Laboratory investigations of online databases to enhance student understanding of energy resources

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Abstract

Recent changes to the general education curriculum in geology at the College of Staten Island have been introduced to make the classes more relevant and useful to non-science majors. One new course involves a thorough investigation of the Earth's resources, with around half the semester spent focusing on energy resources, in particular electricity generation. Students with a non-science background generally come into the class with no idea where their electricity is generated, or what natural resources are required. They are often under the false impression that we mostly use renewable energy, and are shocked to find out that more of our electricity is produced by burning coal than any other source.

Rather than simply lecture the students on the statistics of energy production, the initial class time focuses on the mechanisms of electricity production from various sources, the issues of base load and peak power, problems of variability and unpredictability in some renewable resources and the environmental consequences of using each resource. Accompanying lab investigations allow the students to explore the data relating to electricity generation across the USA and the availability of potential resources for the future, with a lesser focus on environmental consequences where appropriate. In several of the labs, the students compile a series of maps showing the use of energy resources and the potential for their future use on a state by state basis. This information is used in conjunction with population data to interpret the reasons why particular resources are more appropriate in one state than another. Anomalies, such as New Jersey's high ranking in use of solar power, are discussed in terms of their implications for other states. Students then write a series of lab reports, describing and analyzing the data they collected and the maps they compiled. The repeated investigation of different energy resources, with reference to the issues of supply and demand covered in the lectures, has given the students a much deeper understanding of the problems relating to electricity generation in this country. As a result, we are educating students who will be voting based on such issues and who may require such knowledge for future careers that seem unrelated to science.

1.Introduction

General education students at CSI have mostly been taking traditional geology classes (Physical and Historical Geology) with a few taking a third Environmental Geology option. Student engagement in this third option was high, and many students wished they could cover topics in greater detail. It was therefore decided to create 3 new classes covering resources, hazards and pollution, that would be more relevant for students who are not science majors.

The Earth Resources laboratory class complements the lecture class of the same name. It is intended to provide students the experience of hands on, practical applications relevant to the topics covered in the lecture class. When studying energy resources, the students use online data sets to interpret environmental impact, current energy production and future resource potential.

2. Course objectives

General Education Objectives

There are a number of general education objectives that should be met by all science classes, regardless of subject matter, usually in the lecture—lab combination. Objectives met by this lab course include:

Learning Objectives	Example Evidence That Objective Can Be Met
Students will be able to evaluate evidence analytically. They will examine our use of resources and interpret limitations on the supply and the environmental impact of the extraction and use of Earth resources.	After completing several lab exercises on related topics, students will write a comprehensive report summarizing the issues related to finding and using a particular type of resource.
Students will be able to demonstrate how the tools of geology can be used to analyze the geologic processes that lead to the formation of Earth resources and develop an assessment of where resources are more likely to be found and the potential impact of their use.	Lab exercises will include the collection of data (e.g. from maps, USGS sources) that the students will process to interpret the geologic processes forming resources, understand our use of these resources and analyze the environmental impact of using these resources.
Students will be able articulate and evaluate the impact of scientific discoveries regarding resources on the contemporary world, particularly in relation to ethical responsibilities.	Students will be required to write several summary lab reports regarding the discovery and use of Earth resources, and their impact on our lives and the natural environment.

Course Specific Objectives

Subject matter objectives are also important, and the goal of this class is to familiarize students with where our resources come from, their future potential and the consequences our resource use

Objectives met by this lab course include:

Learning Objectives	Example Evidence That Objective Can Be Met
Understand the geologic processes that lead to the formation of Earth resources and use this knowledge to assess where resources are more likely to be found	Lab exercises will require students to locate suitable sources or locations for ore minerals, water supply and energy resources using maps and online data sets.
Examine our use of resources and interpret limitations on the supply of these resources	Students will use data regarding rates of use and known reserves of specific resources to predict/interpret the remaining lifespan of these resources, such as fossil fuels, specific minerals and groundwater.
Examine the environmental impact of the extraction and use of Earth resources	Students will use online data sets, maps and photographs to interpret the environmental impact of mineral/fossil fuel extraction and pollution from burning fossil fuels and chemical fertilizer use.

3. Labs on Fossil Fuels and Nuclear Energy

The labs on fossil fuels and nuclear energy focus on issues of supply and environmental impact. Some examples are given below.

Environmental impact of Coal Extraction

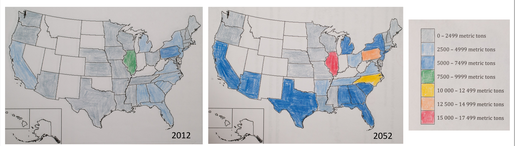
Students examine satellite images available on the USGS website (http://earthshots.usgs.gov/earthshots/Muskingum-Mines), and answer a series of questions based on what the can see in the photographs and how this relates to what they learned about coal extraction in the lecture class. They then compile their results and interpretation in a lab report. This gives students the experience of interpreting raw satellite images, collected through time, and using them for a specific purpose.

July 18, 1985, Landsat 5 (path/row 18/32) — Close up of Muskingum Mines, Ohio, USA

July 15, 2013, Landsat 5 (path/row 18/32) — Close up of Muskingum Mines, Ohio, USA

Nuclear Energy

Students create maps showing how much nuclear waste has already been produced, and how much will be produced by the time a potential repository is available, again using data sets available online. Using these maps and some knowledge of repository design from the lecture class and assigned reading, they assess the options for nuclear waste disposal in the US.

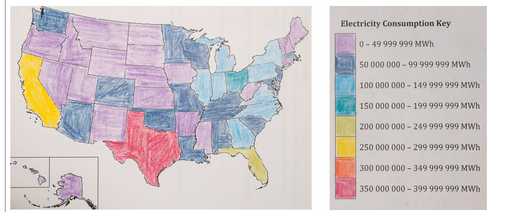


Sample maps of nuclear waste produced by 2012 and predicted by 2052.

4. Labs on Alternative Energy Resources

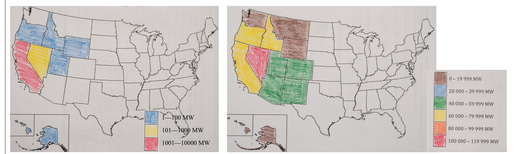
Our current use of alternative energy resources is examined in the context of population distribution and patterns of electricity consumption. Prior to investigating each individual resource, students compile a map of population by state, including the locations of major cities, and a map of electricity consumption by state. These maps are completed using online date sets, e.g. http://www.eia.gov/electricity/state/

Sample map of electricity consumption by state.



Students then compile maps from data sources illustrating current use and future potential of alternative energy resources, including wave, wind, geothermal and solar for electricity production.

Sample maps of current geothermal energy production and future potential.



These maps give students a visual reference for interpreting why some states are more suitable for a particular energy resource, and also any anomalies, such as New Jersey's surprisingly high rank in production of solar power. Lab reports encourage students to interpret the maps in light of concepts from the lecture class, such as the need for electricity to be produced close to population centers, and the need fro a consistent base load as well as peaking power capacity.

5. Lab Reports

Lab reports are an important component of a general education science class, as they teach students how to formally present data and results. Many students in the general education classes have had no previous experience of this form of writing. It is therefore important for them to learn a consistent structure for the lab report, and the same rubric is used each week to provide consistent feedback. Students also require detailed instructions for each report, as they find it difficult to figure out what information to put in each section.

Sample Lab Report Instructions

Use your maps of population and electricity consumption from part 1 of Lab 6, along with the maps from today's lab to write your report.

Title - brief, but descriptive.

Introduction - Briefly introduce solar and geothermal energy, and the importance of location (of both resources and population). What is the purpose of the lab exercise?

Method - Where did the data come from, what information did you collect, and how did you use it to produce your maps?

Results - Where are the most suitable locations for producing electricity from solar and geothermal resources? Refer directly to your maps.

Discussion - Based on both population and availability of solar and geothermal resources, what locations would you propose as having suitable sites for development? Explain your reasoning and refer to your maps. What other issues need to be considered when planning to use geothermal and solar energy (think back to the lecture and your prelab answers).

Conclusions - Brief summary of your findings.

Rubric used to grade lab reports

	0	1	2	3	4
Title Weight 1	Missing	Not relevant to information contained in lab report.	Too short to convey what to expect in lab report.	Describes lab fairly well, but could be more precise.	Describes exactly what to expect in lab report.
Introduction Weight 3	Missing or plagiarized	Does not introduce the topic of the lab or its purpose.	Introduces the topic of the lab but does not clearly state its purpose.	Introduces both the topic and the purpose, but with details missing or incorrect.	Clearly and concisely introduces both the topic and the purpose of the lab.
Method Weight 4	Missing or plagiarized	Method and Results mixed together.	Describes the basic method, but with many details missing or incorrect.	Describes the basic method, but with some details missing or incorrect.	Describes in detail where the data came from and how it was used.
Results Weight 5	Missing or plagiarized	Method and Results and/ or Results and Discussion mixed together.	Results have many details missing or incorrect.	Results have some details missing or incorrect.	Fully summarizes the main results.
Discussion Weight 5	Missing or plagiarized	Results and Discussion mixed together.	Discussion has many details missing or incorrect.	Discussion has some details missing or incorrect.	Fully interprets the results and discusses relevant issues.
Conclusion Weight 2	Missing or plagiarized	Not relevant to information contained in lab report.	Conclusions incorrect or relevant to the topic but not the lab exercise.	Summarizes some aspects of the lab, but not the main conclusions.	Concisely summarizes conclusions/ findings from the lab exercise.

5. Conclusions

The course is now running for its second semester, and there was a very small number of students who signed up for the first semester in Fall 2014, so there is not yet any formal analysis of outcomes.

Some initial observations include:

- Students are coming into the lab class expecting to undertake their own research rather than waiting for "instruction" from the classroom teacher
- Student writing improves significantly over the course of the semester
- Students develop a deeper understanding of the issues surrounding energy resources, particularly electricity generation, than in the lecture class alone. They are able to incorporate this into assignments in the lecture class

Future improvements include:

- Inclusion of data on hydroelectric power
- Incorporating data on current usage of fossil fuels, nuclear, wave and wind energy