Authentic Science

Highlights from the Field

Exploring the NGSS Science & Engineering Practices through the work of Dr. Michelle Soupir featuring insights from Abby Schaefer

Volume 1, Summer 2021

Featuring:

The Authentic Science Podcast, Episodes 1-4

Designed by

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Funding Provided by

USDA National Institute of Food and Agriculture Food Safety Grant

(No. 2018-68003-27468)

A very special "thank you" to Abby Schaefer for devoting her time, expertise, and energy to this innovative project.

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I am an Associate Professor in the Agricultural and Biosystems Engineering Department at Iowa State University. I graduated with a B.S. in Biological and Agricultural Engineering from Kansas State University and M.S. and Ph.D. degrees in Biological Systems Engineering from Virginia Tech. I also worked as an Environmental Engineering Consultant at CDM Smith in Kansas City, Missouri between my undergraduate and graduate degrees.

My research program is focused on soil and water quality, nonpoint source pollution control, watershed management, and water quality monitoring. We use both lab- and field-scale studies to examine the occurrence, fate and transport of pathogens, pathogen indicators and contaminants of emerging environmental concern (CoEECs) such as antibiotics and antibiotic-resistant bacteria to surface and groundwater systems. Findings from our work has implications to improve the Total Maximum Daily Load (TMDL) development and implementation process, identify the impact of land use practices on water quality, and develop management practices to reduce pollutant transport.

The Science and Engineering Practices discussed throughout this booklet are the foundation of my work. Scientists dedicate their lives to answering questions and gathering data through their research and investigations. But what makes an investigation worthy of pursuing? I believe it is curiosity, inspiration and need. I see these as the drivers that help me select my research questions. Sometimes these questions will provide for multiple avenues of work, while some will focus on a narrow, seldom-explored topic.

As you use this booklet to inform K-12 STEM classroom experiences, remember that research labs are “fail-forward zones”. Without failures and mistakes, science would not have advanced as far as it has. So, embrace mistakes and open your mind to failing forward!

www.abe.iastate.edu/soupir/

Dr. Soupir Speaks: Equity at the Center

Connecting

During my time at ISU I have realized that many of the experiences that I have as a female faculty member are shared. While my individual experience might not seem exceptional, when I connect with other female faculty we relate to each other through the challenges we have faced. I have greatly benefited from the community and I hope to extend this beyond my own personal experiences in the hopes that this will have an overall positive impact on the workplace experience for our female and marginalized faculty.

How it Started

I began my engagement with equity, diversity and inclusion at ISU as a member of my departmental diversity and inclusion committee. In that process our committee realized the opportunity to develop a departmental-level strategy which outlined ways in which we can integrate the importance of EDI efforts into nearly all aspects of our common mission (research, teaching, service). I found it very impactful to think of the opportunities to bring EDI to the conversation in all the ways that we interact with students, build our research programs, communicate with external stakeholders, and invest our time in service activities.

Goals & Benefits

In my research program I am fortunate that the goals of my research program, improve water quality, can benefit everyone and while the applications that are typical in my lab group generally focus on agricultural systems, students can take the knowledge they gain and apply those skills to inequitable situations and especially to serve marginalized communities. I also work hard to ensure that my research team is diverse and inclusive, and this broadly applies to ethnic/racial diversity, gender diversity, as well as diverse backgrounds and viewpoints. Students in my research group graduate having the opportunity to engage and know students from all different backgrounds and walks of life.

Photo by Iowa State University

Photo by Iowa State University

Questions & Answers

What's your name and main area of research?

Dr. Michelle Soupir. My research involves improving water quality through basic and applied research on pollutant fate and transport. I work across multiple scales (lab, pilot, field and watershed) to investigate the occurrence, fate and transport of pathogens, pathogen indicators, nutrients and contaminants of emerging environmental concerns such as antibiotics and antibiotic-resistant organisms.

What brought you to Iowa State University?

My choice to come to ISU was both personal and professional. The quick answer is that my family is in Kansas and my husband's family is in Minnesota; ISU is a perfect midpoint location for us. But I also made the decision to come to ISU because of the opportunity to work with the world-class faculty and staff in the department of Agricultural and Biosystems Engineering. The Agricultural Engineering profession was founded at ISU in 1905 by Dr. Davidson and has since then been a leader solving global engineering problems related to all aspects of agricultural systems, including soil and water health, food production and storage, machine systems for food and biofuel production, safety of agricultural systems, and advancing processing of biological systems.

Where is your lab located on campus?

Our lab space is located in Sukup Hall on Iowa State's campus. We also have office space in adjoining Elings Hall.

How many people work with you?

I have three full-time research staff members. The staff are responsible for managing many different aspects of our ongoing research projects, including our water quality research lab which is responsible for analyzing water quality samples from researchers across campus, as well as some of our long term monitoring projects. Currently, we have eight graduate students in our group and a handful of undergraduate students at any given time. The graduate students are either M.S. or Ph.D students who are responsible for leading research projects while our undergraduate research assistants help with day-to-day activities and sometimes have the opportunity to lead their own independent research projects.

How does your research impact our community and state?

Our group works on solving problems related to many different types of contaminants, including nutrients, bacteria or pathogens, or other emerging contaminants such as antibiotic resistant bacteria or antibiotics, and how these pollutant move to water. We focus much of our work on contaminants derived from agricultural sources and we want to find sustainable solutions that protect our waters while also suppoting our farmers and the important agricultural economy in Iowa. Very simply, our work helps make the world a safer place for people to live and helps protect our environment.

Are there any partnerships that support the Soupir lab's work?

We collaborate broadly, and our work has been funded by agricultural commodity groups, state agencies, federal agencies, and nonprofit organizations. We have enjoyed successful and long-term collaborations with the Iowa Egg Council, the Iowa Soybean Association, the Iowa Nutrient Research Center, and the Iowa Department of Natural Resources. We've also been fortunate to receive federal funding from US Dept. of Agriculture, National Science Foundation, and Environmental Protection Agency. The diverse funding sources allows us to work to answer a range of questions related to water quality, from advancing basic science questions to more applied work that is useful for farmers and policymakers.

Student Spotlight: Abby Schaefer

What are your main areas of research?

Very generally, I study microorganisms that remove pollutants from water and the kinds of molecules these microorganisms consume for energy.

More specifically, woodchip bioreactors are one way that we can reduce the environmental impact of some of our agricultural practices that producers use to increase crop yields. Microorganisms that can consume nitrates (a chemical that is used to increase crop yields) inhabit what is essentially a trench filled with wood chips. The trench receives water that is being drained from an agricultural field, and after the water flows through the trench, the nitrates have been removed. Researchers and farmers want to know how long these systems will last, which is what my research is focused on determining.

Why did you choose Iowa State University?

I came to Iowa State specifically for the top-ranked Agricultural and Biosystems Engineering Department. However, the small size of the department combined with the large university was the perfect opportunity to be involved in a close-knit community in the department while also enjoying the benefits of a larger university community.

Why do you like being a researcher?

I enjoy tackling challenges that don't have a solution yet. Research involves a fair amount of creativity, whether that's being involved in designing experiments or through writing and creating presentations, and being able to be creative is what I enjoy about both research and engineering.


Photo by A. Schaefer


Photo by A. Schaefer

What keeps you motivated to "do science" when things get tough?

One challenging aspect about science is that things don't always work out the way you expect them to. This doesn't mean that you were wrong, it just means that you get the chance to learn something unexpected. However, this can be frustrating, and what helps me is remembering the bigger picture. I enjoy my research because I know it will help producers have less of an environmental impact, and that keeps me going.

What advice do you have for young women who are aspiring scientists and engineers?

When kids (especially boys) enjoy cars and other mechanical hobbies, adults can be quick to suggest engineering as a career. What I want girls and young women to know is that no matter what their interests are, there is usually always a branch of engineering that is somewhat related. For example, chemical engineering can be thought of as cooking or baking on a really large scale. Sewing involves a machine and precision in measurement, two concepts that are very transferable to engineering.

The NGSS Investigating Practices

Asking Questions and Defining Problems

A practice of science is to ask and refine questions that lead to descriptions and explanations of how the natural and designed world works and which can be empirically tested.

Planning and Carrying Out Investigations

Scientists and engineers plan and carry out investigations in the field or laboratory, working collaboratively as well as individually. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters.

Using Mathematics and Computational Thinking

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; statistically analyzing data; and recognizing, expressing, and applying quantitative relationships.

SEP descriptions from ngss.nsta.org/PracticesFull.aspx

Questions & Answers

with Abby S.

How do you “Plan and Carry Out Investigations” in your research?

Most of the time, planning an investigation starts when I read something that I want to examine further. For example, maybe I read about something another scientist did that I think could have been done in a different way. I try to think of a question that I can answer by collecting data based. This question is sometimes also called a hypothesis. Then, I think about which research tools are available to me that can help me answer my question. This helps me understand whether the question I want to answer is practical for me to answer. Next, I make predictions about my hypothesis and I determine if those predictions are true after I do my experiments and collect and analyze data.

For example, I had the hypothesis that different types of bacteria would colonize different types of woodchips, and that the various types of bacteria would cause changes in the level of nitrate (a pollutant) in water. To test this hypothesis, I set up a bunch of jars containing different woodchips with the same amount of water containing the same amount of nitrate. I measured the amount of nitrate remaining in the jars after several days in order to determine which type of woodchips was the best at reducing the amount of nitrate. I then identified the different types of bacteria that were present. I analyzed both the change in the nitrate amount and the amount and types of bacteria in order to conclude which type of woodchips are the best for woodchip bioreactors.

How do you know if an experiment/investigation will yield the information you want?

When you are picking an experiment to do, you want to be very careful that you are only testing one variable. You want to reduce as many other factors that could influence your results as possible, so you can be sure you are testing the question that you think you are testing. However, it can be very difficult to control for every possible variable in an experiment. For example, in my jar experiment, I could not control the bacteria that were present on the woodchips initially when the experiment started.

However, one of the fun parts about science is that sometimes an experiment does not turn out the way that you predicted. This is okay and a totally normal part of doing science!

How do mathematics and computational thinking support your work as a scientist?

Statistical tests are the way that scientists and researchers determine whether a result they are observing is random (due to chance) or an outcome based on their experimental design. If I do an experiment at a small scale (in the lab), math can help me determine if my results are viable at a larger scale (watershed, etc). Though math is important for science, I think it’s important to emphasize that you do not need to be a mathematician to succeed in or to enjoy science.

The Authentic Science Podcast

Episode 1: The Investigating Practices

Episode 2: The Sensemaking Practices

Episode 3: The Critiquing & Communicating Practices

Episode 4: Women in STEM

Photo by Cup of Couple from Pexels

Visit Anchor.fm/authenticscience to listen

Highlighted Resources for the Classroom

Visible research project
The Visible Research Project (VRP) is a collection of tools to help educators and researchers collaboratively design high quality student-facing curriculum materials which use authentic research projects to support students' science learning.
https://hallscience.us/visible-research

From Here to There with Woodchip Bioreactors
A high quality curriculum for use in 6-12 grade science classrooms based on the woodchip bioreactor work being done by Dr. Soupir.
https://www.oercommons.org/courseware/lesson/71904

What Can We Do? Antimicrobial Resistance in Agriculture and Beyond
Curriculum materials for use in 9-12 grade science classrooms focusing on the antimicrobial resistance (AMR) research being done in Dr. Soupir's lab.
https://www.oercommons.org/courseware/lesson/71017

NGSS@NSTA SEP full listing
One of the best, most simple online listings of the NGSS Science and Engineering Practices K-12 progressions.
https://ngss.nsta.org/practicesfull.aspx

The NSTA Atlas of the Three Dimensions
A user-friendly guide for teachers to better understand how ideas (SEPs, DCIs, and CCCs) build on one another and relate to each other.
https://my.nsta.org/resource/117948

STEM Teaching Tools Brief #15: How can we promote equity in science education?
One of many STEM Teaching Tool briefs which focuses on equitable learning practices in K-12 STEM classrooms.
http://stemteachingtools.org/brief/15

IowaCore.gov - Supporting the Science and Engineering Practices
A collection of resources curated by the Iowa Department of Education.
https://iowacore.gov/content/supporting-science-and-engineering-practices

The NGSS Sensemaking Practices

Analyzing and Interpreting Data

Scientific investigations produce data that must be analyzed in order to derive meaning. Because data patterns and trends are not always obvious, scientists use a range of tools—including tabulation, graphical interpretation, visualization, and statistical analysis—to identify the significant features and patterns in the data. Scientists identify sources of error in the investigations and calculate the degree of certainty in the results. Modern technology makes the collection of large data sets much easier, providing secondary sources for analysis.

Developing and Using Models

A practice of both science and engineering is to use and construct models as helpful tools for representing ideas and explanations. These tools include diagrams, drawings, physical replicas, mathematical representations, analogies, and computer simulations.

Constructing Explanations and Designing Solutions

The products of science are explanations and the products of engineering are solutions.

SEP descriptions from ngss.nsta.org/PracticesFull.aspx

Questions & Answers

with Abby S.

Students are asked to design, evaluate, and/or refine a solution to a complex real-world problem based on scientific knowledge. What does this look like in your lab?

One really important thing that I do with my work is to relate my results to work that other scientists have already done so that my observations are framed in the context of existing research. For example, I have studied the microbiology of woodchip bioreactors, but other people have studied the microbiology of constructed wetlands. This extra context can help us think of new questions to ask.

How do you define "scientific model"? What are some examples of the various types of models you use?

A scientific model is a simplified representation of the system a scientist or engineer is studying. Our pilot-scale woodchip bioreactors and our lab-scale woodchip bioreactors are both examples of models in my work. These are both examples of models because they are smaller than the full scale system. Working at a smaller scale makes it easier for us to take measurements and reduces the cost of conducting experiments. Models can give us a sense of the way that woodchip bioreactors perform in real life.

What kinds of modeling do you do in your research? How are models used?

Models can be thought of as predictions for the way that we expect our observations to look. We can compare our results to a model, such as an equation, to test how well our observations matched our predictions.

Highlighted Resources for the Classroom

Dr. Soupir's Water Quality Research Lab website
The official web page of Dr. Soupir's lab group. Discover current and past research projects, meet personnel, and access the group's published research.
https://www.abe.iastate.edu/soupir/

@ISUWaterChicks Twitter feed
https://twitter.com/ISUWaterChicks

Helping Students Make Sense of the World Using Next Generation Science and Engineering Practices
An amazing guide to understanding the NGSS SEPs, how to engage students in the SEPs and what do the eight practices look like in the science classroom?
https://my.nsta.org/resource/105619/helping-students-make-sense-of-the-world-using-next-generation-science-and-engine

Appendix F of the Next Generation Science Standards
Outlines how the SEPs connect with the Framework for K-12 Science Education and provides detailed information about each SEP.
https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

Scientific and Engineering Practices in K-12 Classrooms by Roger Bybee
A great article originally published in the December 2011 issue of NSTA's journals. Bybee offers his thoughts on the SEPs and how they look through both science and engineering lenses.
https://static.nsta.org/ngss/resources/201112_Framework-Bybee.pdf

Print-It-Yourself NGSS Classroom Posters
A set of printable posters for the NGSS SEPs, DCI topics and CCCs.
https://neuron.illinois.edu/NGSS-posters

Integrating SEPs into Assessment Tasks
A great resources that includes possible student prompts for use on assessments.
http://learndbir.org/resources/NGSS-TaskFormats_March2016v3.pdf

Implement: PLC Work Sessions

- Consider an upcoming unit of instruction in your science classes. Which SEPs are required for students to learn, if any? Which SEPs are suggested, if any?
- How might an authentic research project (like the ones highlighted in this resource) connect with the learning goals of your upcoming unit of instruction?
- How might the research connect with Science & Engineering Practices and Crosscutting Concepts in the Next Generation Science Standards (NGSS)?
- What will students be interested in? Is the topic/s something that will connect with students' interests and identities? Remember, while some phenomena may seem really "flashy" and get students' attention, there may be better local phenomena that will engage students more deeply.
- Are there way to build in aspects of equity or social justice into the work? How does students' use of the SEPs make lives better?

Partnering with a Researcher

- Working with authentic problems or community issues engages students and builds a strong sense of purpose to the learning experience. Partnerships should be formed around these real situations, events or phenomenon so that the products are worthy of students' time and attention.
- Questions to consider as you engage with a research partner:
    - What are the values, goals and needs of this partnership?
    - What strengths does each person bring to the partnership?
    - How might students gain from this experience in ways that they would not have without the partnership?
    - Does the partnership address the deeper needs confronting the teacher, students and researcher?
    - How is your partnership tethered to an existing organizational structure, or made part of a new structure that is supported by your current systems?

The NGSS Critiquing & Communicating Practices

Engaging in Argument from Evidence

Argumentation is the process by which explanations and solutions are reached.

Obtaining, Evaluating, and Communicating Information

Scientists and engineers must be able to communicate clearly and persuasively the ideas and methods they generate. Critiquing and communicating ideas individually and in groups is a critical professional activity.

SEP descriptions from ngss.nsta.org/PracticesFull.aspx

Questions & Answers

with Abby S.

What suggestions do you have for students who might struggle with "critiquing and communicating ideas individually and in groups"?

Receiving constructive feedback is an important part of being a researcher and engineer. At first, receiving feedback can be hard if it is treated as a magnification of the flaws in the work. It can help to try to think of receiving feedback as a way to make your work even more outstanding.

One of the cool things about science is that even though I am a relatively young researcher, I am still an expert in what I study. What this means is that even though my work can still be critiqued and improved, it doesn't take away from the work that I have already done.

In what ways do scientists communicate information with one another? Are there formats (email, journals, meetings) that you use more often than others?

The two most common formats of communication are through published journal articles and presentations. Both of these communication formats are opportunities to have a conversation about your work because other scientists will typically ask you questions following your presentation and other scientists will review your work and provide feedback when you are trying to publish with a journal.

Have you ever had to support a claim you've made with evidence? How did you do that effectively?

Virtually everything that is said in the scientific or engineering arena must be supported with evidence. The best way to do this is to provide citations and to point out if a statement you're making is conjecture (your best guess).

Have you ever had your research findings challenged? How did you handle it? How do scientists determine who is "right" in these situations?

I think "challenged" is a strong word. I think the closest I've come to something like that would be during the peer review process, but the aim of peer review is to make your work better, not to prove your work incorrect. The best way to handle peer review is through the lens of trying to make your work more complete, because it's not possible for one scientist to grasp every concept possible, it helps to have an outside perspective on your work. It's important to note that no one scientist or lab group is 'right.' Every new piece of work adds to the existing body of knowledge. I like to think of scientific consensus on different topics as an oscillating pendulum; new work may appear to show opposite findings of another piece of work, which swings the pendulum in the other direction. Future work may agree with that first piece of work, and back the pendulum swings until we have enough evidence to find some middle ground, and that's where consensus is found.

IMpACT in Classrooms

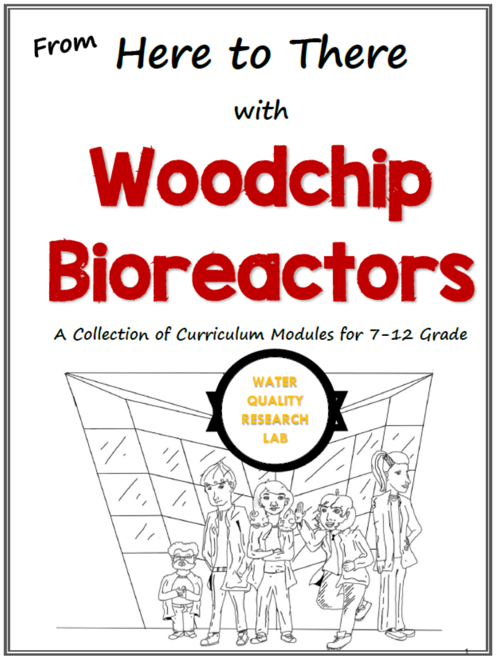
The Implementation Map for Administrators, Coaches and Teachers (IMpACT) is a tool designed as a self-reflection to assist in determination of the level of implementation of the Iowa Science Standards and the five innovations of the Next Generation Science Standards (NGSS). These innovations include: the use of relevant phenomena, three-dimensional learning, coherence of instruction, integration of math and ELA, and a focus on addressing inequalities.

Additionally, the IMpACT gives teachers intentional language around the implementation of the Iowa science standards. The descriptors for each aspect of implementation should provide insight into what actions teachers can take to deepen implementation of the standards and help focus ongoing professional learning. Additionally, the linked resources on IowaCore.gov provide targeted opportunities to learn more about each aspect.

Below are selected features from the IMpACT which address the Science and Engineering Practices directly. While there are certainly other connections to be made, these are simply a place to begin. Check out https://iowacore.gov/content/science-resources for more information!

Expanding Implementation	Implementation	Beginning Implementation	No Implementation
Criteria 1—Authentic Learning Experiences			
Students examine and experience science content in authentic ways that encourage greater depth of knowledge and build towards answering essential questions. When appropriate, students use science concepts from different domains (Earth/space, life, physical) to construct explanations.	Students interact with science content within one domain (Earth/space, life, physical) by figuring out phenomena. Any connections to prior learning or across science domains is loose or requires teacher prompting for students to see the connections.	Students interact with science content in some ways that encourage greater depth of knowledge (i.e. students read about a phenomenon or talk about how scientists/engineers engage with a related phenomenon or problem) but do not apply the content to real-world situations or phenomena.	Students interact with the science content mostly through reading a text, answering teacher-developed questions, or completing worksheets.
Criteria 2—Three-dimensional Learning			
Students engage in grade-appropriate elements of the scientific and engineering practices to learn about the world around them and solve problems with little prompting and teacher guidance.	Students engage in grade-appropriate elements of the science and engineering practices but their engagement is teacher-directed.	Students engage in the science and engineering practices in service to learning the disciplinary core ideas but engagement does not meet grade level expectations.	Students use a standard scientific method or are given a set of step-by-step procedures to follow.
Students use elements of the SEPs, CCCs, and DCIs to make sense of given phenomenon/ problems and are able to transfer their understanding/skills to explain related phenomenon or design solutions to new, related problems.	Student engagement in making sense of phenomena/designing solutions requires student performances that integrate grade-appropriate elements of the SEPs, CCCs, and DCIs.	Students engage in all three dimensions, but they are incorporated as 3 separate entities. Instructional activities utilize two of the three dimensions (disciplinary core ideas, or science/engineering practices, or cross-cutting concepts).	Students learn the three dimensions in isolation of each other. Instructional activities appear to only utilize one of the three dimensions with student learning centered on facts; content is an end in itself.

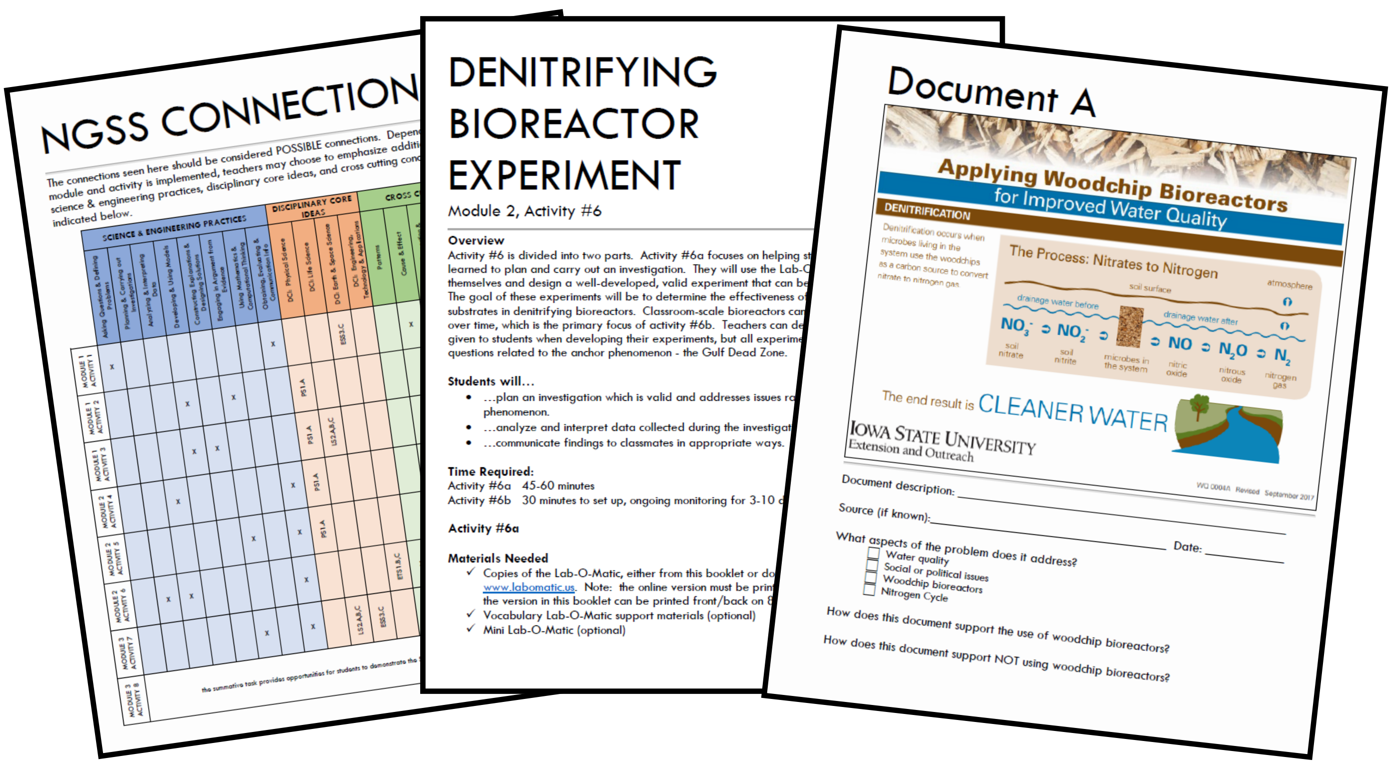
Expanding Implementation	Implementation	Beginning Implementation	No Implementation
Criteria 3—Coherence			
In designing and implementing instructional units, the teacher uses knowledge of the progressions of all three dimensions (DCI Matrix, SEP progressions, CCC progression;) and actively seeks information from students about previous instructional and life experiences to build upon prior knowledge and skills.	The teacher is aware of the progressions of all three dimensions (DCI Matrix, SEP progressions, CCC progression;) and works to connect current learning to past concepts but does not attempt to uncover what knowledge and skills students bring to the unit from life experiences.	The teacher is aware of past experiences students have engaged in but only for the reason of not repeating them in the current grade level.	The teacher is unaware of prior learning and experiences so each instructional unit starts from scratch with foundational ideas and skills.
Criteria 4—Appropriate Integration of ELA/Literacy and Mathematics			
Students use journals/notebooks to record and reflect on data/ evidence. Students appropriately communicate scientific ideas/ designs to different audiences through multiple modes of expressions including drawing, writing, video, etc. and use self, peer or teacher feedback to revise their understanding or to improve their communication skills.	Students utilize science notebooks/journals as a way to record information in words, drawings, graphs, etc and as a way to organize their own ideas and explanations, but do not have the opportunity to use peer or teacher feedback to revise their understanding or to improve their communication skills.	Students use journals/notebooks to record and organize information and build on these ideas throughout their learning.	Students record information on worksheets or in class notes but do not refer to these items in subsequent learning experiences.
Students create, evaluate, or analyze mathematical models and/or graphical displays of data in their explanations which encourage conceptual understanding, vocabulary development, and mathematical or computational thinking.	Students use scientific formulas, make calculations, and appropriately represent and analyze data to deepen their conceptual understanding.	Students perform mathematical calculations, graph their data and make sense of various displays of data but their analysis does not advance conceptual understanding.	Students use mathematical calculations to determine correct answers. Students learn graphing skills in isolation of context (i.e. there is a measurement and graphing unit).
Criteria 5—Supporting ALL Learners			
All students are provided necessary support (e.g., scaffolding, extension, or accommodations) to aid in the sense-making process. Students use additional and/or related phenomena within the targeted DCI to stretch their use of the SEPs and conceptual understanding (CCCs) for enrichment when they demonstrate mastery. Engagement in these practices is language intensive and requires students to participate in intentional science discourse. Differentiation occurs within and across all three dimensions and allows all students to grow in their sense making abilities.	Learning experiences are designed to differentiate so that all students are appropriately challenged in their sense-making and communicate that each and every student is capable of learning and doing well. Planned learning provides opportunities for students to use multiple modes of communication as they present ideas or engage in reasoned argumentation. All students engage in the SEPs as part of the scientific sense-making process as they develop scientifically-based conceptual understandings (CCCs) to explain phenomena (DCIs).	Learning experiences are designed for the "average ability" student. Accommodations or modifications are in place for students, as required by documentation (i.e., IEP and/or 504 plan). Students' use of the SEPs is limited and lacks intentionality and therefore does not support conceptual understanding (CCC) to explain phenomena (DCIs).	Learning experiences are aligned to the "average ability" student, with little-to-no differentiation for diverse learning styles and students' needs. Planned learning provides limited or no opportunities for students to practice the SEPs, develop conceptual understanding (CCCs) or explain phenomena (DCIs).



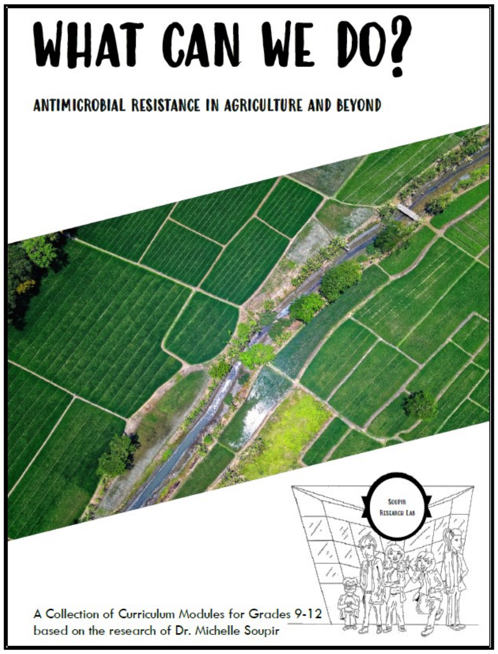
Bioreactors for the Win!

Many parts of the Upper Midwestern United States have wet soils that require drainage in order for them to be used for agriculture. Draining of subsurface water (tiling) in farm fields is a practice that farmers have used for more than 100 years because doing so results in a significant increase in crop yield. Concerns have grown, however, about the effect this practice has on the movement of pollutants (i.e., nitrates and phosphates) through fields and into waters. systems. Nitrate (NO3-1), which can be present in high amounts in drainage water, makes its way into streams, rivers and lakes where it unbalances ecosystems and can result in hypoxic conditions, as we have seen develop in the Gulf of Mexico, also known as the Gulf Dead Zone.

Woodchip bioreactors have proven to be a simple, yet highly effective way to remove nitrate pollution without impacting current land management practices. Field runoff water is collected via tiling and diverted into the bioreactor, which is essentially a buried trench filled with woodchips. Denitrification occurs when microbes living on the surface of woodchips (or other suitable material) use the wood as a carbon source to convert nitrate to nitrogen gas (N2). The result is cleaner water which can be discharged into existing streams and rivers.



These curriculum materials can be found at https://www.oercommons.org/courseware/lesson/71904



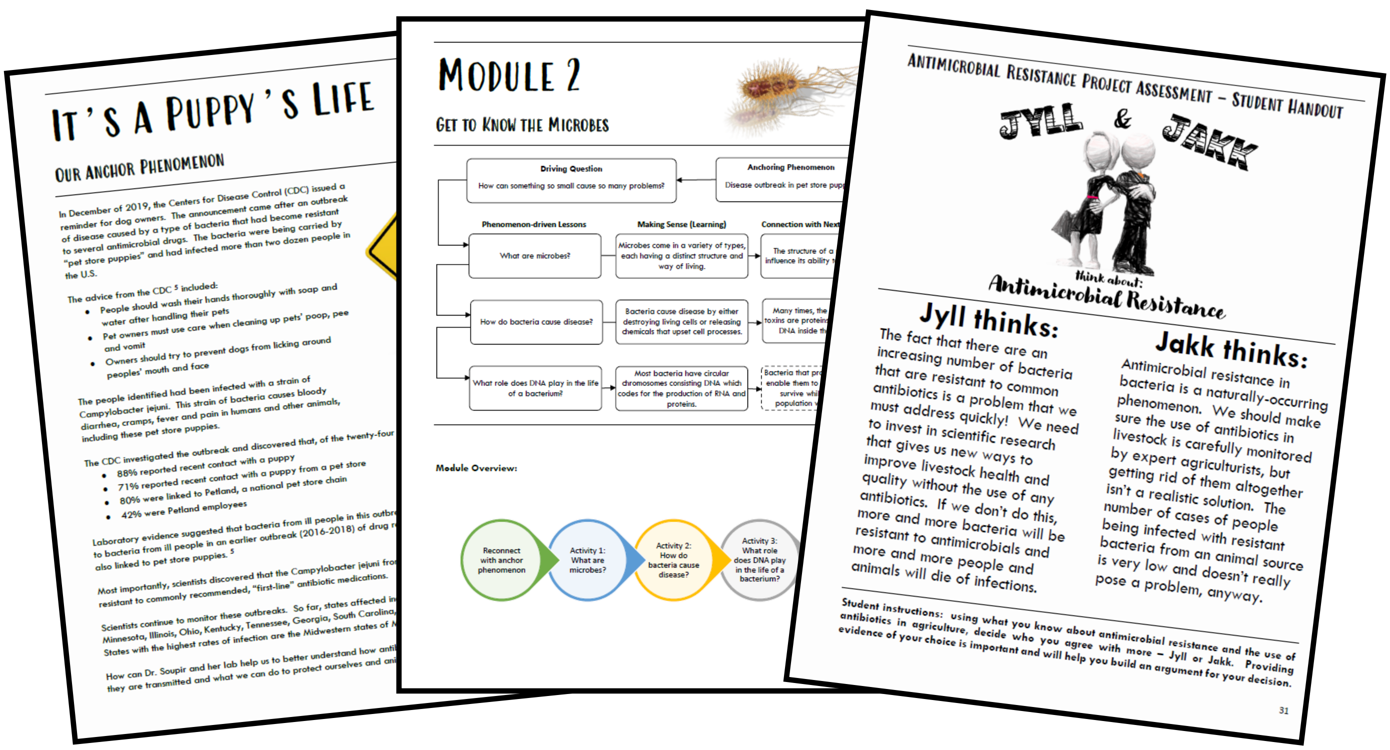
It’s a Puppy’s Life

Antimicrobials are used widely in animal production. They improve animal health and animal welfare, and also enhance animal growth rates and raise animal productivity. The use of antimicrobials, however, can lead to the emergence of resistance and the transmission of resistant genes and resistant bacteria between species.

Access to effective and cost-efficient antimicrobials is critical for human and animal health, animal welfare and food security. The potential consequences of antimicrobial resistance include reduced food production, reduced food security, greater food safety concerns, higher economic losses to farm households, and contamination of the environment.

The condition of antimicrobial resistance (AMR) develops when potentially harmful organisms such as bacteria, viruses and fungi no longer respond to medications generally used against them. AMR continues to pose a growing threat to the health of both humans and animals, since infections will linger and spread if the treatments we have for them are no longer effective. 1

In this curriculum, students will learn about a particularly “lovable” phenomenon that will, no doubt, engage them in further making sense of important concepts and topics.



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