ACTIVITY 5

Evidence of Well-Being

INVESTIGATION

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ACTIVITY SUMMARY

Students use the indicators of causation to analyze the strength of a set of evidence for one of the four proposed strategies to improve well-being at Salas High School. Each group evaluates the strengths and weaknesses of three pieces of evidence for a strategy and considers alternative explanations. Then, using a classroom jigsaw approach, students discuss the evidence and collaboratively arrange the strategies from weakest to strongest evidence.

ACTIVITY TYPE
INVESTIGATION

NUMBER OF
40–50 MINUTE
CLASS PERIODS
1–2

KEY CONCEPTS & PROCESS SKILLS

1. Confidence in a cause-and-effect relationship should depend on the quality, variety, and consistency of the evidence supporting it.
2. Indicators of causation include the timing of events, observed associations between variables, and plausible mechanisms for the possible cause and effect.
3. A likely alternative explanation for an effect reduces the probability that the cause being investigated is the correct one.

NEXT GENERATION SCIENCE STANDARDS (NGSS) CONNECTION:
Apply concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to scientific and engineering questions and problems, using digital tools when feasible. (*Science and Engineering Practice: Analyzing and Interpreting Data*)

CONCEPTUAL TOOLS

MATERIALS & ADVANCE PREPARATION

FOR EACH STUDENT

- STUDENT SHEET 5.1 (a, b, c, or d) "Evaluating Indicators of Causation"
- STUDENT SHEET 1.2 "Unit Concepts and Skills" (OPTIONAL)

In Part A, each student in a group of four will receive the same version of Student Sheet 5.1 (a, b, c, or d). Before the activity, decide which group will receive which version.

When previewing the graphs on Student Sheets 5.1a, 5.1c, and 5.1d, please note that all data points are simulated to match the given *r*-values.

TEACHING NOTES

Suggestions for **discussion questions** are highlighted in gold.

Strategies for the **equitable inclusion of diverse students** are highlighted in lime.

GETTING STARTED (10 MIN)

1 **Review key concepts about causal reasoning.**

- Have students read the Introduction in the Student Book, either as a class or individually. Support students, particularly emerging multilingual learners, in sensemaking and language acquisition as they read the text. Circulate around the room and check in with students as they use the strategy to decode scientific ideas and construct meaning as they read.
- At this point in the unit, students should be familiar with some of the bigger concepts in the unit including cause and effect, correlation, correlation coefficient, indicator of causation questions, and alternative explanations. Although this activity does not introduce any new content, it allows students to look further into the role of evidence in determining causation.
- Depending on your student population, you may want to conduct a word sort before starting the activity to make sure students have an understanding of the major themes they will need to complete this activity. This quick formative assessment presents two lists of words. In each list, one word is not related to the others, and another word encompasses the remaining words. The following two word sorts can be used to support a review of basic causation ideas. For more information on a word sort, see Appendix 1: Literacy Strategies.

LIST 1	LIST 2
correlation	timing
reasoning	assumption
causation	association
opinion	causal reasoning
evidence	alternate explanations
	mechanism

- In each list, look for a relationship among a list of five or six words or phrases related to a topic.
- Cross out the one word or phrase that does not belong.
- Highlight any word or phrase that includes all the other words.
- Explain how the highlighted word or phrase is related to all the other words or phrases in the list. (There may be more than one correct answer to a single word sort.)

Sample Student Response

LIST 1

correlation
reasoning
causation
~~opinion~~
evidence

Causation requires more than just a correlation; it is supported by evidence and reasoning.

LIST 2

timing
~~assumption~~
association
causal reasoning
alternate explanations
mechanism

Timing, mechanism, association, and alternative explanations are used in causal reasoning.

- Review the idea from the Introduction that when experiments aren't an option, scientists use different types of evidence—such as associations, timing, and mechanisms—to study cause and effect. Emphasize that scientists consider alternative explanations not just for correlations but also for timing and mechanisms. Let students know that they will practice this by analyzing evidence for each of the four well-being strategies Salas High School is considering.

PROCEDURE SUPPORT (20 MIN)

2 Students evaluate a set of Evidence Statements related to one well-being strategy.

- In Procedure Step 1, provide four copies of Student Sheet 5.1 (a, b, c, or d), "Evaluating Indicators of Causation," to each group (so each group member in a group gets the same student sheet). Each version of the student sheet focuses on one of the four proposed strategies for Salas High School. Let students know that they will be evaluating data from peer-reviewed scientific journals for all four strategies. Distribute the strategies as evenly as possible among groups and inform students that each group is responsible for becoming an expert on the evidence for their assigned strategy. For emerging multilingual learners and other diverse learners, it may be helpful to provide the student sheets in advance, have groups read the text aloud, or both.

- Before starting the activity, you may want to review the following ideas to help students assign a rating from 0 to 5 for the strength of each piece of evidence for their strategy:
  - The possible cause should occur before the possible effect.
  - Stronger correlations provide better evidence because they reduce the likelihood that the association is due to chance. However, even a strong correlation does not prove causation.
  - A reasonable mechanism strengthens the evidence more than a mechanism that is unlikely or unclear.
  - Alternative explanations are important in avoiding incorrect conclusions. Students should think about other possible reasons for the observed timing, correlation, or mechanism that could influence their ratings.

- In Procedure Steps 2–3, students work in their groups to complete their student sheets. Remind students that their ratings for the strength of evidence for each study should be based on the available information, even if the information is incomplete. Scientists often make evaluations with partial data. A rating of 0 means the evidence is irrelevant, while a rating of 5 means it is extremely compelling. Encourage students to use the numbers in between the range. The exact ratings for group members don't have to match, and there is no single correct answer. The goal is to practice evaluating evidence strength.

- If students find it difficult to choose a number to rate the strength of evidence, encourage them to reread the Evidence Statements and ask them the questions related to indicators of causation: *Does the possible cause come before the effect? How strong is the correlation? Is there a reasonable mechanism?* You can also ask, *What are alternative explanations?*

- For those students who may need extra support identifying the indicators of causation for each piece of evidence, help them highlight key terms in the Evidence Statements, such as *after* for timing or *many times* for association. When considering possible mechanisms, encourage students to focus on statements that include relevant scientific concepts, as these can help explain how one variable might cause a change in another.

3 Address misconceptions about alternative explanations.

- Before students move on to Part B, remind them to record any alternative explanations for one or more of the Evidence Statements. These should be possible explanations for one Evidence Statement, not alternative factors of well-being or explanations that cover all three Evidence Statements. Responses will vary, but one sample student response for each strategy is shown at the end of this activity.

- A common misconception about alternative explanations is that they are alternative causes for an *effect*, but they can also be alternative reasons for the *evidence*. For example, when considering how a bad mood may be caused by poor sleep or by being hungry, being hungry is an alternative cause for a bad mood. However, it is not an alternative explanation for the association between sleep quality and mood (unless hunger affects both sleep quality and mood separately). Ask, What is another possible explanation for the evidence? Students should see that answering this question illustrates that they should be looking for alternative explanations for the evidence, not alternative causes for the effect.

4 Use a jigsaw classroom approach to help students consider all the available evidence.

- In Part B, move students into new groups, making sure each new group has at least one "expert" representing each strategy. Students then compare the strength of the overall evidence for each strategy in their new groups.

- In Procedure Step 6, some groups may want to simply take the average of their group members' evidence ratings and arrange the student sheets based on those numbers, without any discussion. Encourage groups to go further by pointing out that group members may have used different criteria or expectations when rating their evidence. Therefore, students should explain and compare their thinking in evaluating the evidence. Point out that there is no one correct way to arrange the student sheets. Groups may come up with different sequences, and this is acceptable. Remind students that this process may result in a final order that does not match their previous ratings.

- The goal of this activity is for students to practice evaluating evidence and recognize the difficulties in doing so. The following sample student response shows only one possible sequence. Reasons for this sequence include the sample sizes used and the likelihood of alternative explanations.

Sample Student Response, Procedure Step 6

Strongest overall evidence	*Gratitude Writing (3.5)* *Quality Sleep (3.0)* *Pet Therapy (3.0)*
Weakest overall evidence	*Green Spaces (2.75)*

SYNTHESIS OF IDEAS (10 MIN)

5 Discuss the complexities of evaluating evidence to support causation.

- This activity asked students to apply what they have learned to novel questions and contexts. Ask, What were some of the difficulties in evaluating the evidence for causation? Student responses may include the idea that they were missing some background knowledge about these topics or that they were missing some details about study designs. Follow this with a question about the Salas High School scenario. Ask, How does what you've learned influence your thoughts about the choice of the four strategies? Students' responses should indicate that the strategies with stronger evidence are more likely to be effective treatments for well-being at Salas High School.

- An important takeaway from the activity is that evidence should not be evaluated simply by counting how many pieces of evidence there are, or whether there is at least one piece of evidence for each indicator of causation (timing, association, mechanism). Instead, each piece of evidence must be evaluated on its own merit, and then the multiple lines of evidence can be brought together. An example of this is when all three indicators of causation are present, yet each piece of evidence is very weak, and there are many possible alternative explanations.

- Build Understanding item 3 engages students in metacognition about why alternative explanations reduce the strength of evidence. This helps students understand the important function of looking for alternative explanations. A prompt that asks students to reflect on which well-being strategy would be most effective for their own lives is provided in Connections to Everyday Life item 4.

- You may wish to revisit optional Student Sheet 1.2, "Unit Concepts and Skills," to help students formally organize the ideas introduced in the unit so far. Students can place the headings of the main ideas related to correlation and causal reasoning into the organizer and add examples from their classroom experiences. See the end of Activity 1 in the Teacher's Edition for a sample student response.

- Foreshadow Activity 6 by letting students know they will be reading about other techniques that help make research findings stronger by focusing on the quality, variety, and consistency of the evidence.

- To conclude the activity, evaluate whether your students are able to answer the Guiding Question, *How do scientists use evidence to evaluate causation?* Use this as a chance to revisit and summarize the key concepts and process skills of the activity.

SAMPLE STUDENT RESPONSES

BUILD UNDERSTANDING

① **How does what you've learned about indicators of causation and alternate explanations influence your thoughts about the choice of the four well-being strategies for Salas High School?**

After learning about indicators for causation, I feel more confident in recommending strategies that have clear timing and mechanisms, like getting more sleep or spending more time in green spaces. The science behind sleep and its impact on well-being makes sense, and I can see how it works right away. Knowing that being in a green space might affect your nervous system to calm you is good evidence, too. On the other hand, green spaces did not show that strong of a correlation. Most importantly, when looking for alternative explanations, I realized that lots of other things, like personality or stress levels, can make it really hard to figure out how well the strategy works on its own.

② **In Activity 3, you explored questions about cause and effect in everyday life. In this activity, you applied those questions about causation to research on well-being. What are similarities and differences in how these questions are used in everyday life and in scientific research?**

In everyday situations and research, people use observations to understand what causes something to happen. The questions about causation help us figure out if one thing can cause another, and the answers are useful in both cases. However, research uses larger groups, precise measurements, and more reliable methods. Research also looks at more complex situations. In everyday life, we often rely on personal experience and assumptions because we don't need to be as careful when figuring things out.

③ **How do alternative explanations impact the strength of a piece of evidence about cause and effect? Explain your reasoning.**

They reduce the strength of the evidence because if another explanation could explain the result, then we can't be sure if the cause we are investigating was the reason for it.

CONNECTIONS TO EVERYDAY LIFE

④ **After learning about each of the four well-being strategies and considering what you know about yourself, which one do you think would be most effective for improving your own well-being? Explain why you believe it would work best for you.**

I believe more sleep would work best for me. I know I feel tired all the time, and I've noticed that when I don't get enough sleep, I'm more moody and less focused. If I could improve my sleep schedule, I think I'd be more energetic and in a better mood during the day. I've read that sleep helps with mental health, so I think it could really help me.

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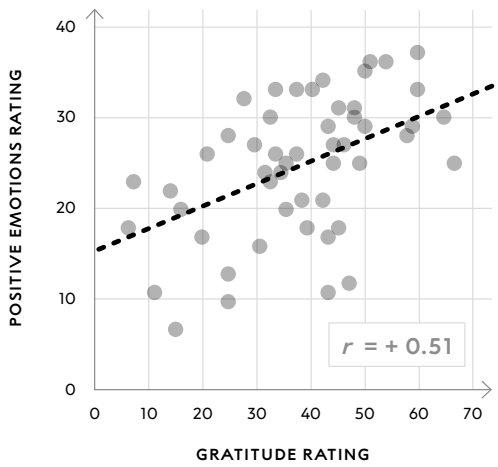
Well-Being Strategy: Gratitude Writing

CAUSE-AND-EFFECT CLAIM: **Gratitude increases positive emotions.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 A study of 77 romantic couples showed that when one partner recorded a video to express their gratitude and the other partner watched it, couples felt a stronger connection to each other. Social connection is closely linked to many aspects of well-being.		
Study 2 In a study with 132 college students, one group was asked to write once a week about things they were grateful for, while the other group wrote about any events. Afterward, the students in the gratitude group reported feeling more satisfied with their lives, had a more positive outlook on the future, and exercised more than those in the other group.		
Study 3 The scatter plot shows the correlation from a study of 201 college students on gratitude and positive emotions.  		

What is an alternative explanation for one or more of the Evidence Statements described above?

Well-Being Strategy: Pet Therapy

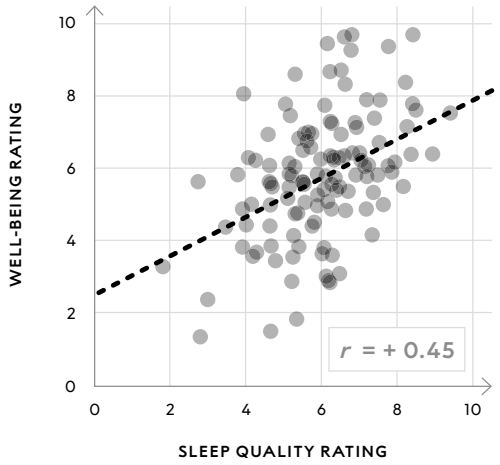
CAUSE-AND-EFFECT CLAIM: **Time with pets decreases stress and makes people happier.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 Using a Social Stress Test, researchers tested 99 children with pet dogs, both with and without their dogs present. Having a dog present was associated with more positive emotions compared to those who did the test without a dog present.		
Study 2 In a study with 20 dog owners, spending 25 minutes with their dogs increased levels of oxytocin, a hormone linked to feelings of relaxation and happiness.		
Study 3 An analysis of 27 scientific studies looked at the effects of therapy dogs on people with disabilities. It found that one-third of the studies showed improved well-being after receiving a therapy dog, two-thirds showed no change, and almost none showed negative effects.		

What is an alternative explanation for one or more of the Evidence Statements described above?

Well-Being Strategy: Quality Sleep

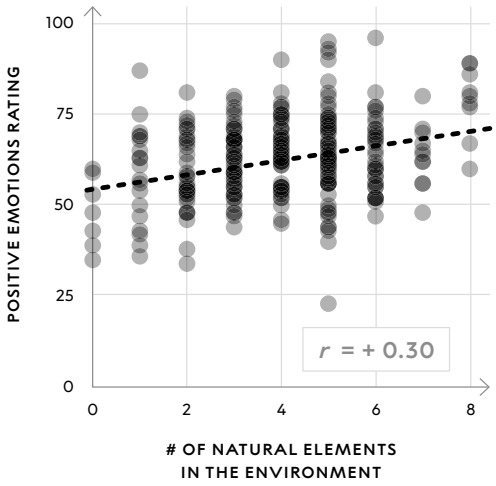
CAUSE-AND-EFFECT CLAIM: **Better sleep improves mood and leads to higher alertness.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 Researchers had 34 teenagers sleep in a lab dormitory for 9 nights and get either 5 hours, 7.5 hours, or 10 hours of sleep per night. The group that got only 5 hours of sleep reported feeling more angry, confused, and depressed compared to before the study.		
Study 2 A study of 488 adults in Australia found a correlation between sleep quality and overall well-being. 		
Study 3 A review of multiple studies suggests that poor sleep can reduce how well the immune system functions, making people more vulnerable to illnesses.		

What is an alternative explanation for one or more of the Evidence Statements described above?

Well-Being Strategy: Green Spaces

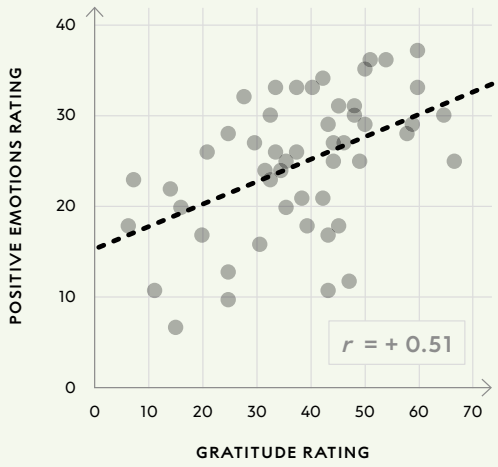
CAUSE-AND-EFFECT CLAIM: **Time in green spaces lowers stress and improves mood.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 Researchers purposely stressed out 46 college students and then had them look at pictures of either natural green spaces or urban areas. The students who viewed the nature images showed stronger activation of their parasympathetic nervous system, which helps calm the body (including lowering heart rate and slowing breathing).		
Study 2 The scatter plot shows the relationship between positive emotions and the number of natural elements in a person's surroundings (such as trees, plants, or flowers). The data comes from 51 college students who were randomly surveyed a total of 1,120 times at different times of the day.  		
Study 3 In the Netherlands, researchers added live plants to green walls to four elementary classrooms and tested students' attention and well-being before, two months, and three months after the plants were added. Students in classrooms with green walls scored better on attention tests than those without them.		

What is an alternative explanation for one or more of the Evidence Statements described above?

Well-Being Strategy: Gratitude Writing

CAUSE-AND-EFFECT CLAIM: **Gratitude increases positive emotions.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 A study of 77 romantic couples showed that when one partner recorded a video to express their gratitude and the other partner watched it, couples felt a stronger connection to each other. Social connection is closely linked to many aspects of well-being.	*mechanism*	*3*
Study 2 In a study with 132 college students, one group was asked to write once a week about things they were grateful for, while the other group wrote about any events. Afterward, the students in the gratitude group reported feeling more satisfied with their lives, had a more positive outlook on the future, and exercised more than those in the other group.	*timing*	*4*
Study 3 The scatter plot shows the correlation from a study of 201 college students on gratitude and positive emotions. 	*association*	*3*

What is an alternative explanation for one or more of the Evidence Statements described above?

For Study 3, maybe having a higher well-being causes someone to have more things to be grateful for, and not the other way around.

Well-Being Strategy: Pet Therapy

CAUSE-AND-EFFECT CLAIM: **Time with pets decreases stress and makes people happier.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 Using a Social Stress Test, researchers tested 99 children with pet dogs, both with and without their dogs present. Having a dog present was associated with more positive emotions compared to those who did the test without a dog present.	*association*	*3*
Study 2 In a study with 20 dog owners, spending 25 minutes with their dogs increased levels of oxytocin, a hormone linked to feelings of relaxation and happiness.	*mechanism*	*4*
Study 3 An analysis of 27 scientific studies looked at the effects of therapy dogs on people with disabilities. It found that one-third of the studies showed improved well-being after receiving a therapy dog, two-thirds showed no change, and almost none showed negative effects.	*timing*	*2*

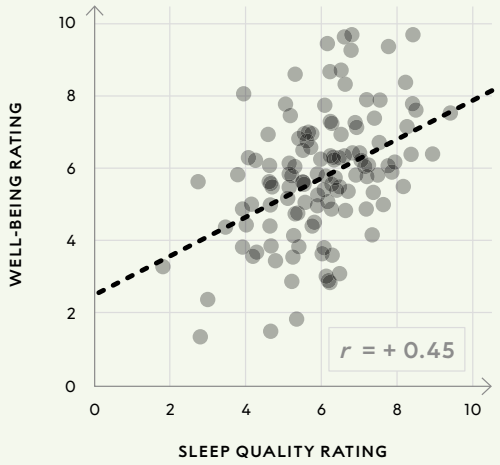
What is an alternative explanation for one or more of the Evidence Statements described above?

For Study 3, people who were already feeling more optimistic may have been more likely to get therapy dogs. This could mean that their positive feelings were due to other factors, not to getting therapy dogs.

SAMPLE STUDENT RESPONSE

Well-Being Strategy: Quality Sleep

CAUSE-AND-EFFECT CLAIM: **Better sleep improves mood and leads to higher alertness.**

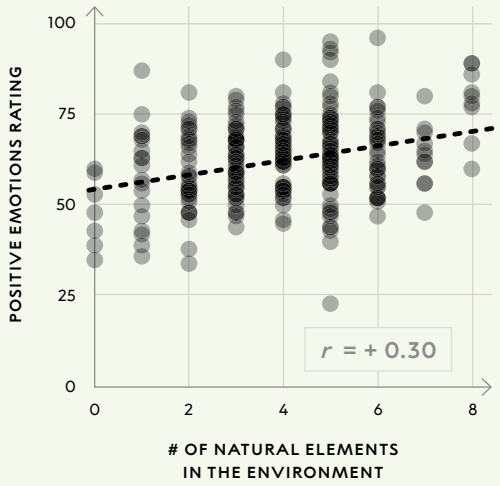
EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 Researchers had 34 teenagers sleep in a lab dormitory for 9 nights and get either 5 hours, 7.5 hours, or 10 hours of sleep per night. The group that got only 5 hours of sleep reported feeling more angry, confused, and depressed compared to before the study.	*timing*	*4*
Study 2 A study of 488 adults in Australia found a correlation between sleep quality and overall well-being. 	*association*	*3*
Study 3 A review of multiple studies suggests that poor sleep can reduce how well the immune system functions, making people more vulnerable to illnesses.	*mechanism*	*2*

What is an alternative explanation for one or more of the Evidence Statements described above?

For Study 2, it's possible that higher well-being is due to lower stress levels, rather than to better sleep. In other words, people with lower stress levels may feel better and sleep better, which could explain the results.

Well-Being Strategy: Green Spaces

CAUSE-AND-EFFECT CLAIM: **Time in green spaces lowers stress and improves mood.**

EVIDENCE STATEMENT	TYPE OF INDICATOR FOR CAUSATION	STRENGTH OF EVIDENCE (0–5)
Study 1 Researchers purposely stressed out 46 college students and then had them look at pictures of either natural green spaces or urban areas. The students who viewed the nature images showed stronger activation of their parasympathetic nervous system, which helps calm the body (including lowering heart rate and slowing breathing).	*mechanism*	*4*
Study 2 The scatter plot shows the relationship between positive emotions and the number of natural elements in a person's surroundings (such as trees, plants, or flowers). The data comes from 51 college students who were randomly surveyed a total of 1,120 times at different times of the day. 	*association*	*3*
Study 3 In the Netherlands, researchers added live plants to green walls to four elementary classrooms and tested students' attention and well-being before, two months, and three months after the plants were added. Students in classrooms with green walls scored better on attention tests than those without them.	*timing*	*1*

What is an alternative explanation for one or more of the Evidence Statements described above?

For Study 2, maybe the students who had more natural things around them were in places with friends. This could mean it was the time with friends that gave them more positive emotions instead of being near natural things.