

Assessment of Majors/General Education Competency Template

Assessment of Scientific Reasoning

Program/Department: Natural Sciences

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Key Learning Outcomes: What should students be able to do AFTER completing this program? State learning outcomes simply and in measurable terms. Please limit the number of outcomes to five or fewer. If your department reports on General Education competency areas (writing, foreign language, quantitative reasoning, scientific reasoning), please use this form to report on those areas in a separately generated document.

Learning Outcomes

The Department of Natural Sciences will provide courses that promote the development of scientific literacy skills. Specifically, graduates will demonstrate scientific reasoning skills necessary to evaluate data common to popular publications. We define scientific reasoning as being able to:

- Make statements about the natural world based on objective data and observations
- Reject any statement that is inconsistent with or unsupported by data and observations
- Generalize statements based on data and observations in order to identify trends and relationships in nature
- Seek out confirmation of generalizations with further observations or controlled experiments
- Use confirmed conclusions to make logical predications that can be tested experimentally, supporting or rejecting original conclusions

Please link learning outcomes to the College's Desired Accomplishments/Goals

All outcomes can be linked to 1.1, 1.2, 1.5, and 3.3.

Through what courses/assignments will you ensure that all students have the opportunity to learn this? List key courses, capstones, internships, experiences, etc.

Beginning Spring Semester 2006, students will complete the scientific reasoning instrument during their general education science courses. Courses recognized as fulfilling the general education requirement in science include the following:

ASTR 101, 301
BIOL 103, 104, 160, 180
CHEM 100, 101, 102, 255
GEOG 201

GEOL 101, 314, 324
NASC 100, 101

Please list all tools used for assessing student achievement (CRTs, MFTs, capstones, exit interviews, external reviews, etc.) and frequency of testing.

Scientific reasoning exams will be given each semester in each of these courses as a required portion of the course final exam. Scores from the scientific reasoning test will not count toward the course grades, but will be used solely for assessment purposes. The highest score for each student will be used as their final scientific reasoning assessment. A score of five (5) or higher will be considered competent in scientific reasoning, and a score of eight (8) or above will be considered highly competent.

How will you assess how well your students are learning? List standards/performance indicators, etc., taking care to provide quantifiable means (for example, all students should earn a minimum 50% on exit exam; 65 % should earn a minimum 70%; with a rubric, indicate the scale used, the levels of competence, what is identified as “competent,” and what constitutes competence for each outcome measure, what percentage of students you would expect to see at each level, etc.). Be sure to spell out criteria.

Assessment of Competency in Scientific Reasoning

100% of students will achieve a score of five (5) or higher on the scientific reasoning test (competent), at least 65% of graduates will achieve a score of six (6) or higher on the scientific reasoning test (more than competent), and at least 15% of graduates will achieve a score of eight (8) or higher (highly competent).

Action Plan: What plans have you for the future based on the data gathered that will aim to improve student learning/achievement? Should students perform at less than the standard expected, what steps will the department take to improve their learning/performance? What steps does the department anticipate to improve the program otherwise?

Data Analysis and Action Plan

In order to fully assess the effectiveness of the curriculum in the Department of Natural Sciences in developing scientific reasoning skills, specific types of data will need to be provided to faculty members. These include descriptive statistics (i.e., measures of central tendency and dispersion) for all students taking the scientific reasoning instrument during each semester in which the test is given, and a collective item analysis for each student completing his/her degree at the College.

1) These data analyses will be examined on a yearly basis by faculty committee comprised of all disciplines represented the Department of Natural Sciences in order to more specifically identify deficiencies in the curriculum regarding scientific reasoning skills.

2) Items on the Scientific Reasoning Instrument which the majority of non-competent students answered incorrectly will be examined to determine whether the items were missed due to an anomaly on the instrument itself.

3) The concepts addressed by legitimately missed test items will be evaluated by means of ongoing curricular revision in the science courses listed previously.

In order for this process to be effective, these revisions must be continuous and supported by all faculty in the department. It is the goal of this assessment process to identify student needs in scientific reasoning, work to better address those needs in our curriculum, and develop a process of continuous evaluation and improvement of the program areas in the Department in order to benefit all graduates.

State Council in Higher Education in Virginia (SCHEV)
 Scientific Reasoning Instrument
 Fall 2005

Name: _____

SSN: _____

Year in College (circle one) Freshman Sophomore Junior Senior

This is my (circle one) 1st 2nd 3rd 4th college science course

Major or Probable Major is: _____

This test does not assume any prior scientific knowledge, but tests, rather, scientific reasoning.

Please use the information contained in the table below to answer questions 1-10 on the following pages.

The values in the table below represent the concentrations of some ions and dissolved gases (labeled A-F) sampled from various depths in the sediment that has accumulated at the bottom of the ocean. A depth of 0 centimeters (cm) represents the top of the sediment. The concentrations are expressed in parts per million (ppm). The acidity of a solution is represented on a scale known as pH. A pH of 1 is very acidic, a pH of 7 is neutral, and a pH of 14 is very basic. Using the information in the table, answer the questions below.

Depth (cm)	Temperature (°C)	pH	Concentration in sediment (ppm)					
			A	B	C	D	E	F
0	4	7.0	7.0	0.0	1.0	0.5	4.0	2.0
5	5	6.5	5.0	2.0	1.5	1.5	3.0	1.0
10	7	6.0	3.5	3.5	2.0	2.0	2.0	0.0
15	9	5.5	3.3	3.8	3.0	3.8	0.8	0.0
20	10	5.0	3.0	4.0	1.0	4.0	0.5	0.0

(Table adapted from R.M. Atlas and R. Bertha, 1981, *Microbial Ecology: Fundamentals and Applications*, by Addison-Wesley Publishing Company.)

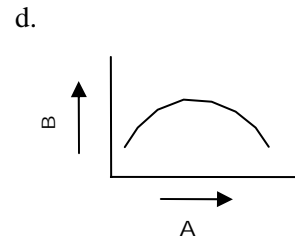
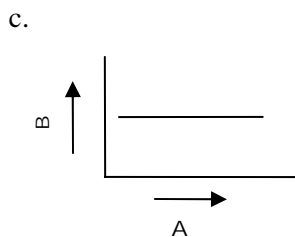
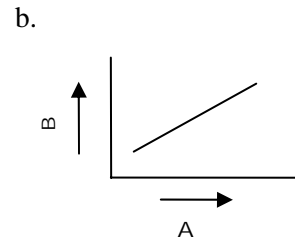
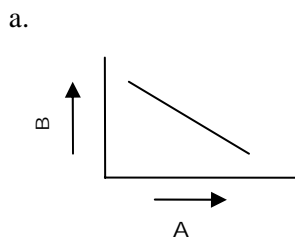
1. What is the general change in concentration of A as depth in the sediment increases?
 - a. It increases
 - b. It decreases
 - c. It remains constant
 - d. Cannot be determined

2. Which ion or gas has its maximum concentration at a depth of 15 cm in the sediment?
 - a. B
 - b. C
 - c. E
 - d. F

3. A sediment-dwelling microorganism is known to favor slightly acidic conditions with high concentrations of C, low concentrations of F, and high concentrations of D. At what sediment depth should this microorganism be the most plentiful?
- 5 cm
 - 10 cm
 - 15 cm
 - 20 cm

4. If the trends indicated in the table were to continue, one would predict the temperature of the sediments at a depth of 35 cm to be approximately:
- 3 C
 - 6 C
 - 8 C
 - 15 C

5. Which of the following graphs most accurately illustrates the relationship between the concentrations of A and B? The arrows point in the direction of increasing concentration for both ions.



6. Predict the temperature of the water immediately above the sediment.
- 0 C
 - 4 C
 - 10 C
 - 32 C

7. Which of the following statements could be tested using only the data in the above table?
- pH values near 7.0 are best suited for animal life.
 - Areas with low concentrations of F always have high temperatures.
 - It is possible to have pH values less than 6.0 when F is not present.
 - Changes in temperature directly cause changes in the concentration of A.

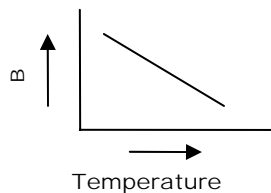
8. To better understand the affects of various ions and gases on living organisms within the sediment just below the ocean floor, a scientist developed a series of experiments. The scientist predicts that:
- Temperature within the sediment increases with increasing depth of the sediment below the ocean floor.
 - The concentration of E always decreases with increasing concentrations of D.

If the data from the table above were all that were available to you, which of the following statements is correct?

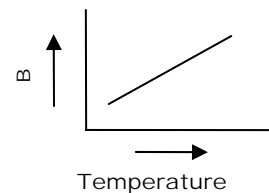
- a. Both predictions are likely to be supported by further experiments.
 - b. Only the first prediction is likely to be supported by further experiments.
 - c. Only the second prediction is likely to be supported by further experiments.
 - d. Neither prediction is likely to be supported by further experiments.
9. A scientist believes that many microorganisms live in the sediment just below the ocean floor. She says that these organisms consume F and release C. She also claims that these organisms should live about 5-15 cm below the water-sediment boundary and evidence may already exist to support her predictions. What would be your response to her statements?
- a. The data support her statements.
 - b. The data do not support her statements.

10. Which of the following graphs most accurately illustrates the relationship between temperature and the concentration of B? The arrows point in the direction of increasing temperature and concentration.

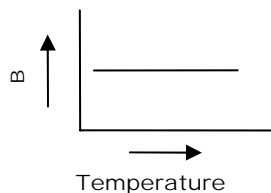
a.



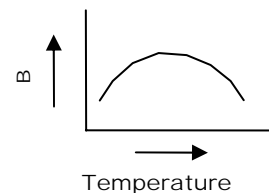
b.



c.



d.



Please use the information contained in the following passage (taken in part and with permission from *The Austin Chronicle*, Austin, TX) to answer questions 11-15 on the following pages.

According to the U.S. Environmental Protection Agency, every single fish sample caught in Texas lakes was contaminated with mercury, with 57% deemed dangerous for women of childbearing age. Nationwide, the stats weren't much better, as 76% of fish sampled surpassed safe limits for children under 3. Nationwide, at least 45 states have issued fish advisories because of mercury contamination (including Virginia). The culprit? Power plant emissions, specifically from those that burn coal, account for the bulk of mercury in the atmosphere. Once airborne, it falls into our water as methyl mercury, which is ingested by the fish. Cerebral palsy, mental retardation, deafness, and blindness are all side effects of high levels of exposure to methyl mercury, while far lesser amounts pose the risk of learning disabilities and motor-skill difficulties for 630,000 children annually. Another study, by the Mount Sinai Medical School, estimated that mercury pollution costs the U.S. economy \$8.7 billion a year in lost productivity by exposed children. (By comparison, that is about twice the value of all coal mined in West Virginia every year, according to industry figures.) In keeping with President Bush's Clear Skies Act, which attempts to roll back the bulk of 1990's Clean Air Act signed by his father, the EPA has worked to slow implementation of stricter emissions standards until 2018. The Clear Skies plan is "literally suggesting that we take mercury out of the Clean Air Act and regulate it as nonhazardous. Something that causes brain damage in children is certainly hazardous."

11. Within the context of the article, which of the following statements would be appropriately addressed by a scientific investigation?
- The newer Clear Skies Act is better legislation than the older Clean Air Act.
 - The economic benefit of coal mining far outweighs the human cost of mercury pollution.
 - Cerebral palsy can be caused by high mercury levels in a developing fetus.
 - The U.S. Environmental Protection Agency should not be the agency that determines appropriate mercury levels in public waterways.

The following questions have another purpose and will not be used for assessing scientific competency.

Although still utilizing the passage on the previous page, the following questions address your views and opinions and do not necessarily have a correct answer.

12. After reading the sentence from the above passage, "Cerebral palsy, mental retardation, deafness, and blindness are all side effects of high levels of exposure to methyl mercury...", the likelihood that I would want to see the sample sizes and/or funding source of the supporting research would be
- not at all likely.
 - somewhat likely.
 - likely.
 - extremely likely.
13. After reading the above passage, the confidence that I would have in finding scientific journal articles related to deafness and exposure to methyl mercury would be
- not at all confident.
 - somewhat confident.
 - confident.

d. extremely confident.

14. After reading the above passage, the likelihood that I would be interested in knowing the differences between the Clean Air Act and the Clear Skies Act would be

- a. not at all likely.
- b. somewhat likely.
- c. likely.
- d. extremely likely.

15. If I read this passage in a local newspaper about mercury pollution in the United States, the likelihood that it would affect my decision to vote in a local or national election based on the candidates' environmental position/policies would be

- a. not at all likely.
- b. somewhat likely.
- c. likely.
- d. extremely likely.