

Introducing Science Student to Cutting Edge Research through PBL Activities

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NSF GK-12 Fellowship Program



The Activity



Understanding Hydrothermal Vents

Phase 1: Background Information

Phase 2: Geochemist for a day

Phase 3: Marine Biologist for a day

Phase 4: Oceanographer for a day

Phase 5: Geologist for a day

Overview

University research, centered on hydrothermal vents, has been integrated into the 9th grade physical science curriculum.

PBL activities have been designed to highlight the significance of the material covered in the Delaware State Standards.

Technology is central to the project allowing students to gain valuable web-based experience.

Thematic course/program design can be an efficient way to motivate students and introduce all undergraduates to cutting edge research.

Motivation

The idea for this project developed after giving a presentation on hydrothermal vent research to 9th grade science students. Students were excited by the thought of alien ecosystems on our ocean floors and were able to see the relationship between our research and what they were covering in their physical science class. The concept for this project is simple, (1) allow the student to take ownership of the material and (2) show them that what they are learning matters in relation to the world around them. Group PBL activities cover both points in that they allow students switch roles to peer-teach and the activity can be designed to address 'real-life' research questions.

This project is a product of the Graduate Teaching Fellows Program in K-12 Education (GK-12 Fellowship Program), a collaborative effort between the University of Delaware and Delcastle Technical High School, made possible by the NSF. Some of the content for this project is adapted from 'Black Smokers' Webquest: An Internet Based Webquest on Hydrothermal Vents by UniServe Science (science.uniserve.edu.au).

Learning Goals

In the true spirit of the GK-12 fellowship program, this activity is designed to not only enhance student understanding, but also provide valuable educational experiences for both the teacher and graduate student. Broadly listed below are the goals set out for each member of the learning process.

Student

- Exposure to cutting edge research
- Technological experience
- Meet specific Delaware State Standards

Teacher

- Exposure to cutting edge research
- Technological experience
- Familiarization with PBL activities

Graduate Student

- Develop classroom management/communication skills
- Technological experience
- Familiarization with PBL activities.

The Basic Idea

Throughout the semester, groups of 4-5 students work to complete the five phase project (See *Understanding Hydrothermal Vents*). Addressing the ecosystem surrounding hydrothermal vents using a multidisciplinary approach mimics the way research in done in 'real-life.'

Each phase of the project has two subsections.

- (1) A webquest addressing basic vocabulary
- (2) An in-depth assignment highlighting specific learning objectives.

Example: Geochemist for a day

Use the information provided by the internet links to answer these questions specifically related to geochemistry:

- (1) Outline the role of a geochemist.
- (2) Describe the chemical environment of 'black smokers'.
- (3) What is the smoke?
 - Describe in terms of atoms, ions and chemical bonding.
- (4) How is the 'chemical soup' made?
- (5) Define 'chemosynthesis'.

Hands On: Qualitative inorganic analysis of Fe, Cd, and Zn.

Before you begin...

- (1) Define soluble, insoluble and precipitate.
- (2) Determine the oxidation states of Fe, Cd, Zn, Na, Cl, and S
 - Use the Periodic Table and the MSDS provided.

Students observe the reactions between each of the metal salts with sodium sulfide and use their results to determine the identity of an unknown sample containing Fe, Cd, or Zn. After completion of the lab, they related their observations to the 'smoke' seen in the pictures collected during Phase 1 of the project.



Technology in the Classroom

This project is technology heavy by design.

- Research is done primarily using webquest activities.
- Students record their research findings and observations on their group wiki page.
- Final product is a poster made using Power Point.

Assessment

Four primary assessment techniques were used for this project: Low-stakes formative assessment of student learning, student evaluation of the project and instructor performance, peer review of student performance, and high-stakes summative assessment of students' final product.

Informal questioners were given to the students following the completion of each part of the activity. Questions were designed to address the following:

- (I) Student learning
 - Ex 1: Using the chemical formula CuCl_2 , determine the oxidation state of Cu (Fig 2).
 - See *Formative Assessment Results* for additional examples.
- (II) Student perception of the project (Fig 3).
- (III) Instructor/Project evaluation

Formal student grades are determined by peer review in addition to instructor assessment of the students' wiki pages and final poster presentation.

Formative Assessment Results

Question 1: What took us so long to explore these underwater environments (Fig 1)?

Example response:

"We had not built the right equipment such as the deep-towed vehicle or Alvin. These are submersibles used to explore the underwater environments."

Question 2: Describe a hydrothermal vent and the physical properties of the environment surrounding them (Fig 1).

Example response:

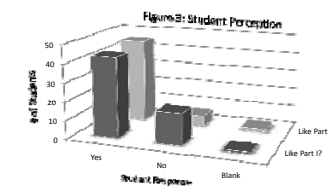
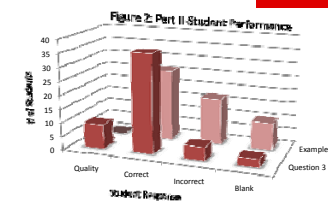
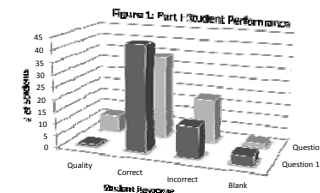
"A hydrothermal vents are openings in the ocean floor that allow water to seep through and rise/shoot out of the cracks after being heated by the magma. They are in the depths of the ocean. Some are as deep as 7,000 ft under. Not many organisms live around them due to the extreme conditions/temperatures near them."

Question 3: From the view of a geochemist, describe the 'smoke' that comes out of hydrothermal (Fig 2).

Example responses:

"The smoke is a heavy black smoke that contains zinc, iron, sulfur and other metals."

"The smoke that comes out of a hydrothermal vent starts of as an insoluble solution, then to a soluble solution, then the smoke is the precipitation."



Thoughts on College Settings

Although this project was designed for a high school setting, the adaptation to a college curriculum would be a workable transition. The same basic questions can be asked of college students with the expectation that they will address the problem at a higher cognitive level (analysis, synthesis, evaluation).

One could even imagine multiple research themes spanning entire programs instead of single courses. In a chemistry program for example, a research theme could be addressed from the perspective of each of the divisions (organic, inorganic, physical, analytical, and biochemical) during the entire undergraduate experience.

Teaching courses thematically not only acts to motivate students by highlighting the connectivity between what the student is learning and the world around us, but it also exposes all students to cutting edge research, not just the top students that seek out undergraduate research experiences.