



Developed by: Sufen Chen

Format: Pre/post, Multiple-choice, Agree/disagree

Duration: 15 minutes

Focus: Beliefs / Attitudes (nature of science, theories and laws, tentativeness, creativity, objectivity, subjectivity, scientific method, teaching the nature of science)

Level: Upper-level, Intermediate, Intro college, High school

How to give the test

- If you are interested in learning how your students' nature of science ideas change as a result of your course, give it as both a pre- and post-test.
 - Give the pre-test before you cover relevant course material.
 - Give the post-test at the end of the term.
- Use the whole test, with the original wording and question order. This makes comparisons with other classes meaningful.
- Make the test required, and give credit for completing the test (but not correctness). This ensures maximum participation from your students.
- Tell your students there are no right or wrong answers to any item and that the intention is to elicit their views on some issues related to nature of science. Tell them that correctness will not affect their grades (only participation). This helps alleviate student anxiety.
- For more details, read the **PhysPort Guides** on implementation:
 - **PhysPort VOSE implementation guide** (www.physport.org/implementation/VOSE)
 - **PhysPort Expert Recommendation on Best Practices for Administering Belief Surveys** (www.physport.org/expert/AdministeringBeliefSurveys/)

How to score the test

- The VOSE has 15 statements, each of which has 3-9 possible responses for students to agree or disagree with. Students may agree with more than one of the responses. There are no right or wrong answers, but each statement corresponds to a particular "position" on one or more subtopics of nature of science (NOS). The developer has created an extensive list of coding categories to "create an in-depth profile of a [student's] NOS views and educational ideas." For the coding categories, see the **PhysPort VOSE Implementation Guide** (www.physport.org/implementation/VOSE).

Views on Science and Education Questionnaire

Instructions to participants:

Each question of this questionnaire starts with a statement about the nature of science or science education. Most statements adopt a certain radical stance. You may strongly agree with it, strongly disagree with it, or have other thoughts about it. Each statement is followed by several responses. **Please read all of the responses first**, then circle your opinion on the right side (SD, D, U, A, SA) of each response according to your knowledge of scientific activities or scientists, or what ought to be taught in science courses. There is no right or wrong answer. Thank you.

SD= Strongly Disagree

D = Disagree

U = Uncertain or No Comment

A = Agree

SA = Strongly Agree

1. When two different theories arise to explain the same phenomenon (e.g., fossils of dinosaurs), will scientists accept the two theories at the same time?

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|---|----|---|---|---|----|
| A. Yes, because scientists still cannot objectively tell which one is better; therefore, they will accept both tentatively. | SD | D | U | A | SA |
| B. Yes, because the two theories may provide explanations from different perspectives, there is no right or wrong. | SD | D | U | A | SA |
| C. No, because scientists tend to accept the theory they are more familiar with. | SD | D | U | A | SA |
| D. No, because scientists tend to accept the simpler theories and avoid complex theories. | SD | D | U | A | SA |
| E. No, the academic status of each theory proposer will influence scientists' acceptance of the theory. | SD | D | U | A | SA |
| F. No, scientists tend to accept new theories which deviate less from the contemporary core scientific theory. | SD | D | U | A | SA |
| G. No, scientists use intuition to make judgments. | SD | D | U | A | SA |
| H. No, because there is only one truth, scientists will not accept any theory before distinguishing which is best. | SD | D | U | A | SA |

2. Scientific investigations are influenced by socio-cultural values (e.g., current trends, values).

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|--|----|---|---|---|----|
| A. Yes, socio-cultural values influence the direction and topics of scientific investigations. | SD | D | U | A | SA |
| B. Yes, because scientists participating in scientific investigations are influenced by socio-cultural values. | SD | D | U | A | SA |
| C. No, scientists with good training will remain value-free when carrying out research. | SD | D | U | A | SA |
| D. No, because science requires objectivity, which is contrary to the subjective socio-cultural values. | SD | D | U | A | SA |
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3. When scientists are conducting scientific research, will they use their imagination?

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|--|----|---|---|---|----|
| A. Yes, imagination is the main source of innovation. | SD | D | U | A | SA |
| B. Yes, scientists use their imagination more or less in scientific research. | SD | D | U | A | SA |
| C. No, imagination is not consistent with the logical principles of science. | SD | D | U | A | SA |
| D. No, imagination may become a means for a scientist to prove his point at all costs. | SD | D | U | A | SA |
| E. No, imagination lacks reliability. | SD | D | U | A | SA |
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4. Even if the scientific investigations are carried out correctly, the theory proposed can still be disproved in the future.

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|--|----|---|---|---|----|
| A. Scientific research will face revolutionary change, and the old theory will be replaced. | SD | D | U | A | SA |
| B. Scientific advances cannot be made in a short time. It is through a cumulative process; therefore, the old theory is preserved. | SD | D | U | A | SA |
| C. With the accumulation of research data and information, the theory will evolve more accurately and completely, not being disproved. | SD | D | U | A | SA |
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5. Is scientific theory (e.g., natural selection, atomic theory) “discovered” or “invented” by scientists from the natural world?

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|--|----|---|---|---|----|
| A. Discovered, because the idea was there all the time to be uncovered. | SD | D | U | A | SA |
| B. Discovered, because it is based on experimental facts. | SD | D | U | A | SA |
| C. Some scientists discover a theory accidentally, but other scientists may invent a theory from their known facts. | SD | D | U | A | SA |
| D. Invented, because a theory is an interpretation of experimental facts, and experimental facts are discovered by scientists. | SD | D | U | A | SA |
| E. Invented, because a theory is created or worked out by scientists. | SD | D | U | A | SA |
| F. Invented, because a theory can be disproved. | SD | D | U | A | SA |
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6. Is scientific law (e.g., gravitational law) “discovered” or “invented” by scientists from the natural world?

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|---|----|---|---|---|----|
| A. Discovered, because scientific laws are out there in nature, and scientists just have to find them. | SD | D | U | A | SA |
| B. Discovered, because scientific laws are based on experimental facts. | SD | D | U | A | SA |
| C. Some scientists discover a law accidentally, but other scientists may invent a law from their known facts. | SD | D | U | A | SA |
| D. Invented, because scientists invent scientific laws to interpret discovered experimental facts. | SD | D | U | A | SA |
| E. Invented, since there are no absolutes in nature, therefore, the law is invented by scientists. | SD | D | U | A | SA |
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7. In comparison to laws, theories have less evidence to support them.

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|---|----|---|---|---|----|
| A. Yes, theories are not as definite as laws. | SD | D | U | A | SA |
| B. Yes, if a theory stands up to many tests it will eventually become a law, therefore, a law has more supporting evidence. | SD | D | U | A | SA |
| C. Not quite, some theories have more supporting evidence than some laws. | SD | D | U | A | SA |
| D. No, theories and laws are different types of ideas. They cannot be compared. | SD | D | U | A | SA |
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8. Scientists' observations are influenced by personal beliefs (e.g., personal experiences, presumptions); therefore, they may not make the same observations for the same experiment.

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|---|----|---|---|---|----|
| A. Observations will be different, because different beliefs lead to different expectations influencing the observation. | SD | D | U | A | SA |
| B. Observations will be the same, because the scientists trained in the same field hold similar ideas. | SD | D | U | A | SA |
| C. Observations will be the same, because through scientific training scientists can abandon personal values to conduct objective observations. | SD | D | U | A | SA |
| D. Observations will be the same, because observations are exactly what we see and nothing more. Facts are facts. Interpretations may be different from one person to another, but observations should be the same. | SD | D | U | A | SA |
| E. Observations will be the same. Although subjectivity cannot be completely avoided in observation, scientists use different methods to verify the results and improve objectivity. | SD | D | U | A | SA |
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9. Most scientists follow the universal scientific method, step-by-step, to do their research (i.e., state a hypothesis, design an experiment, collect data, and draw conclusions).

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|---|----|---|---|---|----|
| A. The scientific method ensures valid, clear, logical and accurate results. Thus, most scientists follow the universal method in research. | SD | D | U | A | SA |
| B. Most scientists use the scientific method because it is a logical procedure. | SD | D | U | A | SA |
| C. The scientific method is useful in most instances, but it does not ensure results; therefore, scientists invent new methods. | SD | D | U | A | SA |
| D. There is no so-called the scientific method. Scientists use any methods to obtain results. | SD | D | U | A | SA |
| E. There is no fixed scientific method; scientific knowledge could be accidentally discovered. | SD | D | U | A | SA |
| F. No matter how the results are obtained, scientists use the scientific method to verify it. | SD | D | U | A | SA |
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10. Students in junior and senior high schools should learn the procedure of the scientific method.

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|---|----|---|---|---|----|
| A. Yes, so the students have guidelines to work within. | SD | D | U | A | SA |
| B. Yes, because the students are still incapable of coming up with more appropriate methods. | SD | D | U | A | SA |
| C. Yes, they should learn what scientists do. | SD | D | U | A | SA |
| D. Yes, because the scientific method is the best method that scientists have developed so far. | SD | D | U | A | SA |
| E. Yes, it helps the students to learn an objective way of studying science. | SD | D | U | A | SA |
| F. Yes, it could help the students to understand the essence of science. | SD | D | U | A | SA |
| G. No, we should not only teach one scientific method. Students should be given space to think and develop their own methods. | SD | D | U | A | SA |
| H. No, there is no so-called the scientific method. | SD | D | U | A | SA |
| I. No, the teachers and the students should brainstorm different research methods together. | SD | D | U | A | SA |
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11. In junior and senior high school science classes, when students are observing the same event, the teacher should expect the students to come up with the same findings.

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|---|----|---|---|---|----|
| A. Yes, the teacher should advise students to carry out objective observations to get identical findings. | SD | D | U | A | SA |
| B. Yes, if the students are careful enough, they should arrive at the same findings. | SD | D | U | A | SA |
| C. Yes, experimental facts will not differ with the person, thus no matter who makes the observation, the result will always be the same. | SD | D | U | A | SA |
| D. No, the observation will be affected by the students' preconceptions. | SD | D | U | A | SA |
| E. No, the teacher should discuss with the students how observation can be affected by preconceptions. | SD | D | U | A | SA |
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12. Students should understand that scientific knowledge may change.

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|---|----|---|---|---|----|
| A. Yes, so they realize the real nature of science. | SD | D | U | A | SA |
| B. Yes, so they realize the reason why science advances. | SD | D | U | A | SA |
| C. No, it will decrease the students' interest in learning science. | SD | D | U | A | SA |
| D. No, it will decrease the students' acceptance of science. | SD | D | U | A | SA |
| E. No, the students only need to learn about the constant fundamentals of scientific knowledge. | SD | D | U | A | SA |
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13. The science course in high school should investigate the definitions of and the relationships between hypothesis, theory, and law.

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|---|----|---|---|---|----|
| A. Yes, because they represent the structure of scientific knowledge. | SD | D | U | A | SA |
| B. Yes, because they are the fundamentals of scientific inquiry. | SD | D | U | A | SA |
| C. No, knowing the definition of and relationships between these terms does not help much in learning scientific knowledge. | SD | D | U | A | SA |
| D. No, because hypothesis, theory, and law lack definite meaning. | SD | D | U | A | SA |
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Please read carefully the following story about two scientists before answering the last two questions.

It is the year 2016. A and B are professors at a biotechnology center, and they are researching the selection and transfer of organic genes. If their project succeeds, humans will be free from congenital limitations. In addition to the total prevention of hereditary diseases, people will be free to choose and transfer eugenic genes. The human world will never again have congenital hereditary deficiencies. The research is already into the last step, but the general public opposes it, and even the institution itself has the intention of cutting back the budget. In fact A is already starting to question the continuation of the research. A is a devoted Christian, believing that God will open doors for everyone. Thus, even if people are born with various diseases and deficiencies, the diversity and unpredictability of humankind are what has created history. A doesn't believe that scientific development should change the core essence of a human being. Therefore, when socio-cultural values and beliefs of science are in conflict, choice should be made based on socio-cultural values because the ultimate values of science rely upon the "person" him/herself.

However, B doesn't think this way. B believes that the nature of science is absolutely objective, and that socio-cultural values are just like the public preference, always changing with the social environment, and are a very subjective representation of values. In other words, research that is rejected by today's socio-cultural values could become an aspiration of tomorrow. Therefore, it is unworthy and foolish to abandon the constant objective nature of science just for a fleeting subjective value. B and A start to fight over this matter. Finally, A chooses to withdraw from the research, but B chooses to continue developing it. Since giving up the well-developed research techniques would be very regrettable, A changes research interest to genetic selection and transfer of plants, in an attempt to choose a topic accepted by the dominant socio-cultural values. A eventually successfully transfers the anticancer genes from *Taxus mairei* to rye, creating anticancer rye. Looking back, A does not regret withdrawing from the project and believes that although the nature of science could be objective, the manifestation of the values should eventually return to the fundamental essence of "human beings."

B, persisting in continuing the original project, has received success on animal live-forms research, continuing on to do research on humans. B does not regret the choice either and even works harder on the project because of the belief that this story does not end here. The entire nature and value of the investigation will unfold in the future. It is left for history, rather than the contemporary socio-cultural values, to judge.

14. From the perspective of science education, what can junior/senior high school students learn from these two scientists?

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|--|----|---|---|---|----|
| A. A—scientists should have a conscience when doing research. | SD | D | U | A | SA |
| B. A—consider both scientific research and social values simultaneously. | SD | D | U | A | SA |
| C. A—scientific research cannot be totally divorced from socio-cultural values. | SD | D | U | A | SA |
| D. A—respect the diversity of people. | SD | D | U | A | SA |
| E. B—scientific research should be completely detached from personal beliefs. | SD | D | U | A | SA |
| F. B—scientific research should be completely detached from social subjective values. | SD | D | U | A | SA |
| G. Neither of them provides a good example to learn from because science courses should not involve value-choices. | SD | D | U | A | SA |

15. From the perspective of the nature of science, what aspects of A and B's thinking do you agree with?

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|--|----|---|---|---|----|
| A. A—scientists should have a conscience when doing research. | SD | D | U | A | SA |
| B. A—consider both scientific research and social values simultaneously. | SD | D | U | A | SA |
| C. A—scientific research cannot be completely divorced from socio-cultural values. | SD | D | U | A | SA |
| D. A—respect diversity in human beings. | SD | D | U | A | SA |
| E. B—scientific research should be completely detached from personal belief. | SD | D | U | A | SA |
| F. B—scientific research should be completely detached from subjective values. | SD | D | U | A | SA |
| G. B—persisting with the highest value of science—pursuing the truth. | SD | D | U | A | SA |
| H. Both, since they both have scientific spirit though they are influenced by personal values. | SD | D | U | A | SA |
| I. Neither, neither are objective enough since they are influenced by their personal beliefs and values. | SD | D | U | A | SA |
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