# The Hoosier Science Teacher

Vol. 45, No. 2, 2022

ISSN 2475-451x


THST is an Open Access peer-reviewed journal published by the Hoosier Association of Science Teachers, Inc. https://hasti.org

HASTI

Hoosier Association of Science Teachers, Inc.

Open Access

# The Hoosier Science Teacher

## Volume 45, No. 2, December 2022

## Editorial Team



*The Hoosier Science Teacher is looking for volunteers to serve on the Publications Committee. If you are interested, please email thst@hasti.org*

### Do you have an image to contribute for a *THST* cover?

The editors invite readers to submit cover images - photos or art-work are accepted. Image must be submitted in .jpg format, with a resolution at least 140 dpi. Larger dimensions are better.

You can use the **Submission Page** to upload your cover image, and the editors will select images for future covers. All photos used for the covers are credited to the owners.

**Cover Image, THST Vol 45, no. 2:**
*Snowy Cataract*
(2017, Cataract Falls, Cloverdale, IN)
Photo by Christian Collins, CC BY-SA 2.0
https://flic.kr/p/J9UxZn

THST invites you to apply to be a reviewer on the Editorial Board. Potential reviewers can register for an account on the THST website:

**Register for THST Account**

**Published by the Hoosier Association of Science Teachers, Inc** (https://hasti.org)

Open Access

# The Hoosier Science Teacher

Volume 45, No. 2, December 2022

## Editorial Team

## Contents



**Published by the Hoosier Association of Science Teachers, Inc** (https://hasti.org)

Hootman, S. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.35496



Open Access

# The President's Paragraph: Notes from HASTI's President

# HASTI's Preservice Teacher Scholarship: An Opportunity for Inspiration, Excitement, and Professional Development

**Stacy Hootman**

**2022-23 HASTI President
Stacy Hootman**

*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 Stacy Hootman shares information about support for preservice teachers attending the HASTI Conference and feedback from preservice teachers about the annual conference.*

In the late-1990s, while an undergraduate science education major at Indiana University, my science methods professor insisted that all of us in the class attend the annual HASTI conference. I'll be honest that I wasn't particularly excited to attend. I had demanding courses and mounds of coursework to complete that I was sure would be more important than this required task. I begrudgingly attended (I'm not typically a rule-breaker and letting my professor down would have devastated me), but I ended up leaving the conference with feelings of inspiration, excitement, and acceptance into a professional community of those who were like-minded.

My professor knew what he was doing, as 20+ years later I'm still attending the annual HASTI conference and now am serving as President of the organization. As a preservice teacher, I couldn't have recognized the impact that attending this one conference would make on my professional career. For that reason, it is my opinion that it is imperative for us who have gained from HASTI to share this wonderful organization with the next generation of science teachers.

When I began planning to teach my own science methods course, I followed the lead of my former science methods professor and asked my preservice teachers to engage in some type of professional development focused on science education. My preservice teachers were expected to complete 10 hours of this professional development on their own time and submit written reflections about each one that would together comprise 10% of their overall course grade. As I first taught this science methods course during the pandemic, I brought in guest speakers on Zoom as well as sent my preservice teachers to NSTA's free online webinars to complete their hours. My preservice teachers were given choice on the topics they attended so that they could personalize it toward whatever they were most interested in learning about. However, it was always my goal to bring my preservice teachers to HASTI just like my science methods professor had done for me years ago.

As Vice President of HASTI, I worked with the board members to make our Preservice Teacher Scholarship a reality. Thanks to this generous gift to future educators from HASTI, any Indiana preservice teacher can attend the annual HASTI conference completely free of charge.

In the spring of 2022, I had my science methods preservice teachers attend the annual HASTI conference for the first time. I watched the same begrudging attitude that I had as a preservice teacher

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

prior to the conference turn to glee and amazement during just their first few hours of attendance. Like the previous assignment where preservice teachers completed 10 hours of professional development focused on science education, my preservice teachers were given a choice to attend sessions that interested them. Each 45-minute session required a short reflection and counted as one hour toward their professional development assignment. Most of my preservice teachers attended on Sunday as it fit most easily into their schedule, but they could attend at any time during the three days of the conference. My preservice teachers were told that they had to attend at least one session at HASTI, but then additional hours could be completed using NSTA online webinars the same as before. Most of the preservice teachers completed all their professional development hours at the HASTI Conference, and feedback was tremendously wonderful.

The day that we returned to class after attending the HASTI Conference, my preservice teachers were given five questions to respond to on chart paper that had been placed throughout the room. My goal was to give them an opportunity to share honest feedback about their experience. The questions I asked them to respond to were:

- What did you learn at HASTI?
- What did you enjoy the most?
- How was this helpful to your future career?
- What would you have liked to see/do and/or any suggestions?
- Anything else you want me to know?

Below are their responses to each individual prompt.

**WHAT DID YOU LEARN AT HASTI?**

- New science standards coming out
- Ideas on integration
- How to use cooperative quizzing in a classroom
- How to gamify in my classroom to make quizzes/worksheets/etc. more fun
- How to handle and debunk teacher frustrations
- Science standards
- Ways to incorporate aspects of science into lessons
- New ways to teach science
- How to include STEM
- How to make lessons involving the outdoors
- Where to get free lesson plans for different grades
- How to get kinders [kindergarteners] started with STEM
- How to make notes more engaging
- How to seek resources out for myself
- How other universities are teaching science and future teachers
- New ways to make teaching fun and engaging
- How to get assessments in ways that are not too long or boring
- New ways to teach science to students in a more engaging and motivating way
- I learned different ways to make science more engaging for my students.
- I learned how to make science more engaging while also adding in other disciplines. I learned about interactive experiments to do in my classroom.
- I learned more fun ways to incorporate science into my future classroom.
- I learned about tinker kits and other activities to give my students when there is extra time, or they finish early with work.
- I learned how to incorporate science into my classroom even if I am not teaching science.
- I learned what gamification means in education.
- I learned different types of language/words to use when teaching science.
- I learned about some different strategies I could use like gamification. I also loved learning about flying classrooms.
- I learned to explore then explain. Allowing students to find it interesting before them just sitting and listening.
- I learn a lot of engagement and STEM design strategies.

**WHAT DID YOU ENJOY THE MOST?**

- Connecting with other teachers
- Meeting educators from all different levels, from all over the state
- Sharing the passion for teaching and science education
- Learning from people who know more than me and have more experiences
- Networking
- Having things to bring into my future classroom
- Learning about successful lessons from experienced educators

- I enjoyed listening to experienced teachers give their feedback on things that go well and don't when doing science
- I enjoyed seeing the different age ranges at the conference because you could tell who was just starting and who was a vet.
- Being around like-minded people
- The professional environment
- I enjoyed learning about the different science programs in Indiana
- Resource room
- Hearing all different stories
- The interactiveness of the sessions- ex: the CSI experiments
- Learning about how to add gamification in the classroom
- Getting the opportunity to experience hands-on activities that I can use in my future classroom. (LOVED the CSI)
- I enjoyed the virtual escape room and CSI techniques. They were very hands-on and I gained so much knowledge. I also enjoyed the non-fiction biology books conference where I got to see different non-fiction books I could use for different sections of science.
- I really enjoyed the interactive aspects.
- I enjoyed that they gave you some of their own lesson plans to make your own.
- I enjoyed learning how to gamify my classroom.
- The exhibit hall was great and had tons of information and resources.
- I really enjoyed being able to just be a part of the conference and experience. I really enjoyed the Amplify Conference where we did an egg drop.
- I enjoyed actually doing a hands-on experience during the meeting.
- Interaction with new people.

**HOW WAS THIS HELPFUL TO YOUR FUTURE TEACHING CAREER?**

- I was able to collect lots of free resources
- It gave me new ideas to incorporate in my teaching and classroom
- Ideas and new info I can change to fit whatever grade I teach
- This was the first time I was able to see and think of myself as a professional
- The resources and techniques I was able to gain from other teachers
- Learning strategies and techniques that I can utilize in my future classroom
- Gained resources, books, methodologies, and engaging ways to teach my students in a way they enjoy
- Finding resources and making connections with other educators
- New resources and how to use them
- Gave me new ideas for what I could use in my classroom
- Resources…not just free stuff but the lessons too
- HASTI taught me different ways to make teaching fun for not just me but for my students.
- Helped introduce me to lots of teaching resources.
- Taught me different hands-on experiences that I can use to make science and teaching more interactive and engaging.
- Helpful by allowing us to listen to the experience of other teachers and what works best for them and what does not.
- It taught me many different ways to engage my classes.
- Introduced me to more resources.
- Taught me many new activities and ways to get students engaged and interested in science.
- It taught me how I can keep my classroom engaging and fun. I loved the virtual escape room and CSI techniques.
- It helped me explore different ideas and different concepts about phenomenon.
- I was able to get some ideas for my classroom that integrated multiple disciplines.
- I learn ways to engage students and make learning fun.

**WHAT WOULD YOU HAVE LIKED TO SEE/DO AND/OR ANY SUGGESTIONS?**

- More technology
- Share-a-thons for classroom and STEM
- Opportunities for partners/communication between preservice/first year teacher and veteran teachers
- More opportunities for these types of conferences
- How to use science materials
- Labeling sessions based on age range
- More elementary stuff
- Different vendors each day
- A way for the pre-service teachers to connect
- Communication between us and presenters

- Group discussions
- Interactions with experienced teachers
- Encouraging open discussions as opposed to lectures
- More seminars focused on elementary education. I felt like a lot of it was high school/middle school focused.
- More info for pre-service teachers
- More seminars on special education
- More focus on what to do as first year teachers -> a lot of it was too hard to be applicable because we do not have a grade level
- Maybe some classroom management tips
- I would have like more seminars for El Ed
- More seminars that were hands-on/ had the educators physically do the activities that are being introduced
- More stuff geared to younger students
- Wish we would have learned a little more about the content than how the classes were taught
- Give some classroom tips

**ANYTHING ELSE YOU WANT ME TO KNOW?**

- Board and committee members were so welcoming and fun.
- Everyone made the experience so exciting
- The free resources were amazing
- Everyone was so nice and welcoming
- The emails keep coming even though I unsubscribed. AHHH!
- Free resources, the emails get out of hand a little bit but nothing too bad
- Whova worked well but the notifications were frustrating when I only attended Sunday
- Loved the welcoming committee each day
- I wish I could have gone to more sessions or gone more days.
- I loved the opportunity and wish I could have gone all 3 days
- I really enjoyed my time and took so much away from this experience. 20/10
- It was so engaging to me because I built little robots. I really like it.
- If this would happen again, I would go.
- I really enjoyed going to the conference and had such a great experience.
- It was really fun overall.
- I really enjoyed the conference, but I wish I had an opportunity to go all three days. I also wish we had more time to network.
- I enjoyed the conference. I wish I could have gone more than one day.
- It was a really fun and educated/inspirational experience, and I would definitely go again.

Overwhelmingly, the preservice teachers' attendance at the HASTI conference was a very worthwhile endeavor. Most asked about returning to the conference in future years, demonstrating that by attending just one conference they already felt a connection to the organization and other like-minded educators.

At a time when so many beginning teachers are leaving the profession within the first few years, perhaps introducing them to a professional organization that relates to their chosen field can help them to build a professional identity, connect with dedicated educators, commit to ongoing professional development, and find a place full of people where they can find support. In fact, all teachers can gain in each of those positive qualities by attending our next annual conference! We look forward to seeing everyone at this year's HASTI/ ICTM Conference, February 12-14, 2023, at the Indianapolis Marriott East. Join us!

## Author

Stacy Hootman (president@hasti.org) is the Dean of the School of Arts, Sciences and Education and the School of Health Sciences at Ivy Tech, Hamilton County, Indiana, USA.

Butler, D. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.35611



Open Access

# HASTI/ICTM 2023 Conference Update

**David Butler, Conference Chair & HASTI Past President**

The HASTI/ICTM conference will be held February 12-14, 2023 at the Marriott East, Indianapolis. This year's theme is "Opening Doors to the Future." In this update, you can learn more about what to expect at this year's conference.

**Keywords:** HASTI/ICTM Conference; Science teacher PD; Math teacher PD

The Conference team has been working diligently to bring yet another high-quality professional devel- opment and networking experience to science, math- ematics, and STEM teachers or aspiring teachers; administrators; and others interested in improving science and mathematics education in Indiana.

Plenary speakers will include Dr. Crystal Morton and Cynde McInnis. Dr. Crystal Morton is an associate professor of mathematics education in the department of Urban Teacher Education at IUPUI School of Education. Dr. Morton's scholarly work focuses on secondary mathematics education, emphasizing the role of informal STEM learning in fostering equitable and transformative mathematics teaching and learning experiences. Cynde McInnis, who grew up in Fort Wayne, Indiana, is a Whale Watch naturalist who has led over 2500 whale watching trips and taught hundreds of thousands of people about whales and the threats they face in our oceans today.

Two field trips are scheduled for the conference, both on February 13 from 1:00 to 2:30 PM. The Cadaver Lab Experience will begin with an introduction to cadaveric gross anatomy and covers the history of cadaveric dissection. This tour will help you to learn about how medical schools obtain cadavers and how they are used to educate physicians and other healthcare professionals. You will also get an opportu- nity to work through a series of activity stations in the gross lab.

Back by popular demand is the field trip to the Indianapolis Zoo Tour where participants will spend time with zoo professionals learning about what it takes to care for and run a zoo from behind the scenes. Both fieldtrips cost $30.00, and participation is limited.

WHOVA, the online mobile app, is back! Features include evaluations for presentations, PCP credentials, and networking with presenters, attendees, and vendors. There will be no printed program.

Lunch for both Monday and Tuesday are covered with conference pre-registration.

There will be many ways to meet up with other Hoosier Science and Math Educators. Sunday evening will include the HASTI Awards and two socials, one sponsored by the Indiana University Integrated Program in the Environment (IU-IPE) and the other an ICTM Business Meeting and Social. On Monday, look forward to music and dancing to the That's What She Said band and a Bring your Own Board Game event.

Stay tuned for more information about these fun ways to network.

Pre-registration is now open. The deadline for Online registration is February 6, 2023. While onsite registration fees will be the same, they will not include meals.

Come join us this February 12-14, 2023 for a lifetime experience. Invite your colleagues!

[Click here to Register]

## Author

David Butler (dbutler@adamswells.com) is a Biology Teacher at Southern Wells Junior-Senior High School, near Montpelier, Indiana, USA.

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

Open Access

# 2023 HASTI - ICTM Conference
# Registration is open!

**HASTI Board of Directors**


**Register now for the 2023 HASTI - ICTM Conference**
**February 12-14, 2023!**

**Marriott East Indianapolis**
**7202 E. 21st St.**
**Indianapolis, IN 46219**
**Rooms available at a special price - Ask for the HASTI Price!**

**Conference Theme - Math and Science: Opening Doors to the Future**

**Conference Strands**

STEM: Math in Science and Science in Math
Learning How To School Again
Teacher Education
For the Love and Joy of Math and Science
Access, Equity, Social Justice, and Empowerment

To find more details and register for the event,
[Visit the HASTI Conference Page]

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

Sharp, M. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.35621



Open Access

# HASTI AFFILIATE – ENVIRONMENTAL EDUCATION ASSOCIATION OF INDIANA (EEAI)

**Megan Sharp**

A lot has happened at EEAI in the past year. In November 2021, we hired our first employee. Megan Sharp has served the organization as Resource Coordinator for just over a year now, and the introduction of her position has enabled EEAI to grow considerably in that time. We have expanded our participation within the affiliate network of the North American Association for Environmental Education, embarked on new organizational partnerships, begun a statewide database of environmental education programs and completed a 5-year business plan. Each of these undertakings will enable us to broaden and deepen the services we provide to EEAI members and educators throughout the state.

In the coming year, watch for us to share resources, professional development opportunities, and more from organizational partners such as the NAAEE, the Outdoor Learning Store, state agency partners and others. If you are not yet an EEAI member, consider joining now at eeai.org/join, so you do not miss any of these exciting updates and opportunities.

Our 2022 annual conference took place November 4-6 at Camp Alexander Mack in Milford and was an EEAI first - the conference was planned and executed entirely by one of our college student chapters. The members of the Purdue University chapter, led by their faculty advisor and EEAI board member, Megan Gunn, conducted an incredible weekend built around theth-eme “Turning a New Leaf in Environmental Education.” Speakers, breakout sessions, panel discussions, and activities centered around the three topics of *Finding Value in Green Spaces, Accessibility of Green Spaces, and Incorporating Indigenous Teachings in Environmental Education.*

Haley Higdon from Natural Curiosity gave a wonderful interactive keynote on this last topic, sharing the efforts Natural Curiosity is taking to elevate Indigenous voices in nature education and the resources available to help educators everywhere do the same.

With 2022 drawing quickly to a close, planning for next year’s conference is already underway. It will be held at Pokagon State Park November 10-12th. If you are interested in helping with the 2023 conference or other ways to engage with EEAI, please contact us for more information on how to get involved.

## Author

Megan Sharp (resourcecoordinator@eeai.org) is the Resource Coordinator for the Environmental Education Association of Indiana, Indiana, USA.

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

Terry, K. L. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.35645



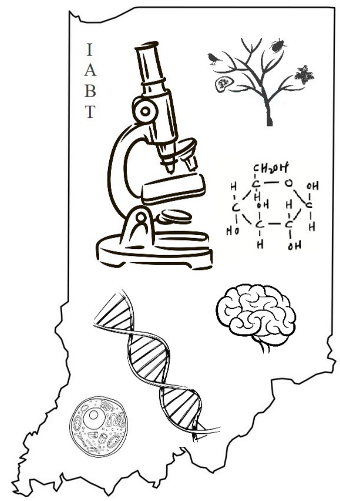
Open Access

# HASTI AFFILIATE –
# INDIANA ASSOCIATION OF BIOLOGY TEACHERS (IABT)

**Kim Little Terry**

The Indiana Association of Biology Teachers (IABT) was organized to support Indiana's biology and life science teachers. IABT is dedicated to the dissemination of biological knowledge, encouraging scientific thinking, and the utilization of the methods of science through the teaching of biology. We strive to help others understand the interrelationships of biology with other sciences, different educational experiences, and their lives. In support of these goals, each year, we endeavor to plan, organize, and administer professional development for advancing and utilizing knowledge in biological science education.

Each year the IABT presents a session at the Hoosier Association of Science Teachers Conference, sharing our favorite "quick hits.' The session provides many different lesson ideas participants can take home and easily integrate into their class. Following the quick hits, there is a short business meeting in which we elect officers and make plans for the upcoming year.




The IABT website has information about becoming a member, grants, lesson ideas, and upcoming professional development.

**IABT Quick Hits during the HASTI Conference:**
Presentations (Practical Ideas, Activities, Labs and Information for the Classroom)

- Membership Information/Registrations
- Mini-Grant Opportunities
- Officer Elections
- Door Prizes

See HASTI Conference Schedule for Day and Time

If anyone would like to do a Quick Hit presentation (5-10mins) please contact the current President-Elect. Please include your name, school, and any files of the activity you wish to present. The file(s) will be placed on Google Drive for all to view electronically (bringing handouts are optional and not necessary). The deadline for all presentations will be 1 week prior to HASTI. Please contact the current President-Elect with if you have questions.

## Author

Kim Little Terry (kterry@svcs.k12.in.us) is a Biology Teacher at South Vermillion High School, Terre Haute, Indiana, USA.

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

Kern, L. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.35167



Open Access

# You Should Teach About Climate Change: Why and How Every Teacher of Science Should Teach About This Important Topic

**Lisa Kern**

**Abstract**

Teachers from Kindergarten through grade twelve who cover science in the curriculum should find a way to include teaching about climate change. The reasons why this is so important and some suggestions for ways to do so are discussed in this article.

**Keywords:** Climate change; Science education

You, Yes You, Should Teach About Climate Change.

Every teacher of science in Indiana from pre-K through college should teach about climate change. If you are reading *The Hoosier Science Teacher*, that includes you. You may ask two questions: why and how?

***Why?***

According to the Yale Program for Climate Communication, climate change can be summed up in five facts and ten words: "It's real. It's bad. It's us. Scientists agree. There's hope." As a high school chemistry and environmental science teacher who has been teaching about climate change in both classes for years, I would sum up students' thoughts on learning climate change in eight words: It's interesting. It's important. We're curious. We care.

Topics that get students talking, thinking, and engaged are those that are relevant to students' lives, have multiple avenues for interest, and have a component of social intrigue. It is relevant because the younger generation will be the ones to feel the deepest effects of a warming planet. Climate change is a very large topic and can be interesting to students who are concerned about the conservation of endangered species, students who have migrated to Indiana from other parts of the country or world, students who are interested in weather and storms, students interested in economics and business, students who want to become engineers, students who are interested in marine biology and love Finding Nemo, students who want to travel and have cultural experiences, and students who want to become farmers. Can you think of a student who has any of those interests? Climate change is something kids hear about on social media or when their parents watch the news. They often think there is some controversy surrounding the subject. Politically, this may be true, but scientists are in close agreement about it (AAAS, 2018). They are intrigued that they hear two sides to the story, but they really want to know which one is *right*. Of course, for a science teacher, right and wrong, or true and false, are often better phrased as "which side's view is better supported by the evidence?"

We are responsible for bringing up the next generation of citizens who will vote at the ballot box and with their wallets. The world must act on climate change decisively and soon (IPCC, 2022). Change will only come when the public debate about climate change moves from questions about if it is happening or what is causing it, to debates about what we should do about it. The first step in making that transition is to ensure all citizens have a basic understanding of the issues. Since environmental science is not a required course for graduation in Indiana, many students never take a class that directly addresses climate change. For this reason, every teacher in Indiana who teaches any science subject should include climate change in their course.

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

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

As Greta Thunberg said, "We teenagers and children shouldn't have to take the responsibility, but right now the world leaders keep acting like children and somebody needs to be the adult in the room" (Smith & Breaux, 2019). The adults making decisions that could do something to stop climate change are not getting the job done. The least we teachers can do is provide the students with the information they need to understand the situation they will face as they become adults.

***How?***

1. Learn more about climate change yourself. Not all science teachers, myself included, took many environmental science classes in college. Do you understand the evidence for, and consequences of, a destabilized climate? The members of the Scientist Rebellion wrote a letter explaining their demands. In it, they said, "Self-reinforcing feedbacks within the climate system, in which hotter climates cause additional heating (e.g., increased forest fires, thawing permafrost, melting ice) threaten to drive the Earth irreversibly to a hot and uninhabitable state. These effects are being observed decades earlier than predicted, in line with the worst-case scenarios predicted." Do you understand why thawing permafrost is of such concern? If not, do a little research to learn more using the links provided in this article.

2. Find ways to tie it into your curriculum. Seek out reading assignments, activities, or labs related to climate change, or just have class outside and discuss weather versus climate. NASA has a good section for younger kids and older ones, too. NOAA also has great resources for children and adults.

3. Check out some curricular connections that might work for you below. For younger grades that cover a broad array of scientific content, this might be easier to imagine how the standards can be taught to include climate change. High school physics or anatomy teachers might find including climate science to be more challenging, but connections can be made.

Indiana's Science and Engineering Process Standards (SEPS, IDOE, 2022) can obviously be applied to climate change. For example, SEPS.1 says, "A practice of science is posing and refining questions that lead to descriptions and explanations of how the natural and designed world(s) work and these questions can be scientifically tested." A teacher could ask students to pose a testable question about what ice melting into a container of water will do to the water level in the container, then after an experiment, explain that melting glaciers (on land) makes sea levels rise.

Kindergarten teachers could discuss climate change after students have collected most of a year's weather data and covered the standard, "K.ESS.3 Investigate the local weather conditions to describe patterns over time." They could compare data from past decades and see an increase in average temperatures.

Fifth grade teachers could teach the standard, "5.ESS.3 Investigate ways individual communities within the United States protect the Earth's resources and environment" by researching how renewable and non-renewable resources are used to generate electricity in Indiana. Then they could research the long-term consequences of each.

An anatomy and physiology teacher might teach, "AP.13.4 Describe how the body monitors changes in blood pH and carbon dioxide using specialized receptors and how the respiratory system adjusts in order to maintain homeostasis" with a demonstration of water's pH changing with added dry ice. Then mention that this decrease of pH happens in both blood and sea water as carbon dioxide is increased. A short discussion of how atmospheric carbon dioxide can be affected by deforestation and burning of fossil fuels causing ocean acidification would be interesting to students. This would help to clarify that the chemistry of the body is no different than the chemistry of the larger world.

A physics teacher can use global heat balance as an example when teaching HS-PS3-2. "Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects)." Show students a diagram of how thermal energy from the sun is absorbed causing gas particles to move faster and re-radiated into space. Then discuss how excess carbon dioxide changes that balance.

Chemistry classes provide many ways to incorporate discussion of climate change. A reactions or stoichiometry unit could allow a teacher to talk about the combustion of various fossil fuels and the carbon dioxide produced. Here is an example of one standard that could apply: "C.4.5 Use a balanced chemical equation to calculate the quantities of reactants needed and products made in a chemical reaction that goes to completion." Doing this with methane would give an opportunity to discuss the differential warming potential of various gases and why methane flaring at a landfill is an important way of reducing our climate impact (EPA, 2022). Gas laws, gas solubility, pH, thermochemistry, solution properties, and other topics lend themselves to at least brief mentions of the climate system and the changes it is undergoing.

A biology teacher will cover ecology and evolution, both of which are great opportunities to tie in climate change. (Will species be able to adapt, or will they go extinct?) Photosynthesis and respiration provide another one, as deforestation is a major driver of climate change.

No matter which age group you work with, you should take some time to see how a lesson or two about climate change could help you connect with your students and prepare them for their future. Use the links provided above to get started. We owe it to this generation to acknowledge and explain the problems humanity has created and help them find hope to create change.

## References

American Association for the Advancement of Science [AAAS]. (2018). *AAAS Statement on Release of the 4th National Climate Assessment*. Washington, DC: AAAS.

Environmental Protection Agency [EPA]. (2022). Basic information about landfill gas. Washington, DC: EPA.

Indiana Department of Education [IDOE]. (2022). *Indiana Science and Computer Science Standards.* Indianapolis: IDOE.

Intergovernmental Panel on Climate Change [IPCC]. (2022). *The evidence is clear: The time for action is now. We can halve emissions by 2030*. IPCC.

Smith, Z. O., & Breaux, A. (2019). Greta Thunberg drives a Tesla to Iowa to join in student-led climate strike. Iowa City Press-Citizen, Oct. 4, 2910.

*Yale Program on Climate Communciations*. (2021). New Haven, CT: Yale University.

## Author

[1]Lisa Kern (email) teaches AP Environmental Science and Chemistry at Avon High School, Avon, Indiana, USA.

DOI 10.14434/thst.v45i2.34717


Open Access

# Column: Elementary Explorations
# Snowflake Science! A Wintertime Inquiry

**Kristen Poindexter**

*Elementary Explorations is a recurring column in The Hoosier Science Teacher.*

Kristen Poindexter is a veteran Kindergarten teacher, and 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. Kristen has served as HASTI's President, and has held other leadership positions in the organization. Look for her regular contributions to THST!

**Keywords:** Elementary Science Education, Snowflakes

One of our favorite wintertime studies is all about snow and how we experience it! I like to think of this study as an on-again, off-again study, because the weather will play a big part as to when you are able to do some of these activities.

I begin by finding out what my students already know about snow, their experiences with snow, when and where they have experienced snow, and their favorite things about snow. I capture most of their thinking on a KOWL chart so that I know how to move forward. A KOWL chart is made up of 4 boxes or columns where we can capture our prior knowledge (K), our observations (O), our wonderings (W), and our learning (L) at the end of our unit. I like to add in the "O" to our chart to capture what we discover when we go out in the snow or capture snowflakes so that every student in my class is able to add their ideas to our chart.

### Catching Snowflakes

After finding out what my students know, wonder, and observe about snow, we move on to catching snowflakes so that we can study them. I keep half sheets of black construction paper in the freezer all winter long so that I can grab them when the forecast calls for snow. We bundle up and each take a hand-lens and construction paper in the freezer all winter long so that I can grab them when the forecast calls for snow. We bundle up and each take a hand-lens and construction paper sheet out into the snow to catch some snowflakes. As each child catches a snowflake or two on their paper, they quickly observe it using their hand-lens to find out all they can. I also try to photograph as many as I am able so that I can print them out and have my whole class study them together.

Once we are all back inside, I print out the pictures I took while my students draw their observations of their snowflakes in their science notebooks or using the Seesaw app. We gather together to discuss what we noticed about each of the snowflakes, both those observed and those I printed out. Usually, my students start to notice that there most always seems to be a hexagon in the middle of the snowflakes. We look at more pictures of snowflakes to determine if that is most always true and notice that there are usually six branches extending from each snowflake as well. This is the point when I help them with the word branches, as they will use words like arms, legs, wings, so I help to give them the science word branches so that as we discuss snowflakes further, we will all know which part of the snowflake we are speaking about. I also like to introduce several books about snow to my students so that they are able

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

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

to do more inquiring about snow after we read and enjoy them together.

- *The Story of Snow* by Mark Cassino with John Nelson Ph.D
- *Snowflake Bentley* by Jacqueline Briggs Martin
- *The Snowflake* by Ken Libbrecht (several different books with the same title)
- *Snow* by Andrea Rivera
- Other snow related books on Epic!

### Building snowflakes

When we have had ample time to observe actual snowflakes and discuss them, I give my students loose parts and let them explore making snowflakes on their own. You can see (Figures 1, 2, & 3) that many students still have an undeveloped idea that snowflakes typically have 6 branches, however, they do have an understanding that those branches are there and are identical. The materials I use all came from the dollar store and were placed on a round placemat from IKEA. Other materials that my students use to make snowflakes include pattern blocks, rocks/pebbles, jewels/rhinestones, plastic bottle caps, and straws.

### Watching the Radar, Patterns in the Weather

As part of our study of snow, we also discuss changes in the weather that happen during the winter season. We keep track of our weather daily on our classroom calendar along with noting the daily temperature each day. These methods of data collection not only enhance our math skills, they help us notice the gradual shift down in temperatures throughout the seasons.

When snow is forecast, I will often show my students how to recognize snow using the radar from the National Weather Service office located in Indianapolis, so that my students can understand, at a very primary level, how a meteorologist uses tools to help them forecast the weather. They also use patterns to determine what is likely to happen with our weather and when more severe weather, such as a blizzard or heavy snow might be moving our way. In all kinds of weather, I use it as an opportunity to learn with my students about the right clothing to wear for the weather and how to stay safe in different kinds of weather.

**Figure 1.** Student snowflake model

**Figure 2.** Student snowflake model

**Figure 3.** Student snowflake model

### Melting Snow

One of the ways we wrap up our unit about snow is by watching it melt! We read "On a Snow-Melting Day: Seeking Signs of Spring" by Buffy Silverman (2020) to start our conversation. When I notice the sun shining, we will either look out our classroom window or go outside to observe the snow melting. I will ask my students how they think the snow melts. They usually respond by saying that it is warm, or we stepped on it and melted it, or that the ground is warm and melted it. This is an opportunity for my students to understand one of the sun's effects on the earth. How the sun warms the snow and melts it creating runoff. Wonderopolis has a wonderful page all about snow melting for younger students.

At the end of our study, my students gather together and we spend time filling out the last column on our KOWL chart, the "L"! I give each student a sticky note or index card and ask them to draw or write about one thing they learned about snow. Before adding those to our larger chart, students share with 1-2 other classmates their new learning and listen to others' new learning as well. We celebrate by making snow either in individual bowls or our water table. One can of shaving cream mixed with one box of baking soda creates the perfect faux snow for some indoor snow fun!

### References

Cassino, M., & Nelson, J. (2011). The story of snow: The science of winter's wonder. Chronicle books.

Libbrecht, K. (2003). The snowflake. Voyageur Press.

Martin, J. B., Astin, S., & Reading, D. J. (1998). Snowflake Bentley. Boston, MA: Houghton Mifflin.

National Weather Service. (2022). NWS Forecast Office Indianapolis, IN. NOAA.

Poindexter, K. (n.d.). Snow: Collection created by Mrs. Poindexter. Epic! Collections.

Rivera, A. (2017) Snow. ABDO Publishing.

Silverman, B. (2020). On a Snow-Melting Day: Seeking Signs of Spring. Millbrook Press.

Wonderopolis (n.d.). Where Does Snow Go When It Melts? Wonder of the Day #1141.

### Author

Kristen Poindexter (kpoindexter@msdwt.k12.in.us) is a Kindergarten teacher in MSD Washington Township, Indianpolis, Indiana, USA.

McConnell, T. J. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.34836





# Adapting to the New Indiana Science Standards: A 3D Lesson Planning Template

**Tom J. McConnell**

**Abstract**

The new Indiana Science and Computer Science Standards (IDOE, 2022) have created a lot of questions among teachers about what "three-dimensional" teaching is, and how to implement the new standards. The 2022 standards are very closely aligned with the Next Generation Science Standards (NGSS Lead States, 2013), with standards presented using the same terminology focusing on phenomena, Practices, Disciplinary Core Ideas and Crosscutting Concepts. While this may feel new, the NGSS was published in 2013, and some features of the national standards were incorporated in the 2016 standards. In this article, the author draws from previous experience writing science learning materials to align with NGSS to offer a model to help teachers modify their lessons to fit the new standards.

**Keywords:** 2022 Science Standards, NGSS, Three-dimensional learning, Lesson planning

## Introduction

In June of 2022, the Indiana Board of Education approved a new set of Science and Computer Science Standards (IDOE, 2022). Very little discussion of the standards appeared in the news and social media prior to the release of the new standards. However, there is a growing discussion among science educators in the state about what the new standards mean. The Hoosier Association of Science Teachers, Inc. (HASTI) has been quick to address the uncertainty among teachers by offering workshops to help educators shift to the updated standards.

My own observations have shown two main threads of online discussion about the standards. One of these threads is about the adoption of the three-dimensional framework of the Next Generation Science Standards (NGSS Lead States, 2013). Many teachers posting in social media groups about science teaching are not well-versed in the NGSS framework, so they have important questions about what three-dimensional science teaching looks like. This article is intended to address this issue and try to help present an explanation and an example for educators.

The second thread of discussion is about the shift in grade levels at which content is addressed. An early review of the new standards certainly shows that some content standards have moved to different grades. This raises questions about how schools should transition to a new curriculum as they match curriculum maps to the new standards. This problem is not a new one. Teachers address issues like this with each new set of standards, so I trust that we will navigate the move to the new standards in time, and teachers will adapt just as we have in the past.

In this article, I will focus on an approach for thinking about the science concepts and skills we teach that should make the new Indiana Science and Computer Science Standards less intimidating to show that much of what we see in effective science classrooms will fit very well with our revised standards.

## The NGSS Framework

Some of the more surprising comments I have seen online talk about the "new" NGSS framework. The National Research Council first published the *Framework* a decade ago (NRC, 2012), followed by the *Next Generation Science Standards* (NGSS Lead States, 2013), published the following year. In these documents, the NGSS presents a "three-dimensional" framework for how we do and learn science. The dimensions include the

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

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

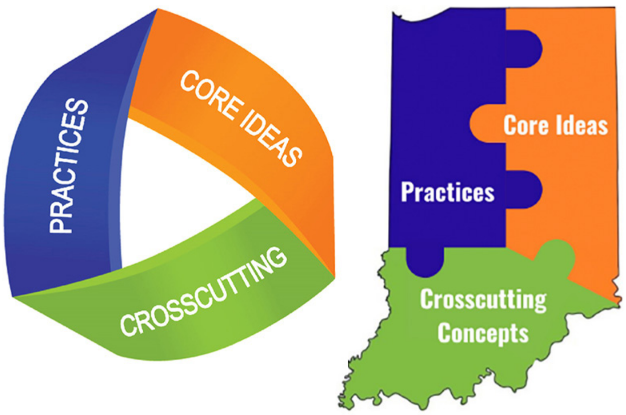



**Figure 1.** The NGSS Three-Dimensional Framework (NGSS Lead States, 2013; IDOE, 2022)

*Practices*, *Disciplinary Core Ideas*, and *Crosscutting Concepts*. Those dimensions are reflected in the graphic seen in so many NGSS publications and the new Indiana Standards (Figure 1). More discussion of those dimensions and how they are reflected in the 2022 Indiana standards will follow.

Many states adopted the NGSS standards, and the National Science Teaching Association (NSTA) has been publishing resources for teachers since 2014 that focus on using the NGSS. In fact, the editors at NSTA Press, began began integrating the NGSS into nearly all their publications in 2014 to help educators implement the new standards. This has been part of most of the books published by NSTA Press for the last eight years.

## Seeing the NGSS in Indiana Standards

Here in Indiana, the NGSS have also been an important influence on our curriculum. Indiana's prior standards, published in 2016, were not a wholesale adoption of NGSS, but the "Science and Engineering Processes" featured in those standards (IDOE, 2016) are a direct link to the "Science and Engineering Practices" (SEPs) from the NGSS, almost verbatim. The new Indiana standards have changed terminology to directly align with the NGSS, including the addition of the Crosscutting Concepts. These Crosscutting Concepts (CCs) present a series of themes that are universal to all the sciences. The science concepts previously labeled as "Content Standards" are now called "Disciplinary Core Ideas," or DCIs. These three dimensions are the core framework created by the writers of the NGSS. They reflect a view of how scientists do science, based on extensive research. The revised terminology may take a little getting used to unless teachers have been immersed in NGSS language prior to 2022. Figure 2 shows a representation of these elements of the new Indiana standards.

In addition to these three dimensions, the NGSS presents "Performance Expectations" – in essence, behavioral learning objectives that describe how students will use the practices to learn the concepts embodied in the DCIs. The text of the Performance Expecations includes the verbs teachers us in objectives. Many teachers will view these as the "standards," but the NGSS hopes teachers will use these as the learning outcomes students will achieve as they learn about the DCIs and put the Practices into action.

## Phenomena – Making Science Relevant

Another element from the NGSS that may seem new to Indiana teachers is the "Anchoring Phenomenon." These are examples from the real world that can be explained using the science concepts, can be studied or observed using the practices, and can be connected to the Crosscutting Concepts of science. It is important to note that the phenomena are practical representations of the DCIs.

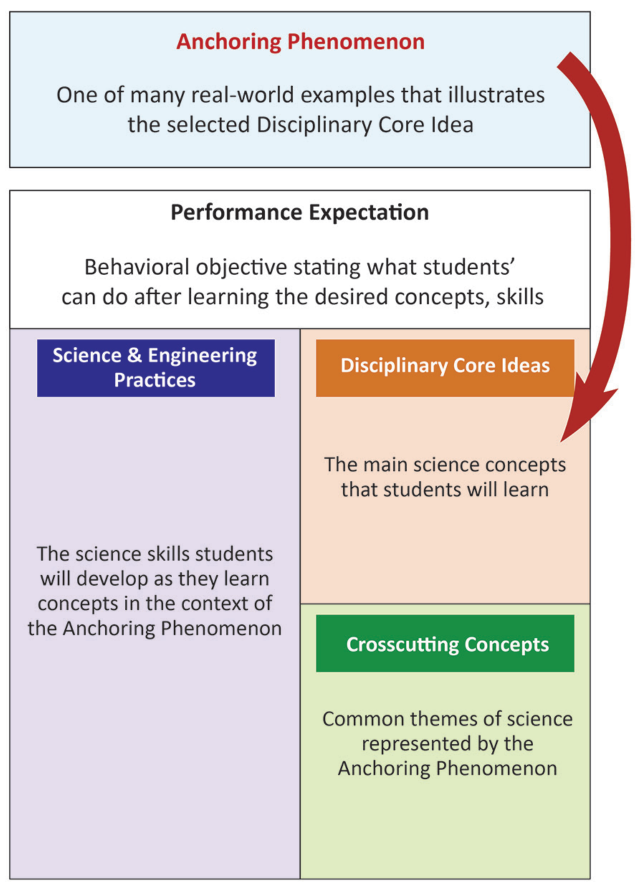



**Figure 2.** The 3-D framework for thinking about "doing science" (IDOE, 2022).

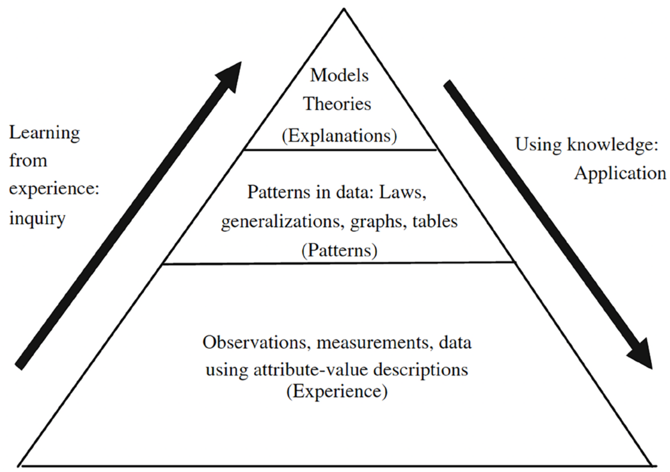



**Figure 3.** The EPE model (Sharma & Anderson, 2003)

There have been previous conceptual models for how scientists work and how students learn science. One of the models that seems to have influenced the NGSS was published in 2009 by a team of researchers at Michigan State. The EPE model (Sharma & Anderson, 2009; see Figure 3) suggests that we learn about science by learning about multiple Examples of science concepts ("Experiences" in the EPE model) . For instance, learners may see many different examples of gases expanding or contracting as pressures change – balloons, flower colors and scents that attract pollinators, visible signs of a chemical reaction, etc. Observation of examples ("Experiences" can help learners recognize Patterns in nature that we describe as scientific laws, like Boyle's Law that says that volume of a gas decreases when pressure increases. Studying the mechanism behind that pattern can help scientists develop an Explanation, or theory, of why this pattern occurs. In the gas law example, the theory is based on the spacing of gas molecules as the force behind pressure and an increase in pressure when molecules are pushed together to increase the rate of collisions. The sequence – Examples, Pattern, Explanation – is what we describe as inductive reasoning.

The common characteristic between the EPE model and the NGSS is the importance of basing our lesson on real-world examples – the Anchoring Phenomenon seen in Figure 2. For any concept found in the DCIs, there are many different phenomena that can serve as examples of the concept. While the NGSS does not list these phenomena, the authors of the NGSS are clear that teaching the standards should begin with an "anchoring phenomenon" (Krajcik, Codere, Dahsah, Bayer, & Mun, 2014) to help learners related to the concepts we teach. This part of the lesson plan gives teachers a great deal of freedom to find the best examples to help their students make sense of the concept. In the *PBL in the Science Classroom* series (McConnell, Parker & Eberhardt, 2016), we used this approach to present activities that begin with these types of phenomena, but we also described the importance of teachers selecting relevant phenomena to fit the needs of their own students. Science educators have been talking about relevance for many years (Stuckey, Hofstein, Mamlok-Naaman, & Eilks, 2013). But the NGSS makes the need to select locally relevant examples an explicit part of the curriculum.

As an example, a teacher in California can describe food webs by using a set of organisms that are completely unfamiliar to students in Indiana. We can help students learn about life cycles by observing the development tadpoles, caterpillars, mealworms, or plants. The concepts that students learn are the same, regardless of which examples the teachers choose. Ideally, presenting multiple examples can help strengthen learner's understanding because they can notice Patterns in the Experiences (Sharma & Anderson, 2004).

The brief examples I have mentioned so far may help illustrate the connections between phenomena and the standards but planning a true "three-dimensional" lesson is more than just finding a good example. Let's explore a bit more deeply how a teacher might plan a three-dimensional lesson or unit.

## A Structure for Lesson Planning

Describing what a three-dimensional science lesson includes is a first step in helping teachers adopt this approach. This approach to planning a lesson may be new to you, so it may help to show additional examples of the process.

As a science teacher educator, I have been sharing lesson plan templates for years. The templates I use have evolved over time. With these new standards, I saw a need to change the template, this time to more directly reflect the structure of the NGSS and three-dimensional framework. As I mentioned earlier, most of the revisions relate to terminology. Surprisingly, the changes in the template were not as significant as I first expected.

The **3D Learning Plan Template** (see Supplemental File) was tested with teachers at a summer workshop during the summer of 2022. Participants at that workshop developed lessons to use in the 2022-23 school year, spanning science teaching across the K-12 spectrum, including lessons in Art and ENL (ESL). Students in my science teaching methods classes will also use the template as they plan for teaching.

I share this with readers of this journal knowing that experienced teachers do not always create such detailed plans for their classroom. Some may jot down a sentence or a few phrases in a planning book while the majority of their planning is done in their heads. But teachers are also increasingly expected to submit detailed plans to building administrators for accountability purposes. Perhaps this template can help with that process, or even with departmental planning of curriculum maps as the new standards are implemented in your school districts. The template is flexible enough to be useful for a one-day lesson or multi-day unit plan.

One of the main features of this planning template is the "Anchoring Phenomenon or Problem." Previous versions of the template used this space for the "big idea," the "driving question," or the "key concept" as a starting point for the plan. As teachers adapt to the new structure of the standards, this element of the plan may help teachers think more explicitly about the type of phenomena that might help students relate to the lesson. This may also help you plan for that ever-present question: "Why do I need to learn this?"

As you plan a lesson, think about authentic and local phenomena that can be explained using the DCI you are targeting. You may want to think of more than one phenomenon and be ready to adjust as you find out what ignites your students' interests. One approach to this step is to keep an eye out for news stories that relate to the DCIs. For instance, a recent press release on the phys.org website (Indiana University, 2022) reporting that researchers at Indiana University have discovered a type of bacteria that can help honeybee larvae get more nutrition from their food to help avoid colony collapse. This story could help lead into a lesson about symbiotic relationships between the microbe and the bees and between bees and flowers.

Most of the other components of the "Learning Goals and Assessment" section of the template can be drawn directly from the standards. The cells in the template are color coded to match the sections in the NGSS and Indiana Standards, making it easier for teachers to cut and paste from those sources.

Page 2 of the template features the meat-and-potatoes portion of the plan. It prompts teachers to include what the teacher will do, a list of materials needed for the lesson, student handouts or files that need to be included, and a list of the products students will create. The template shows three "activities," letting the teacher add or delete activities as needed. Teachers can also use other resources without re-inventing the entire plan.

### A Sample Lesson Plan Outline

Let's dig a bit deeper into this three-dimensional approach to planning a science lesson. I chose to draw from my own teaching experience as a high school teacher in Biology and Environmental Science. The reasoning I describe is a model for how to think about lesson planing in any science subject. In Figure 4, I present a graphic organizer with the Anchoring Phenomenon and a screenshot from the Indiana Science and Computer Science Standards (IDOE, 2022). It may also help to open the 3D Learning Plan Template file to help visualize my comments about assessments and activities.

### Learning Goals as a Starting Point

As an educator who guides pre-service teachers to use the "backwards design approach" (Wiggins, Wiggins & McTighe, 2005), I should begin with my learning goals. A good place to identify these is found in the standards. The "Performance Expectations" are behavioral learning objectives. Figure 4 shows the Performance Expectation for HS-LS2-6, a standard that addresses Ecosystem Interactions, Energy and Dynamics.  That box is NOT at the top of Figure 4, though. That choice is deliberate on my part; I chose to highlight the phenomenon. To ensure that the phenomenon I choose is appropriate, I started by selecting the Performance Expectation – my objectives or learning goals that tell what students should be able to do.

In that standard, you can also see the Disciplinary Core Idea (DCI) in the orange box. This is a statement of the science concept that is the focus for this lesson or unit. There may be other DCIs that can be taught with the same performance expectation, or more than one performance expectation that addresses this DCI. But for now, let's focus on this one standard. The DCI will help me focus on the science concept as I think about how to help my students understand this in the context of the community in which we live.

## Anchoring Phenomenon

Shipshewana Lake in LaGrange County is surrounded by farm fields, including pastures for a dairy farm. It was once a popular fishing lake, but has gradually gotten shallower, and aquatic plants now grow to the surface across the entire lake. The only fish remaining in the lake are small bluegills, minnows and carp.

What might have caused this change?

### HS-LS2-6 Ecosystems: Interactions, Energy and Dynamics

Students who demonstrate understanding can:

**HS-LS2-6.** **Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.** [Clarification Statement: Examples of changes in ecosystem conditions could include modest biological or physical changes, such as moderate hunting or a seasonal flood; and extreme changes, such as volcanic eruption or sea level rise.]

#### Science and Engineering Practices

**SEP.7: Engaging in Argument from Evidence**

Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.

- Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.

***Connections to Nature of Science***

**Scientific Knowledge is Open to Revision in Light of New Evidence**

- Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

#### Disciplinary Core Ideas

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

- A complex set of interactions within an ecosystem can keep its numbers and types of organisms relatively constant over long periods of time under stable conditions. If a modest biological or physical disturbance to an ecosystem occurs, it may return to its more or less original status (i.e., the ecosystem is resilient), as opposed to becoming a very different ecosystem. Extreme fluctuations in conditions or the size of any population, however, can challenge the functioning of ecosystems in terms of resources and habitat availability.

#### Crosscutting Concepts

**CC.7: Stability and Change**

- Much of science deals with constructing explanations of how things change and how they remain stable.

**Figure 4.** Example of the 3-D Framework for a locally relevant lesson structure (IDOE, 2022).

**Selecting an Anchoring Phenomenon**

For the DCI in Figure 4, I can think of several examples from Indiana that illustrate the way an ecosystem can be altered by changes in various factors. In an age in which signs of climate change are all around us, there are many from which to choose. But I taught in northern Indiana in the region known for glacial lakes. Most of my students lived on or within sight of a lake, and the health of those lakes is an important factor in that community.

I selected a real situation in a community my students would know. When picking a phenomenon to anchor your lesson, it is very helpful that it be authentic – either a real situation or a very realistic one. My choice to describe Shipshewana Lake is based on my own personal experience. If you live in another place, you can certainly choose locally relevant examples. They may be right outside your school, or you may have seen a story in the local newspaper about a related situation.

Note that the red arrow points to the DCI. It helps to ask if the phenomenon you chose is a reasonable case that can be explained by learning the concept described in the DCI. As the teacher writing the plan, it is up to you to do this check. The standards deliberately do not include a phenomenon, a choice made in the NGSS because the NRC wants you to make this choice. If you try out the lesson for a couple of years and it gets stale or outdated, change the phenomenon. It will still help students learn the desired concepts.

**Thinking About the Practices**

Science concepts are not the only thing we want our students to learn. I personally place a high value on the Practices. These are the skills we use to do science, and I'd like all my students to at least know how scientists go about their craft as they develop the theories, laws, and technologies we use.

The next thing I look at are the practices that students can develop as they learn about the concept described in the DCI. If you refer to Figure 4 again, the Practices are listed in the blue box on the left side of the standard and in Figure 5. For this Performance Expectation ("Evaluate the claims…"), the main Practice listed is SEP 7 ("Engaging in argument from evidence") This implies they are also using SEP 8 ("Obtaining, evaluating and communicating information"), so I can add that to my list of Practices in my plan.

However, I'd like to add some practices. I know that I can have students do water quality tests on a local lake (or even Shipshewana Lake) to measure phosphates, nitrates, dissolved oxygen, turbidity and more. If they do that, they are also using SEP 3, 4 and maybe 5 when they collect data, analyze it, and create graphs to compare results. There is a chance to also work on SEP 6 if I ask students to offer in their own explanations or design a solution to the problems they are studying. So in a single lesson, I can address at least one DCI and six of the eight Practices, all with a single local example.

By the way, the first time I ever taught this lesson with this example was 1999. I did not create a new lesson. I adapted the way I describe an older lesson. This is the type of process you can do as you plan activities you probably already use in your science classroom – there is no need to start over as you implement the NGSS and new Indiana Standards.

**Science & Engineering Practices**

1. Asking questions and defining problems
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics and computational thinking
6. Constructing explanations and designing solutions
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information.

**Figure 5.** Science & Engineering Practices (IDOE, 2022)

**Crosscutting Concepts**

Now it is time to think about the green box in Figure 4, Crosscutting Concepts (CCs). This is the "new" feature from NGSS that has been added to the Indiana Standards. What do we do with that? This question has been discussed in the literature and national conferences since 2013. The authors of the NGSS say your science lessons become truly three-dimensional when you plan to address *and* assess all three components of the Framework. We will get to the assessment boxes in the template soon. For now, let's talk about the CCs.

The CCs are a list of scientific "themes" that are seen in all the science disciplines. In the old AAAS Benchmarks (AAAS, 1993), these were called "overarching concepts." The NGSS suggests you be explicit in talking about which of the CCs (see Figure 6) can be seen in the Phenomenon you select, and the DCI included in the standard. There may be more than one that applies. You should also plan to include at least one assessment that asks students to discuss something about that CC to show that they have made a connection to this concept.

In the sample lesson plan (Figure 4), the standards identify CC 7 ("Stability and Change") as the connection for this concept, but just as with the Practices, I am free to list more of the CCs. In the Phenomenon I described, there is a clear "Cause and Effect" relationship to learn about, and the DCI can also reinforce the idea that Systems and System Models have inputs that can alter the outputs, so I would also list CC 2 and 4.

**Crosscutting Concepts**

1. Patterns
2. Cause and Effect
3. Scale and Proportion
4. Systems and System Models
5. Energy and Matter: Flow, Cycles and Conservation
6. Structure and Function
7. Stability and Change

**Figure 6.** Crosscutting Concepts (IDOE, 2022.)

**Planning for Assessment**

As we think about this lesson, we also need to plan to assess the outcomes. Hopefully you noticed that beside each "Performance Expectation" space in the template (Figure 4), there is a place to describe how I will assess each objective. And remember that the author of the NGSS discuss the need to assess all three dimensions, so let's look at that part of our sample lesson.

***Assessing content (DCI).*** Let's begin by assessing content. How will I know if students understand the answer to the problem I posed in this phenomenon? If I focus on the terms in the Performance Expectation, I need to ask students to evaluate the interactions in the Shipshewana Lake phenomenon. They need to explain what factors caused the lake to become shallower with a thick growth of aquatic plants and a loss of most of the fish species that used to be in the lake.

How they explain that is open to the teacher's and students' creativity. They could write answers to an essay prompt, or create a presentation, poster or some other performance assessment. The details are for the teacher to outline, and there are multiple "right" ways to do this. But I should expect students to apply concepts they learned in class. This is an appropriate place to create a rubric for the concepts I want to see in students' presentations or papers, such as the role of nitrates and phosphates from the farm fields on the growth of algae, the impact of decomposition on dissolved oxygen levels, and the resulting effect on certain fish species. There are several science concepts we can include.

***Assessing Practices.*** Explaining the science concepts is not enough. I also expect students to show that they can use the Practices. Recall that the main Practice is "Engaging in Argument from Evidence." In other words, the guidelines for whatever assessment I assign should require students to use supporting evidence. This could mean citing sources or using data they collected when they tested some lake water. ("We found that the lake next to the cow pasture has a lot of phosphates in it from the manure….") If I include Practices 3-7 in my plan, I might also require students to explain why the selected certain samples, compare data from different sites, and tell me if the differences are large enough to be significant.

With a single project or paper, students can show that they understand the DCI and the Practices. This is a good way to address two of the three dimensions. And I still have the flexibility of using a variety of different assessment strategies. We all know that it helps to have multiple assessments during the work students do for the lesson rather than relying only on a summative assessment.

***Assessing Crosscutting Concepts.*** This is the dimension that has generated the most confusion for teacher, in my experience. How do we assess this dimension? Won't it show up in the other assessments? That may happen, but you cannot take this for granted. In some cases, it is natural for students to write or talk about "Stability and Change" if they explain what happened at Shipshewana Lake. It helps to have one or two prompts, or maybe a rubric row or a discussion question that helps you elicit your students' ideas about the Stability and Change theme. I'd like my students to know that a healthy lake ecosystem goes through many changes during the seasons or after rainstorms and droughts. But I'd like to make sure they mention that the dynamic balancing act of an ecosystem can be thrown out of whack if one variable changes drastically. In our selected phenomenon, that means the fertilizer runoff that causes algae blooms and lower dissolved oxygen in lakes.

To complicate this even more, a normal process of ecological succession in a glacial lake in northern Indiana will cause the lake to fill in and change into a marsh or swamp ecosystem. The change in Shipshewana Lake might be natural. My students are not likely to think about that unless I toss them a question and ask them to write or talk about it.

In a discussion I had with one of the NGSS authors some years ago, his suggestion for such a case was different. He felt it was important to ask students to describe some other phenomenon that shows a similar pattern of "Stability and Change" to show that they can transfer the idea to a different scenario.

I think all of these ideas have merit, and I will continue to support the idea that teachers need to have the freedom to adapt how they assess the three dimensions. Use the tools you have at hand, and draw from your experience, and you will be able to build a lesson that teaches and assesses the three dimensions.

**Inserting Activities into the Template**

In an effort to follow the backward design approach, now is the time to think about the sequence of activities. I've identified my learning goals and considered ways to assess whether students learn what those ideas. Now I can build a plan to help student learn the concepts and practices and explain the connections to the crosscutting concepts.

Page 2 of the 3D Learning Plan Template has space where you can build your own sequence of activities. That page allows you to add or delete rows to build as much or as little as you need – from a one-day plan to a multi-week unit. In each "Activity," you can add new labs, lectures, videos or projects as you see fit. The boxes for each activity give you space to include your list of materials, the handouts you need to provide, and the products that students will turn in for a grade. The most important part is your outline of what the procedures for the lesson.

And yes, I still recognize that most teachers do this work in their heads. The template gives you a place to jot down ideas to help you organize your work. This may be a good tool to create the plans to submit to your administrators.

For the sample lesson, I would begin my unit with a discussion of the phenomenon. I can collect photos or video from the lake to show students the location. I might also plan for a discussion of the problem to let students ask questions, propose possible explanations, plan what they should look for in the coming days, and organize a way to record some water testing data.

In the following class sessions, I would plan time to do some library or online research, so I might need to reserve the computer lab. I also would like to test water from Shipshewana Lake and maybe another location at the local park. I might also look for a good online simulation of a lake ecosystem that lets students change levels of nutrients to see the effect on living things in a lake. If so, the template helps me store the URL so I can share it with students more easily when the time comes. The template helps me a map it all out.

On Page 3 of the template, you will find space to attach files, insert URLs, and paste references. These spaces are there to record the set of materials you will use, including the files you already have from previous years. This last page is based on the recognition that you likely have good lesson activities from textbooks, workshops, websites, and other valuable resources. Again, you are encouraged to use what you have while leaving room to adopt new activities and materials.

## Discussion

It can be challenging when the state adopts new standards. The change creates more work for teachers who must align their curricula to a new set of expectations. This is especially true when the framework or language in the new standards looks and sounds different than what you've grown accustomed to using. My hope is that this example can show that the process of re-aligning your curriculum to the new Indiana Science Standards is not as drastic as you might think.

The teachers I know already teach science in ways that reflect the Three-Dimensions described in the NGSS, and now in the Indiana Standards. The terminology used to describe it is new to Indiana, but the concepts are not. While we may be uncomfortable with a new set of standards, I encourage you to look at the activities you already use, and modify the labels.

The one change some teachers may need to consider is building your plans around a locally relevant and authentic "Anchoring Phenomenon." Some of you, though, probably already do this, even if you use some other term for them. Maybe the realignment will be a chance to revisit those examples and update the Phenomena you use in your teaching.

I hope the 3D Learning Plan Template will make that transition a bit easier. Modify it as needed and share with others. We are all working through the same issues, so we can help each other through it. As you try new things and find ideas that work, bring them to a HASTI Conference or submit them to The Hoosier Science Teacher. We can all learn from your successful move to 3-D Science Teaching.

## References


American Association for the Advancement of Science [AAAS]. (1993). *Benchmarks for Science Literacy*. New York: Oxford University Press.

Indiana Department of Education [IDOE]. (2016). *Indiana Science and Computer Science Standards*.

Indiana Department of Education [IDOE]. (2022). *Indiana Science and Computer Science Standards*.

Indiana University. (2022, June 27). *Microbe protects honey bees from poor nutrition, a significant cause of colony loss*. Phys.Org.

Krajcik, J., Codere, S., Dahsah, C., Bayer, R., & Mun, K. (2014). Planning instruction to meet the intent of the Next Generation Science Standards. *Journal of Science Teacher Education, 25*(2), 157-175.

McConnell, T. J., Parker, J. M., & Eberhardt, J. (2016). *Problem-Based Learning in the Life Science Classroom, K-12*. Alexandria, VA: NSTA Press.

National Research Council [NRC]. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting concepts, and Core Ideas*. National Academies Press.

NGSS Lead States. (2013). *Next Generation Science Standards*. Washington, DC: National Academies Press.

Sharma, A., & Anderson, C. W. (2009). Recontextualization of science from lab to school: Implications for science literacy. *Science & Education, 18*(9), 1253-1275.

Stuckey, M., Hofstein, A., Mamlok-Naaman, R., & Eilks, I. (2013). The meaning of 'relevance' in science education and its implications for the science curriculum. *Studies in Science Education, 49*(1), 1-34.

Wiggins, G., Wiggins, G. P., & McTighe, J. (2005). *Understanding by Design*. ASCD.


## Author

Tom J. McConnell (tjmcconnell@bsu.edu) is a Professor of Science Education in the Department of Biology at Ball State University, Muncie, IN, USA.

# 3-D Lesson Plan Template

<table>
<tr><td>Author:</td><td colspan="3">Insert your name(s) here. Include the name of your school or institution.</td></tr>
<tr><td>Lesson Title:</td><td colspan="3">Insert lesson/unit title here</td></tr>
<tr><td>Lesson Topic:</td><td colspan="3">What science topic – i.e., adaptations, food chains, or biogeochemical cycles</td></tr>
<tr><th colspan="4">Context</th></tr>
<tr><td>Grade Level, Course</td><td colspan="3">For what grade level(s) and/or course is the lesson intended?</td></tr>
<tr><td>Anticipated timeline</td><td colspan="3">Estimate the number of days/class periods/hours your students will spend on the project</td></tr>
<tr><th colspan="4">Learning Goals and Assessments</th></tr>
<tr><td>Anchoring Phenomenon or Problem</td><td colspan="3">Write a brief paragraph describing the “phenomenon” or problem that will be the central focus of your lesson.</td></tr>
<tr><td rowspan="3">Performance Expectation</td><td colspan="2">Successful learners will…</td><td>How will you assess this objective?</td></tr>
<tr><td colspan="2">• …</td><td>• …</td></tr>
<tr><td colspan="2">• …</td><td>• …</td></tr>
<tr><td rowspan="2">Standards alignment</td><td rowspan="2">Practices<br>List the Practices students will develop in this lesson</td><td colspan="2">Disciplinary Core Ideas<br>List the DCIS students will learn about</td></tr>
<tr><td colspan="2">Crosscutting Concepts<br>List the Crosscutting Concepts that relate to this DCI and phenomenon</td></tr>
</table>

| Daily Activity Details | | |
|---|---|---|
| Activity 1 | *Teacher instructions* | *List materials, supplies, equipment needed* |
| | *Student Handouts – list here, attach files to lesson plan* | *List student products for assessment (attach rubric or answer key)* |
| Activity 2 | *Teacher instructions* | *List materials, supplies, equipment needed* |
| | *Student Handouts – list here, attach files to lesson plan* | *List student products for assessment (attach rubric or answer key)* |
| Activity 3 | *Teacher instructions* | *List materials, supplies, equipment needed* |
| | *Student Handouts – list here, attach files to lesson plan* | *List student products for assessment (attach rubric or answer key)* |
| *Insert/delete rows as needed* | | |

**References:**

*List all resources used in the production of this plan.*
*Include references for any textbook sections your students will use.*

*** Use the Appendices on the following pages to attach any additional files you use with this lesson, including links to online materials, presentations (PowerPoint, Prezi, etc), and references to any hard copy handouts you use.*

## APPENDIX A

### Handouts

*Insert any handouts you create for this lesson/unit. If activities are from another copyrighted source, include just a URL or bibliographic reference to the materials.*

## APPENDIX B

### Assessment Instruments

*Insert any assessments and rubrics you create as part of this unit. If assessments are from another copyrighted source, include just a bibliographic reference to the materials.*

Wang, L., & Oliver, J.S. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.33731





# Exploration of secondary science prospective teachers' development of PCK during a school-based practicum

**Lu Wang[1] and J. Steve Oliver[2]**

**Abstract**

Considering the amount of time prospective teachers spent in practicum during teacher education programs, it is important to understand how they develop their knowledge of teaching and learning in this setting and further inform how teacher educators can design adequate support. The objective of this study is to investigate a group of secondary prospective science teachers' knowledge development as described by the pedagogical content knowledge (PCK) framework when they attended practicum associated with a block of teacher education courses. With qualitative approaches, we analyzed prospective teachers' interviews to probe their learning experiences. Results show that prospective teachers' development of PCK is idiosyncratic, and they implemented different strategies to learn in the practicum when they are in the same practicum classes. Implications of designing practicum experiences to support prospective teacher learning are discussed.

***Keywords:*** Prospective Science Teachers; Practicum; PCK; Teacher Preparation

Pedagogical content knowledge (PCK) is a framework that has been widely adopted to understand teacher knowledge since Shulman put it forward in the 1980s. Shulman described PCK development as a process of transforming the subject matter knowledge for the purpose of pedagogical use (Shulman 1986, 1987). Research indicates that teachers need to be exposed to some sort of practical experience to develop their PCK (Barnett & Friedrichsen, 2015; Beyer & Davis, 2012; Van Driel, de Jong & Verloop, 2002). A bulk of studies have documented that teachers developed their PCK through teaching practices (Gess-Newsome, 2015; Harris & Hofer, 2011), but the question of how prospective science teachers (PSTs) who have limited practical experiences develop their PCK has not been adequately researched. The objective of this research is to investigate how PSTs build their knowledge as described by the PCK framework while they participate in the classroom activities associated with their practicum in a block of school-based science teacher education courses.

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

## Conceptual Framework

Shulman and his colleagues defined PCK as an amalgam of teachers' subject matter content knowledge, pedagogical knowledge, and knowledge of the context (Shulman, 1986, 1987; Grossman, 1990). Magnusson, Krajcik, and Borko (1999) put forward a pentagon-shaped PCK model, which contains five components: orientations towards science teaching (ORNT), knowledge of science curriculum (KSC), knowledge of assessment for science (KAS), knowledge of student understandings (KSU), and knowledge of science instructional strategies (KIS). These labels for the components offer a broader view of the original conceptualization (Abell, 2007). Building on the previous models, Park (2005) developed a hexagon PCK model by adding an affective dimension of PCK to the pentagon model, teacher efficacy, which she described as teachers' beliefs about their ability to perform teaching. We adopted this hexagon-shaped model in this paper to analyze the PSTs development of PCK.

Assessing PCK is a complex task. Researchers have inferred in-service teachers' PCK by observing their instruction (Nilsson & Vikstrom, 2015; Rozenszajn & Yarden, 2014). When working with prospective

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

teachers, who have limited teaching experience, the interview becomes a common method (Wang & Oliver, unpublished work). Interviews provide researchers opportunities to probe what PSTs know, which is an effective way especially when instruction observation is not available. Other measures were also developed to measure PCK, such as questionnaires (Van Driel De Jong & Verloop, 2002).

**Research questions**

This research attempts to gain an understanding of PSTs knowledge development as they participate in the practicum in their final year of the teacher education program. The hexagon PCK model (Park, 2005) is used to characterize prospective science teachers' PCK. However, it is necessary to state that in this study, the PCK framework is regarded as a conceptual framework and a tool to characterize PSTs knowledge. Because the PSTs have limited chances of teaching but observing and assisting their mentor teachers, their "proto-PCK" may not be the same as experienced teachers' PCK.

The research questions guide this study include:

(1) How does PSTs knowledge for teaching develop when analyzed using a PCK framework?

(2) What are the potential sources that contributed to PSTs development of PCK when they are in the practicum?

(3) How do the PSTs PCK components develop and interplay with each other?

## Method

**Participants and data collection**

A group of prospective secondary science teachers (PSTs) enrolled in a block of secondary science methods, secondary science curriculum, and practicum in science teaching during a secondary science teacher education program. We recruited four PSTs through purposeful sampling (Patton, 2014). All four PSTs content background is biology. During the semester, PSTs spent three mornings a week (75-90 mins) in their mentor teachers' classrooms after a 75-minute class period with their university instructors each morning. All PSTs were placed in two classrooms, one middle school and one high school. They attended the first placement from week 1 to week 8 and transferred to the second in week 9. All four PSTs worked in groups of two. Gabby worked with Jane across the semester. Carlie and Cary were respectively in groups with the other two PSTs who did not participate in the study, but they exchanged their placements in week 9. All names used are pseudonyms. While in their practicum classrooms, PSTs observed the mentor teachers' classes, assisted teaching as needed, taught once or twice, and were provided opportunities of participating in other activities, such as morning tutoring and sitting in teachers' co-planning meetings.

The major data source is PSTs interviews. Four semi-structured interviews were conducted with each participant across one semester. The first interview was carried out in the first two weeks, the objective of which was to probe PSTs' previous teaching experiences and orientations to science teaching. The second, third, and fourth interviews lasted about 60 minutes and were conducted in week 4, week 9, and week 13 of the semester. In each of those interviews, PSTs were asked to elaborate on what they had noticed while in their practicum classrooms and what they learned from observing and assisting their mentor teachers. All interviews were audio-recorded and transcribed verbatim. PSTs weekly journals and the researcher's non-participant observations serve as supplementary data sources.

**Data analysis**

The interview transcripts were first segmented into PCK units. To qualify as a PCK unit, the following criteria need to be met: 1. Descriptions of what teachers/students were doing; 2. PSTs interpretation or evaluation of what and why the teacher/students did what they did. 3. PSTs comments on the behaviors of mentor teachers and/or students. If a PCK segment contains information that the PST also shared in their weekly journals, the relevant descriptions from the journal were also added to construct the PCK unit.

Each PCK segment was then coded using the six components of the hexagon PCK model (Table 1) to identify the PCK statements and observations reflected on by the PSTs.

The sources through which PSTs developed their PCK were also coded. If there is more than one source within a PCK segment, each source was marked separately. For example, in one PCK segment, the PST developed their understanding of KIS and KSU through interacting with students and observation of their mentor teachers. To represent this correlation, we marked 1 under "interacting with students" with KIS and another 1 with KSU. Then we marked 1 under "observation" with KIS and again another 1 with KSU (Table 2).

**Table 1**. PCK Components Based on Magnusson et al (1999) and Park (2005).

| Components | Codes | Meaning of the components |
|---|---|---|
| Orientations toward science teaching | ORNT | Teachers' beliefs about the purpose of science teaching and learning. |
| Knowledge of science curriculum | KSC | Teachers' knowledge of curriculum materials both horizontally and vertically. |
| Knowledge of assessment for science | KAS | Teachers' knowledge of the important concepts needs to be assessed and how to deliver assessments. |
| Knowledge of student understandings | KSU | Teachers' knowledge of what students already know, their learning difficulties, and learning needs. |
| knowledge of science instructional strategies | KIS | Teacher's knowledge of strategies to represent science content, including subject-specific strategies and topic-specific strategies. |
| Teacher efficacy | TE | Teachers' beliefs about their ability to perform teaching. |

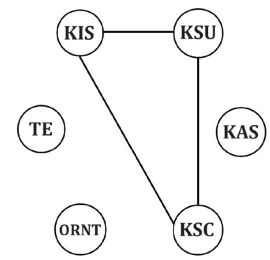



**Figure 1.** An Example of PCK Components Interplay

**Table 2.** PCK Components and Learning Sources

| PCK segment | PCK components | Sources | |
|---|---|---|---|
| | | Interacting with students | Observation |
| Gabby, segment 1 | KIS | 1 | 1 |
| | KSU | 1 | 1 |

Finally, to portray the interplay of PCK components, a PCK map was constructed for each of the participants based on the components reflected from all their PCK segments (adapted from Park & Chen, 2012). After identifying the PCK components within each segment, if more than two components were recognized, one interplay was recorded between any of the components. For example, if KIS, KSU, and KSC were identified within one PCK segment, one connection was recorded between KIS and KSU, KIS and KSC, and KSU and KSC respectively (Figure 1).

## Results and Discussion

Four PSTs PCK were summarized in Table 3. The analysis results suggest four features of their PCK: (1) PSTs PCK development is idiosyncratic; (2) KIS and KSU are the two common components of PCK that PSTs developed and their connection is central for all connections; (3) KAS is the least PCK component that PSTs developed; (4) PSTs

### PCK development is idiosyncratic

The four PSTs developed different aspects of PCK. Gabby developed the knowledge for teaching related to all six PCK components, Carlie and Jane exhibited knowledge connected to four PCK components and Cary developed knowledge related to three components (Figure 2).

Gabby and Jane worked together as a pair for their practicum placements, but they exhibited different knowledge related to PCK. Both developed PCK components of KIS, KSU, ORNT, and TE but Gabby also developed two more components, KAS and KSC, than Jane. In addition, even within the same PCK component they developed, Gabby and Jane focused on different aspects of the components. For example, they both developed KSU but Gabby focused on students' learning difficulties and

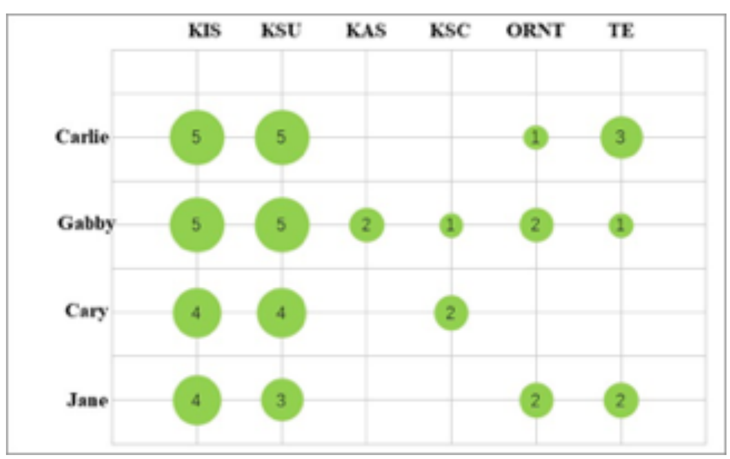
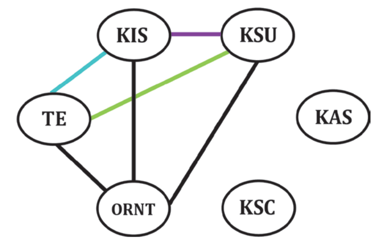
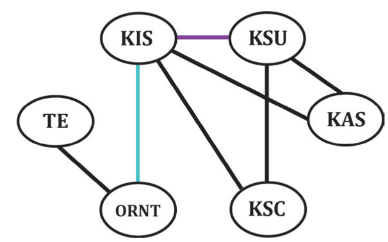
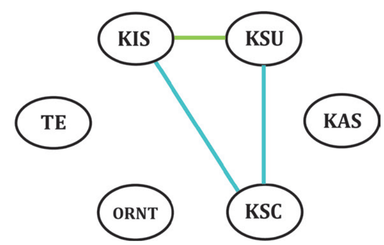
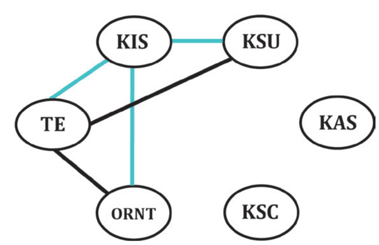



**Figure 2.** PSTs PCK components

**Table 3.** PSTs PCK Profiles

| PSTs | Number of PCK segments | PCK components | Sources | | | | PCK map |
|---|---|---|---|---|---|---|---|
| | | | IWS | POT | OBSV | PLE | |
| Carlie | 6 | KIS | 4 | 2 | 1 | |  |
| | | KSU | 4 | 2 | 1 | | |
| | | ORNT | 1 | 1 | | | |
| | | TE | 3 | 2 | | | |
| Gabby | 7 | KIS | 3 | | 4 | |  |
| | | KSU | 4 | | 3 | | |
| | | KAS | 2 | | 1 | | |
| | | KSC | 1 | | 1 | | |
| | | ORNT | | | 2 | | |
| | | TE | | | 1 | | |
| Cary | 4 | KIS | 2 | | 3 | |  |
| | | KSU | 2 | | 3 | | |
| | | KSC | 1 | | 2 | | |
| Jane | 5 | KIS | | | 4 | 2 |  |
| | | KSU | | 1 | 2 | 1 | |
| | | ORNT | | | 2 | 1 | |
| | | TE | | | 2 | | |
| Note: Interaction with Students: IWS<br>Observation: OBSV<br>PSTs own teaching: POT<br>Previous learning experiences: PLE | | | | | | | Interplay Strengths 1: (black line)<br>2: (turquoise line)<br>3: (green line)<br>4: (purple line) |

misconceptions, whereas Jane's knowledge was about what teachers could do to address students learning difficulties. For example, Gaby shared in the second interview that she realized students learning difficulties in understanding the question statement. She stated:

> *"So I realized a lot of the problem is that students faced with these questions, is they don't know like an important part of the question to be able to answer the questions even if they are familiar with the knowledge or the content knowledge."* (Gabby, S3).

In this example, Gabby identified the specific learning difficulties students encountered as she interacted with them: they didn't understand "an important part of the question". This PCK unit was coded as knowledge of student understanding (KSU), as Gabby identified student learning difficulties. Jane came across a similar situation when students experienced learning difficulties:

> *"While lecturing he (Mentor teacher) taught about concentration and diffusion. Some students had a hard time grasping this concept so Mr. Smith asked the students about their sweat tea recipes." (Jane, S-2)*

She then continued discussing how her mentor teacher used the sweet tea example to explain concentration. In this example, although Jane reflected her knowledge of student understanding, instead of focusing on students learning difficulties, she paid more attention to her mentor teacher's strategy of dealing with students' learning difficulties and the effects.

This idiosyncratic PCK development is also apparent in Carlie and Cary's PCK profiles, who worked with the same two mentor teachers at different times of the semester. Among the six components, they developed two common ones: KIS and KSU. One possible reason that may contribute to their different PCK development is that they switched their placements at week 9. After a half-semester of observation, they might be at very different places in their professional development.

The PSTs were provided limited directions regarding what to observe in the practicum. They made sense of what happened in the classes, so they developed different PCK components even when observing within the same context. This idiosyncratic development of teachers' PCK has also been documented by other researchers (Loughran, Mulhall, & Berry, 2008; Park & Chen, 2012; Park & Oliver, 2008). This finding suggested that PSTs made sense of the same events and incidents in the same context in a variety of ways and subsequently developed different PCK components.

**KIS and KSU components**

Despite the variations in PSTs PCK components, all of them developed KIS and KSU, which were exhibited within the highest number of PCK segments. Considering that the PSTs were observing in their mentor teachers' classes, it is not surprising that they focused on what strategies their mentor teachers used as well as on the status of what students were learning.

Furthermore, the connection frequencies between the two components are the highest compared to all other connections in their PCK maps. Carlie and Gabby's KIS and KSU connection frequencies are 4, Cary's is 3, and Jane's is 2. This implies that PSTs related their understanding of instructional strategies with students learning behaviors. In other words, the co-occurrence of KIS and KSU within one PCK segment means when PSTs made sense of their mentor teachers' instructional strategies, they also checked the effects of the strategies: student understanding.

Given that KIS and KSU are the two most common components of the PSTs PCK and the strong connections between these components, it seems clear that these two components are the central features of the PSTs knowledge for teaching. In other words, KIS and KSU guided what other components were included. As shown in Table 3, the only PCK component that PSTs developed but is not attached to KSU or KIS is Gabby's knowledge of teacher efficacy.

**KAS is least developed component of PCK**

Knowledge of assessment of science learning is the component that PSTs developed least and therefore has the most limited connection to other components. KAS refers to teachers' knowledge of what are important issues to be assessed and knowledge of the appropriate approaches to use to assess students' learning (Park, 2005). The assessment approaches considered include both formative and summative assessments. Gabby is the only PST who developed this component. She exhibited an understanding of assessments regarding how teachers used formative assessments to guide subsequent instruction, the reasons behind students' low performances, and the way tests were delivered.

**PSTs draw from different sources to build their PCK**

As shown in Table 3, the four PSTs drew from different sources to build their PCK. Carlie's major source for her PCK development is interaction with students. Gaby and Cary developed their PCK through both interactions with students and observation. Based on their PCK segments, the numbers of their learning instances from observation and interactions with students are similar. Most of Jane's learning happened from her observation of her mentor teachers. She is also the only PST who processed her learning by comparing what she observed with her own learning experiences and developed her knowledge by building on her own learning experiences as a student.

## Conclusion and Implication

This study examined four PSTs development of PCK. Although PSTs were placed in the same learning context, the outcomes and experiences of their learning are different. Their PCK development is idiosyncratic in nature and cultivated various learning aspects within the same component. They drew from different sources to build their knowledge and developed different components of PCK. These results suggest that prospective science teachers as learners have diverse learning strategies when they are prepared to be science teachers during practicum. This implies that when preparing science teachers, their existing knowledge and experiences need to be considered when designing learning opportunities. Future studies are needed regarding questions such as what some possible reasons contribute to PSTs' diverse development of PCK, and how we provide learning supports to make sure teacher candidates can develop appropriate PCK before they start their teaching career. Results of this study also have implications for the design of practicum experiences within teacher education programs. PSTs development of PCK from different sources indicates that exposure to diverse learning experiences may benefit PSTs learning in the practicum. Therefore, the availability of different learning opportunities in the hosting schools is important to promote PSTs development of PCK, such as direct interactions with students through small group and whole group instruction, observation of mentor teacher modeling, as well as professional development opportunities.

Two limitations need to be considered when interpreting the conclusions. First, we inferred PSTs' PCK through their interviews. As described above, PCK can be reflected in teaching practices. But because our participants are prospective teachers who had limited teaching practices in the practicum, we had to infer their PCK through their descriptions of their learning. Another factor that was also a powerful shaping force in the PSTs development of PCK is that they attended the practicum three days each week instead of the whole week, therefore, were not able to observe the complete implementation of the curriculum. This incomplete observation of the whole teaching may influence their understanding of teaching and learning in the practicum classes.

**References**

Abell, S. K. (2007). Research on science teacher knowledge. In Abell, S. K. and Lederman N. G., (Ed.), *Handbook of Research on Science Education*, 1105-1149.

Barnett, E., & Friedrichsen, P. J. (2015). Educative mentoring: How a mentor supported a preservice biology teacher's pedagogical content knowledge development. *Journal of Science Teacher Education, 26*(7), 647-668.

Beyer, C. J., & Davis, E. A. (2012). Learning to critique and adapt science curriculum materials: Examining the development of preservice elementary teachers' pedagogical content knowledge. *Science Education, 96*(1), 130–157.

Gess-Newsome, J. (2015). A model of teacher professional knowledge and skill including PCK: Results of the thinking from the PCK Summit. In *Re-examining Pedagogical Content Knowledge in Science Education.* (pp. 38-52). Routledge.

Grossman, P. L. (1990). *The making of a teacher: Teacher knowledge and teacher education*. New York: Teachers College Press. Grove.

Harris, J. B., & Hofer, M. J. (2011). Technological pedagogical content knowledge (TPACK) in action: A descriptive study of secondary teachers' curriculum-based, technology-related instructional planning. *Journal of Research on Technology in Education, 43*(3), 211-229.

Loughran, J., Gunstone, R., Berry, A., Milroy, P., & Mulhall, P. (2000). *Science Cases in Action: Developing an Understanding of Science Teachers' Pedagogical Content Knowledge.*

Magnusson, S., Krajcik, L., & Borko, H. (1999). Nature, sources and development of pedagogical content knowledge. In J. Gess-Newsome & N.G. Lederman (Eds.), *Examining pedagogical content knowledge* (pp. 95-132). Dordrecht, Netherlands: Kluwer Academic Publishers.

Nilsson, P., & Vikström, A. (2015). Making PCK explicit - Capturing science teachers' pedagogical content knowledge (PCK) in the science classroom. *International Journal of Science Education, 37*(17), 2836–2857.

Park, S. (2005). *A Study of Science Teachers for Gifted Secondary Students Going Through the National Board Certification Process.* (Unpublished Dissertation). University of Georgia, Athens, GA.

Park, S., & Chen, Y. C. (2012). Mapping out the integration of the components of pedagogical content knowledge (PCK): Examples from high school biology classrooms. *Journal of Research in Science Teaching, 49*(7), 922-941.

Park, S., & Oliver, J. S. (2008). Revisiting the conceptualisation of pedagogical content knowledge (PCK): PCK as a conceptual tool to understand teachers as professionals. *Research in science Education, 38*(3), 261-284.

Patton, M. Q. (2014). *Qualitative evaluation and research methods integrating theory and practice* (4th ed.). Sage Publications.

Rozenszajn, R., & Yarden, A. (2014). Expansion of biology teachers' pedagogical content knowledge (PCK) during a long-term professional Development program. *Research in Science Education, 44*(1), 189–213.

Shulman, L. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(1), 4-14.

Shulman, L. (1987). Knowledge and teaching: Foundations of the new reform. *Harvard Educational Review, 57*(1), 1-22.

Van Driel, J. H., De Jong, O., & Verloop, N. (2002). The development of preservice chemistry teachers' pedagogical content knowledge. *Science Education, 86*(4), 572–590.

This work is based on Lu Wang's dissertation and an earlier version of this project was presented at the 2020 International Conference of National Association of Research and Science Teaching (NARST).

## Authors

[1]Lu Wang (lwa1@iu.edu) is an Assistant Professor of Science Education at Indiana University Kokomo, Kokomo, Indiana, USA.

[2]J. Steve Oliver (soliver@uga.edu) is a Professor Emeritus at the University of Georgia, Athens, Georgia, USA.

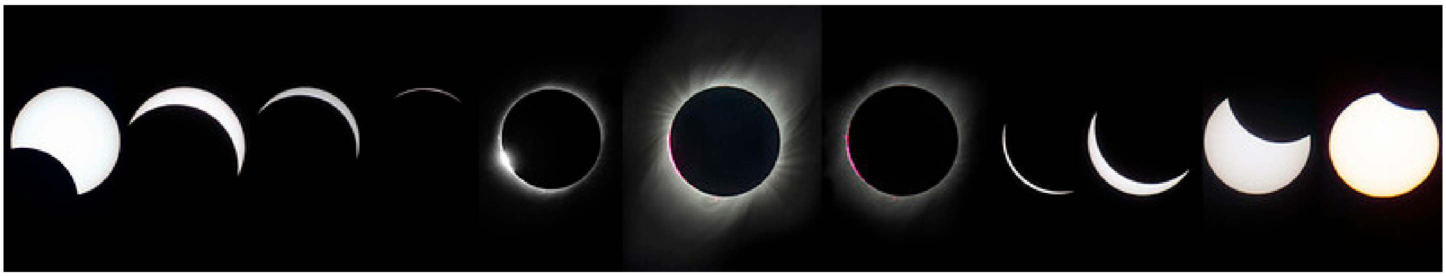
Harris, T. (2022)
*The Hoosier Science Teacher*, *45*(2)
DOI 10.14434/thst.v45i2.35496



Open Access

# Solar Eclipse: Looking Safely Forward to April 2024

**Tina Harris**



HASTI's Solar Eclipse Committee offers ideas to help teachers plan for safe viewing of this astronomic event in 2024.

**Keywords:** Solar eclipse; Earth Space Science; Safe science teaching

Your HASTI Solar Eclipse Committee met October 19, 2022, to discuss the role HASTI should play in disseminating information to our membership about the April 2024 Solar Eclipse. The citizens of the entire State of Indiana may enjoy the event, either in totality or as a partial eclipse.

We discussed what types of information might be the best to share. It was decided that HASTI members would benefit from curriculum information, safety information, information on how to obtain solar filters prior to the event, ideas to get principals and superintendents on-board with allowing students to observe the event, and suggestions for possible sponsors for Indiana specific viewing needs. We also brainstormed potential collaborations with other organizations to either sponsor equipment or provide programs on eclipse-related topics.

We decided that we would encourage input from membership concerning eclipse lessons that teachers used during the August 2017 partial eclipse that they felt were effective. We will also be posting links to websites that provide NGSS based eclipse lessons from other organizations such as NSTA, AAS (the American Astronomical Society), The Planetary Society, AAAS, etc. These organizations already have developed materials from the 2017 eclipse, as well as the annular eclipse of October 2023 and the total eclipse of April 2024. We feel the sooner we start generating excitement in our classrooms concerning "The Great American Eclipse" the better – especially because the eclipse over Indiana will be one of the longer eclipses on record.

We also discussed collaboration with informal science education providers for programming and information. We brainstormed a list of possible partners that could include:

- Libraries
- The Challenger Center in NW Indiana;
- Science museums like the Children's Museum in Indianapolis, Science Central in Ft Wayne, and WonderLab in Bloomington, and others around the state. (Please send us suggestions for museums not listed here that might like to join us or that we can work with!)

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

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

- Universities – especially those with astronomy programs or planetariums like IU-Bloomington, IU-Kokomo (planetarium), Butler, Ball State, etc. (We are aware that some of the planetariums can stream live programs to other planetariums, including planetariums at schools around the state, and would like to contact people who might make that happen.)
- SEFI, the Science Education Foundation of Indiana who sponsor the Science and Engineering Fairs and Science Indiana every October at the IN State Fairgrounds
- Television stations, including the PBS stations around the state
- Cities along the path of totality
- NASA Outreach Center for our region located in Brook Park, OH – the Glenn Research Center

Please let us know if we are missing anyone.

We are also very interested in disseminating solar eclipse glasses to every school district in the state as well as providing information on ways to watch the eclipse safely without solar glasses. We discussed looking into corporate sponsorship to help with the costs and will be discussing the logistics of timing and distribution (we are looking for member input in this area too). But don't feel like you must wait for us. There is a link on the HASTI eclipse page to information on vendors who sell reliable and safe products for eclipse observation. The sooner you order the more likely you will have at least some to share in 2024.

We are accepting input from our members through several options. Feel free to talk to your HASTI representative (these are listed on the HASTI website). You can also contact us via the HASTI Facebook page, at our breakout room at the HASTI conference in February that is open to everyone, and/or through a survey that we are currently developing that will go out to all Indiana teachers. This affects not just HASTI membership but all teachers around the state. We would love to get everyone on-board for this unique and unforgettable event!

If you have a suggestion that can't wait, feel free to email Craig Williams, chair of the committee (craig.williams@nwsc.k12.in.us) or Tina Harris (tiaharri79@gmail.com) to share your ideas and/or contacts. Even better, join our committee.

Remember, this eclipse will affect everyone in Indiana in some way, so we would love to simply be a clearinghouse for contacts for anyone who would like to learn how to watch this eclipse safely.

See the HASTI Eclipse 2024 page for more information!

## Author

Tina Harris (taharris79@gmail.com) teaches Envionmental Science at Bedford North Lawrence High School, Bedford, Indiana, USA.

# HASTI Events Calendar

**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

**Dec 16 - Feb 19**
Nikon's Small World Exhibit **- Celebrating photography through the microscope**. Indiana State Museum, Indianapolis, IN

**January 12**
**Indiana Association for Agriculture Education** Winter Meeting

**January 12**
**Indiana STEM Education Conference** Theme: Advancing STEM with Students." Early-bird registration closes on December 16

**January 13, 14, 20, & 21**
**Tour of the Winter Sky** Charles W. Brown Planetarium, Ball State University. 6:30pm

**January 14–17**
**American Association of Physics Teachers Winter Meeting**, Portland, OR

**February 4 & 11**
**Eclipse: The Sun Revealed**, Charles W. Brown Planetarium, Ball State University

**February 12-14**
**2023 HASTI-ICTM Conference** Indianapolis Marriott East Click here to Register!

**February 12, & May 6**
**HASTI Board Meetings,** 10:00 AM, Marriott East Indianapolis

**March 1**
**Deadline to Apply for the Summer Experience in Sustainability and the Environment (SESE)**.

**March 22-25**
**National Science Teaching Association National Conference on Science Education**, Atlanta, GA

**March 31**
**Deadline to apply for the Biology Summer Institute,** Biology Department, Indiana University Bloomington

**IN Regional & State Envirothon Competitions**

March 8 South Central Regional, Lawrence County Fairgrounds, Bedford, IN. lcswcd.hannah@gmail.com
March 9 Northwest Regional, Red Mill County Park, LaPorte, IN. Jlute@laporteco.in.gov
March 14 Southwest Regional, Warrick County 4-H Center, Boonville, IN. Susan.King@in.nacdnet.net
March 14 East Central Regional, Hayes Arboretum, Richmond, IN. Luanne.holeva@in.nacdnet.net
March 15 North Central Regional, Camp Buffalo, Monticello, IN. Mary.watson2@in.nacdnet.net
March 16 Northeast Regional, Peabody Public Library, Columbia City, IN. nadean.lamle@in.nacdnet.net
March 17 West Central Regional, Ivy Tech Community College, Terre Haute, IN. jan.came@usda.gov
April 26 Indiana State Envirothon Competition, Camp Illiana, Washington, IN.

**April 14-15**
**Indiana Section for the American Association of Physics Teachers Spring Meeting**. IU Kokomo

**June 12–16**
**Biology Summer Institute at Indiana University**, Indiana University Bloomington. Week-long program for high school teachers to engage with faculty and graduate students to develop hands-on lesson plans.

**June 15-16**
**2023 Summer Elementary PD**, Purdue University, West Lafayette, IN. K-12 Outreach will incorporate solar eclipse content into the Summer PD.

**June 12-14**
**Summer Middle School PD**, Purdue University, West Lafayette. Offered both in person and virtually this summer.

**July 2023**
**Physics Inside Out**. Five-day on-campus summer physics program for middle school students.

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

# Freebies! Free (and almost 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!**

**Kikim Media**, the NSTA and Kennebunkport Climate Initiative have put together short videos on Vimeo on various environmental and climate change topics

**NASA has Next-Gen Science lessons**, including lessons on the Artemis Missions and the Orion Rocket used to propel it to the moon and back.

**Indiana DNR** has a number of YouTube videos about the parks, the history of their location, and the nature you can find there.

**Women in Mining (WIM) Educational Foundation** has free lessons you can download (and a few posters) on materials science and mining and energy resources.

**American Museum of Natural History produces Ology**, with short courses and games over a variety of topics for children.

**Laura's Best Freebies** is Laura Candler's Teacher Resources collection of her most popular freebies. She regularly goes through to check links and company offers.

**The Smithsonian Institute** has resources for educators for many of its museums and gardens.

Teachers get into the **Indiana State Museum** OR any of its 11 associated sites for FREE with Teacher ID any day. In addition, field trips that are pre-arranged with 12 or more students, everyone gets in free.

If you are one of the first 35 people to sign up for a **American Meteorological Servce Datastreme** course in your area you can get the $400 fee waived for a short time only (applications available NOW).

**Kids STEM Degrees** program consists of 10 videos (3-5 minutes) and assessments for each level. Collect 10 codes and be eligible to earn a 'degree' from Purdue Science, Individually by students, or together as a class.

**Saturday Morning Astrophysics at Purdue (SMAP)** Virtual programs offered monthly for middle and high school students in grades 7-12. Dive into current topics in astro research, historical background and discovery, and grade-appropriate fundamental principles related to physics and astronomy.

**You can suggest other Freebies to include in the next issue of THST!**
**Email a description and URL to thst@hasti.org**

**Published by the Hoosier Association of Science Teachers, Inc. (https://hasti.org/) ISSN** 2475-451x

Open Access

# 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.

*THST* does not charge authors a publication fee. Authors retain ownership of the content of the article that will be published under a Creative Commons 4.0 BY-NC-ND license, with permission granted to THST for our uses.

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