The lesson concludes with teacher-led discussions regarding marine cloud brightening's associated limitations and risks.

Lesson 3: Climate Engineering Blueprint

In Lesson 3, each student selects one of their three initial designs to refine and develop further throughout the module, creating an engineering blueprint of a technology they develop. Students use a decision matrix (Table 2) to quantitatively evaluate how well each concept adheres to new design constraints and criteria; high scores indicate strong solutions. Key considerations include the feasibility of small-scale testing to uncover potential issues or side effects, the scalability of the design for regional or global climate impact, and the estimated costs and resource requirements. Students are prompted to use technology resources for their research. They also assess the uniqueness of their designs compared to their peers' proposed climate engineering technologies. Peer evaluation is encouraged, with students helping each other rate their preliminary designs. Evaluating, revising, and selecting designs are

Table 2. A decision matrix to aid the students in selecting one design to move forward to the blueprint creation step.

Criteria to Consider when Selecting and Revising your Designs	Score 1-5
How well does your design slow global warming and/or climate change? (1 - not well, 5 - very well)	
Does your technology modify or work with an environmental system? (1 - does not, 5 - perfect match)	
What is the cost of your technology (consider materials, resources, and upkeep)? (1 - high cost, 5 - low cost)	
Does your design scale well (can you test your technology on a small-scale, then expand to large-scale deployment)? (1 - not well, 5 - very well)	
Rate the amount of unintended negative consequences of deploying your technology? (1 - many, 5 - few)	
Is your design unique? (1 – other students have similar designs, 5 – it's one-of-a-kind!)	
Total (max 30 points)	

essential steps in the engineering design process (Figure 3). These steps offer students the opportunity to emulate engineers effectively.

It is worth noting that students - and their teachers! - might not have a complete understanding of what materials might be used for different products and/or the cost of those materials and still encourage students to use their resources, previous experiences, and problem-solving skills to make educated guesses as they create their engineering designs. Some of our students have enjoyed designing "wild" climate engineering solutions, like those from Peterson's classroom shown in Lesson 5's section, while others take a more practical approach, often designing new applications of renewable energy and/or low-carbon technologies and practices. This year, Milks' students' designs have included car-free street plans, bicycle shares, portable solar-powered charge banks, luxury bus stops, and plans very similar to [those currently locking atmospheric carbon away via concrete production](#).

This lesson leaves students with an appreciation for the need to balance innovation and practicality in engineering designs while addressing the identified need. After choosing the design that best fits the constraints and criteria, each student drafts an informative engineering blueprint. By the end of this lesson, students have nearly completed the modified engineering design process shown in Figure 3, with only one step remaining: sharing the design, which is the focus of Lesson 5.

Lesson 4: Model U.N.

In Lesson 4, students engage in a challenging activity designed to explore the multifaceted issues surrounding the deployment of climate engineering technologies, focusing on their social, ethical, economic, and political implications. Working in groups (usually groups of four to six), students assume the roles of delegates from six fictional countries during a United Nations summit set in 2030 (Figure 5). These countries differ significantly in wealth, fossil fuel resources, renewable energy availability, and access to climate engineering technologies. Furthermore, each nation has its own economic ambitions in the context of climate change. The summit's key goal is to make a decision on the implementation of climate engineering by 2035, a critical juncture when the global mean temperature is projected to be 1.5°C higher than pre-industrial levels.

Conducting a Model U.N. lesson presents unique challenges, especially for science teachers who may lack experience in facilitating discussions on socio-economic-political issues. Our lesson plan includes several strategies to enhance teacher efficacy and tips on adapting the lesson to different levels of students. Based on feedback from teachers who have conducted the lesson and our EfEC workshop participants, we recommend the following tips for a successful lesson:

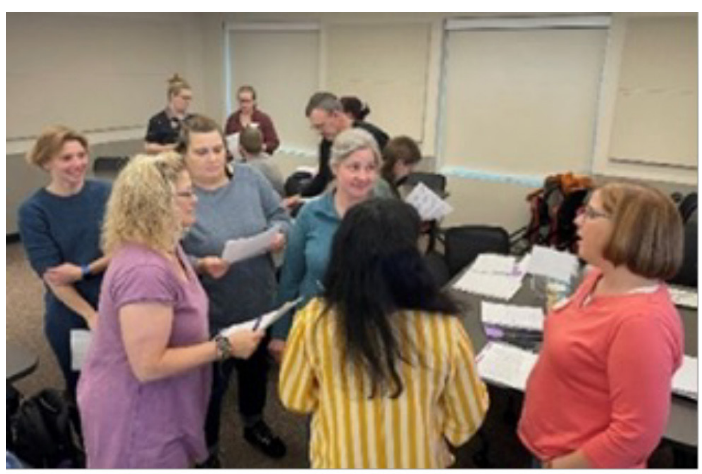

Figure 5. Teachers partcipating in Model UN activity.

1. *Selecting Student Groups*. Although Milks and Peterson group students randomly for many science activities, we've learned that "casting" is important for this lesson in two ways.
   - First, Molvania's (one of the activity's six fictional countries) representatives must be duplicitous in their negotiations, and we suggest selecting students who will be up to the play-acting and in-the-moment critical thinking that is required by the role.
   - Second, we are highly intentional about which students are asked to pretend to be the low-power states in the simulation (Tanoa, an island nation soon to be underwater, and Durhan, a financially struggling country who has a long history of being exploited by other countries). If your class of students is socioeconomically diverse, make sure to select students with high socioeconomic status as representatives of these countries. Similarly, if your class of students is racially diverse, we strongly suggest placing students of color in teams representing the higher-power nations.
2. *Student Preparation*. Prior to negotiations, students should familiarize themselves with the public and private information of their country and the public information of other countries. Then, work within their groups to establish what resources or bargaining chips they have to drive negotiations and develop treaties with other countries. Finally, each group (country) should decide whether climate engineering should be deployed and why. This decision should be framed in terms of advantages or disadvantages for their country.
3. *Group Structure*. If desired, teachers may define roles for members in each country's delegation:
   - President (1): Remains at the group's table overseeing diplomats and consulting with the science advisor. The President approves or vetoes treaties.
   - Diplomats (2-4): Engage in negotiations and treaty writing with delegates from other countries. This includes both diplomats that visit other tables (countries) and one who stays at their table to receive other delegations.
   - Treaty Writer (1): Collaborates with the delegation to compile information and draft treaties. All treaties require the signatures of the country's President, the treaty writer, and the involved diplomats.
   - Science Advisor (1): Supports the President and diplomats by integrating relevant climate science and climate engineering knowledge into the negotiations.
4. *Lesson Implementation*. Smooth operation of the lesson can be aided by simple measures, such as providing name tags indicating each student's country and role, distributing printouts or having students self-construct documents showing public and private information, and utilizing the provided worksheets to facilitate treaty negotiations and strategic planning following disruptive news briefs at the summit.

This lesson encourages students to consider the complex socio-political and ethical dimensions of climate change and climate engineering, highlighting the often-secondary role of scientific and technological understanding in geopolitical negotiations. Milks, who facilitated this project with her co-taught Earth and Space science students, notes that science teachers might be tempted to skip this lesson, but she strongly suggests giving it a try. She's been impressed with how students, with appropriate scaffolds, can pick up on important ideas and learn to explain the connections between climate science and climate policy.

Lesson 5: Climate Engineering Presentations

In the fifth lesson, students apply their acquired climate engineering knowledge and the understanding of socio-scientific issues surrounding its implementation by presenting their technological solutions to a select audience of scientists, engineers, and policymakers. First, presentations (either in-person or via Zoom) of their technological blueprints are observed by scientists (and co-authors) Goddard and Kravitz, along with IU graduate students and postdoctoral researchers. This activity provides a platform for students to communicate their design ideas effectively to a knowledgeable audience, allowing them to converse and receive feedback from science professionals. Sharing their designs (Figure 6) represents the culmination of the engineering design process (Figure 3). It also serves as a mock exercise in presenting their ideas to potential investors or decision-makers.

Additionally, students may participate in drafting letters to state politicians as a capstone activity, expressing their concerns and viewpoints on climate mitigation and engineering strategies. A provided template assists students in composing letters that outline

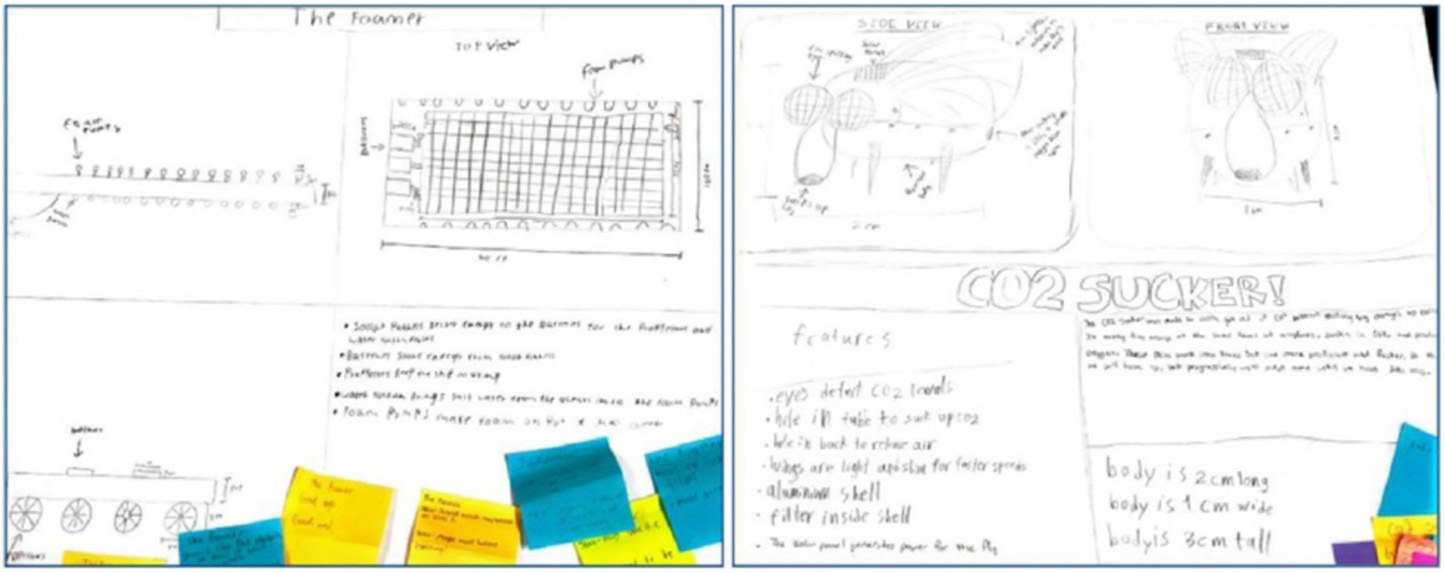

Figure 6. Student geoengineering designs from Peterson's classroom depicting autonomous solar-powered boats (left)and a swarm of flying, insect-sized CO2 scrubbers (right).

potential actions the state of Indiana could undertake to reduce greenhouse gas emissions, along with the advantages and disadvantages of climate engineering. This activity serves as an excellent opportunity to demonstrate to students the importance and power of advocacy and communication in science.

Next Steps

Teachers, including co-authors Milks and Peterson, who have implemented the module, reported high levels of student engagement and expressed a desire to teach the unit again. Peterson observes that many students have mentioned their enjoyment of the unit, stating it provided information that "actually mattered" and found it empowering to learn about actionable climate change solutions.

The project team will persist in updating our CETM workshops and lessons to enhance teachers' pedagogical content knowledge and efficacy in teaching climate engineering. However, one aspect we have yet to specifically address is how to tailor these lessons to fit individual classroom needs and curriculums.

We are seeking funding to establish an annual autumn workshop focused on tailoring our climate engineering lessons to specific subject areas, grade levels, and curricular needs. Initially, teachers and the project team will work together to either create new lesson plans or adapt existing ones, ensuring they align with the specific needs of each teacher's subject area and grade level. This collaborative effort is designed to continuously improve and expand the CETM lessons. Additionally, teachers will develop a comprehensive plan for integrating climate engineering education into their classrooms. This plan will detail the concepts and activities to be covered, learning objectives, required materials, and other critical information. These plans will be finalized during or shortly after the workshop and reviewed by the project team. Each teacher will then receive feedback, enabling them to integrate climate engineering education seamlessly into their winter or spring curriculum.

Finally, as part of our website's future development, we will introduce a discussion forum to enable better communication between the project team and teacher cohorts. Through this forum, teachers will have the opportunity to share strategies for tailoring lessons to their specific classroom and curriculum needs, as well as pose questions directly to the project team. With this publication and launch of the CETM website, our ultimate goal is to facilitate the integration of climate engineering education in classrooms across the country and the world.

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Open Access

Where to Go

Arthur J. Stewart

Abstract
This summer's anicipated and rare two-brood cicada emergence event is very likely, but the fates of individual cicadas is far less certain.

Where to Go

A small dark lump
on the asphalt driveway this morning as
the sun was working
over the eastern ridge, and the lump

moved a little, letting me know
it was alive. Stooping
close, I discovered the dark lump
was a fresh cicada,

and carefully picking it up, I found
the body was still
soft in places, but with
hardened transparent wings

and red eyes. It thrashed briefly
in my open hand as it tried at first to fly.
The pallid belly
glistened as the creature

righted itself, hesitated
and suddenly thereafter
buzzed off, up into the maple tree.
Unlike me it knew

exactly where to go.

Eli Duke, 2004
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Open Access

Class Notes from Geometric Physics 101

Arthur J. Stewart

Abstract
Long ago, the author took high school courses in Physics and Geometry. Our long-suffering teachers tended to talk somewhat faster than we could comfortably write, so inevitably some factual errors crept into our study notes. And we weren't really very good students at that age, either, which I'm sure didn't help. In any case, in "Class Notes..." I try to capture my sense of things when trying to rapidly learn a lot of new information, while lacking good idea-distillation and writing skills. How many technical errors can you find in this poem?

Class Notes from Geometric Physics 101

Lesson 1.

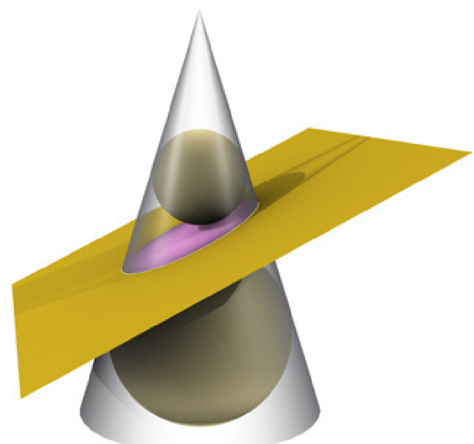
1. A line is the straightest
distance between two points. A point
takes no space. Space curves.

2. The line carried becomes an arc,
the arc an ellipse, the ellipse
a right circular cone.
A circle is a special ellipse, the square
is a special rectangle. Two lines
intersect to make angles;
opposite angles are equal, adjacent, add.
Four makes a circle; the circle, a curved line.

3. Velocity is a vector,
a line with direction and length.
Speed is distance over time,
and great speed slows time.

4. Mass is an energy lump; mass
moves in a straight line,
a long light arc. Energy lumped
times light times light is
energy.

5. Gravity
makes a black hole black. Mass
falls in & makes energy. Energy
moves like light, & light
makes matter. Matter moves
& makes a line; the point
is time.



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Lesson 2.

Acceleration is a, a change in velocity.
Force makes mass accelerate. Mass accelerated
releases energy, energy released makes heat, &
heat makes matter move. Heat
moves in a circle.

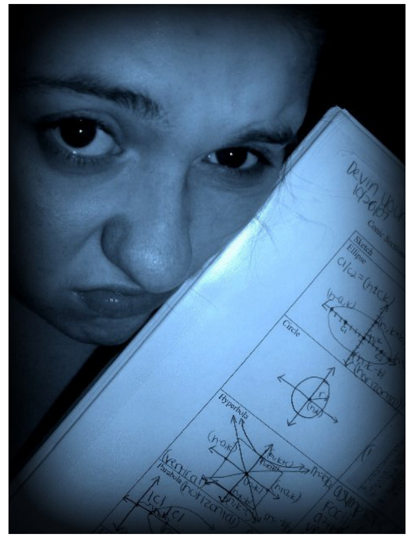
Velocity is direction & speed;
spinning matter at a constant speed
accelerates a circle & gives off energy;
energy matters.

Stars that spin
give off energy that moves to meet matter.
Moving matter takes time & needs force.

A black hole
is a massive star that consumes matter.
Matter consumed releases energy that moves like light.
Mass makes gravity, gravity moves light along a line,
& light has no mass. Spinning stars
accelerate gravity in a circle; a mass moves

along an arc of points. Stars spin
from point to point
through space & accelerate gravity;
gravity moves matter & accelerates mass
to a point along a line, an arc, a circle.

Light moves.



Devin Young (2008) "Sometimes I think this cycle never stops. CC BY 2.0. https://flic.kr/p/4pB2B9

Lessen 3.

Schrödinger still dreams restlessly
of waves pitching endlessly on a black ocean;
Heisenberg was more

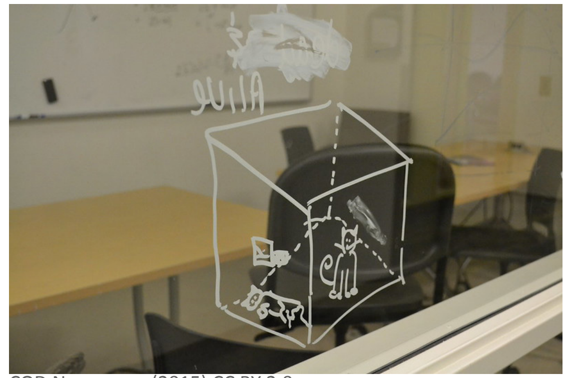
: uncertain :

Plank surely had a good hard think
about quanta, and Bohr
perceived the relentless spin of matter
(plus, zero, minus), remember that.

Uncertain waves spin certainly to make
matter & light. Waves have height
& length; light & gravity
move as waves, & moving matter
is light times light. Energy happens.

1st Einstein lumped light & matter
& accelerated matter along gravity
to a line meeting at time squared.
Then Hawking energetically mixed matter
in a black hole spinning along points
moving near the speed of light at the edge of time &
space happens.

==> (Test on Tuesday!) <==



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Author's Note: In writing "Class Notes..." I was thinking back to my high school days, when I took a course in Physics and a course in Geometry the same term. Our long-suffering teachers tended to talk somewhat faster than most students could comfortably write, so inevitably some factual errors crept into our fragmented notes. And honestly, none of us were very good students at that age, which I'm sure didn't help. In any case, in this poem I try to capture a student's initial intimidation and sense of things when struggling to rapidly learn a lot of new information, while lacking good idea-distillation and writing skills. As I hope you'll see, it is meant to be humorous. S/he starts note-taking very carefully, even numbering important points, and in Lesson 1, the topic moves tidily from predominately geometry to predominately physics. Later in the term, the student is more comfortable and casual with their learning: some shortcuts are invoked ("&s" rather than "ands"). Also in Lesson 2, the topics shift more towards large-scale physics, and some of the important points are almost accurately expressed: the student is more confident about their learning, and the lecture topics are captured in note form in more complete statements—even though important errors still creep in. Lessen 3 (deliberately spelled wrong) has a very different flavor. The student's learning effort now is 'lessen', even as deeper learning happens, and the physics ideas are broader, concept-rich, and more abstract. There also is more attention on the scientists who conceptualized these big ideas. But then, reality slams back in: Test on Tuesday!

Author

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2024 HASTI Award Recipients

Georgia Everett

Each year at the annual HASTI Conference we have an opportunity to recognize some amazing Science educators. Each year the awards committee accepts nominations for Elementary, Middle School, High School, and College Science Educators for their respective level award. The committee also accepts nominations for distinguished service to HASTI as well as Environmental Science Teaching. On February 19, 2024, we were able to recognize 7 outstanding educators from across the state of Indiana. Here, I will introduce the winners and include the words of support their colleagues offered during the nominations process.

Edward Frazier Distinguished Service Award

This prestigious award is given to a HASTI active member who demonstrates distinguished service and leadership as seen through participation in committees for HASTI and serving on the HASTI Board of Directors. The 2024 Ed Frazier Distinguished Service Award Winner was **Shannon Hudson**.

Shannon has been steadfast in her love of HASTI since she joined the board over 10 years ago. Shannon has stayed consistently involved in HASTI and always ready to step in and help however she is able. When it comes to HASTI, I have not ever heard Shannon express not having time to complete a task or volunteer to help with a new endeavor. Instead, she asks how she is able to help, often taking the role of spearheading a committee or task and tackling the entire project on her own. Shannon does all this while being a prepared middle school science teacher, mom, wife, dog mom, daughter, author, quilter, board member of several other boards, tour guide, friend, and so many more roles! Her passion is unmatched and allows her to tackle the biggest of issues, head on! (K. Poindexter)

Shannon has held the top 3 Executive offices of HASTI and during her service had to face the challenge of keeping HASTI a viable active force for teachers during a time when COVID prevented HASTI members from meeting in person. Her creativity not only helped HASTI survive but also set the stage for HASTI to emerge a stronger organization, ready to meet the challenges that rebuilding in the face of a non-supportive political climate for teachers in Indiana would throw in front of her. (G. McCurdy)

Students are the source of her inspiration, and she wants to share her passion for science teaching through her leadership, support for HASTI and professional development opportunities at state and national conferences. She is a great role model regarding what it means to be a professional, a leader, and a lifelong learner. (C. Hayes)

HASTI President, Craig Williams, gives Shannon Hudson her award.

Full listing of authors and contacts can be found at the end of this article.

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Gene Stratton-Porter Environmental Science Award

This award is given annually to an Indiana science teacher who exemplifies the spirit of the great Hoosier naturalist and author, Gene Stratton-Porter. The candidate exemplifies curiosity, independence, love of nature, and appreciation of the importance of science and the natural world. This year the Awards Committee celebrated two Environmental Science Educators, **Robyn Embry** and **Mike Hanback**.

Robyn Embry embodies the spirit of the namesake of this award. When Robyn's nominator told her that she would like to nominate her she responded that she "admired Gene Stratton Porter for a long time and [she] could remember—[her] mom was also a fan." Stratton Porter's books inspired Robyn's love of and curiosity about nature which she, in turn, inspires her students. (T. Phillipson-Mower, nominator)

Mrs. Embry becomes so involved in her students and their success in her class. Here are some of the things she has done with her students: Youth Environmental Leadership Summit at IU, Annual field trip to Crane with a focus on forestry, wildlife and water quality, Raising, tagging and releasing monarchs (they did butterfly wing replacement surgery this year) and Project based learning school campus projects. These PBL projects include planting and maintaining the pollinator garden on campus, planters for the new football courtyard, solar panels for the school roofs (which was approved by the school board in the last meeting!). She is partnering with Baxter for a PBL for this year. She takes the environment and brings it to her students in the most fascinating ways. She instills in them a desire to learn about and to protect what we have. (R. Mason, coworker)

In 2010, I sat in her classroom, desk closest to the window, reading Sand County Almanac. By anyone else's standards, this was taking away valuable time to study, but not for Robyn. She encouraged me to go beyond our textbooks and standard curriculum - because learning was so much more important than the test scores. Her environmental science class was when I started observation journals, plant phenology records, and really opened my eyes to the natural world. She gave me the words to describe my observations and the space and time to do so. She gave me permission to be curious about what I was seeing and challenged me to see differently. She allowed me to be independent, creating my own hypotheses and ideas. She really took the idea of the scientific method from a theory on the page, to a living system for me (E. Phelps, former student).

Mike's teaching style is exceptional. He possesses a unique ability to engage his students and make complex environmental concepts accessible and relatable. He goes above and beyond to create innovative lesson plans that incorporate hands-on activities, field trips, and real-world examples. I have witnessed firsthand how his students become more environmentally conscious and develop a genuine passion for preserving our planet under his guidance. (R. Coffman, nominator)

Janet McCabe recognizing Robyn Embry with her award.

Craig Williams and Janet McCabe recognize Mike Hanback before giving him his award.

Mr. Hanback embodies the very essence of Gene Stratton-Porter's spirit and values, particularly curiosity, independence, a profound love for nature, and a deep appreciation for the significance of science in understanding and preserving the natural world. These qualities are manifest in every aspect of his teaching, and he has a remarkable ability to inspire students to share in their enthusiasm. His environmental science courses fill because of his love for the subject and his students. (A. Evans, Principal)

Mr. Hanback's approach on teaching Environmental Science has not only helped me find interest in the subject, but a multitude of other students. With projects such as collecting soil samples for pH and nitrogen tests, building terrariums, and going on walks to identify processes in the carbon cycle, I can tell my peers are enjoying this fun approach to science. His classroom is designed in a manner that allows for students who want to succeed to be able to grow past just the basics and dive into much more than just introductory materials. His class is challenging in a way that allows us to flourish and grow beyond what we may have thought our previous capabilities were. (H. Thomas, student)

Clyde Motts Award for Outstanding High School Science Teaching

This award is given annually by the Hoosier Association of Science Teachers, Inc, to an outstanding high school teacher who exhibits a passion for innovative science teaching. This year HASTI had two outstanding educators being recognized, **Kelly Book** and **Jenny Veatch**.

Kelly is an amazing teacher! She is creative in her lessons and brings real world applications into her classrooms. For example, Kelly has sought out grant money to purchase real field notebooks for student use. Kelly uses these notebooks with her students to get them thinking and acting like real scientists. She takes students outside into the 'field' to conduct observations and data collection related to current content being taught in class. Students are journaling and recording both qualitative and quantitative data, in addition to also illustrating their findings. This has been so popular that she was asked to present using "Field Notebooks" at I.U.S, as part of their teacher summer institute. Additionally, Kelly uses extensive hands-on experiments in all her classes. These labs introduce and/or reinforce concepts taught. Students gain valuable knowledge through her upper course labs preparing them to continue their science studies at the university level.

Besides all the things that Kelly does for her students in and out of her classroom, Kelly is just as passionate about serving and mentoring fellow teachers. She believes in paying it forward to help train up the next generation of science teachers. She has willingly shared her content knowledge, lessons, and labs to help new teachers get a great start on their careers. She touches base with them weekly, if not daily, to see if there is anything they need or to see how she can help them out. She goes out of her way to research new ideas and lessons for use in class, oftentimes sharing ideas with teachers in other disciplines. She is a fabulous colleague to collaborate with in the afternoons. She and I often will meet after school to discuss our concerns about students or to run ideas past each other on new things we want to try out. She always has time to help out a fellow teacher. Always! (G. Shirley, co-worker)

From the first day of school, Jenny challenges her students. She teaches biology and vertebrate zoology to all levels of students and has the uncanny ability to meet students at their level and push them to the next level. She has her students read relevant books (not textbooks) and offer solutions to benefit humankind. Her students all agree that she's "tough", but she deeply cares about them all as students and as persons who will contribute to society. She makes them critically think, solve real-world problems, and apply their knowledge to situations from the past and present so they can think about the future. As an indication of this, she was just awarded Montgomery Chamber of Commerce's 2023 Emerald Educator Award for all of Crawfordsville Schools. (S. Hudson, nominator)

Craig Williams presents Kelly Book with her Clyde Motts award.

Jenny Veatch was given her award by a former student, Tyler Hudson.

Mrs. Veatch is a teacher that believes in the power of knowledge. Students learn her subject because they know she values the importance of science and understands the impact that it can have on their lives. Science requires a teacher to explain the subject matter of science, but it is also necessary to teach a love of science. This is a challenge that Jenny does not take lightly. I have had the opportunity to observe her classroom teaching and found myself caught up by her enthusiasm for the subject, along with her students. She has a real passion for the subject matter and her students can sense it. She is always using new and unique ways to enhance learning. These are educational moments that students will never forget, and these are moments that Mrs. Veatch creates often in her classroom. (J. Wentland, coworker)

Charlotte Boener Award for Outstanding Middle School Science Teaching

This honor is awarded annually by the Hoosier Association of Science Teachers, Inc. to an outstanding middle school teacher who exhibits a passion for innovative science teaching. **Karen Burke** was this year's middle school science teacher being recognized.

Karen Burke receives her award from HASTI president, Craig Williams.

It is common knowledge that teaching middle school students is challenging. It is imperative that an educator finds ways to engage students in active learning rather than only lecture type classroom exchanges. Karen Burke is an excellent example of how to reach students in today's classrooms. As a parent of one of Karen Burke's former students, I am pleased to recommend Karen for this award. Karen effectively utilizes hands-on activities to engage students in learning. They are often having so much fun with the activity that the learning may not seem as obvious to them. My daughter, Alaina, is an honors student that often found school boring because she was not feeling challenged. Karen provided Alaina multiple challenge opportunities including engineering paper roller coasters for marbles, as well as the excitement of creating water rockets. But Karen's engagement with Alaina did not end with science class, she also provided extra learning options through enrichment classes such as genius hour and passion projects. Knowing that Karen was at school to actively push my daughter to learn and participate in projects that were new and exciting, but also challenging allowed me to know that my daughter was actively learning rather than simply memorizing facts. Alaina was blessed to have Mrs. Burke who spent countless hours working to provide multiple chances to learn by doing and be immersed in the education process. (H. Allyn, Parent)

Karen possesses a remarkable blend of intellect, determination and vibrant personality that sets her apart as an exemplary teacher and leader in our school community. Karen has also demonstrated creativity and innovation in shaping our science curriculum. Her annual projects and lessons, such as the Paper Roller Coaster and Coaster Carnival, have proven to be exceptionally engaging for both students and staff alike. She has taken the helm of our school's science fair and leads a group of students in participating in the University of Southern Indiana fair, showcasing her dedication to nurturing students' academic growth. I must also mention the memorable moments she has created through innovative projects like the bowling ball pendulum and water rockets. Additional projects and STEM challenges she oversees, including windmill power, Oobleck experiments, and fossil studies, have all added depth and excitement to our science program. Furthermore, Karen leads our Genius Hour initiative, promoting student enrichment and encouraging exploration beyond our classroom walls. (M. Hostetter, Principal)

Distinguished Award for Outstanding College Science Teaching

This recognition is awarded annually by the Hoosier Association of Science Teachers, Inc. to an outstanding college science teacher who exhibits a passion for innovative science teaching. This year's HASTI recognized **Terri Hebert** for her outstanding work with pre-service teachers.

Dr. Hebert's inexhaustible ingenuity and genuine enthusiasm serve her well as she promotes science education and collaboration by inviting the educational community and the community-at-large to partner. She is the epitome of a lifelong learner, and an invaluable asset to Indiana University South Bend and teachers in the surrounding community. (T. Slattery, Program Coordinator)

Dr. Terri Hebert creates opportunities to incorporate hands-on experiences for all students inviting them to actively engage through real-world experiments and group projects. Establishing a collaborative learning environment encourages positive interaction among peers as they deepen their critical thinking and problem-solving skills. Promoting inquiry-based learning opens the space as students are expected to ask questions, conduct research, and investigate topics. Encouraging students to reflect on their own learning progression through journaling and discussion improves metacognition while nudging them to set goals for personal improvement. (Nomination Submission, self)

Although assigned a traditional classroom, it was often more likely to find Dr. Hebert and her students building skills and knowledge at the local zoo, in the county parks, or alongside the St. Joseph River. She wrote grants, like the long-running Earth Day Every Day series to support science instruction for area in-service teachers, and she was at the forefront of the South Bend Community School Corporation Federal Teacher Quality Partnership grant that led to a year-long residency program and master's degree for new teachers with a STEM focus. Dr. Hebert's dedication to making science learning both practical and fun, while also knitting together the larger, more theoretical concepts for educators is inspiring and laudable. The joy that she has in teaching in this area is infectious, and we are grateful to have her working again so closely with the future educators in our program. (H. Smith Daves, Dean)

Craig Williams, HASTI President, presents the award to Dr. Terri Hebert.

HASTI is extremely proud of all of the work that science educators do each and every day and looks forward to celebrating all of your accomplishments.

If you know of someone who deserves to be recognized for their work, be sure to nominate them this fall!

You can find more information about the awards and how to nominate someone at our HASTI webpage. (https://hasti.wildapricot.org/awards)

We look forward to reading your award submissions this fall.

Author

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HASTI Calendar of Events

HASTI Board of Directors

The HASTI website has a calendar of upcoming events to help you see upcoming meetings, conference and professional developments.

HASTI Events Page

To submit an event you would like to add to that list, email info and URL to thst@hasti.org

August 15, 2024 - **Deadline to commit to STEM Exploration Day 2024** at the Indianapolis Children's Museum to be held on September 28, 2024 from 10 AM to 3 PM (setup begins at 9 AM). To participate by hosting an activity table, complete the form. For more info, contact Melissa Trumpey, Director of Public Events aand Family Programs at melissat@childrensmuseum.org

October 1, 2024 - **Indiana Envirothon** - Check out the updated website for what's in store for the 2025 natural resource learning competitions at the regional and state levels. The 2025 NCF Envirothon (the international competition) will be held in Alberta, Canada.

October 5, 2024 - **Indiana University Science Fest**, 9:00 to 3:00 PM on the Bloomington campus.

October 12, 2024 – **Celebrate Science**, 9:30 – 5:00 PM at the Indiana State Fairgrounds in the Exposition Hall

November 7, 2024 - **Indiana Life Sciences Summit**. This year's theme is Transforming Healthcare Indiana's Role in Revolutionizing Diabetic and Obesity Management. Registration opens July 8, 2024.

February 15 – 17, 2025 - HASTI Conference at Noblesville High School. Information including proposal information will be posted soon on the HASTI website at

May 2025 - **Educating for Environmental Change (EfEC).** Since 2017 the EfEC has provided professional development to help K-12 science educators teach the science and policy of climate change. The dates for the 2025 workshop will be announced in early 2025. For more information contact J. Adam Scribner, Director of STEM Education at jaascrib@iu.edu

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Freebies! Free resources for teachers

HASTI Board of Directors

This feature of THST will provide information for teachers about free resources, PD activities, and materials.
Look for this feature in each issue!

The National Center for Science Education supports teachers with free classroom resources to "tackle the most common and pervasive climate change, evolution, and nature of science misconceptions that students bring to the classroom."

Customized Environmental field trips for high school students through the IU Integrated Program in the Environment. Contact Elspeth Hayden at haydene@indiana.edu

The On-Campus Writing Lab (OWL) at Purdue University offers on-line, easy to use, free MLA, APA, and Chicago style guides to help you with your writing projects. For those writing for The Hoosier Science Teacher, the APA Formatting and Style Guide (7th Edition) can be found here!

NSTA's Free Resources Page - A permanent feature of NSTA's website, free to anyone! Take advantage of these freebies from the biggest science teaching association in the world.

Free Planetarium Shows. **View the schedule of shows** at the Charles W. Brown Planetarium, Ball State University. Attend a public show, or schedule a FREE show for your class or organization.

The 17 Best Education Podcasts for Teachers, posted by Becton Loveless on March 11, 2024 on the Education Corner website. While these are about general teaching, #8 is about the science of learning.

Ologies with Alie Ward, a favorite, more science focused podcast is Ologies with Alie Ward. The language is unsuitable for the classroom so here are some "bleeped episodes."

Three Facebook Groups:
Teacher Freebies and Deals.
Free Teacher Stuff, Discounts and Tips.
Teacher Deals, Codes, Coupons and Freebies by Buying on a Budget.

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The Hoosier Science Teacher

Open Call for Papers

The Hoosier Science Teacher is an open-access journal that shares a collection of information to help science educators of all grades and contexts in the state of Indiana. *THST* is published by the Hoosier Association of Science Teachers, Inc.

The editorial board of the *THST* invites authors to submit manuscripts in categories that include: "Editorials, Opinions, Announcements," "Lessons," "Stories, Poems, Nonfiction," "Articles, Research," and "Curriculum & Learning Environments." Authors need to consider the target audience when planning and writing the manuscripts they submit.

THST publishes at least one issue of the journal each year, and we offer an open call for manuscripts submitted by authors. There are no submission deadlines for our regular issues, and authors may submit manuscripts at any time. Special "themed" editions may be produced with guest editors. *THST* will post Calls for Papers on the journal's website to announce those issues.

Manuscripts may include photos, diagrams, tables, graphs and figures. Any identifiable photos of minors must be accompanied by a permission form signed by a legal guardian. Images may be in full color since the articles are published as online files. Authors can also include "supplemental files" to support readers if files include appendices.

Authors should consider the specifications listed in the **THST Guidelines page**. In addition to images, authors may include hyperlinks to supplemental materials such as lesson plans, assessments, large data files, and video or other media. In general, manuscripts should follow APA Styleguide, 6th Ed, and citing sources is required.

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Submitted manuscripts undergo a double-blind review process, and authors may be asked to revise text or images before final publication. Communications about submitted articles will be managed through **THST's Author Submissions** system.

Call for Reviewers

Authors and other individuals are invited to apply to be Reviewers. Reviewers may be asked to read and assess submitted manuscripts as part of the peer review process, and will be listed as members of GJTE's Editorial Review Panel. This panel is an important part of a rigorous publication process, and we invite a diverse group of reviewers from a variety of relevant areas of expertise. Click here to **Register as a Reviewer.**

Please direct any questions about submissions to the editors:
thst@hasti.org