PATHWAYS TO SCIENCE TEACHING:

Using Authentic Research and Teaching to Improve the Preparation of K-12 Science Teachers

Heather Petcovic*, Steve Bertman, Todd Ellis, Stephen Kaczmarek, Kevin Koch, Valerie Long, Robert Ruhf, Laura Tinigin, & Paul Vellom

Western Michigan University

What is the *Pathways* program?

- Diverse and well-prepared K-12 teachers are critical to expanding the future geoscience workforce.
- Most teacher preparation programs do not include experiences in designing and conducting a scientific investigation, and connecting research to teaching scientific practices as articulated by the Next Generation Science Standards Framework (NRC, 2012; NGSS Lead States, 2013).
- *Pathways to Science Teaching* engages undergraduate students in a 10-week summer program:
  - ***Learn Science*** – an introduction to local water quality issues through interaction with community stakeholders
  - ***Practice Science*** – a participant-designed water quality investigation in urban and rural watersheds
  - ***Teach Science*** – mentored teaching preparation and practice, followed by teaching in K-8 summer camps
  - ***Think Science*** – participants learn about the nature of science and scientific inquiry, reflect on their research and teaching experiences, and share experiences with stakeholders
- The project ***goal*** is to recruit, support, and sustain a diverse team of undergraduates who become invested in K-12 earth science education, competent in geoscience research, competent in teaching NGSS scientific practices, and aware of both local water quality issues and potential earth and environmental science careers.

Who are the target students?

How did we recruit?

- *Pathways* website, narrated PowerPoint, face-to-face
- In-class and email announcements in 28 introductory level science and education courses at WMU and two partner community colleges
- Applicants submitted an application form, purpose statement, transcripts, and two letters of recommendation

https://www.wmich.edu/science/pathways

How did we select participants?

- Academic Competence (GPA >2.5)
- Preparation (>1 college-level science course)
- Diversity (race/ethnicity, gender, age, first generation college student)
- Commitment (prior work with K-12 youth, prior research experience, and evidence of grit and tenacity)

Who participated in summer 2018?

- 8 students selected from an applicant pool of 21
- Demographic Diversity: gender (5 women), age (range 19-42 years), race/ethnicity (4 students of color)
- Academic Diversity: college experience (6 with community college experience) and academic program of study (3 science/engineering, 3 secondary science education, 2 elementary education)
- Diversity with complementary strengths:

"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."

*Corresponding author: heather.petcovic@wmich.edu

How did we learn, practice, teach, and think science?

Pre-Program: Getting to Know The Team

- Goals: Get to know participants and instructional team, learn to ask scientific questions
- Activities: Afternoon walk through local nature preserve. Participants were asked to make observations of natural features and generate "I wonder" statements about their observations.

WEEK 1: Identifying Local Water Quality Issues

- Goals: Introduce NGSS, identify water quality issues in the region
- Activities: Introduction and group discussion of NGSS scientific practices, disciplinary core ideas, and cross cutting concepts using "I wonder" statements. Meetings with local stakeholders to identify critical water quality issues. Daily writing assignment summarizing each stakeholder visit.

WEEK 2: Planning & Collecting Data

- 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 water quality study 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 (NOS).

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: Teaching Framework & Planning

- Goals: Present results of water quality research to the teaching team, become familiar with inquiry and the NGSS, become familiar with lesson planning and draft potential lessons for summer camps
- Activities: Present water quality study. Discussion of safety and responsible conduct when working with minors. Begin working with the NGSS. Working through a NGSS activity with "learner" and "teacher" hats. Introduction to 5E lesson design and planning (Bybee, 2006).

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.

WEEKS 8 - 9: Teaching Summer Camps

- Goals: Teach two grade 6-8 and one grade 1-5 summer day camps and reflect on experiences
- Activities: Teach two week-long, ½ day middle school summer camps ("What's in your water?" and "Water in, water out"). Teach three, 2 hour sessions of children's camp ("Cloud Camp"). Discuss successes and improvements; adapt and revise lesson plans after each day of camp.

WEEK 10 & Beyond: Communicating Results

- Goals: Communicate results of the research and teaching experiences to stakeholders, peers, and the professional community
- Activities: Final round of data collection before and after a storm event to confirm earlier findings. Discuss poster presentations and writing abstracts. Prepare abstracts and posters for submission to fall GSA meeting. Give poster and oral presentations about the research findings to an audience of week 1 community stakeholder groups, peers and family members, and WMU faculty. Attend and present research and teaching at 2018 GSA meeting.

How do we know it works?

- Science and Math Program Improvement (SAMPI) at WMU provided project evaluation.

Evaluation parameter - measures participants'	Data source	When collected
Understanding of the nature of science (NOS) and scientific inquiry (NOSI)	SUSSI (Liang et al., 2006; 2008)	First day of program, at transition, last day of program
Knowledge of and comfort with using NGSS science and engineering practices in the classroom	SIPS (Hayes et al, 2016)	First day of program, at transition, last day of program
Identity as a scientist and as a teacher	Survey developed by SAMPI	First day of program, at transition, last day of program
General experiences, most and least impactful parts of the program, suggestions for improvement	Individual participant interview	Last day of program

- Program impact on participant views of NOS:
  - Overall, participants held informed view of NOS that changed little over the program
  - Research experience reduced the belief that scientists follow a step-by-step scientific method
  - Teaching experience developed awareness that cultural values and expectations determine what science is conducted and accepted
- Program impact on knowledge of and comfort with NGSS science and engineering practices:
  - Increased knowledge of choosing what variables to investigate (in a lab or field setting), analyzing relationships using charts or graphs, using models to predict outcomes, designing investigations, and arguing from evidence
  - Increased comfort in teaching youth to design and implement investigations, use physical and conceptual models to generate explanations, and argue from evidence
- Program impact on scientist and teacher identities:
  - Five participants developed or reaffirmed an interest in the geosciences
  - Five participants reported increased identity as a geoscientist or science teacher ("*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. I definitely feel like an actual scientist.*")
- Overall, participants valued the
  - **Authentic research experience** ("*I feel like I can provide a better perspective of science for my students. I went through it and understand that it is frustrating.*")
  - **Teaching experience** ("*The teaching reassured me that I really want to be a teacher.*")
  - **Building relationships with peers and instructors** ("*Working with others in the group made me feel like I have colleagues; having people who are invested in the same thing as you are.*")
- Improvements for Cohort 2 will include: 1) emphasis on the NGSS throughout the research, and 2) improved alignment between the methods training and research.

Acknowledgements

We thank the community organizations and WMU faculty and staff for the time they spent with our project participants. This work is supported by the National Science Foundation under Grant No. GEO-1701007. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

References

Bybee, R. W., Taylor, J. A., Gardner, A., Van Scotter, P., Powell, J. C., Westbrook, A., & Landes, N. (2006). *The BSCS 5E instructional model: Origins and effectiveness.* Colorado Springs, CO: BSCS, 5, 88-98.

Hayes, K. N., Lee, C. S., DiStefano, R., O'Connor, D., & Seitz, J. C. (2016). Measuring science instructional practice: A survey tool for the age of NGSS. *Journal of Science Teacher Education*, 27(2), 137-164.

Liang, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2006, April). Student Understanding of Science and Scientific Inquiry (SUSSI): revision and further validation of an assessment instrument. In *Annual Conference of the National Association for Research in Science Teaching (NARST), San Francisco, CA (April)* (Vol. 122).

Liang, L. L., Chen, S., Chen, X., Kaya, O. N., Adams, A. D., Macklin, M., & Ebenezer, J. (2008, June). Assessing preservice elementary teachers' views on the nature of scientific knowledge: A dual-response instrument. In *Asia-Pacific Forum on science learning and teaching* (Vol. 9, No. 1, pp. 1-20). The Education University of Hong Kong, Department of Science and Environmental Studies.

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

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas,* Washington, DC: The National Academies Press.