Geoscience of Energy and Mineral Resources in a Societal Context

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Abstract

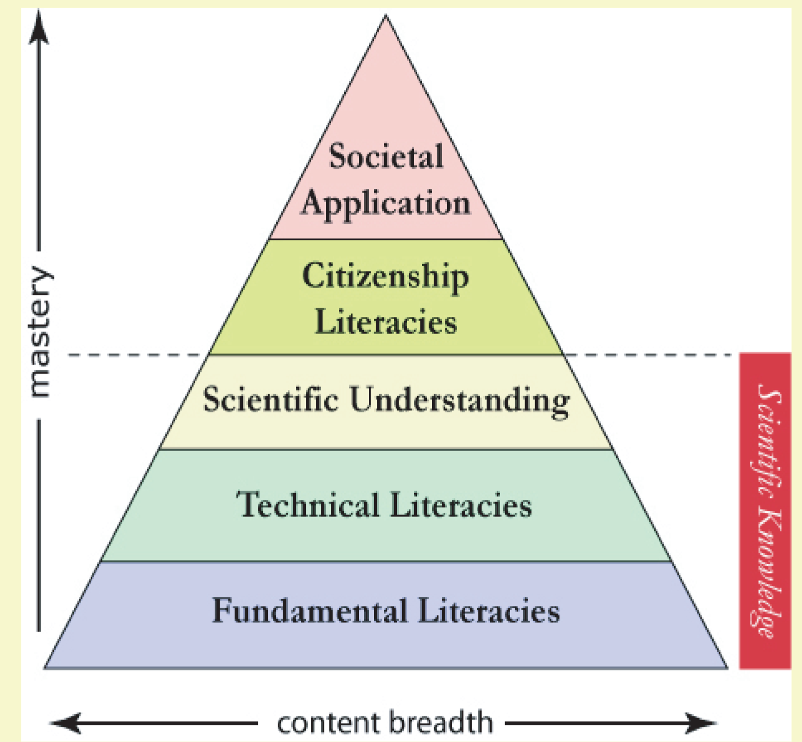
A primary goal of many geoscience courses is to provide students with the scientific knowledge necessary to make informed decisions about societal issues that encompass geologic components, e.g. siting dams, opening mines, building in earthquake zones, etc. Unfortunately, many geoscience courses provide students with a wealth of geologic and scientific content, but do not assist them with developing the tools (literacies) necessary to master this content. In addition, courses commonly fail to help students develop life-long practices for applying scientific knowledge to societal issues in a logical, systematic and effective manner.

As part of a U.S. Department of Education Fund for the Improvement of Postsecondary Education grant, we identified literacies (tools) that students must master to turn geologic knowledge into geologic understanding. In light of these literacy classes, we redesigned our courses so that literacies are integrated into all aspects of the class, e.g. reading, lab and lecture, thereby providing students with continuous and extensive practice while they learn and master geoscience content. The resultant geologic understanding is applied to a variety of societal issues, giving students practice with the skills they will need as citizens to make informed, rational decisions about a variety of societal issues.

Scientific and Citizenship Literacies

Literacies: Tools necessary for understanding and application of scientific information

- Scientific Literacies
  - Fundamental (common to many disciplines)
    1. quantitative calculations
    2. qualitative assessment
    3. reading graphs, charts and tables
  - Technical (specific to geosciences)
    1. map interpretation
    2. spatial visualization
    3. temporal conceptualization
- Citizenship literacies,
  - Critical thinking skills
    1. consequenses
    2. impacts
    3. externalities
    4. reconciliation
  - Social context evaluation
    1. population
    2. economics
    3. history
    4. connections



The Courses

The literacy focus is being employed in three courses at the University of Wyoming. In the introductory geology course for both majors and non-majors, *Physical Geology*, the labs have been revised to incorporate the fundamental and technical literacies. These scientific literacies as well as the citizenship literacies are actively addressed in two upper-division courses for both majors and non-majors: *Earth and Mineral Resoruces* and *Energy: A Geological Perspective*. The upper division courses are built around case studies in which students examine real life geologic, economic and social issues.

Identifying Students' Learning Needs

False Assumptions About General Education Science Courses

1. Students are proficient in literacies necessary to master scientific content
2. Students can integrate scientific content into other courses
3. Students, as citizens, can apply integrated scientific knowledge to societal issues independently

Truths About General Education Science Courses

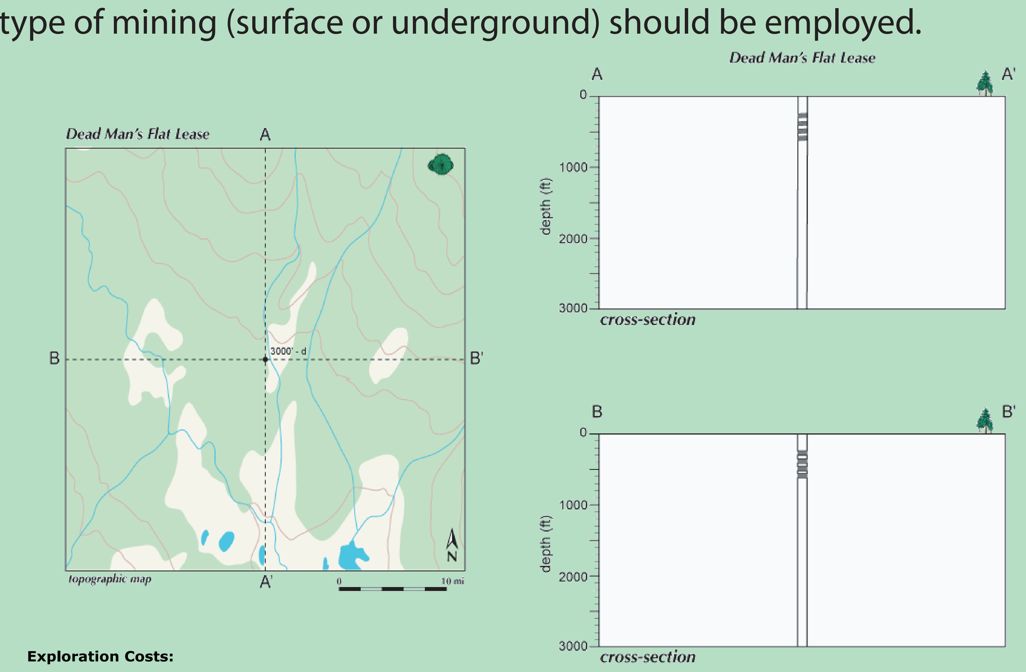
1. Students need help mastering literacies
2. Students rarely see connections between courses (even within a discipline)
3. Students have difficulty applying information to new settings and situations
4. Students need instruction in literacies integrated with learning scientific content

Citizenship Literacy Case Study Example: Coal in China (http://www.gg.uwyo.edu/geol3650/index.asp?callNumber=14276)

Planning Resource Development

The geology component of each case study has students apply geologic principles discussed in lecture to hypothetical problems. In particular, students locate and assess potential resources and give oral and written presentations on their development recommendations.

For this exercise, students are given maps, cross sections, exploration costs and a $1 million development budget for a variety of coal leases. They conduct an exploration program, complete the cross sections, recommend if mining is feasible for each lease and what type of mining (surface or underground) should be employed.



Exploration Costs:

	depth		
drilling	<1000 ft	1000-2000 ft	2000-3000 ft
diamond	$50/ft	$95/ft	$140/ft
rotary	$35/ft	$80/ft	$125/ft
percussion	$15/ft	-	-
logging			
cutting	$20/ft	$35/ft	$75/ft

Analytical Costs:

analysis	cost
proximate	$85/sam
ultimate	$95/sam
complete (proximate & ultimate)	$160/sam

Power Plant Technology, Economics and Emissions

For this part of the project, students enact the scenario that they are working under the Clean and Clear Air Defense Task Force to conduct economic assessment of a carbon tax on power plant technology. Different groups examine different potential replacement/retrofit scenarios for an old, coal-fired power plant that had formerly been exempt from meeting modern emissions standards. Each group presents their results so the class can determine the best course of action.

Steps:

1. Using the plant size and efficiency, calculate MW_{th}.
2. Calculate construction costs and spread them over 30 years (normal economic lifetime of a large power plant)
3. Estimate, in J and Btu, the energy needed to run this plant for a year
4. Determine annual fuel requirements of the plant and their costs
5. Calculate yearly emissions of CO_2 and SO_2. Sum this over the plant's lifetime.
6. Determine annual operating costs and how much generating costs are ($/kW)

scenario	plant type	capacity (MW_e)	efficiency (%)	capital costs ($/$kW_e$)	sulfur reduction (%)	fuel	fuel cost	other
stealth retrofit	steam boilers	300	36	$1100	-	coal: 8,350 Btu/lb 2.5 % S 75 % C	$14/ton	
Clean Air Act compliant	install scrubbers	550	38	$550	90	coal: 8,350 Btu/lb 2.5 % S 75 % C	$14/ton	$4/ton SO_2 over 1.2 lb/10^6 Btu
	Steam boilers w/scrubbers	300	38	$900	90			
Carbon tax 1	PFBC	850	42	$1700	90	coal: 10,275 Btu/lb 0.6 % S 69 % C	$20/ton	$4/ton SO_2 over 1.2 lb/10^6 Btu; $9/ton CO_2
Carbon tax 2	PWR	750	42	$301 6	-	mi n: 60.16x10^6 Btu/gm avg: 88.02x10^6 Btu/gm max: 133.08x10^6 Btu/gm	$29.18/g 51.76/g 143.49/g	$4/ton SO_2 over 1.2 lb/10^6 Btu
	Combined cycle gas turbine	100	47	$520	-	1031 Btu/ft^3	$9. 80/tcf	$9/ton CO_2

Coal, China, and the Kyoto Protocol

In the final part of the case study, students revisit the Kyoto Protocol taking the position of a participant in the talks. They try to meet the emission reduction target in a way that meets their country's interests (and the interests of the constituencies that influence their country's actions: citizens, corporations, unions, government agencies, etc.). One group takes the position of China, another will be the United States government, another will take the role of the European Union, and the fourth group will be Japan.

A goal of the 1997 Kyoto negotiations was to limit carbon dioxide in the atmosphere to 550 parts per million(ppm) by the year 2012. The class tries meet this target by reducing emissions of all participating countries by 30%.

Students can choose to embrace the mechanisms for reduction already proposed in the protocol or offer new mechanisms or inducements. Their choices should be guided by their country's preferences as well as what they have learned about energy production, economics, and environmental impact.

Matching Priorities and Mechanisms Worksheet

Indicate with an X those mechanisms that are best for attaining each priority.

Priority	Mechanisms: Cap & Trade	Carbon Sinks	Clean (Green) Technologies	Renewables (Wind, etc.)	Energy Efficiency	Nuclear
Maintaining robust economic growth						
Protecting the environment						
Increasing energy security						
Promoting conservation of energy						
Keeping or improving your citizen's lifestyle						

Defining Your National Priorities Worksheet

Country: ______________________

priority	ranking	brief explanation
Maintaining robust economic growth	low 1 2 3 4 5 high	
Protecting the environment	low 1 2 3 4 5 high	
Increasing energy security	low 1 2 3 4 5 high	
Promoting energy conservation	low 1 2 3 4 5 high	
Keeping or improving your citizen's lifestyle	low 1 2 3 4 5 high	

Calculating Emissions Reductions Worksheet

Country: ______________________

Current Carbon Emissions: ______________________ tons

Target Carbon Emissions: ___________________ tons

Mechanism	Value in Reducing Greenhouse Gasses	Associated Carbon Reduction (tons)	Plan to Adopt (Yes/No)
Cap & Trade	Low: 4 %		
Carbon Sinks	Low: 2%		
Clean (Green) Technologies	Medium: 6%		
Renewable Energy	High: 12%		
Increased Efficiency	High: 15%		
Nuclear Power	High: 10%		

How many tons of greenhouse gas emissions will be reduced with these practices? ____________

New Emissions Total: ______________________ tons

Other Citizenship Literacy Case Studies

We invite you to explore, use and adapt the other case studies developed for our courses. Please visit the websites for the courses on *Earth and Mineral Resources*, and *Energy: A Geological Perspective*. For both sites, use the navigation bar at the top and select ***Laboratory*** then *Exercise Schedule*. We particularly recommend the exercises on South African gold and Nigerian oil.

Earth and Mineral Resrouces http://www.gg.uwyo.edu/geol3600/index.asp?callNumber=34981

Energy: A Geological Perspective http://www.gg.uwyo.edu/geol3650/index.asp?callNumber=14276

Acknowledgements

We would like to thank Garth Massey (UW Sociology and International Studies) for his large contribution to the development of these exercises. This project would not have taken place without funding from FIPSE through a grant to Audrey Kleinsasser and Jane Nelson.