Project COOL
Chemical Oceanography Outside the Classroom

Overview of the COOL Out of School Time (COOL-OST) Curriculum

Updated November 2015
About Project COOL

*Bringing together youth development, science education, and social justice*

Project COOL (Chemical Oceanography Outside of the Lab) is part of a funded National Science Foundation project to study ways that university faculty, students, and youth from underrepresented groups engage in the practice of contemporary science. UW undergraduate students participate in a professional learning community while engaging in field experiences with middle school youth.

The program is supported by a partnership of the Institute for Science + Math Education at the University of Washington and partners in UW Ocean Sciences, local middle schools, and community organizations. Many of the lessons in this curriculum are adaptations of activities from the *My Place in the Puget Sound* curriculum developed as part of the Centers for Ocean Sciences Education Excellence (COSEE).

The **University of Washington Institute for Science + Math Education** creates partnerships to envision, cultivate, and study equity-focused educational models and practices in areas of science, technology, engineering, and mathematics (STEM). The Institute is hosted at the LIFE Center and is part of the University of Washington College of Education.

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**More information about Project COOL is available here:**  
[http://sciencemathpartnerships.org/node/5#COOL](http://sciencemathpartnerships.org/node/5#COOL)

About the COOL Out of School Time (OST) Curriculum

The COOL-OST Curriculum was designed for implementation in an after-school setting in Seattle-area middle schools. The curriculum engages youth in discovering geosciences and chemical oceanography with a specific focus on the Puget Sound watershed. Through the activities provided in the curriculum, youth engage in games, lab experiments, discussions, field trips, and research projects. This document provides a general overview of the activities and learning experiences that make up the COOL-OST curriculum, organized around a series of guiding questions.
Curriculum Design Principles

Project COOL is a National Science Foundation (NSF) funded project aimed at broadening participation the geosciences for youth from groups traditionally underrepresented in the Science, Technology, Engineering, and Mathematics (STEM) fields. Design principles are the foundational beliefs that guide the work we do. They undergird choices we make about materials, resources, activities, pedagogical practices, philosophies of learning, and what we choose to count as evidence of learning. The following design principles guide COOL work:

1. **Youth are developing experts with knowledge and skills from their cultural repertoires of practice that have prepared them to engage in a variety of scientific practices.**

   We do not believe that youth are blank slates or empty vessels, we believe that they have many relevant experiences that pertain to STEM fields. Educational researcher Louis Moll and colleagues call these relevant experiences funds of knowledge. These are the resources that youth can draw on from their personal lives and experiences both in and out of school. In collaboration with youth, we seek to identify relevant experiences, unpack the skills and cognitive resources embedded in youth’s everyday practices, and make the link between youth’s experiences and scientific practices, e.g. NGSS.

2. **Broadening participation involves more than changing who participates in STEM it also entails changing what it means to participate.**

   We believe that broadening participation (i.e., increasing participation) for people from groups traditionally underrepresented in STEM fields entails more than just increasing numbers. While approaches to broadening participation can focus on increasing numbers, we believe this is a short sighted and potentially assimilationist approach. A focus on bringing people from underrepresented groups into STEM fields without examining these contexts can be a missed opportunity to reframe participation and STEM fields. In COOL we seek to influence gatekeepers to STEM, what STEM fields count as participation because we see these as intimately related to ideas about who can or should participate.

3. **In order for youth to see themselves as the kinds of people who can be and become scientists they need to engage in contemporary science.**

   We engage learners in activities that are rooted in contemporary STEM practices so they can learn core ideas of STEM through extended apprenticeships, citizen science efforts, and project-based investigations (ISME website).
A Note About Ice Breaker Activities
Each OST session typically begins with an Ice Breaker activity. These games help “melt the ice” as youth and mentors get to know each other, build camaraderie, and in some cases, introduce concepts that tie to the overall guiding questions.
Guiding Question: What is Project COOL?

Objective: Participants will be introduced to Project COOL and the resources available to them as they work on their final projects and/or research questions.

Hand Contract (20 minutes)

Materials:
- Butcher paper
- Colored pens

The Hand Contract serves as a way for all participants to agree to a set of behaviors that they feel will make the COOL community strong. It is a way to set norms and expectations for the way that your community—the mentors and youth—will function. All students and mentors trace their hands on a piece of butcher paper. Students then add to the Hand Contract things that make a community strong, things that make working in communities difficult, and things that they bring to the group. Everyone then signs the Hand Contract, which is displayed during all COOL-OST sessions.

COOL Program Overview (10 minutes)

Materials:
- PPT Presentation, computer, projector

Project COOL is introduced—using a PowerPoint presentation—as a place where students can explore their research questions and interests related to Puget Sound; a workshop environment where they can share their own ideas and learn from each other; a community in which they can connect to mentors who are scientists and educators; a place where students can learn about and contribute to authentic, contemporary science practices. The major components of the COOL-OST program include: weekly COOL after-school sessions, use of science notebooks, field trip to UW, research projects, field trip to Salish Seas Student Science Symposium.
Introduction to Science Notebooks (5 minutes)

Materials:
• Sample science notebooks
• Craft supplies (construction paper, cardboard, yarn, hole punch, pens, etc.)
• Blank paper (blank, lined, and graph paper options)

Students use a variety of craft materials to make their own science notebooks. Mentors introduce students to the practice of notebook use among scientists. A science notebook is a place where participants can explore their questions, ideas, frustrations, as well as observations, designs, and findings. Mentors share how they use science notebooks in their own professional practice.

Draw a Scientist (15 minutes)

Materials:
• Draw a Scientist Worksheet (or notebook prompt)
• Colored pens or pencils

Using a worksheet (or their science notebooks), students engage in a Draw A Scientist activity to elicit their preconceptions of who a scientist is and what he or she does.
Guiding Questions: What are watersheds? What are chemicals? What are pollutants? How do they get into Puget Sound?

Objective: Participants will be able to describe what chemicals are and why they are important. Participants will explore the meanings of “clean” and “dirty” water, and will understand that there are many ways to sense chemicals and science can help us detect chemicals we cannot sense alone. They will recognize the Puget Sound on a map, and understand the basic definition and function of watersheds. They will become familiar with the parts of the wastewater treatment system and the ways that chemicals travel through the Puget Sound watershed.

Puget Sound Zoom (5 minutes)

Materials:
- Large map of Puget Sound region
- Google maps and Fieldscope websites
- Computer with internet access, projector

Students investigate a map of the Puget Sound region. They locate their school on the map and then use the school’s location to help them locate the Puget Sound as well as major landmarks and other bodies of water around Seattle, such as Lake Washington, Lake Union, and the Duwamish River. Students are challenged to begin thinking about where chemical pollutants might come from and how they might travel to and enter the Puget Sound.

Watershed Discussion (5 minutes)

Materials:
- Map from Puget Sound Zoom activity

Students first share their ideas for a definition of “watershed” and then compare their ideas to the scientific definition of the word: a watershed is both the water source plus all the land upslope from the water. Students revisit the Puget Sound map, focusing on geographical features, in order to delineate the boundaries of the entire Puget Sound watershed. (Optional: Compare their watershed boundaries to a watershed map, such as a King County WRIA map).
Watershed Design Challenge (30 minutes)

Materials:

- Watershed model supplies (1 of each per group):
  - Model design sheet *(Optional design step)*
  - Paint tray
  - Handiwipe
  - Sponge
  - 10” square of wax paper
  - Scissors
  - 8” of painter’s tape
  - Small ball of sticky tac

- Shared supplies (for entire group):
  - Bag of soil/coffee grounds
  - Cooking oil
  - Dish soap
  - Chocolate sprinkles
  - Spray bottle
  - Paper towels (for cleanup)

This design challenge facilitates students’ understanding of watersheds and that everything that happens in the surrounding area ultimately ends up in the Puget Sound. Working in small groups, students are challenged to build a model of the Puget Sound watershed, using only the provided materials. Their ultimate goal is to see which group can make the water that ends up in their water body ("Puget Sound") the cleanest. The materials represent permeable/impermeable surfaces and natural/artificial surfaces. For example:

- The paint tray drains into the basin at the bottom ("Puget Sound").
- The handiwipes represent grass.
- The sponges represent trees.
- The wax paper represents surfaces that humans have built over.
- Tape and “fun tac” may be used to hold the various elements into place.

Once the models are constructed, students record their predictions in their science notebooks. Then, it is time to test the models. Equal amounts of pollutants are added to each group’s watershed model. These materials include examples of point-source and non-point source pollution. For example:

- Soil/coffee: pesticides, or soot and exhaust from vehicles.
- Oil: motor or cooking oil.
- Oil/cocoa powder mixture: spilled oil or fuel from a ship.
- Dish soap: soap from washing cars or body soaps from shower drains.
- Chocolate sprinkles: animal/human waste.

Then it is time for a rainstorm! Using a spray bottle, “rain” is sprayed on top of each group’s
watershed model (~20 sprays). As a group, students evaluate which group’s model resulted in the cleanest water and discuss reasons for why this design may have been effective at protecting water quality in the Puget Sound. Students capture their observations in their science notebooks.

**Chemical Shuffle (10-15 min)**

Materials:
- Butcher paper
- Pens

This activity can be used as an ice breaker, since it gets students talking to one another about chemicals. It is best done outside or in a large indoor space. Students stand in two rows facing one another. The activity is done in three rounds, with students having a brief “chemical conversation” with the person standing across from them. One row stays stationary and the other row will move at the end of round. At the end of each round folks in the right hand row will move over one and the person at the front of the row will circle around to the back. The prompts for the three rounds of chemical conversations are as follows: 1) What have you heard people say about chemicals?; 2) What kinds of things are chemicals?; 3) What do people use chemicals for? After each round, have a share-out among the large group and make notes on a piece of butcher paper for later reference. When all three rounds are over, guide the participants in collaboratively developing a definition for “chemical.”

**Chemical Sort (15 minutes)**

Materials:
- Chemical Sort Cards (1 set per small group)

First, the group discusses what chemicals are, and the differences between synthetic/natural and harmless/helpful/harmful chemicals. Then, students work in small groups to sort a set of Chemical Cards into three different groupings: Part of your life/ Not part of your life; Human-made & Artificial/ Naturally-occurring; Dangerous/ Safe. Each group then shares their reasoning for each sorting.

The Chemical Cards are simply small cards with one of the following words written on them: Natural vanilla; Water; Oxygen; Salt; Hormone; Pesticide; Aspirin; Perfume.
Collaborative Definition of Clean Water (5 minutes)

Materials:
- Chart/butcher paper
- Pens

Before beginning the Water Filtration Activity, students share their ideas of what “clean” water is. Suggested questions include: How do you know if water is clean? Consider the senses - what does clean water look, taste, or smell like? Responses should be recorded on chart paper.

Water Filtration Design Challenge (40 Minutes)

Materials:
- Filter rigs (1 per pair of students; consists of a plastic soda bottle cut in half)
- Coffee filters
- Gravel
- Sand
- Activated Carbon
- Ammonia test strips (from the aquarium section of a pet store)
- Goggles (1 per student)
- Gloves
- Lab coats (1 per student)
- Tape
- Lab diapers
- Paper towels
- “Dirty” water (water with soil, coffee grounds, oil, etc. with a small amount of ammonia added to it)

The purpose of this design challenge is to show participants that although they can filter out many of the large substances from the water, water-soluble chemicals (as well as other things like bacteria and viruses) can still remain in the water. The activity is launched with a discussion of “clean” and “dirty” water. Then, small groups of students are challenged to design, build, and test a water filter to clean a sample of “dirty” water, using the provided materials. Their goal is to get the water as clean as possible. Once the filters have been constructed, each group will test their set-up by filtering a sample of “dirty” water and then comparing the “filtered” and “unfiltered” water samples. After making observations of their “filtered” water and comparing it to the other group’s samples, students will use ammonia test strips to test for the presence of a “chemical compound.” Students use their science notebooks throughout the design, build, and test process.
Wastewater Treatment Puzzle (20 minutes)

Materials:
- WWT Puzzle Pieces (ideally, at least one puzzle piece per student)
- WWT PowerPoint Presentation
- Computer and projector

Students are introduced to the wastewater treatment plant: when water leaves our houses, businesses, and factories through the sewer system, it gets treated at a wastewater treatment plant to help clean it up before it gets to the Puget Sound. Each student is given a piece of the WWT Puzzle; as a group, the students work together to move around the room to assemble to puzzle so that it illustrates the wastewater treatment process. The WWT PowerPoint Presentation is used to both as an answer key for the puzzle and to provide additional information about the wastewater treatment process. Students discuss how not all chemicals are removed through the treatment process and think about what chemicals might end up in effluent that is released into the Puget Sound—making connections to their own observations of their water filtration models. Students learn that although WWT plants are really good at cleaning lots of things out of the water, they can’t clean everything out. Scientists from a chemical oceanography organization called Sound Citizen have measured chemicals from foods and everyday household products in the treated water that are being released into Puget Sound. Finally, a brief discussion about point source and non-point source pollution helps students understand that wastewater effluent, combined sewer outflows, storm water drains, and point-source pollution together account for much of the pollutants entering the Puget Sound.

Water Filtration Re-Design (10 Minutes)

Materials:
- Science Notebooks

After completing the Wastewater Treatment Puzzle activity, students now know more about the WWT process. Students are encouraged to reflect on their designs of their filters in the Water Filtration Design Challenge. How was their design similar to the steps in the WWT process? How was it different? How would they re-design their filters? Students will write and draw in their notebooks to make comparisons between the WWT process and their own filter design and ideas for re-design.
Guiding Questions: What do chemicals do? How do they affect living organisms in the Puget Sound?

**Objective:** Participants will create a useful definition of the word “chemical.” They will be able to describe the families of chemicals that Sound Citizen measures (i.e., fragrances, spices, and household cleaners). Participants will also be introduced to the endocrine system, the impacts of Endocrine Disrupting Chemicals, and the case of feminization of English Sole fish in the Puget Sound.

**Introduction to Sound Citizen (15 min)**

Materials:
- Sound Citizen PowerPoint Presentation
- Computer and projector

Refer back to the Chemical Shuffle and Chemical Sort activities, and the group’s collaborative definition of a “chemical.” Lead a brief group discussion about what the students think chemicals do, how different types of chemicals get into Puget Sound, and how different types of chemicals might affect the plants and animals living in the Sound. How do we know what types of chemicals are in the Puget Sound? Share the Sound Citizen PPT Presentation to provide an overview of the organization Sound Citizen and their chemical oceanography research. What chemicals does Sound Citizen measure? Why?

Lead a brief discussion about families of chemicals. We use the term families of chemicals to group together different chemicals that are used for the same purpose or have the same effects on the environment. Parabens for example are a family of chemicals used as preservatives by the health and beauty industry that function as endocrine disrupting compounds. Additional information: [http://en.wikipedia.org/wiki/Paraben](http://en.wikipedia.org/wiki/Paraben).

**Mystery of Fish Feminization: Explaining the Endocrine System (10 min)**

Materials:
- Fish Feminization & Endocrine System PowerPoint Presentation
- Computer and projector

Using the Fish Feminization & Endocrine System PPT Presentation, ask students what they know about the ways that organs work in our body. How do organs work together in systems? What are these systems? Discuss the role that the brain plays as the control center. Then explain the way that chemicals carry messages to organs through the endocrine system. You’ll
want to make sure to talk about reproductive chemicals like hormones that cause the reproductive organs to make eggs or sperm. It is important to express the following main point: in the endocrine system chemical messages are sent between organs in our bodies to tell them what to do—grow, make hormones, make sex cells, etc.). Endocrine disrupting chemicals (EDCs), such as parabens, can disrupt these chemical signals. These chemicals mimic (or act like) hormones in the endocrine systems in fish and other organisms. This tricks the organs in the endocrine system into doing things they wouldn’t ordinarily do.

Exploring the Skin Deep Guide to Personal Care Products (10 minutes)

Materials:
- Environmental Working Group’s Skin Deep Guide website [http://www.ewg.org/skindeep/]
- Computer with internet access and projector

What types of products have endocrine disrupting chemicals (EDCs) in them? Why do we use them? Through what pathways do these chemicals get into the Puget Sound? Together, students will explore the Skin Deep Guide, looking up the names of the personal care products that they regularly use (i.e., shampoo, toothpaste, make-up, lotion, hair dye, etc.). When evaluating a product’s ingredients, pay special attention to endocrine disrupter, ecotoxicology, persistence, bioaccumulation, organ system toxicology, and other similar designations.

Mystery of Fish Feminization: Silent Opera Game (15-20 minutes)

Materials:
- Blindfolds
- Assorted objects for students to collect or move from one place to another
- Index cards to write the group challenges

The purpose of this game is for the group to develop non-verbal communication strategies and to collectively solve a problem but it also illustrates the way the endocrine system works—chemicals pass messages from one part of the body to the other but the organs receiving the messages can’t always tell where the message is coming from). This is an activity that calls upon us to solve a problem. Some students will be able to see the problem but won’t be able to talk, other students will be able to talk and communicate information but won’t be able to see the problem. Finally one brave student will be completing a task blindfolded. Those who are in Row A (silent) will be issued a challenge and their task will be to communicate with gestures to the speaker (Row B) about what needs to
happen. The speaker (Row B) will tell the blindfolded student what to do. Here are some sample tasks: Pick up object 1 and place it on the table; Collect objects 2 & 3 and carry them to location A. At the end of the activity, ask students what they noticed. Then, draw connections between students’ experiences in the game and the way that chemical messages are communicated through the endocrine system. Tell students that some of the tasks they followed came from the brain and others came from EDCs.

**Mystery of Fish Feminization: The Case of the English Sole (5 minutes)**

**Materials:**
- Student Handout with numbers of feminized and non-feminized male fish (one copy per pair of students)

Discuss the fact that this case study comes from a peer-reviewed paper. Hand out the sheet with the pictures of the fish and the numbers of feminized and non-feminized male fish. Provide a clear definition of “feminized” and “non-feminized”. Summarize the paper. Explain that scientists collected fish at each site listed, that they tested for a protein called Vtg that is used in egg production. Male English Sole fish do not typically make this protein because male fish of this species do not make eggs. *Mention our research question: Where were the feminized male fish found and why might this be the case?* Make sure to mention that the scientists don’t know what the answer is and that we’re going to recreate the data they collected from their study and see what we notice about feminized male fish and where they are found in Puget Sound.

**Mystery of Fish Feminization: Making Tiles (10 minutes)**

**Materials:**
- Information Sheet with numbers of feminized and non-feminized male fish (one copy per pair of students)
- Circular data tiles
- Red and black markers (enough for students to work in pairs)
- Large Puget Sound maps

Assign each pair some of the tiles to complete. Students should put a red dot over the feminized male fish and a black dot over the non-feminized male fish columns. Place the tiles on the large Puget Sound map to denote the sampling location and the data from that site.
Mystery of Fish Feminization: Mapping Debrief (5 minutes)

Materials:
  • Completed map (with data plates posted on it) from previous activity

Remind students about what the dots and numbers represent. Ask students to use the information on the map they’ve made to make some observations about the English Sole fish in this study in Puget Sound. We are looking for patterns that might be related to other information. Re-visit our research question: *Where were the feminized male fish found and why might this be the case?*
Guiding Questions: What topics we most interested in that relates to Project COOL, chemical oceanography, and the Puget Sound? What question do we want to investigate as part of our research project?

Objective: Participants will identify potential research topics and questions that interest them and then form small research groups. They will collaborate on online research to address their research questions, utilizing research skills and tools from their own and their mentors’ experiences. Each group will prepare a proposal for the Salish Seas Student Science Symposium. Participants will work in their groups to develop and deliver a research presentation (poster, PowerPoint, talk, etc.).

Salish Seas Student Science Symposium Proposal (20 minutes)

Materials:

- Proposal form for Salish Seas Student Science Symposium
- Laptops

Look over the formatting guidelines for the Symposium. Work with the students to understand what each piece of the proposal is asking for. Divide and conquer, having students choose a section of the proposal they want to work on in a small group.

Research Think-Aloud (20 minutes)

Materials:

- Computer and projector
- Examples of research websites and/or online tools
- 5 Point Search & Resource Value Pyramid handouts

Demonstrate how you do online research, using a topic of interest to you and the students (e.g., your own research interests, or an example COOL research question). Model searching for information about that topic online, talking out loud through your process of narrowing in on reputable sources, and eliciting from students what you should do next. Depending on students’ and your own expertise in this realm, you can take this activity in any direction you like: you could track a popular media news story to its original source, or use an example of a fake website that looks real (the Pacific tree octopus is a good example: http://zapatopi.net/treeoctopus/), or use the 5 point search and resource value pyramid tools. Students can use these handouts as they engage in their own research. It may also be useful to model how to take good notes from what you find.
Student Research (ongoing, as much time as needed)

Materials:
- Laptops
- Research resources

Students work in their small groups to investigate background information on their research question. During research time, mentors will circulate among the student groups, pressing them to focus in on their research questions, take accurate notes in their science notebooks, and keep track of their reputable sources. Students may be at different stages of the research process; be prepared to help some students brainstorm their question, while others may need support for translating what they find online into interesting information to share with their community. This research component will be ongoing through several COOL sessions.

Mini-Presentation Workshop (~30 minutes)

Materials:
- Laptops
- Examples of previous COOL student projects

Depending on students’ chosen final products (ranging from a poster at the Salish Seas Symposium, to a science fair presentation, to a community brochure), you can use this time to brainstorm with students and model what are good elements to include in that final product. For example, a poster should have a combination of graphics and text, a presentation should be rehearsed, and a brochure should have an engaging cover. The COOL team can provide examples of these from previous years that you can bring in, or bring in an academic presentation or poster from your own discipline.

Field Trip to the Salish Seas Student Science Symposium

Materials:
- Parent Permission Forms
- Research group presentation materials (posters, PPTs, props, etc.)

Students will share their research presentations with other students and visiting scientists at the Salish Seas Student Science Symposium. Hooray!