Research: The Ultimate in Discovery Based Science Teaching

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August 30, 2001

A Reflection on the Teaching of Science

Science may be built of facts in the way that a house may be built of stones. But a pile of rocks is not a home and a collection of facts is not science.

-paraphrased from writings of Henri Poincare

EALRs emphasize students learning “the nature and methods of scientific inquiry” – how do we do that?

Contrasts Between Nature of Science and (some) Science Instruction

Science, at work, is…	Science instruction can be…
active	passive
collegial	hierarchical
creative	imitative
free-form	structured
risk-taking	risk-averse
empowering	deflating

In Others Words…

- …science at work is "like chocolate", science instruction can be "like spinach!"
- If you were a teenager, would you go for the chocolate (yum…) or the spinach (it's good for you)?
- Schools are not in the entertainment business, but our customers may have important things to tell us
- How can instruction more accurately portray the nature of science, that draws smart people to happily work long hours, often for low pay?

Let's examine why we teach science

- Society needs scientists and technically trained people to maintain national security and economic prosperity
- Society needs scientific literacy and informed voters
- Science education is important for today's job market
- Our brightest students need preparation for challenging careers
- Why would we teach poetry, music and not science?

A radical proposal:

- I propose that we can accomplish all the practical goals of science education and make the experience fun and uplifting for our customers by introducing scientific research to our classrooms.
- This suggestion is not meant to stretch the best of our students, but to involve the "typical" student in our science classrooms
- My intention is to provide broad exposure to research
- I use "broad" in the sense of many students, for many years, in many ways

An experiment in using research in the classroom

- Royace Aikin, of Pacific Northwest National Lab, conceived a "Scientist, Student, Teacher" Program (SST) to team students, science teachers and scientists in effort to conduct research as part of high-school curriculum
- LIGO Hanford Observatory has adopted SST with a goal of dramatically broadening the numbers of students with research experience
- Over 2 years, more than 70 students have participated in LIGO research at Gladstone High School in Oregon
- What did we learn from this?

Research is possible in high school classrooms

- Research assignment needs to be accessible, well-defined in scope, but unstructured enough to manage
- Teacher must do day-to-day mentoring of students
- Teacher needs an on-call scientist for mentoring, advice, planning
- Forget altruism; teacher & students must provide a useful scientific product
- Students must know their work matters
  - » have access to science/technical personnel
  - » see their product used by science/technical people

What kind of research is accessible to HS students?

- Clearly, it cannot depend on exotic equipment or supplies
- It cannot depend on much knowledge of college-level science and math
- Students and teacher must be able to believe they can do it
- It needs to relate to subject matter of course in which it is set

Consider…

- Information technology (IT) has dramatically changed how work gets done
- How has IT changed the way we teach?
- IT is a dominant tool of wealth creation and creativity
- teenagers are masters of IT if only adults don't hold them back

Presenters at Community Science Night, May 2000

Modern IT was invented for scientific collaboration

- A telephone, a computer and a network connection allows access to copious, high-quality scientific data
- Significant public investment in instrumentation has produced this data for a specific purpose
- There are broader scientific benefits to a deeper analysis than limited manpower allows
- The tools required for some of this analysis are conceptually accessible to HS students
- MS Office contains most of the computer tools needed for statistical analysis of this data & more sophisticated software is available as freeware

The nature of scientific inquiry today is…

- A team enterprise with colleagues working collaboratively across great distances
- Values “people” skills as well as science & math
  - » How to factor a problem into a team activity
  - » How to work as a team member
  - » How to manage to a product (No Partial Credit!)
  - » How to effectively tie the team together with written and oral presentations
- More like a orchestra than a solo performance
  - » Everyone knows the music, but each plays one part
- We adopted a team model with Gladstone HS

How LIGO and Gladstone HS worked on physics research

- Problem: analyze seismic data taken at LIGO Hanford Observatory (LHO) and produce long-term study of microseism
- Why? The microseism produces the fastest changes of the LIGO baseline, but there are no historical records of microseism near the Hanford site
- Instrumentation: LIGO has 5 triple-axis seismometers on site connected to a data acquisition system and significant high-speed computing capacity
- GHS supplies commitment to long-term monitoring & data trending

Resources at Gladstone High School

- 1 brave teacher, Mr. Dale Ingram
  - » Background in physical chemistry
  - » Knows his students
  - » Able to “think outside the box”
- Commitment
  - » Ingram would spend two years working with program
  - » School administration would provide matching funds to get program started at GHS
  - » Community has generally been interested in and supportive of school activities (sports, drama, etc.)
- Science class had access to computer with network connection and MS Office

The Program

- We arranged to bring Mr. Ingram and 3 students to a summer internship at LIGO & participation in PNNL program with other teacher/student teams
- During summer, this team would master tools needed for research and write a project management plan for bringing the research program back to the school
- Research would be conducted in regular physics class in 1st semester & as "independent study" in 2nd semester
- By end of year two, infrastructure would exist to support long-term research at GHS

Did it fit?

- Nailed the “nature of science inquiry” EALR!
- Topic naturally involved issues of waves, vibration, harmonic motion, data reduction and math concepts
- Some student teams developed rudimentary instrumentation (demos) to familiarize class with principles of scientific instrumentation
- By factoring problem into manageable team assignments, students were able to achieve successful results & great morale

GHS Teams

- Issue Research
- Instrumentation
- Electronics
- Computing hardware
- Software development
- Web page development
- Analysis

The level of cooperation & cross-teaching between groups was phenomenal

Managing the enterprise

- Approx. 20-30% time commitment to research during course; 100% commitment during independent study
- Student software did fast number crunching on LIGO computer with output written to web-accessible file
- Students downloaded processed data from LIGO using web browser and did further trending and analysis on school computers
- Reports and presentations were posted to GHS web page and reviewed in regular teleconferences between physics class and LIGO personnel

Long-term microseism trend

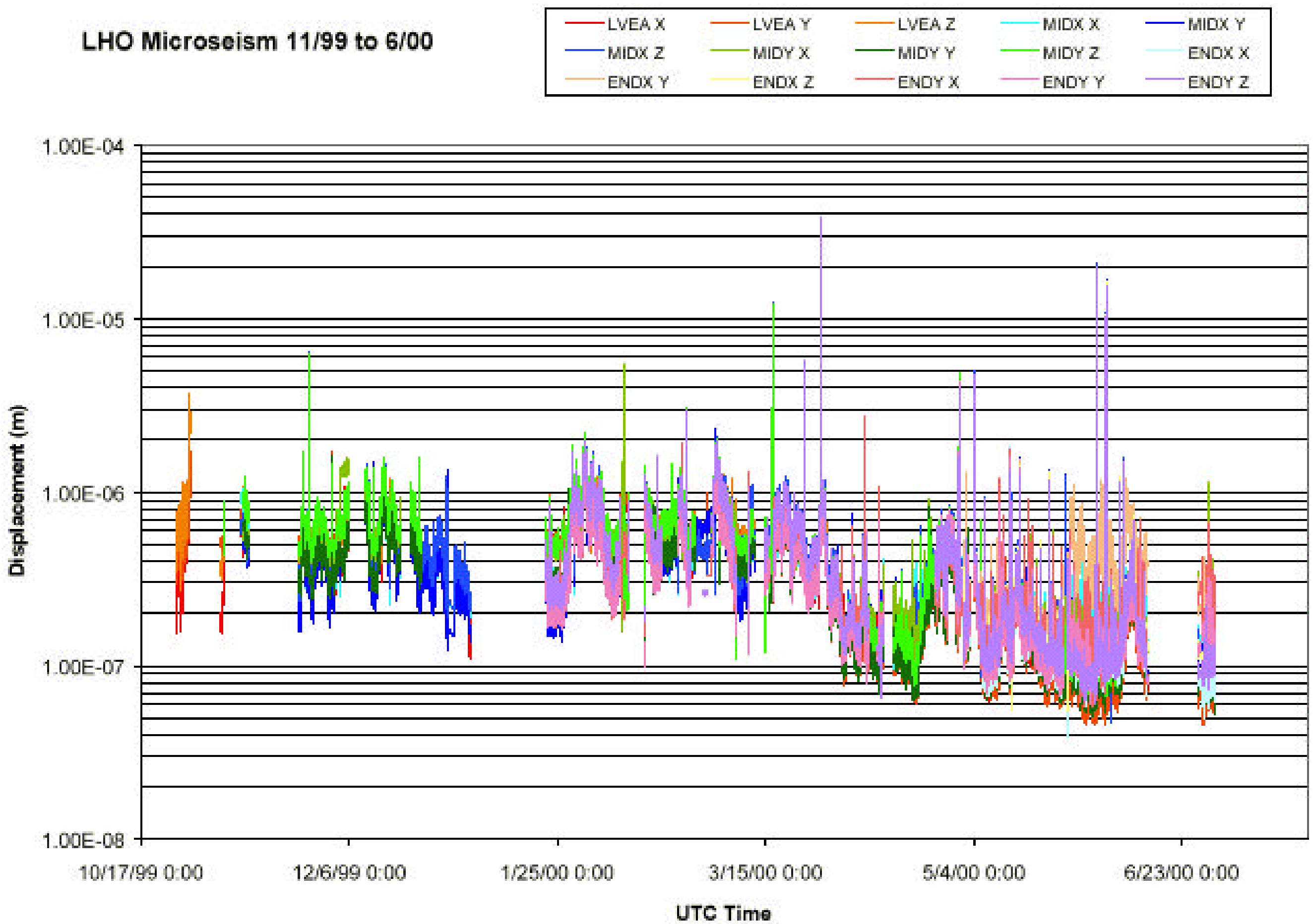
LHO Microseism Data Update
8/9/00
Kierstin Schmidt and Dale Ingram

Gladstone High School has been collecting microseism data from LIGO Hanford seismometers since 11/99. This report contains the most recently updated graph of the microseism data set. Several peaks in the spring of 2000 appear to be attributable to earthquakes.

Introduction

In an ongoing effort to characterize the microseismic peak at LHO, the Gladstone High SST team has edited, calibrated and plotted the most recent batch of 15-min average displacement data that are produced by our microseism accumulator program. All five LHO station seismometers have been contributing to the data stream since April 24. The attached plot displays the entire data set, which spans 11/1/99 to 6/30/00. The data shows a downturn in displacements in the late spring. If last year's pattern is consistent, the data points should move back to higher levels in the fall. We remain very interested in possible environmental driving forces of the microseism, and in the influence of global earthquakes in our microseism frequency band.

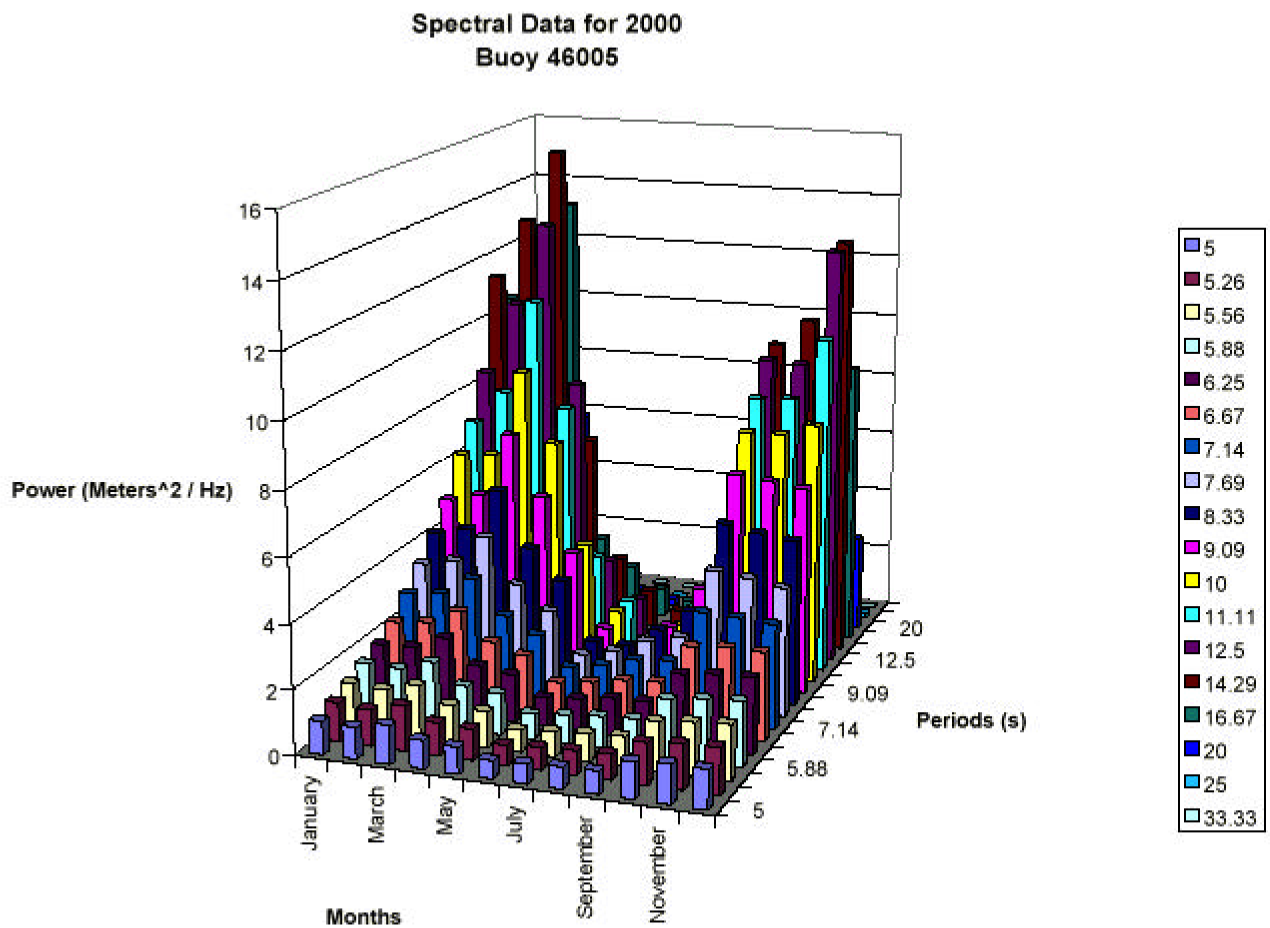
Long-term microseism trend…



Recording of earthquakes in microseism record

Date	Mseism Peak Time	EQ Time	Time Lag to LHO	Mseism Peak Magnitude (m)	Quake Magnitude	Notes
11/26/99	13:50	13:21	0:29	5.98E-06	7.5	Islands off of NE Australia
02/09/00	20:10	20:02	0:08	5.03E-06	4.4	SW border of Mexico and Guatemala
02/25/00	2:34	1:43	0:51	2.98E-06	7.1	Islands far east of northern Australia
03/16/00	15:32	15:20	0:12	1.17E-05	5.9	Off the coast of northern California
03/24/00	4:45	4:23	0:22	5.71E-06	5.6	Between Baja Penin. and mainland
03/28/00	11:52	11:00	0:52	3.76E-05	7.6	In the ocean far off western China
04/07/00	23:49	23:24	0:25	2.76E-06	3.2	Eastern tip of Dominican Republic
04/11/00	0:40	23:34	1:06	1.06E-06	4.2	Tip of the peninsula in far eastern Russia
04/30/00	10:32	10:13	0:19	4.82E-06	5.6	Off the coast of southwestern Canada
05/04/00	5:30	4:21	1:09	4.78E-06	7.6	Indonesia
05/12/00	19:14	18:43	0:31	1.73E-06	7.2	N'west Argentina, border of Chile & Bolivia
05/15/00	7:21	7:11	0:10	1.46E-06	5.6	Off the coast of southwest Canada
05/21/00	20:43	19:58	0:45	1.30E-06	6	Far north of eastern Iceland
05/26/00	2:20	1:56	0:24	1.24E-06	3.3	Southeastern Alaska
06/02/00	11:23	11:13	0:10	1.92E-05	6.2	Off the Oregon Coast
06/04/00	18:10	16:28	1:42	1.55E-05	8	Indonesia
06/29/00	3:14	2:56	0:18	1.12E-06	5.2	Directly off the western coast of Japan

Search for a connection to ocean-wave activity



GHS science successes

- Now have 2-yr record of microseism
- Seasonal variability on high end traced to ocean wave data from specific NOAA buoys
  - » students even measured the wave propagation velocity between buoys by cross-correlation technique
- During quiet season, potential correlation with local weather patterns
- Demonstrated general insensitivity to human noise generation by studying day/night statistics
- Reports on Gladstone High School physics web page at http://www.gladstone.k12.or.us/ghs/users/ingramd/Physics
- Annual community science night draws about 80-100

Other successes

- Students had a ball!
- A number of students each year, who had seemed mediocre, bloomed into serious leaders
- The community applauded the achievements of their students in a public forum
- Students learned to learn by their own wits and solve difficult problems with both inspiration & perspiration
- Students learned to prepare “professional” quality presentations and reports with technically sophisticated content

Finale

Teenagers are a very diverse group and would disagree on many things. But an almost universal complaint of teenagers is that we feel that adults do not take us seriously. All the students loved working on LIGO because we knew that professional scientists were taking us and our work seriously enough to use it in their own work. This gave us a tremendous sense of empowerment.

- a student of Gladstone High School