5E STEM: If I Were A Fish, Where Would I Like to Hang Out?

(Three 90 minute class meetings)

Authors

Karen Hammonds

Erica Taylor-Wilson

SUBJECT/GRADE LEVEL

Subject Area: Biology

Grade Level: High School

Materials

- Long, shallow aquariums or plastic bins (2-3 feet long, at least 6-8 inches deep)
- Aquarium fish
- Clear dividers or barriers to create distinct sediment sections
- Various sediment types (e.g., fine sand, coarse sand, small gravel, woody, smooth river rocks). Ensure all sediments are thoroughly rinsed to remove dust and debris
- De-chlorinated water
- Net for handling fish
- Timers
- Rulers
- Presentation materials
- Video recording device such as phone for observations (helpful for absent group members)

STANDARDS

Next Generation Science Standards

- **HS-LS2-2 Ecosystems: Interactions, Energy, and Dynamics:** Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.
- **HS-LS2-6 Ecosystems: Interactions, Energy, and Dynamics:** Evaluate the claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions, but changing conditions may result in a new ecosystem.
- **HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics**: Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*

Mathematics Standards | Common Core State Standards

- **CCSS.Math.Content.HSN.Q.A.1**: Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays.
- **CCSS.Math.Content.HSN.Q.A.2**: Define appropriate quantities for the purpose of descriptive modeling.
- **CCSS.Math.Content.HSN.Q.A.3**: Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- **CCSS.Math.Content HSS-ID.A.1:** Represent data with plots on the real number line (dot plots, histograms, and box plots).
- **CCSS.Math.Content HSS-ID.A.2:** Use statistics appropriate to the shape of the data distribution to compare center (median, mean) and spread (interquartile range, standard deviation) of two or more different data sets.
- **CCSS.Math.Content HSS-ID.A.3:** Interpret differences in shape, center, and spread in the context of the data sets, accounting for possible effects of extreme data points (outliers).
- **CCSS.Math.Content HSS-ID.A.4**: Use the mean and standard deviation of a data set to fit it to a normal distribution and to estimate population percentages. Recognize that there are data sets for which such a procedure is not appropriate. Use calculators, spreadsheets, and tables to estimate areas under the normal curve.

English Language Arts Standards | Common Core State

- **CCSS.ELA-Literacy.W.9-10.2**: Write informative/explanatory texts to examine and convey complex ideas, concepts, and information clearly and accurately through the effective selection, organization, and analysis of content.
- **CCSS.ELA-Literacy.W.9-10.2.b**: Develop the topic with well-chosen, relevant, and sufficient

facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

LESSON OBJECTIVE(S)

Students will be able to:

- Formulate a testable hypothesis about fish swimming preference and sediment type.
- Design an experiment with appropriate controls and variables.
- Collect and record quantitative and qualitative data.
- Analyze data to draw conclusions supported by evidence.
- Communicate scientific findings effectively.
- Relate sediment type to ecological niches and fish habitat.

CAREER CONNECTION(S)

Mentor Background: Dr. Gaurav Savant

Dr. Savant is a senior research hydraulics engineer at the U.S. Army Engineer Research and Development Center (ERDC), Coastal and Hydraulics Laboratory (CHL) in Vicksburg, Mississippi. He obtained his bachelor's degree in Civil Engineering from Punjab Engineering College, and his Doctorate in Civil Engineering from Mississippi State University. He currently serves as the lead of the numerical and Computational Fluid Dynamics (CFD) teams at CHL and is the lead for the USACE Coastal Compound Flood research. Dr. Savant's specialties include hydrodynamic numerical simulations of the natural hydrologic system including estuaries, coasts, and rivers. Dr. Savant's recent interests include the quantification of NNBF and community resilience under a changing climate. Dr. Savant is currently (1) leading the numerical hydraulic modeling for the ecological restoration of the Los Angeles River, (2) leading the numerical hydraulic and sediment modeling for flood control defenses for the town of Arecibo, PR, (3) CFD simulations for the expeditionary fueling and armament of naval air and sea assets, (4) leading the Mississippi River side numerical hydraulic and sediment simulations for the Old Mississippi Atchafalaya Red (OMAR) study, and others.

Dr. Savant has published over 45 peer-reviewed articles in the areas of numerical simulations of Newtonian and non-Newtonian flows for the civil works and military engineering missions of the USACE. He is an active member of the American Society of Civil Engineers (ASCE), Coasts, Oceans, Ports Research Institute (COPRI), and a senior member of the ASCE Waterways committee. Dr. Savant holds adjunct status at Mississippi State University, Jackson State University, Tennessee Technological University, Florida International University, and the Naval

Post Graduate College. He serves on the editorial boards for the IAHR Journal of Applied Water Engineering and Research and the Journal of Waterway, Port, Coastal, and Ocean Engineering.

STEM Careers:

- **Ethologist:** Specializes in animal behavior, investigating relationships with their environments and publishing research to promote animal well-being.
- **Conservation Biologist:** Focuses on protecting biodiversity, developing strategies to conserve endangered species and restore habitats.
- **Marine Biologist:** Specializes in studying marine organisms and their ecosystems, including behavior and the impact of environmental changes on marine life.
- **Animal Scientist/Researcher:** Focuses on specific aspects like genetics, nutrition, or reproduction, often involving both lab and field work.
- **Wildlife Conservationist:** Works to understand the human impact on the environment and animals, ensuring their protection through research and advocacy.

ENGAGEMENT

Brief Description:

To conjure an interest in fish preference to sediment type and to gain the student's attention for the preference lab.

Procedures:

Prior to the video ask the students the question: "What do you notice about the bottom of these bodies of water? How might these differences affect the organisms that live there?"

on different typeShow the video of sediments present in a stream. Example: Sediment in Streams

Have student lab groups answer the following questions:

"Do you think fish care about what's on the bottom of their environment?

Why or why not?"

Review: the ecology concepts: habitat, niche, and how environmental factors influence living organisms.

Discuss: how human activities (e.g., construction, agriculture) can impact sediment runoff into aquatic environments.

EXPLORATION

Brief Description:

With use of data sets and case studies, the teacher will guide student groups in the experimental design process for the sediment preference lab.

Procedures:
Give the students the research topic: "Today, we're going to investigate: How does the type of sediment influence the direction a fish chooses to swim in a controlled environment?"

Teacher Demo/Guided Discussion:

-Brainstorming Design: discuss how to set up the tank to test sediment preference, provide students with data sets and or research on various types of aquatic ecosystem sediment types and/or local case studies, allow students to determine the data that could be used for evidence in developing testable hypothesis, allow students time to argue from evidence as to what fish prefer. Like minded individuals will be encouraged to work together in a group.

-Guide students towards a design where different sediment types are placed in distinct sections of the tank.

-Experimental Design
Working in groups of 3-4, students will formulate a hypothesis and design an experiment. Each group should choose a different type of sediment from those provided (see materials list).

After group brainstorming session, each group of students determine:

- Independent Variable (sediment type)
- Dependent Variable (time fish spends in sediment)
- Control (sediment fish is typically found in)
- Constants (same: tank size/type, water conditions, fish species, etc)
- Hypothesis
- Procedure
- Data Collection Plan (determine types of charts and graphs to best convey data)
- Ethical Review

Teacher Approval of Designs: Review each group's design, providing feedback to ensure scientific rigor and, most importantly, ethical animal treatment.

Setup and Initial Observations: Students set up their designated tanks with chosen sediments and de-chlorinated water. Allow tanks to settle overnight if possible. Introduce fish after tanks are fully set up and water quality is stable. Give fish at least 30 minutes to acclimate before starting observations. Students should record qualitative data about fish behavior and quantitative by time spent in each sediment type.

EXPLANATION

Brief Description: Students conduct their experiments according to their approved procedures. They should collect quantitative data on fish preference for different sediment types while collaborating within groups and across groups. Students present their findings to others in a Gallery Walk style as others provide peer review.

Procedures:
-Class Data Sharing & Initial Analysis:

Have groups share their raw data on a whiteboard or shared document “Gallery Walk” style. Allow groups time to re-evaluate and make changes in order to re-test.

Teacher-led discussion on:
■ **Sediment characteristics**: Particle size, surface area, interstitial spaces.
■ **Ecological significance**: How different sediments provide different habitats for food sources (invertebrates), spawning grounds, or refuge from predators/currents.
■ **Fish biology relevant to sediment:** How different fish species are adapted to different bottom types (e.g., bottom feeders, fish that lay eggs in gravel).
■ **Validity and Reliability:** Discuss sources of error such as possible contamination errors or skewed data and how to improve experimental design.

ELABORATE

Brief Description: Student groups brainstorm some “what if” scenarios in relation to sediment type, ecological niches and fish habitats.

Procedures:
-"What If" Scenarios:

○ "What if we used a different fish species? Would the results be the same?"

○ "How could we investigate if the fish are seeking food, shelter, or something else in a particular sediment type?"

○ "How would changing the water flow affect fish preference for sediment?

○ “What if reproductive behaviours change sediment preference? Are some sediments better for eggs?”

○ “What if aquarium supply stores are presented with our data? Would they alter their stock?

○ “Would time of day alter sediment preference?”

○”What if preferred sediment became polluted” “Would fish change preference”

○ “What effect would polluted sediment have on the local and global fishing economy?”

-Research Extension: Assign groups to research specific fish species and their known sediment preferences, comparing it to their experimental findings.

EVALUATION

Brief Description: Students will compile their final report into a Claim, Evidence, Reasoning format and present to the class using media such as Canva, Google Slides or poster presentation.

Procedures:
-Lab Report/Presentation:

The report/presentation should include:

○ Hypothesis reformulated as a Claim

○ Materials and Methods (including ethical considerations)

○ Evidence: Data (charts, tables, graphs)
○ Reasoning: Analysis of Results, Conclusion (supported by evidence, addressing the hypothesis)
○ Discussion of limitations and potential sources of error

-Teacher Observation & Questioning:

○ Assess student understanding during group work, discussions, and presentations.
○ Ask probing questions to gauge critical thinking and application of concepts.

-Rubric-Based Assessment:

Use a rubric to evaluate lab reports/presentations, focusing on scientific accuracy, experimental design, data analysis, ethical reflection, and communication skills.

Rubric: If I were a fish, where would I like to hang out

REFERENCES

- Quick Rubric: https://www.quickrubric.com/
- NextGenScience: https://www.nextgenscience.org/
- The Core Standards (Math): https://www.thecorestandards.org/Math/
- The Core Standards (ELA-Literacy): https://www.thecorestandards.org/ELA-Literacy/
- Longseco Water (Aquarium Water): https://longsecowater.com/blog/the-best-water-for-your-aquarium
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- Waves-Vagues (DFO-MPO Library - 255660): https://waves-vagues.dfo-mpo.gc.ca/Library/255660.pdf
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