Unit 2: Lesson 5 – Vaccine Safety

LESSON QUESTIONS

- What are the main issues regarding vaccine safety?
- What is the scientific basis for issues regarding vaccine safety?

LESSON OBJECTIVES

- Describe the main issues regarding vaccine safety.
- Analyze the scientific basis for popular concerns about vaccine safety.

OVERVIEW

Students work in small groups to research online various topics related to vaccine safety issues. Students complete worksheets to evaluate the scientific basis for a vaccine safety concern. Each group creates a media resource that illustrates an issue about vaccine safety and its scientific basis. As a concluding class activity, students debate a motion.

LENGTH

One 45 minute session

GLOSSARY TERMS

assertion, assumption, autism, logical fallacy, misconception, myth, thimerosal, vaccine

STANDARDS

The Next Generation Science Standards for this unit align with three dimensions of learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. Standards reference "NGSS Science and Engineering Practices" and NGSS matrices including: "Connections to the Nature of Science," "Crosscutting Concepts in NGSS," "Connections to Engineering," and "Technology and Applications of Science."

- **Next Generation Science Standards**
    - Scientific Investigations Use a Variety of Methods
        - Science investigations use diverse methods and do not always use the same set of procedures to obtain data.
        - New technologies advance scientific knowledge.
        - Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.

- Scientific Knowledge is Based on Empirical Evidence
  - Science includes the process of coordinating patterns of evidence with current theory. Science arguments are strengthened by multiple lines of evidence supporting a single explanation.

- Scientific Knowledge is Open to Revision in Light of New Evidence
  - Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.
  - Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation.

- Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena
  - A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that has been repeatedly confirmed through observation and experiment, and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.

- Science is a Way of Knowing
  - Science distinguishes itself from other ways of knowing through use of empirical standards, logical arguments, and skeptical review.

- Science is a Human Endeavor
  - Technological advances have influenced the progress of science and science has influenced advances in technology. Science and engineering are influenced by society and society is influenced by science and engineering.

- Science Addresses Questions About the Natural and Material World
  - Not all questions can be answered by science. Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.
  - Empirical evidence is needed to identify patterns
  - Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.

- Science, Technology, Society and the Environment
  - Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications.

        - New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology.

    - Science and Engineering Practices
        - Select appropriate tools to collect, record, analyze, and evaluate data.
        - Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
        - Compare and evaluate competing arguments or design solutions in light of currently accepted explanations, new evidence, limitations (e.g., trade-offs), constraints, and ethical issues. Evaluate the claims, evidence, and/or reasoning behind currently accepted explanations or solutions to determine the merits of arguments.
        - Respectfully provide and/or receive critiques on scientific arguments by probing reasoning and evidence and challenging ideas and conclusions, responding thoughtfully to diverse perspectives, and determining what additional information is required to resolve contradictions.
        - Construct, use, and/or present an oral and written argument or counter-arguments based on data and evidence.
        - Critically read scientific literature adapted for classroom use to determine the central ideas or conclusions and/or to obtain scientific and/or technical information to summarize complex evidence, concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
        - Gather, read, and evaluate scientific and/or technical information from multiple authoritative sources, assessing the evidence and usefulness of each source.
        - Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.
        - Communicate scientific and/or technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).

- **Common Core State Standards**

    - RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account.

- RST.11-12.2 Determine the central ideas or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
- RST.11-12.5 Analyze how the text structures information or ideas into categories or hierarchies, demonstrating understanding of the information or ideas.
- RST.11-12.6 Analyze the author's purpose in providing an explanation, describing a procedure, or discussing an experiment in a text, identifying important issues that remain unresolved.
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
- RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
- RST.11-12.9 Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.
- WHST.11-12.1 Write arguments focused on discipline-specific content.
- WHST.11-12.1.A Introduce precise, knowledgeable claim(s), establish the significance of the claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that logically sequences the claim(s), counterclaims, reasons, and evidence.
- WHST.11-12.1.B Develop claim(s) and counterclaims fairly and thoroughly, supplying the most relevant data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form that anticipates the audience's knowledge level, concerns, values, and possible biases.
- WHST.11-12.1.E Provide a concluding statement or section that follows from or supports the argument presented.
- WHST.11-12.2.B Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

- WHST.11-12.6 Use technology, including the Internet, to produce, publish, and update individual or shared writing products in response to ongoing feedback, including new arguments or information.

- WHST.11-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

- WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

- WHST.11-12.9 Draw evidence from informational texts to support analysis, reflection, and research.

MATERIALS

- Student worksheet
- For Research and Evaluate Vaccine Safety activity (Activity 1), each student group will need:
  - Activity 1 sheet
  - Computer with internet access
  - Logical Fallacies Q & A resource

BACKGROUND FOR TEACHER

Since the mid-twentieth century, vaccines have been a widely-accepted scientifically-based method to safely and efficiently prevent serious childhood diseases. Indeed, significant drops in the incidence of once-common childhood illnesses such as measles, mumps, and chickenpox, are directly attributable to widespread vaccination programs. Vaccine technology helped to eradicate smallpox and polio is now practically unknown in developed countries. The advances have dramatically reduced infant mortality and eliminated costs of treatment and care associated with these diseases.
However, in recent years, a vocal minority of activists has increased public concerns about vaccine safety. While concerns should be tested scientifically, once studies have been completed, those concerns that are not borne out can be put to rest.

Unfortunately, scientific consensus sometimes gets lost in the public rhetoric:

- Cases or incidents cited by activists tend to be anecdotal.
- Valid scientific studies are either misunderstood, deliberately distorted or taken out of context.
- Activists often refute valid scientific data using logical fallacies, such as suggesting biases or conspiracies, using circular arguments, or intentionally presenting information in a misleading manner, among others.

These views can cause real harm as they deter parents from complying with recommended vaccine programs. In 2015, most of the 189 cases of measles cases reported in the United States were due to a single outbreak originating at a theme park in California. Nearly all such epidemics begin among unvaccinated people.
In this lesson, students are required to engage critical thinking in evaluating arguments and evidence related to vaccine safety and efficacy. To help their thinking, guide students to distinguish between a concern, a misconception, and an assumption.
Some issues may be more than one of these, or all three. For example, someone may believe that since diseases like measles and mumps have very low incidence, there is no need for children to be vaccinated. This erroneous belief is based on the assumption that just because a disease is eliminated in our country, we are safe. In fact, many other parts of the world may have epidemic levels of such diseases, and if we are unprotected, an outbreak of a disease could quickly spread here too. In another example, there is a widespread misconception that the vaccine ingredient thimerosal (a mercury-based preservative) causes autism. However, several studies have failed to find a link between mercury contained in vaccines and autism. In any case, thimerosal has been removed from most childhood vaccines.

Arguments are often based on logical fallacies, or errors in reasoning. For example, citing that many parents suspect vaccine ingredients can cause autism is an example of the bandwagon approach fallacy, where the false logic suggests that because many people believe something it must be true. Another example is evoking emotion to replace the discussion of facts. The resource used in this lesson teaches students about 15 different types of logical fallacies.

This lesson provides the opportunity to evaluate evidence for and against vaccine safety and to objectively assess these concerns. Prior learning provides students the scientific basis to understand the arguments for and against vaccine safety. Students should have learned about how the immune system works (Unit 1), how diseases try to circumvent the immune system (Unit 2, Lessons 1 and 2) and how vaccines are made and based on scientific discoveries that came before (Unit 2, Lessons 3 and 4).

TEACHER NOTES

This lesson will be most appropriate after students have completed prior lessons in Units 1 and 2. The information in the prior lessons will provide the scientific knowledge for successfully completing this lesson. Skills introduced in the lesson, mainly evaluating the quality of information found online, can be revisited through the year with other topics and

activities that lend themselves to it. By incorporating the critical thinking and assessment aspects of the activity to future lessons, students will have the opportunity to hone what has become an important life skill.

LESSON RESOURCES

- Lesson glossary
- "Vaccine Safety and Your Child: Separating Fact from Fiction", Vaccine Education Center at Children's Hospital of Philadelphia, http://media.chop.edu/data/files/pdfs/vaccine-education-center-vaccine-safety-eng.pdf
- Credibility Criteria for Evaluating Website Content, WHO, http://www.who.int/vaccine_safety/good_vs_sites/credibility/en/
- Content, Quality and Quantity Criteria for Evaluating Website Content, WHO, http://www.who.int/vaccine_safety/good_vs_sites/content/en/
- Accessibility and Design Criteria for Evaluating Website Content, WHO, http://www.who.int/vaccine_safety/good_vs_sites/accessibility/en/
- Logical Fallacies and Vaccines: What You Should Know (Q & A sheet), Vaccine Education Center at Children's Hospital of Philadelphia, http://media.chop.edu/data/files/pdfs/vaccine-education-center-logical-fallacies.pdf
- Evaluating Information: What You Should Know (Q & A sheet), Vaccine Education Center at Children's Hospital of Philadelphia, http://media.chop.edu/data/files/pdfs/vaccine-education-center-evaluating-info-qa.pdf
- Additional resources that may be helpful:
    - Evaluating Internet Health Information: A Tutorial from the National Library of Medicine (16-minute online tutorial),U.S. National Library of Medicine, https://medlineplus.gov/webeval/webeval_start.html#
    - Policy: Twenty tips for interpreting scientific claims, Nature, https://www.nature.com/news/policy-twenty-tips-for-interpreting-scientific-claims-1.14183
    - Vaccine Science: Evaluating Scientific Information and Studies, Vaccine Education Center at Children's Hospital of Philadelphia, http://www.chop.edu/centers-programs/vaccine-education-center/vaccine-science/evaluating-scientific-information-and-studies

ENGAGE

1. Ask a student if they have heard anything negative about vaccines.
2. Ask another student to state two positive facts about vaccines.
3. Students list any prior knowledge they have heard about vaccines, organizing the information into positive and negative aspects of vaccines.
4. Explain to students that they will be evaluating evidence about issues regarding vaccine safety.

EXPLORE 1

1. Have students research the vocabulary words as an assignment or have an in-class discussion to ensure students understand the lesson vocabulary.
2. Students work in pairs or small groups to research topics related to vaccine safety issues. Each student pair is assigned or chooses one of the following issues related to vaccine safety:
   - The MMR vaccine causes autism.
   - Kids get too many vaccines at one time.
   - The immune systems of infants are too immature to handle vaccines.
   - Vaccines contain harmful ingredients like aluminum.
   - Vaccines are made using aborted fetuses.
   - Vaccines contain harmful ingredients like mercury.
   - The HPV vaccine is not safe.
   - The flu vaccine causes flu.
   - Vaccines don't work because during an outbreak some vaccinated people get sick.
   - It is better to get natural diseases than vaccines.
3. Students should use the Research and Evaluate Vaccine Safety activity sheet (Activity 1) and the World Health Organization criteria to guide their research and assessment. Students should conceptualize and categorize safety issues as:
   - A concern
   - A misconception
   - An assumption
4. On the activity sheet, students list one or more assertions regarding their chosen issue. Alongside each assertion, students specify the source, and their evaluation of the reliability and credibility of the source based on the WHO criteria.
5. Groups discuss their findings using the questions on page 2 of the activity sheet to determine:
   - Whether or not the issue has been shown to be a problem based on their findings
   - The reliability and credibility of the resources
6. Groups draw conclusions about the validity of the concern based on their research findings and discussion.
7. Have groups save their worksheets from Activity 1 to use in Explore 2.

EXPLORE 2

1. Using their worksheets from Activity 1, have students choose two assertions determined to be unreliable.
2. Have groups use the logical fallacies Q & A resource to determine which, if any, type of error in reasoning applies to the incorrect assertions they previously identified. Students should note which fallacy applies next to the assertions on their Activity 1 sheets or transfer the assertions they are evaluating to a clean sheet of paper and indicate which fallacy type they think was used.
3. Have each group share one of their assertions and describe the logical fallacy that they assigned. Have the rest of the class evaluate the accuracy of their choice describing why they believe it to be correct or incorrect. If a group's assigned fallacy is determined to be incorrect, have a class discussion to figure out which type of fallacy is being used in the assertion.
4. If time allows, have the students role play to brainstorm ways to respond to someone who is using that logical fallacy.

EXPLAIN

1. Groups create a media resource that illustrates their chosen issue and its scientific basis as a Public Service Announcement. Example media resources include:
   - Poster
   - Slide presentation
   - Blog post
   - Brochure
   - Social media campaign
2. Groups present their findings to the class.

ELABORATE

1. Students debate a motion: On balance, vaccines are a benefit to society, citing their media resources and findings as evidence for their debate position.
2. Students write a passage on the results of the debate stating:
   a. Their initial position on the motion (e.g., for, against or neutral)
   b. Their final position on the motion
   c. Whether the debate changed their position and why

EVALUATE

1. Evaluate students based on their completion of Activity 1, media resource, and their participation in the class debate.

EXTEND

It is likely that during the first part of the activity (Explore 1), students will identify several unreliable resources. Have students brainstorm and discuss possible solutions around how to address the problem of finding reliable information, particularly on the internet. Potential discussion prompts may include:

- How to make sure parents who are trying to make vaccine decisions get the best information and are not confused by claims that are not scientifically-based.
- Other areas of science that seem to be controversial and whether the situation may be similar to vaccines.
- Where the responsibility rests in terms of ensuring that scientifically-sound messages reach the public.

RUBRIC: STUDENT WORKSHEET

Vocabulary table

- Refer to the lesson glossary for correct definitions of the terms.

RUBRIC – ACTIVITY 1 EXPLORE 1: Research and Evaluate Vaccine Safety

- Students should demonstrate an understanding that not all sources provide accurate information. They should be able to articulate what the differences are between reliable and unreliable sources of information and identify tools and methods for determining reliability. To determine whether students made accurate conclusions related to the specific vaccine issues, refer to the booklet, "Vaccine Safety and Your Child: Separating Fact from Fiction" in the resources section.

RUBRIC – ACTIVITY 1 EXPLORE 2: Identifying Logical Fallacies

- Students should demonstrate an understanding of the types of logical fallacies and identify how they are being used in different assertions. They should be able to explain why the fallacies cause an argument to be unsound. Use the logical fallacies Q & A resource to gauge students' understanding of how the fallacies invalidate different arguments.