NGSS-aligned water quality lessons for middle school grades from the *Pathways to Science Teaching* program

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What is *Pathways to Science Teaching*?

A 10-week, NSF-funded summer training program designed to recruit and support a diverse cadre of undergraduates who are prepared to effectively teach earth and environmental sciences using NGSS science and engineering practices.

- **Learn** science
- **Practice** science
- **Teach** science
- **Think** science
Why *Pathways to Science Teaching*?

We need more, and more diverse, teachers familiar with earth sciences!
Why *Pathways to Science Teaching*?

We need teachers who can engage youth in NGSS practices!

Science and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

What is *Pathways to Science Teaching*?

Provide undergraduates with an opportunity to engage in authentic research and teaching NGSS practices based on their research.

<table>
<thead>
<tr>
<th>Program goal – Develop participants’</th>
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<tbody>
<tr>
<td><strong>Learn science</strong></td>
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<tr>
<td>- Awareness of local water quality issues</td>
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<td>- Awareness of earth and environmental science careers</td>
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<tr>
<td><strong>Practice science</strong></td>
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<tr>
<td>- Competence in geoscience research</td>
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<td>- Understanding of the nature of science</td>
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<td>- Scientist and teacher identities</td>
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The Summer 2018 *Pathways* Experience

**Participants**

- Website, email, CMS announcements and in-class announcements
- Selection based on
  - Academic competence
  - Preparation
  - Diversity
  - Commitment

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<td>3 Science or engineering</td>
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The Summer 2018 *Pathways* Experience

**Pre-Program: Getting to Know The Team**

- **Goals:** Get to know the team, learn to ask scientific questions

- **Activities:** Afternoon walk through Al Sabo Nature Preserve. Participants make observations of natural phenomena and generate “I wonder” statements.
The Summer 2018 *Pathways* Experience

**WEEK 1: Identifying Local Water Quality Issues**

- **Goals:** Introduce NGSS, identify water quality issues in the Kalamazoo region

- **Activities:** Introduction and group discussion of NGSS. Meetings with local government, non-profit, WMU, and industry stakeholders to identify critical water quality issues. Daily writing assignment summarizing each stakeholder visit.
WEEK 2: Training in Research Methods and Design

- Goals: Learn data collection and analysis protocols, design water quality study

- Activities: Training in GLOBE data collection and analyses protocols for water quality. Training in weather and cloud observation. Build and install a weather station. Discussion of calibration, data quality, data recording in field notebooks. Write and finalize research plan.
WEEKS 3 - 4: Collecting Data

- Goal: Collect and analyze water quality data

- Activities: Field sampling (salinity, dissolved oxygen, pH, total dissolved solids, conductivity, temperature) along Portage Creek before and after storm events, sample analysis, and recording/graphing of data. Discussion of measurement error, replication, quality of analysis, graphing, and nature of science.
The Summer 2018 Pathways Experience

WEEK 5: Interpreting & Synthesizing Data

• Goals: Finish water quality study, prepare oral presentation of results

• Activities: Final data collection and analysis. Prepare graphs, maps, and visualizations. Discussion of good practices for oral presentations. Prepare and practice oral presentation of results.
WEEK 6: NGSS and Lesson Planning

- Goals: Become familiar with inquiry and the NGSS, learn 5E lesson planning and draft potential lessons for summer camps.

- Activities: Discussion of safety and responsible conduct when working with minors. Work through an example NGSS activity with master teachers using “learner” and “teacher” hats. Introduction to 5E lesson design. Draft potential lessons for the summer camps.
The Summer 2018 *Pathways* Experience

**WEEK 7: Teaching Preparation & Practice**

- **Goals:** Prepare and practice NGSS-aligned lessons for the middle school and youth summer camps.

- **Activities:** Discussion of classroom management techniques. Working in groups with feedback from the instructional team, develop lessons for the summer camps. Microteach portions of the lessons to peers and the instructional team.
The Summer 2018 *Pathways* Experience

**WEEK 8: Teaching Summer Camps**

- **Goals:** Teach two grade 6-8 day camps and reflect on experiences

- **Activities:** Teach two week-long, ½ day middle school summer camps for the WMU ATYP program (“What’s in your water?” and “Water in, water out”). Discuss successes and improvements; adapt and revise lesson plans after each day.
WEEK 9: Teaching Summer Camps

- Goals: Teach grade 1-5 summer day camp and reflect on experiences

- Activities: Teach three, 2 hour sessions of WMU’s Children’s Place summer camp (“Cloud Camp”). Discuss successes and improvements; adapt and revise lesson plans after each day of camp.
The Summer 2018 *Pathways* Experience

**WEEK 10: Wrap Up & Communicating Results**

- **Goals:** Communicate results of the research and teaching experiences to stakeholders, the public, and scientists.

- **Activities:** Final data collection and analysis. Submit abstracts and prepare posters for the Fall 2018 Geological Society of America national meeting. Present posters and talks to an audience of week 1 community stakeholder groups, peers and family members, and WMU faculty.
The Summer 2018 *Pathways* Experience

**Post-Program: Communicating Results**

- **Goals:** Attend and present research and teaching at 2018 GSA national meeting

- **Activities:** Prepare for attending the Fall 2018 Geological Society of America national meeting in Indianapolis, IN. Apply for travel grants. Finalize posters and present them at the meeting. Reflect on the meeting experience.
Pathways Summer Camp Lessons

What’s in your Water?

Lesson 1: Does Clear Water Mean Clean Water?

SEPs: Asking questions and defining problems
Planning and carrying out investigations
Analyzing and interpreting data
Engaging in argument from evidence

By the end of this lesson, SWBAT

1. Explain that the quality of water cannot necessarily be determined by eye
2. Quantify (through chemical testing) the compounds present in a given water sample
What’s in your Water?

Lesson 2: Water Sampling

SEPs: Planning and carrying out investigations
Using mathematics and computational thinking

By the end of this lesson, SWBAT
1. Demonstrate how to safely and consistently collect surface water samples
2. Demonstrate how to use a turbidity tube and what it means to measure water quality
3. Accurately record observations and questions while in the field and document sampling information in field notebooks
What’s in your Water?

Lesson 3: Water Testing

SEPs: Analyzing and interpreting data
Constructing explanations and designing solutions
Obtaining, evaluating, and communicating information

By the end of this lesson, SWBAT
1. Test water samples collected on Lesson 2 using kits for nitrate, silica, alkalinity, hardness, phosphate, CO$_2$, and dissolved oxygen
2. Explain how each of the parameters is important for water quality
What’s in your Water?

Lesson 4: How do Things get into Water?

SEPs: Developing and using models Engaging in argument from evidence

By the end of this lesson, SWBAT

1. Utilize surface water and groundwater models to describe how contaminants enter water systems through erosion, storm water runoff, and infiltration
Lesson 5: How do we Clean our Water?

SEPs: Developing and using models
Analyzing and interpreting data
Constructing explanations and designing solutions

By the end of this lesson, SWBAT
1. Identify what contaminants may be present in water samples and explain how those contaminants enter water systems
2. Explain how infiltration removes contaminants
3. Construct a working bottle infiltration model using layers of various sediment
Lesson 1: A Water Cycle of Many Paths

SEPs: Developing and using models
Constructing explanations and designing solutions

By the end of this lesson, SWBAT
1. Explain the water cycle and how human activity impacts the water cycle
2. Demonstrate how much fresh water is available earth for human use
Lesson 2: Groundwater Modeling

SEPs: Developing and using models

By the end of this lesson, SWBAT

1. Explain how surface materials control how quickly water will infiltrate into the ground
2. Identify parts of a groundwater system and explain how groundwater and surface water interact
3. Explain how contamination moves through a groundwater system
Lesson 3: Wastewater Treatment

SEPs: Constructing explanations and designing solutions

By the end of this lesson, SWBAT
1. Identify several methods used to purify water
2. Distinguish between suspended solids and dissolved contaminants in water
3. Explain how different methods can be used to remove the solid and dissolved contaminants in water by either physical or chemical means
4. Design a method to purify water using materials provided
Lesson 4: Wastewater Treatment

SEPs: Constructing explanations and designing solutions

By the end of this lesson, SWBAT
1. Explain how water is cleaned in a wastewater treatment facility
2. Build a simple model of a wastewater treatment facility and evaluate its effectiveness
3. Improve the model based on testing and redesign
Lesson 5: Wastewater Treatment

SEPs: Constructing explanations and designing solutions

By the end of this lesson, SWBAT
1. Evaluate the effectiveness of the wastewater treatment models that they designed
2. Use the model to explain common techniques for treating contaminated water
Lesson 1: Cloud Classification

SEPs: Asking questions and defining problems
Developing and using models
Planning and carrying out investigations
Obtaining, evaluating, and communicating information

By the end of this lesson, SWBAT
1. Explain the materials that make up clouds
2. Identify characteristics of the three main types of clouds
3. Explain how clouds form due to condensation
Lesson 2: Clouds and the Water Cycle

SEPs: Asking questions and defining problems
Developing and using models
Planning and carrying out investigations
Obtaining, evaluating, and communicating information

By the end of this lesson, SWBAT
1. Explain how evaporation, condensation, and precipitation move water through the water cycle
2. Make observations of temperature, rainfall, and cloud cover using a weather station
3. Identify clouds and cloud cover
Lesson 3: Modeling the Water Cycle

SEPs: Asking questions and defining problems
Developing and using models
Planning and carrying out investigations
Obtaining, evaluating, and communicating information

By the end of this lesson, SWBAT
1. Explain the difference between a raindrop and cloud droplet
2. Explain how raindrops and cloud droplets relate to the water cycle
3. Model how water moves through the water cycle
How do we know *Pathways* works?

**Project evaluation by SAMPI**

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<tr>
<th>Program component</th>
<th>Program goal – Develop participants’</th>
<th>Data source for Evaluation</th>
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| **Learn science** | - Awareness of local water quality issues  
- Awareness of earth and environmental science careers | - SAMPI survey and interviews |
| **Practice science** | - Competence in geoscience research | - SAMPI survey and interviews  
- Post-GSA survey |
| **Think science** | - Scientist and teacher identities  
- Understanding of the nature of science | - SAMPI survey and interviews  
- Student Understanding of Science and Scientific Inquiry (SUSSI) survey (Liang et al., 2006; 2008) |
| **Teach science** | - Competence in teaching NGSS scientific practices | - Science Instructional Practices Survey (SIPS; Hayes et al., 2016) |
| **Overall program quality and impact on participants** | | - SAMPI survey and interviews |
How do we know *Pathways* works?

Impact on participants’ knowledge of and comfort teaching with NGSS practices:

In the science part -
- Choosing variables to investigate
- Analyze relationships using variables and graphs

In the teaching part -
- Using models to predict outcomes

Overall -
- Design and implement an investigation
- Supply evidence to support a claim
- Create an argument to support a claim

### Science and Engineering Practices

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information
How do we know *Pathways* works?

- Getting to do ‘real’ research impacted participants’ identity as a scientist:
  - “All of my science classes give you a lab manual and everything is written out for you to do, so it was nice to just choose what we wanted.”
  - “I’ve never experienced going out and taking samples and that was awesome.”
  - “Teachers don’t get to have actual research experiences of their own, so it’s nice to get that.”
  - “I didn’t think I was at all interested in any kind of science. Afterwards, it seems official seeing the poster and all the work we did. It’s surreal. I definitely feel like an actual scientist.”
How do we know *Pathways* works?

- Teaching camp affirmed teacher identity and enabled participants to translate the research experience into teaching:

  - “The students taught me as much as I taught them. I learned I could be a teacher. I did not see that before the program but now I see it as a future path.”
  - “It just reaffirmed [that] I love kids and I’m going into the right career, and science can be fun for any age …”
  - “I learned the importance of reflection, of being able to reflect on how things that I do will help me become a better person and a better teacher in the future. I learned that I like doing science.”
  - “I feel like I can provide a better perspective of science for my students. I went through it and understand that it is frustrating.”
How do we know *Pathways* works?

- Strength of the bonds between participants and with faculty and teacher mentors
  - “I wouldn’t have learned what I learned if it was just me and a professor. I learned from my peers because I was with them every day. I leaned on them every day. We had each other’s backs. The Magnificent Eight!”
  - “We all had varying experiences and levels of knowledge. Some of us weren’t as confident with analyzing data or speaking in front of people, so we were able to support each other.”
  - “They [faculty and grad student] wanted us to succeed and they took the time to get to know us. Sometimes the faculty doesn’t care, but these do. I learned much from them.”
  - “When we were teaching they [teacher mentors] would help us through the lessons. They were there with us in the classroom. It was very helpful.”
Thank you:
Dr. Steve Bertman, WMU
Dr. Todd Ellis, WMU
Dr. Steve Kaczmarek, WMU
Laura Tinigin, WMU
Lauri Davis, WMU
Dr. Robert Ruhf, WMU
Summer 2018 Participants