Talking with E.T.

An Authentic Problem-Based Learning Experience Based on Waves and Videoconferencing

Introduction

Problem-based Learning is supposed to be "messy" — real problems tend to be that way. Although we often give students the impression that scientists follow the scientific method with precision, great discoveries are often made in messy situations.

The Constructa-Vision project attempts to give students an authentic problem that gets most kids excited. Their main job is to take some sample signals generated by the instructor and determine which ones, if any, might qualify as a possible SETI (Search for Extraterrestrial Intelligence) signal.

In the process, students discover what signals from satellites and pulsars sound like, discuss possible signals used to contact aliens, debate the pros and cons of targeted versus wide-area surveys, analyze several different possible patterns that could be used as beacon messages, and learn how to recognize wave patterns using a sound synthesis program. They also use CBL/graphing calculator technology to discover the relationship between frequency and pitch, and then construct signals they can use as standards to evaluate unknown signals.

To add another technology twist, students learn to videoconference and hold a symposium online, presenting their findings and using collaboration software in order to support their positions with evidence.

This unit does take a lot of time, but as students work on this problem, they discover and construct their own conceptual understanding of wave theory and technology.

According to Dale's Cone of Experience, people generally remember 90 percent of what they say as they do a thing. This project has students doing many things, then sorting through lots of them to arrive at a final conclusion, which is presented and defended.

Constructa-Vision

Teaching is a lot like building a house. Most of us generally know what we want the house to look like in the end, but we often need to sit down with several plans of finished houses in order to identify the specific house design we will want in the Finished Project.

Just like contractors, we need to have Blueprints drawn up that identify specifications for how to proceed.

Then the actual Site Work is done, which includes foundational work and temporary structures. And of course, during the course of construction, site inspectors check to see if the work is done correctly.

Check out the lesson to see how the Challenging Question unit to the right was put together using Constructa-Vision.

Challenging Question

How could we best communicate with extraterrestrial intelligent life forms?

Time Frame

Single Block: 10-12 days

Double Block: 5-6 days

Finished Project

What will our science students "look like" after this unit? We hope they will be able to do the following:

1. Understand the basic relationships between frequency, wavelengths, and the energy of waves in the electromagnetic spectrum.
2. Determine parameters around which extraterrestrials might attempt to communicate with our civilization.
3. Analyze sample data and compare with self-developed standard data including natural sources and possible signal sources.
4. Judge instructor-supplied sample data for possible authenticity of signals and then defend those decisions in front of an expert audience.

How does this project relate to the Ohio Science Benchmarks?

Physical Science: Benchmarks 9-10

E. Demonstrate that energy can be considered to be either kinetic (motion) or potential (stored).

G. Demonstrate that waves (e.g., sound, seismic, water and light) have energy and waves can transfer energy when they interact with matter.

Science Inquiry: Benchmarks 9-10

A. Participate in and apply the processes of scientific investigation to create models and to design, conduct, evaluate and communicate the results of these investigations.

Scientific Ways of Knowing: Benchmarks 9-10

B. Explain how scientific inquiry is guided by knowledge, observations, ideas, and questions.

D. Recognize that scientific literacy is part of being a knowledgeable citizen.

Earth and Space Sciences: Benchmarks 9-10

A. Explain how evidence from stars and other celestial objects provide information about the processes that cause changes in the composition and scale of the physical universe.

Blueprints

Looking at a model home may help you choose the type of finished house you would like. But in order for the house to actually be built, the contractors must use a set of blueprints, which lay out the specific plans for the house.

In the same way, teachers planning a unit around a challenging question or problem need to lay out blueprints — specific plans for getting to their finished product!

Teachers need to define the Core Content or Concepts that students will be expected to master once the project is complete. What is it that you are trying to teach? Content-driven projects can be used to teach rigorous concepts in new and exciting ways. On the other hand, you should closely analyze a project that has no important underlying concept before doing it!

Teachers need to specifically define and design the Actual Project/Task itself. What is it specifically that the students be doing? How many days will the entire project take? What types of artifacts will be produced to show understanding? What resources will be needed?

Finally, what types of Learning Strategies will be used? Will students discover or construct principles during their project? Will cooperative or collaborative strategies be used? How will data be analyzed and displayed? Does research support these methods?

Core Concepts

A goal of a good teacher is to be sure that students learn core concepts — those practical concepts that will be important in the lives of all students. It is important for teachers planning lessons using technology not to forget that technology can be used to enhance content learning and make it more practical for everyday life.

Below is a list of basic objectives and content for this project.

By the end of this project, students should be able to do the following:

Content

1. Run regression analyses on sample data to determine best fit lines and equations describing that data.
2. Describe general rules regarding the relationships between a) frequency and pitch, and b) wavelength and period.
3. Discover and relate the general rule relating the energy a wave has to its wavelength.

Thinking/Problem-Solving Skills

1. Classify musical notes by frequency/pitch patterns, and make standards to compare with unknown data.
2. Analyze unknown data samples, looking for patterns.
3. Defend a position with self-collected data.

Technology Skills

1. Use TI-83 or computer microphone to collect and analyze sound.
2. Make an electronic portfolio of images of the collected sounds to use as a standard of comparison.
3. Run a simulated radio telescope to examine natural sources of sound.
4. Use Microsoft NetMeeting to collaborate and present evidence in a symposium format to an expert audience.

Actual Project/Task

Students will do the following tasks during this unit:

1. Make comparison standards for musical notes and some natural radio sources using the TI-83 graphing calculators and CBL (Calculator-Based Lab) system. This will be done in a collaborative format so that groups make some of the standards and then share with other groups. Screens of the various sources will be saved as an "electronic" standards key.
2. Will use CLEA's Radio Astronomy Lab to collect natural sources of radio signals, which will also be saved as electronic standards.
3. Analyze teacher-prepared "signals" for possible communication or beacon type characteristics.
4. Present findings to the rest of the class and a panel of experts during an online "symposium", using NetMeeting, CUseeMe or other type of videoconferencing software. Students will use evidence collected to support or refute the possibility of data being a possible SETI message.

The principle task of the students is to analyze radio signals for evidence of extraterrestrial messages and use self-developed standards to support or refute that possibility.

Learning Strategies

Good teachers make it a point to vary their strategies so that all students are able to learn effectively in their classes.

Below is a list of some of the strategies used in this project to help students learn.

1. **Discovery** - Students will use the TI-83 graphing calculators and the CBL (Calculator Based Lab) system with a microphone to record sounds, varying both the pitch and the loudness of the sound. Then they will synthesize a general rule that relates frequency to pitch and amplitude to loudness.
2. **Research** - Students will use videos, books, and the Internet to discover basic SETI principles of communications.
3. **Standards Development** - Students will collect sound and record their images to use as a known standard against which they can compare samples.
4. **Data Analysis** - Students will analyze samples of instructor-prepared unknowns and use patterns to compare and classify data.
5. **Position Defense** - Students will present data via net videoconferencing to an authentic audience, defending their position on potential extraterrestrial communications.

Site Work

Foundation

Most lessons have some basic skills that are required before you are able to begin. These are sometimes called "foundational" or "prerequisite" skills. As in the building of a house, ensuring an adequate foundation is very important in learning.

Scaffolding

You just can't build a structure without introducing some temporary structures — temporary roads, scaffolding, or false walls. In a similar way, most complex tasks in learning require some type of leading activities or temporary bridges that enable students to go from what they know to what they need to know.

Inspection

A house has several inspections along the way, as well as a final inspection after it is completed. Those initial inspections(don) 't cause the whole project to stop &151; they ensure that each step is done correctly. If an electrical circuit fails inspection, the electrician is recalled and the problem is corrected. If the initial inspections are done well, the rigorous final inspection usually goes without a hitch. In fact, that is the goal!

Learning needs to involve "along the way" inspections (formative evaluations) that ensure correctness as well as a final (summative) evaluation that is rigorous, yet is one which students are well prepared.

Foundation

The following skills need to be in place in order for students to be successful on this project:

TI-83 Graphing Calculator and CBL (Calculator-Based Lab) Interface

1. Students should have some experience in running a simple regression analysis of linear or power-based data and determine best-fit equations for that data.
2. Students should have experience in hooking up data probes to the CBL and collecting data in real time.

Astronomy

1. Students should have a basic understanding of the overall structure of the universe. This includes understanding how stars are grouped (singles, binary/trinary, open and globular clusters, and galaxies.
2. Students should have a working understanding of a light year and what that means in terms of time needed to travel to different parts of our universe.
3. Students should have a general understanding of H-R (Hetzsprung-Russell) diagrams and the life cycle of stars.

Computers

1. Students should be comfortable in an icon-based environment and be able to locate and open files.
2. Students should be comfortable using a browser and search engine to locate information on the Internet.

Scaffolding

The following activities will prepare students for the SETI project:

1. **TI-83 Graphing Calculator/CBL (Calculator-Based Lab)** — Students will be given several sets of sample sinusoidal data and asked to mathematically model the data using sinusoidal regression analysis. They need to determine if the data is periodic, and if so, calculate the period. Screens should also be saved to a Word document using the TI-Graph Link software.
2. **Drake's Equation** — Students will view a video and find resources on the Internet to learn about Drake's Equation and how it is used to estimate the probability of finding extraterrestrial life.
3. **Sound Waves** — Students will use the TI-83 graphing calculator and CBL hooked to a microphone to discover 1) the relationships between pitch and wavelength and 2) the amplitude of a wave and its loudness.
4. **NetMeeting** — Students will form teams and hold simple NetMeeting conferences using chat, whiteboards, and file transfers and sharing programs.

What is the probability of an extraterrestrial life form actually communicating with us?

Do your students know the right questions to ask to try to define this mathematically?

Inspection

Have your students presented enough information and artifacts to prove they understand?

Formative (nongraded) Assessments

1. **Synthesis of General Principles** — After the discovery phase of CBL work, ask students to generate a rule relating the energy of a wave to its frequency, the pitch of a sound to its frequency, and the loudness of a sound to its amplitude.
2. **Correct Use of Technology** — When students are making standards of musical sounds, do a quick check of each student group to see if they are measuring two or three notes and equations accurately.
3. **Correct Use of Simulation from the Internet** — When students use a CLEA lab, run a check on one or two natural pulsars that students have recorded.
4. After a test run with NetMeeting, check student whiteboards for material prepared for symposium.

Summative Assessment

1. **Standards Portfolio** — Groups will turn in an electronic portfolio of wave patterns and sinusoidal equations of musical notes from f4 to c6 as well as several natural sources of radio waves such as pulsars. This portfolio will be used as supporting or refuting evidence in deciding if students' sample sounds were ET messages or not.
2. **NetMeeting Whiteboard Presentations** — Each student will turn in a self-prepared whiteboard presentation, which was used in the NetMeeting Symposium to defend decisions about ET messages.
3. **NetMeeting Symposium** — A group grade will be given for overall symposium presentation. Grades will be based on evidence-based defense of position as well as correct interpretation of evidence.

Rubric for Talking with E.T.

Components	Exemplary	Acceptable	Needs Improvement
Communication	Clear, insightful	Generally clear, logical	Unclear, poor idea progression
	Extensive use of topic-specific vocabulary	Appropriate topic-specific vocabulary	Lack of topic-specific vocabulary
	Few Errors	Some Errors	Many Errors
Research	Numerous appropriate resources	Adequate appropriate resources	Few or inappropriate resources
	Wide variety	Some variety	Lack of variety
	Reliability well-documented	Reliability somewhat well-documented	Reliability not documented
Problem Solving	Detailed description of problem	General description of problem	Vague description of problem
	Abundant evidence of Higher-Order Thinking Skills (HOTS)	Demonstrates HOTS (analysis, synthesis, prediction)	Little evidence of HOTS
	Draws insightful conclusions	Draws appropriate conclusions	Draws inappropriate conclusions
Presentation	Clearly focused, richly developed	Generally focused and developed	Lacks focus and coherence
	Creative, engaging	Engaging	Does not engage the audience
	Abundant supporting evidence	Adequate supporting evidence	Little or no supporting evidence

Are you helping students by making sure they know the target you want them to hit?

Are you giving helpful feedback on how they are doing before you take grades?

Additional Resources

Also check out the movie Contact starring Jodi Foster (Warner Brothers, 1997).

Educational Issues Links

Performance Assessment
http://www.weac.org/Professional_Resources/Testing/performance_assessment.aspx

Teaching for Understanding: Educating Students for Performance
http://www.weac.org/News_and_Publications/education_news/1996-1997/under.aspx

Other Useful Links

The Life and Times of Stars
http://webhome.idirect.com/%7ersnow/aboutstars.html

Project CLEA
http://public.gettysburg.edu/~marschal/clea/CLEAhome.html

SETI Frequently Asked Questions
http://www.seti.org/page.aspx?pid=558

SETI: The Drake Equation
http://www.activemind.com/Mysterious/Topics/SETI/drake_equation.html

Texas Instruments Homepage
http://education.ti.com/educationportal/index.jsp