Assessing the Skills of Future Citizens: The Literacy Survey

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Introduction

A primary goal of many introductory geoscience courses is to provide students with the geologic knowledge necessary to make informed decisions about societal issues that encompass geologic components, e.g. siting dams, opening mines, building in earthquake zones. Unfortunately, close examination reveals that most courses provide students with a wealth of scientific content, but do not assist them with developing the tools (literacies) necessary to master fully scientific 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 FIPSE[1] grant, we have assessed the effectiveness of our own courses in preparing students for roles as informed citizens. Regrettably, we found our courses were characterized by many of these same shortcomings.

Based on our analysis, we identified the literacies that students must master to turn geologic knowledge into geologic understanding. In addition, we categorized a series of literacies that are necessary to take this scientific understanding and apply it to societal issues. With this list of literacies, we are redesigning our courses so that these literacies are integrated into all aspects of the class, e.g. reading, lab and lecture. In this manner, students will be provided continuous and extensive practice with literacies while learning fundamental geoscience content. To evaluate the effectiveness of our course redesign, we have developed a survey to measure student literacy proficiency before and after completing our course.

[1] U.S. Department of Education Fund for the Improvement of Postsecondary Education

The Courses

Although our literacy survey is used in a variety of courses, the one described in this poster is for GEOL3300: Earth Resources. This upper division class is for both geology and non-geology majors and examines the geologic formation, production mechanisms and use consequences of a wide variety of Earth resources. Historically, the class has been a 50:50 mixture of majors and non-majors with the non-majors from such diverse fields as international studies, art, business, music, geography and engineering.

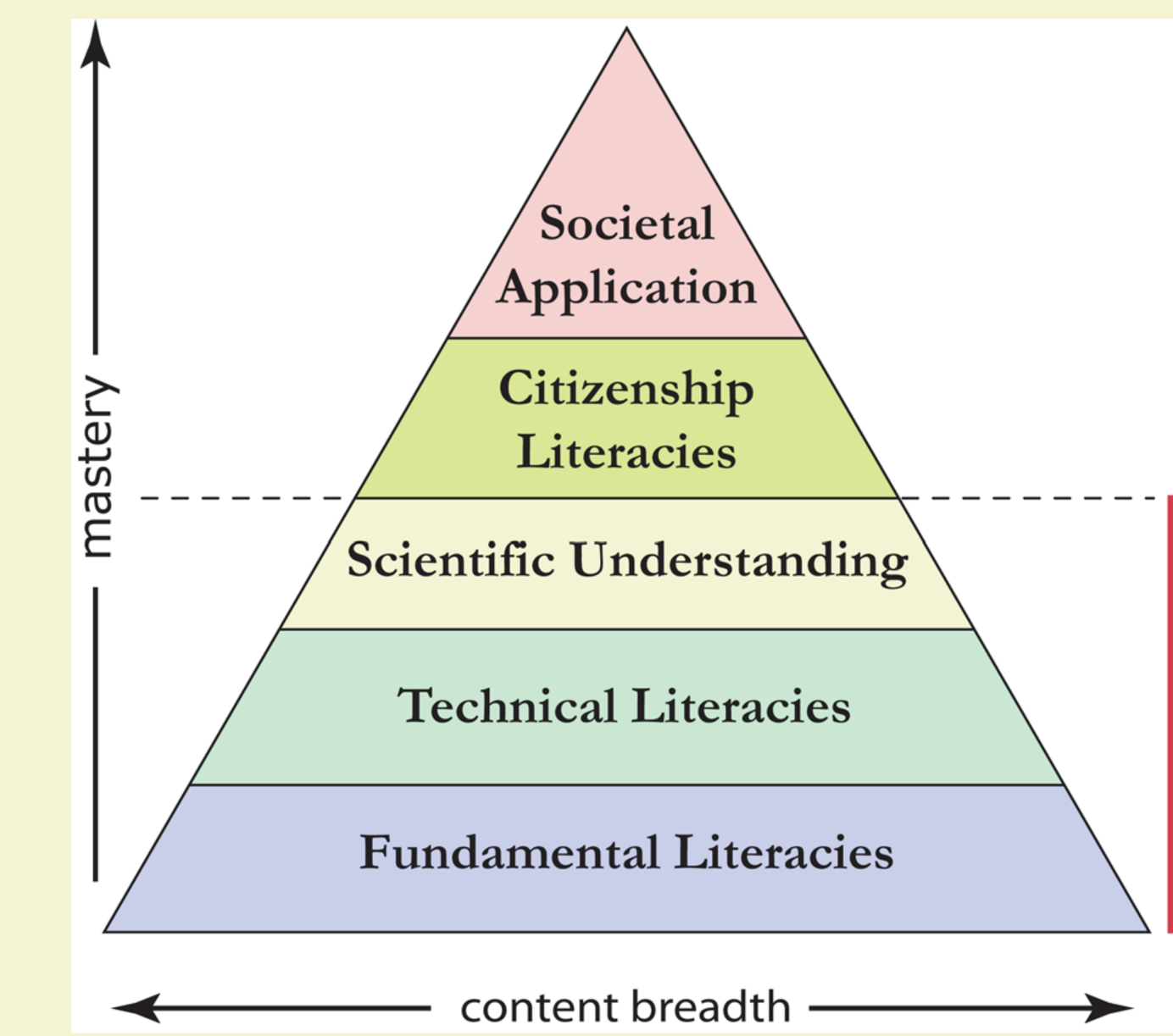
Because of the breadth of the topic and the desire to incorporate better treatment of the citizenship literacies, Earth Resources will be split into two independent courses (Earth and Mineral Resources; and Energy: A Geological Perspective) beginning in the fall of 2005. These new courses will maintain the format of the current course, but will cover each subject in greater depth.

- fulfills University Studies (general education) Earth Science and Global requirements
  - class is 50% geology majors & 50% non-majors
- traditional lecture-lab
  - one lecture section that meets three times a week for one hour
  - 2-3 lab sections with < 20 students
  - instructor, 1 TA
- 4 credit course
- 20-30 students per semester

We have developed a simpler literacy survey for physical geology, an introductory course that typically enrolls 190-210 students each semester. By combining the results from the two classes, we can compare results from very different student populations, e.g. upper division vs lower division, younger vs. older, etc.

The Literacy Concept

Like any other profession, science has a set of literacies that must be mastered before scientific problems can be addressed in an effective and successful manner. Although specific scientific disciplines have some special literacies, all share some common ones. These fundamental literacies are valuable not only to the scientist, but to the citizen as well and consist of tasks that allow individuals to interpret and manipulate facts, data and observations. In addition to these fundamental literacies, each science has a set of special or technical literacies unique to that discipline. For the geosciences, these include the ability to imagine objects in space, deal with spatial data and conceptualize geologic change over a variety of time scales. When combined the fundamental and technical literacies allow an individual to take scientific knowledge and turn it into scientific understanding. Employing this scientific understanding to address societal issues requires yet a third set of literacies, i.e. citizenship. The citizenship literacies permit an individual to use their scientific understanding to evaluate the impact of resource extraction and use on a variety of communities from a range of perspectives, e.g. economic, social, cultural, etc.

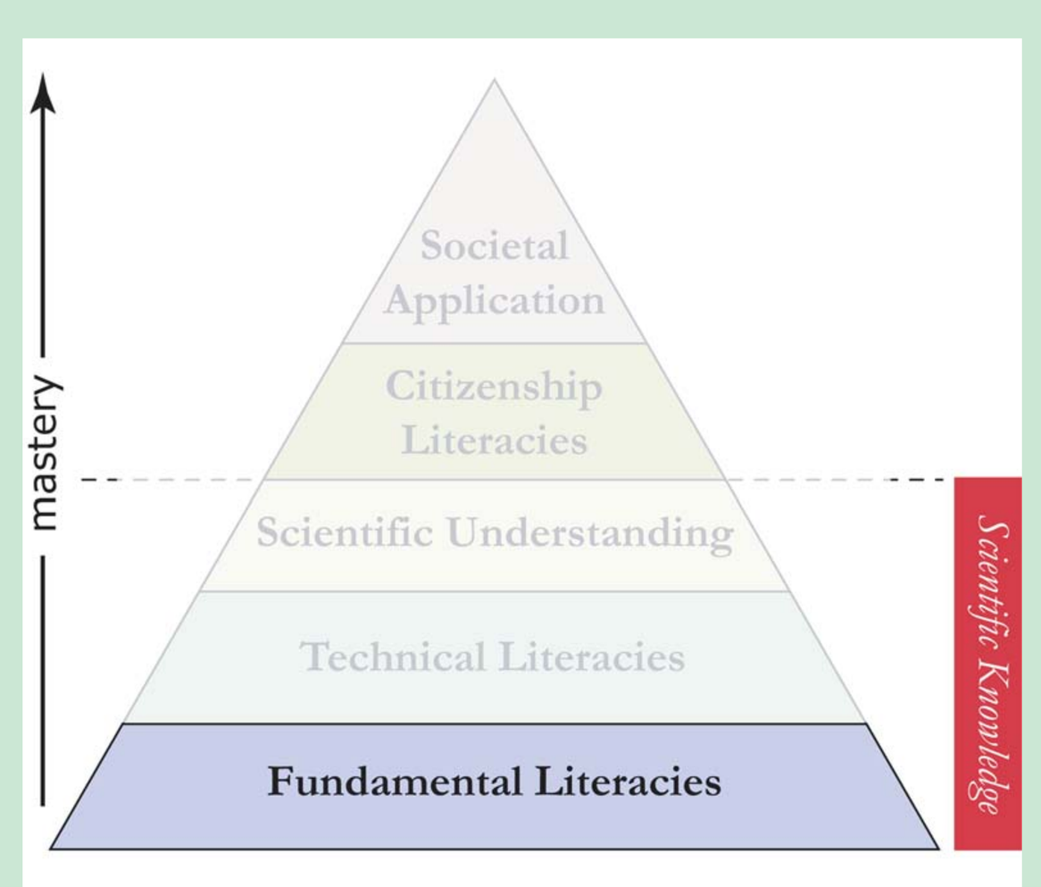


For each science, mastery of the technical and fundamental literacies along with scientific knowledge leads to scientific understanding. Armed with scientific understanding, individuals use the citizenship literacies to address societal problems in a systematic, rational and logical manner.

Literacies: Going from Scientific Knowledge to Scientific Understanding to Societal Application

Fundamental Literacies

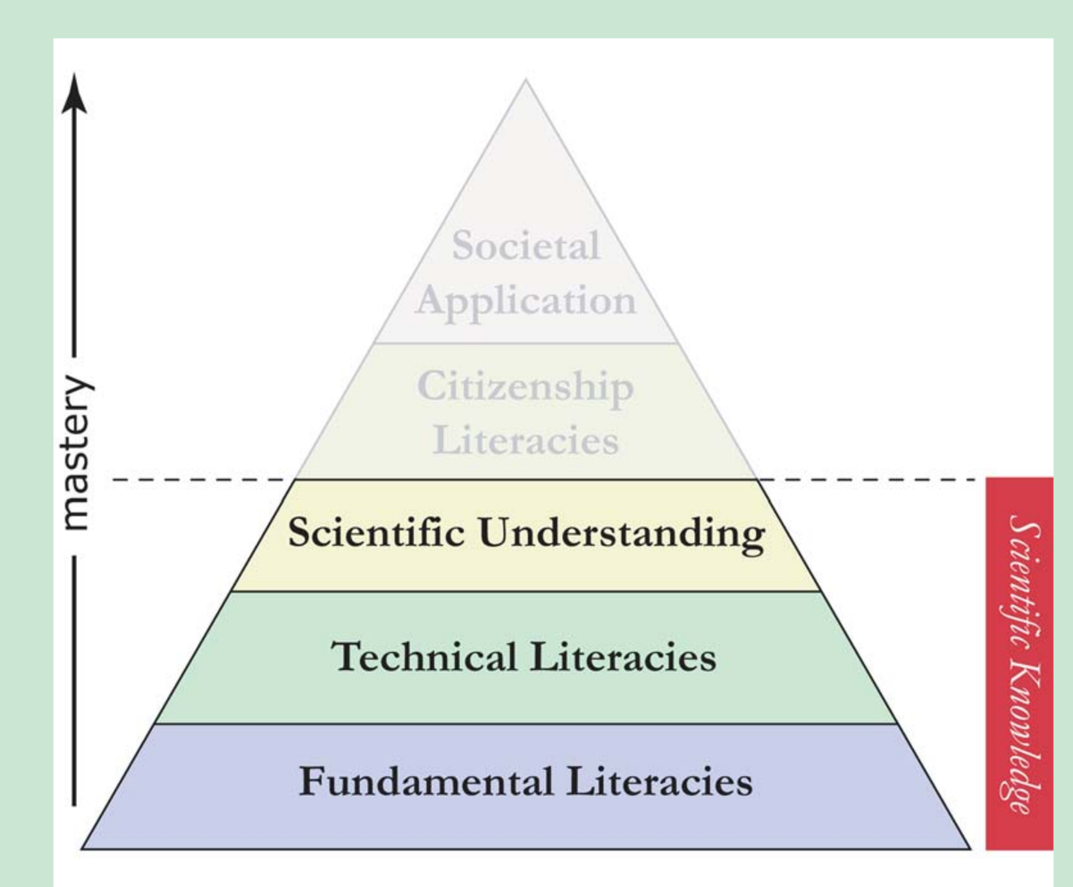
Scientific investigations use large data sets, require assessing qualitatively the relative importance of different variables, and necessitate performing simple quantitative calculations. These skills encompass the fundamental literacies. They are crucial in nearly all endeavors, not just scientific ones. Although students are likely to have been exposed to the fundamental literacies previously in their academic careers, they typically enter an introductory science course with a weak mastery of them. This lack of proficiency may reflect a lack of recent practice or failure to master them when first introduced. Commonly, instructors implicitly assume students know these literacies and are comfortable using them. Unfortunately, most students resist using them. This lack of proficiency often prevents students from concentrating fully on the scientific content and represents a major obstacle to learning.



- power to *read* a table or *interpret* a graph or chart
- facility to *make* qualitative assessments
- capacity to *perform* simple quantitative calculations

Technical Literacies

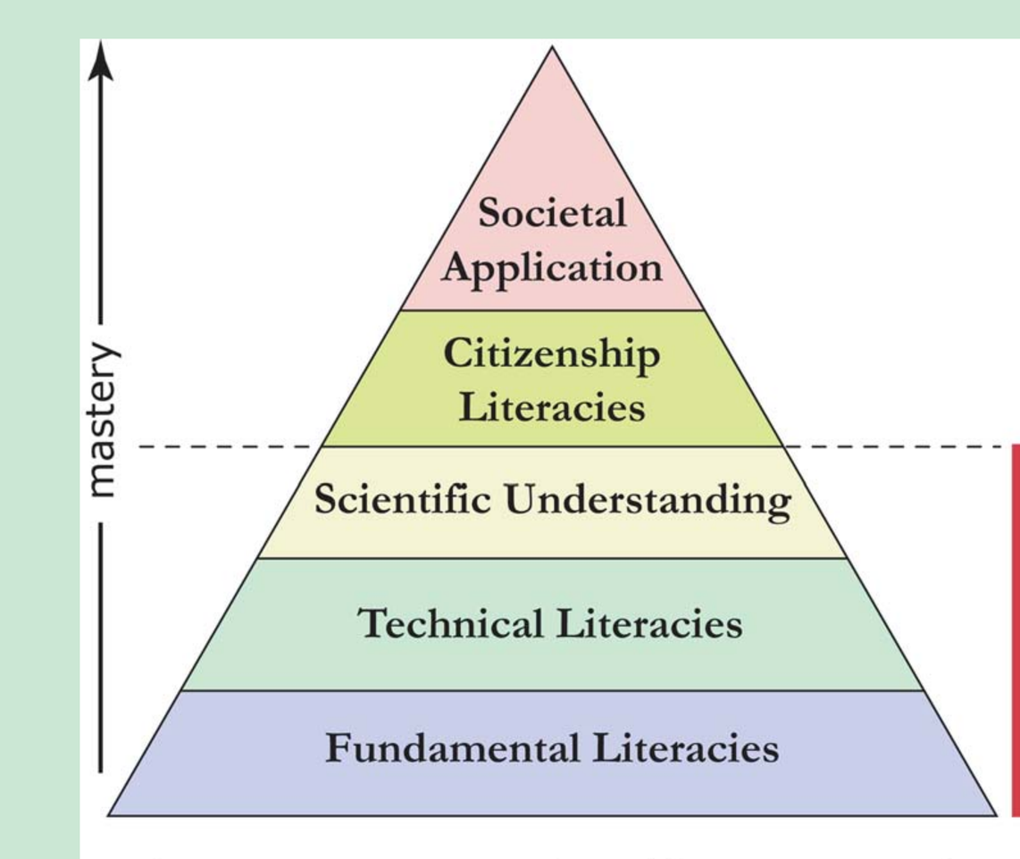
The geosciences investigate physical objects of varying scale that occupy space and change over time. Thus, one must be able to visualize large geologic structures that cannot be viewed directly as well as conceptualize how geologic processes acting over time can change such objects. Because of geology's spatial nature, one must also be able to read a variety of map types. Students must "read" block diagrams, geologic cross-sections and projection planes. Mentally, they need to be able to rotate objects in space, slice them apart and image their interiors. Unlike with the fundamental literacies, few students have had extensive experience with these intellectual tasks. Yet, a quick scan of any introductory geology text demonstrates the importance of these literacies in understanding and applying geologic principles. Without explicit assistance with these skills, they represent a significant barrier to student success.



- skill to *read* different types of maps, e.g. topographic, geologic, etc.
- ability to *visualize* in three dimensions
- capacity to *conceptualize changes* through time

Citizenship Literacies

Despite the view of some scientists and technocrats, the 'scientific answer' to a societal problem or issue, e.g. nuclear power, may not be acceptable for a variety of reasons. Finding a workable solution to such issues requires examining them from a variety of viewpoints, e.g. scientific, political, social, economic, cultural, etc. The citizenship literacies are a group of skills or tools that allow citizens/students to take their 'scientific' analysis of an issue and temper it with the realities of life. Citizenship literacies allow students to place resource extraction and use in a broader social context by considering historical background, population demographics, economic context and social and cultural structure. At the same time, critical thinking skills coupled with a broad geologic understanding of a resource allows individuals to identify hidden and shared costs, predict consequences and recognize potential impacts.



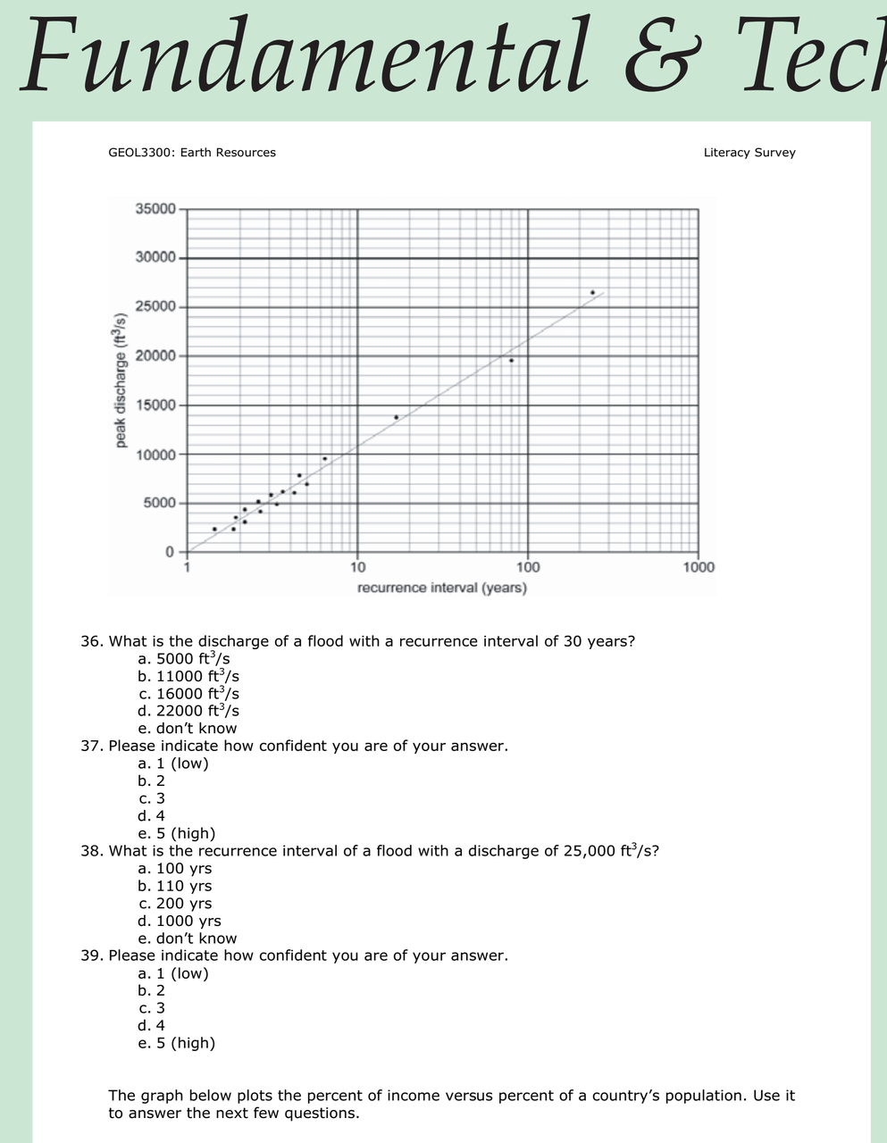
- ability to place resource use in social context
- capacity to use critical thinking to evaluate individually specific resource issues

Assessing Literacy Proficiency: The Surveys

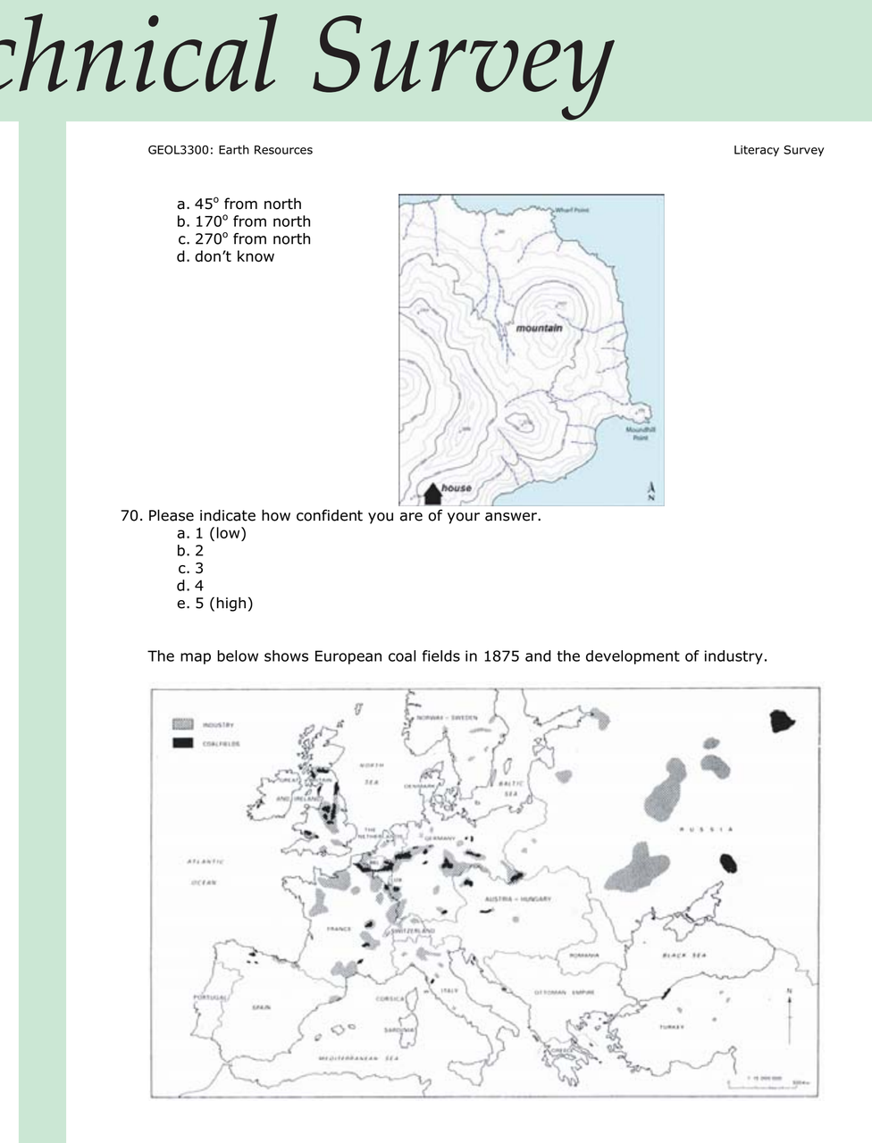
Literacy Survey

At the course's start and end, students complete the fundamental and technical survey in lab. It tests students' skill level in each literacy component. The survey also asks them to assign a confidence level to each answer. The initial survey also collects student background data. Answers and responses are recorded on bubble sheets that are scanned for SPSS analysis. This survey has been administered three times in the past three years. To date, the citizenship survey has not yet been conducted. Preliminary testing with the FIPSE working group suggested potential problems with its length and depth.

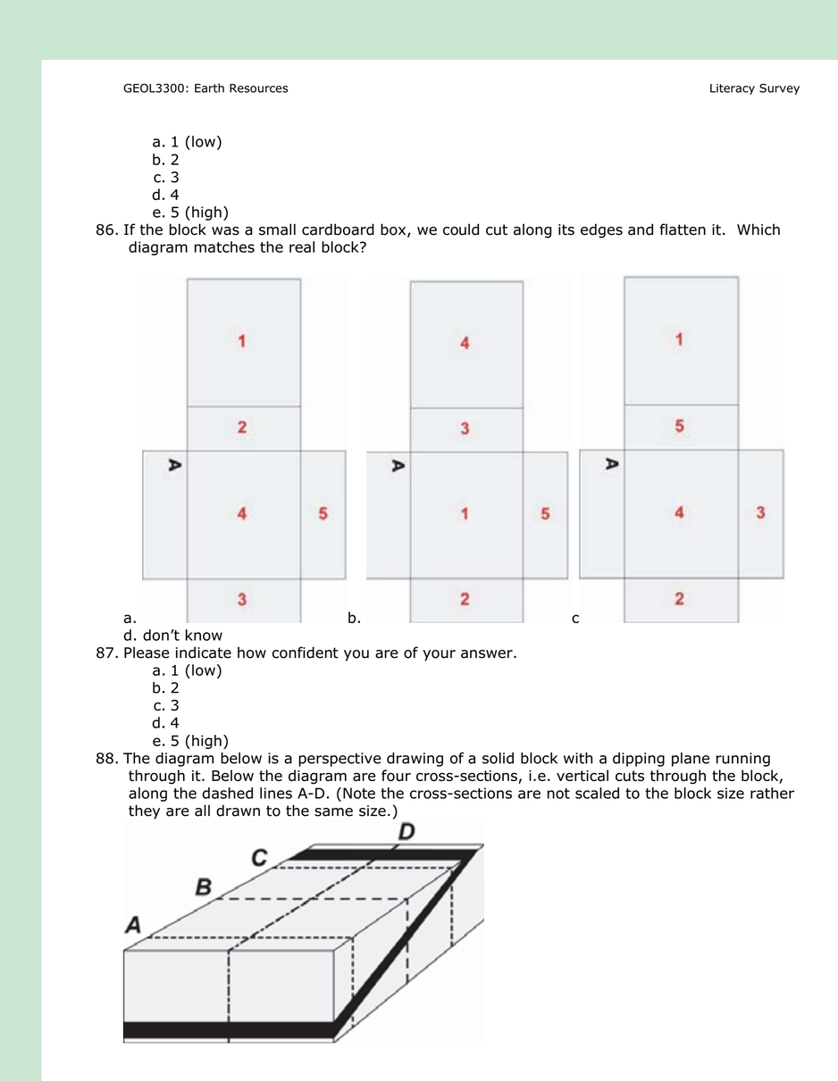
Fundamental & Technical Survey



These questions ask students to interpret flood recurrence data plotted on a semi-log graph. Other fundamental literacy questions require students to read tables and charts, make simple quantitative calculations and qualitatively assess the effect of changing different variables

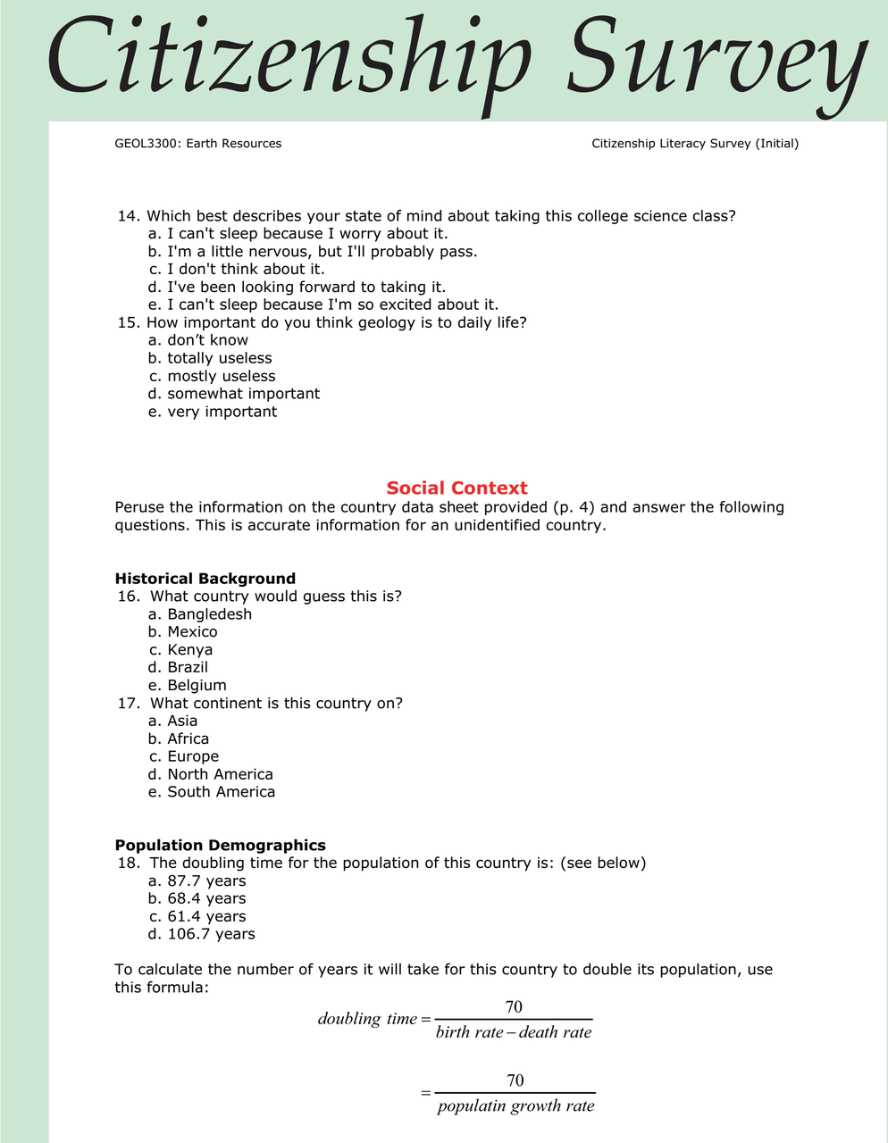


Maps are critical to understanding many geologic principles. In the fundamental and technical survey, we ask students several questions about maps, particularly contour and topographic maps. As the bottom map illustrates, we also assess student's ability to interpret non-geologic maps.

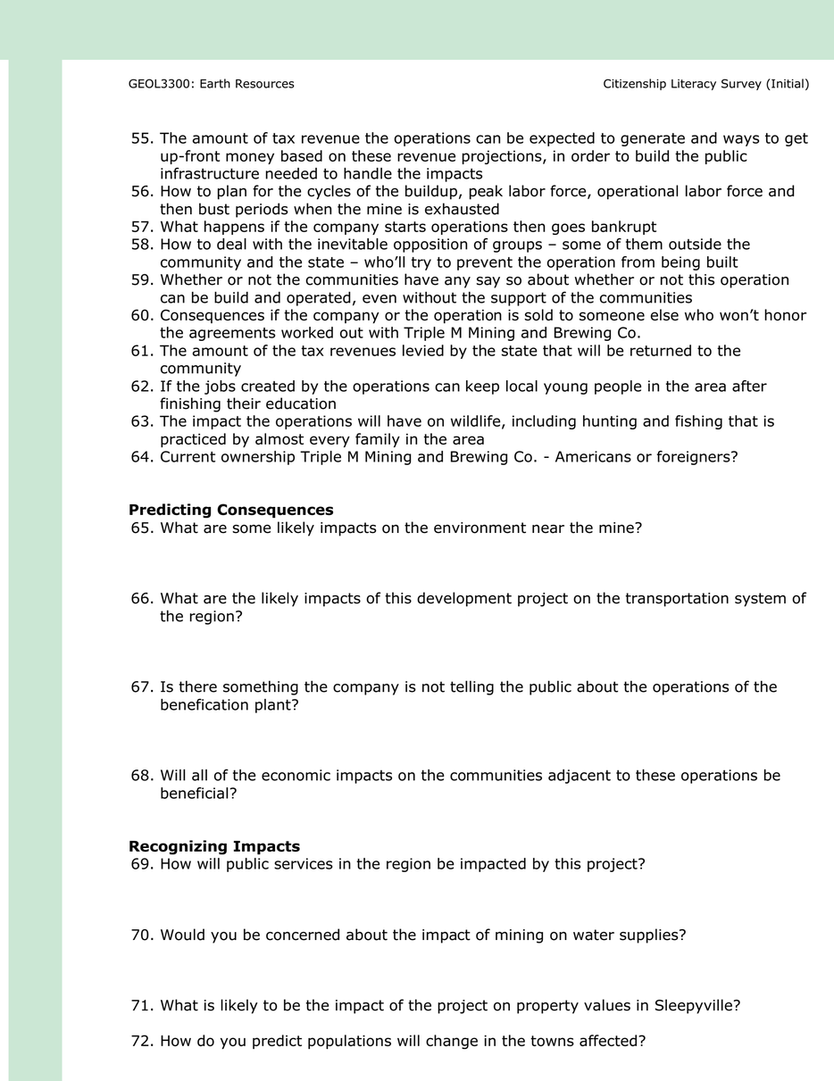


Visualization skills are also addressed by the fundamental and technical literacy survey. The bottom diagram tests a student's ability to visualize the interior of a solid object. Other questions require students to transfer 3-D observations to a two dimensional surface, i.e. paper, and to unfold 3-D objects.

Citizenship Survey



One section of the citizenship survey, part of which is shown above, concentrates on a student's ability to identify the social context in which resource extraction might occur. Thus, we assess their ability to interpret a statistical snapshot of a region or nation. Such data are critical for evaluating impact.



Another section of the citizenship survey focuses on critical thinking skills. It assesses students' ability to use their geologic knowledge to identify hidden and shared costs, predict consequences, recognize impacts and suggest alternative strategies to resource extraction and use.

Summary

- converting scientific knowledge to scientific understanding that can be used to address societal problems requires mastering a set of literacies
- literacies fall into three classes: fundamental, technical, and citizenship
- most students probably have been introduced to fundamental literacies, but they may have not used them for a while or ever mastered them
- technical literacies vary with scientific discipline and may be new to a majority of students
- citizenship literacies allow students to use their geologic knowledge to address societal issues associated with resource extraction or hazards
- our literacy surveys allow us to assess any improvement in the literacies students may have gained during our courses

The UW FIPSE project has provided us with the opportunity to identify the literacies students need to convert scientific knowledge into scientific understanding and to apply this understanding to societal issues of geologic import. Our course redesign explicitly emphasize these literacies along with traditional geologic content. To assess the impact of our redesigned courses, we have developed pre- and post-surveys that have been taken by students enrolled in Earth Resources in 2003, 2004 and 2005. Initial survey results suggest: 1) students have limited mastery of literacies prior to the courses; 2) students' confidence in their literacy abilities has little relationship to their actual level of ability; and 3) there has been some improvement in literacy proficiency after the course.