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Student Questionnaire

Northwest Center for Sustainable Resources (NCSR)
Chemeketa Community College, Salem, Oregon
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Questionnaire – Description and Purpose

This questionnaire has been developed to assist faculty in determining the effectiveness of an instructional unit (normally a term length introductory environmental science laboratory/field based course) in increasing student knowledge of the scientific process of gathering and using data. The instrument is designed to capture students' responses pre and post course. The changes of the aggregate mean score are used as a reflection of change in understanding of the scientific process and use of data to support conclusions based on these data.

The questionnaire should be administered to students prior to the start of instruction and at the end of the academic term. Only scores of students initially completing the questionnaire are used in calculating the post course mean. We have found the need to provide an incentive to students with an incentive to complete the questionnaire. The incentive we provide is a "gift certificate" for the College Bookstore. A certificate is provided for both the pre and post administration of the questionnaire.

NOTE: The purpose of the questionnaire is the scientific process not any specific knowledge in a scientific discipline.

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Student Questionnaire - Science as a Process

Northwest Center for Sustainable Resources

This questionnaire is designed to determine your understanding of how science answers questions about the world around us. Please answer each of the following questions directly on the questionnaire.

I. This section will test your ability to distinguish the "scientific" from the "non-scientific" and your understanding of the scientific process.

1. Below is a list of phenomena along with some brief descriptions. Rank each of them on a scale from 1 to 5, where "5" is "completely scientific with a strong basis in science" and "1" is "completely un-scientific - no basis in science". Enter a "0" for those terms you have never heard of before.

		Brief description
____	Astrology	The influence of planets and stars on human affairs (i.e., horoscopes, astrological signs, etc.)
____	Creationism	All things were created in their current form by an omnipotent creator
____	Global warming	Increased global temperatures due to increased greenhouse gases such as carbon dioxide
____	Intelligent design	The universe is so complex that it must have been designed by an intelligent entity
____	Animal cloning	The intentional production of genetically identical organisms
____	Crop circles	Complex circular patterns in wheat fields
____	Loch Ness Monster	The occurrence of a large, undescribed species in a Scotland lake
____	The Great Flood	The universal deluge in the days of Noah
____	Genetically modified organisms	DNA from one species inserted into a different species
____	Acupuncture	Ancient Chinese practice of healing by inserting special needles into the skin
____	Dinosaur fossils	The occurrence of bones of extinct creatures in rocks
____	Bermuda Triangle	The disappearance of ships and aircraft in the south Atlantic Ocean
____	Psychic phenomena	Seeing the future, ghosts, communicating with the dead
____	Herbal remedies	The use of plants (e.g., ginseng, echinacea) to treat human disease
____	Continental drift theory	Continents move and are in different positions now than they have been in the past
____	Atomic theory	Describes the internal structure of atoms (neutrons, protons, electrons, etc.)
____	Natural selection	"Survival of the fittest"

2. Which of the following statements best describes a "scientific theory"?

A. a prediction made by scientists prior to performing an experiment
B. a highly tentative explanation for an observed phenomenon
C. an opinion accepted by most scientists
D. a collection of ideas and concepts that best explain available data and observations
E. an educated guess based on the scientific method

3. Which of the following sources of information generally holds the greatest credibility for an environmental science-related issue?

A. an editorial in the New York Times
B. a peer-reviewed article in a science journal
C. a national radio talk show host
D. an opinion written by a well-respected scientist
E. a web site maintained by an environmental group

4. A scientist wishes to test the effects of different amounts of water and fertilizer on yields of corn. She has chosen a large agricultural field as her study site where her plants will receive the same amount of rainfall and sunlight and will be exposed to the same soil characteristics. In a series of field tests, she varies the supply of water and the amount of fertilizer applied to a given strain of corn and measures the weight of the corn crop that results. She predicts that moderate amounts of water and fertilizer will produce the greatest yields.

For this experiment, identify or describe each of the following in the space provided:

data - _____

hypothesis - _____

independent variable(s) - _____

dependent variable(s) - _____

controlled variable(s) _____

replicate - _____

5. Science is but one method that we have of "knowing things". Place a check (✓) beside those statements that properly characterize the process of science.

- ❑ Conclusions are based on an interpretation of the data
- ❑ Experiments are repeatable (i.e., the same experiment under similar conditions should yield similar results)
- ❑ Investigations are limited to observable phenomena
- ❑ Conclusions are based on authority
- ❑ Science can answer moral questions such as the abortion question
- ❑ Scientific explanations cannot be "supernatural" (i.e., they must adhere to what we already know about the world around us)
- ❑ Conclusions are based on consensus (i.e., an explanation is correct as long as everyone agrees to it)
- ❑ Explanations are based on evidence, not authority
- ❑ Explanations must be able to accommodate new information
- ❑ Theories cannot be modified even if new information becomes available
- ❑ Starts with a question or statement of a problem
- ❑ Tests hypotheses
- ❑ Conclusions are known before the study begins

6. Although scientists use a number of methods to answer questions, one process is called the "scientific method". Place the following steps in the scientific method in their proper order by entering the letter in the space provided:

____ **A. Analyze the data**
____ **B. State the question or problem**
____ **C. Perform an experiment**
____ **D. Make a prediction (i.e., a hypothesis)**
____ **E. Draw a conclusion from the data**

7. Rank the following examples of "evidence" in order of their credibility (1 = <u>most</u> credible, 5 = <u>least</u> credible). All examples are presented as supporting the contention that frogs are disappearing in the tropical forests of Costa Rica.

____ A. A remote site in Costa Rica that is reported by locals to have frogs was visited by scientists this year and found to have no frogs.
____ B. A 1980 scientific survey of 5 sites in Costa Rica found 110 frog species. An identical survey conducted in 2006 found only 17 species.
____ C. A Costa Rican scientist reports an increase in the number of frogs found dead on roads.
____ D. An environmental group claims that Costa Rican frogs are in trouble and they need our help.
____ E. A frog enthusiast keeps a diary of frog calls once a week for two years and notes a decrease in the frequency of frog calls over that time.

II. This section presents you with a hypothetical scientific study and then asks you to determine appropriate experimental design and proper methods for presenting and evaluating data. Place your answers in the space provided.

Dow Chemical has just developed a new chemical pesticide called *Nuke-em* that targets an insect pest of corn. It will be sprayed on corn plants when they are half grown and will probably increase yields for farmers. Before *Nuke-em* can go to market, the Environmental Protection Agency (EPA) requires Dow Chemical to demonstrate that the pesticide is safe for aquatic life. They are concerned that although the chemical will not be sprayed over water, the spray may drift into aquatic ecosystems or it may run off of agricultural fields into natural waterways.

The EPA solicits proposals from several scientists who will design experiments to determine whether or not *Nuke-em* is safe for aquatic organisms.

1. Scientist A plans the following:

He will place 500 rainbow trout in one large tank and 500 rainbow trout in a second, identical tank. He will then expose the trout in the first tank to *Nuke-em* at various concentrations and observe how many trout die over a one week period. The trout in the second tank receive no *Nuke-em*.

Scientist B plans the following:

She will place 1000 rainbow trout in a large tank and expose them to *Nuke-em* at various concentrations and then observe how many trout die over a one week period.

Which approach is best - that of Scientist A or Scientist B? _____

Explain why.

_____

_____

_____

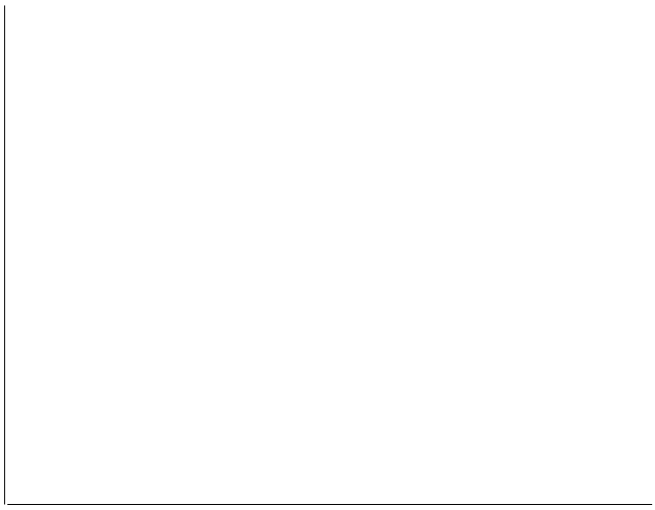
_____

2. Another scientist designs an experiment that tests *Nuke-em*'s effect on mosquito larvae, a common aquatic insect. Twenty aquatic tanks are established, each with a different concentration of *Nuke-em* and each with 500 mosquito larvae. The number of dead mosquito larvae in each tank is recorded after 24 hours. The data are recorded on the data sheet below:

Tank #	Concentration of *Nuke-em* (mg/l)	Number of Dead Mosquito Larvae
1	0	21
2	0.1	23
3	0.2	19
4	0.3	27
5	0.4	122
6	0.5	238
7	0.6	302
8	0.7	471
9	0.8	500
10	0.9	500

A. In the space below prepare a properly constructed graph that illustrates the effect of

Nuke-em concentration on mosquito larvae.



B. At what concentration do 50% of the mosquito larvae die? _____

C. Dow Chemical claims that *Nuke-em* is safe for aquatic organisms at concentrations of 0.0 to 0.5 mg/l. Do you accept this claim? Explain why or why not.

_____

_____

_____

_____

D. A 100 mg container of *Nuke-em* is accidentally dumped into a 1000-liter fish pond. Use the results of this study to predict the effects on mosquito larvae in the pond after 24 hours. Describe the logic you have used to make this prediction.

_____

_____

_____

_____

E. What do you think accounts for the 21 deaths in Tank #1?

_____

_____

_____

F. Explain the function of Tank #1 in this experiment.

_____

_____

_____

Science as a Process – Scoring Guide

Northwest Center for Sustainable Resources

I. Science vs. non-science (**one point each**)

		Brief description
1	Astrology	The influence of planets and stars on human affairs (i.e., horoscopes, astrological signs, etc.)
1	Creationism	All things were created in their current form by an omnipotent creator
4/5	Global warming	Increased global temperatures due to increased greenhouse gases such as carbon dioxide
1	Intelligent design	The universe is so complex that it must have been designed by an intelligent entity
4/5	Animal cloning	The intentional production of genetically identical organisms
1/2	Crop circles	Complex circular patterns in wheat fields
1/2	Loch Ness Monster	The occurrence of a large, undescribed species in a Scotland lake
1/2	The Great Flood	The universal deluge in the days of Noah
5	Genetically modified organisms	DNA from one species inserted into a different species
3/4	Acupuncture	Ancient Chinese practice of healing by inserting special needles into the skin
5	Dinosaur fossils	The occurrence of bones of extinct creatures in rocks
1/2	Bermuda Triangle	The disappearance of ships and aircraft in the south Atlantic Ocean
1/2	Psychic phenomena	Seeing the future, ghosts, communicating with the dead
3	Herbal remedies	The use of plants (e.g., ginseng, echinacea) to treat human disease
4/5	Continental drift theory	Continents move and are in different positions now than they have been in the past
5	Atomic theory	Describes the internal structure of atoms (neutrons, protons, electrons, etc.)
5	Natural selection	"Survival of the fittest"

2. D (**two points**)
3. B (**two points**)

4. For this experiment, identify or describe each of the following in the space provided (**two points each**):

   data – "numbers/observations recorded" or "weights of corn"

   hypothesis – "moderate amounts of water and fertilizer will produce the greatest yields"

   independent variable(s) – "manipulated variable" or "water and fertilizer"

   dependent variable(s) – "responding variable" or "weight of corn"

   controlled variable(s) – "variable held constant" or "rainfall, sunlight, soil, etc."

   replicate – "sites where experiment is repeated" or "5 local agricultural fields"

5. Science is but one method that we have of "knowing things". Place a check (✓) beside those statements that properly characterize the process of science. (**one point each**)

(✓) Conclusions are based on an interpretation of the data
(✓) Experiments are repeatable (i.e., the same experiment under similar conditions should yield similar results)
(✓) Investigations are limited to observable phenomena
❑ Conclusions are based on authority
❑ Science can answer moral questions such as the abortion question
(✓) Scientific explanations cannot be "supernatural" (i.e., they must adhere to what we already know about the world around us)
❑ Conclusions are based on consensus (i.e., an explanation is correct as long as everyone agrees to it)
(✓) Explanations are based on evidence, not authority
(✓) Explanations must be able to accommodate new information
❑ Theories cannot be modified even if new information becomes available
(✓) Starts with a question or statement of a problem
(✓) Tests hypotheses
❑ Conclusions are known before the study begins

6. Although scientists use a number of methods to answer questions, one process is called the "scientific method". Place the following steps in the scientific method in their proper order by entering the letter in the space provided:

__4__ **A. Analyze the data**
__1__ **B. State the question or problem**
__3__ **C. Perform an experiment**
__2__ **D. Make a prediction (i.e., a hypothesis)**
__5__ **E. Draw a conclusion from the data**

7. Rank the following examples of "evidence" in order of their credibility (1 = most credible, 5 = least credible). All examples are presented as supporting the contention that frogs are disappearing in the tropical forests of Costa Rica.

__2__ **A.**
__1__ **B.**
__4__ **C.**
__5__ **D.**
__3__ **E.**

II. This section presents you with a hypothetical scientific study and then asks you to determine appropriate experimental design and proper methods for presenting and evaluating data. Place your answers in the space provided.

1. Which approach is best - that of Scientist A or Scientist B? **Scientist A (one point)**

Explain why.

Scientist A uses a "controlled experiment" and will therefore, know that deaths in the second tank are likely due to the pesticide. Scientist B has a larger sample size but no means for comparison.
(3 points)

A. Graph

1. **Independent variable on X-axis/Dependent variable on Y-axis (2 points)**
2. **Data properly plotted (2 points)**
3. **Axes properly labeled (2 points)**

B. At what concentration do 50% of the mosquito larvae die? **Approximately 0.52 mg/l (accept 0.5-0.6 mg/l) (one point)**

C. Dow Chemical claims that *Nuke-em* is safe for aquatic organisms at concentrations of 0.0 to 0.5 mg/l. Do you accept this claim? Explain why or why not.

This claim should be questioned (one point)

Response should include some reference to their graph such as a comparison between deaths in experiment and concentrations within the range claimed "safe" by Dow Chemical (2 points)

D. A 100 mg container of *Nuke-em* is accidentally dumped into a 1000-liter fish pond. Use the results of this study to predict the effects on mosquito larvae in the pond after 24 hours. Describe the logic you have used to make this prediction.

Probably minimal effects (one point)

Logic:

First step requires proper calculation of resulting concentration (0.1 mg/l) (2 points)
Second step requires some comparison of <u>this</u> concentration to a <u>graphed</u> value (2 points)

E. What do you think accounts for the 21 deaths in Tank #1?

"Natural death" or "not *Nuke-em*" (one point)

F. Explain the function of Tank #1 in this experiment.

"**Tank #1 is a control" (one point)**
"For comparison" or some other description of the role of a control (one point)

Results of Pilot Test

The "Science as a Process" test was administered to 24 Environmental Science students in January 2006. Students were asked to complete the test outside of class and were presented with a $10 gift certificate to the college bookstore for a completed test. Respondents were also asked to rate the test for clarity and difficulty. Fourteen useable responses were obtained which are summarized below.

The test was also reviewed by four Chemeketa life science and physical science faculty members.
Their reviews were used to clarify test questions and to develop the attached scoring guide.

I. STUDENT PERFORMANCE

The average score was 69.1% (range 55-84%).

II. STUDENT EVALUATION OF THE TEST

1. Difficulty

A.	Extremely difficult	0
B.	Difficult	5
C.	Average	9
D.	Easy	0

2. Any confusing/poorly worded questions?

YES – 2
NO – 12

3. Which questions were confusing/poorly worded?

Question III

4. How long did it take to complete the test?

20 – 25 min.	2
26 – 30 min.	3
31 – 35 min.	1
36 – 40 min.	1
41 – 45 min.	3
46 – 50 min.	1
51 – 55 min.	2

As a result of the pilot test and reviews by faculty, the test was modified to its current form. A scenario-type question (Question III) in the original test that required students to develop an experimental design was omitted. Students performed poorly on this question and it was judged as "too difficult" by faculty reviewers.

FUTURE PLANS

The test will be administered in Fall 2006 to *Environmental Science* students at Chemeketa Community College during the first week of class. As in the pilot test, students will be awarded a $10 gift certificate to the bookstore for their complete participation. The test will also be administered at the end of Fall Term and at the end of Spring Term 2007 to test the hypothesis that enrollment and completion of the course results in an increase in "science literacy" as measured by this test.