

Explanation Phase: Research Presentations

Purpose of the Research Presentations Activity: During the Explanation phase, students participate in the *Research Presentations* activity, where they develop scientific claims – supported by evidence from data collected during the Exploration phase – to explain how the light color they investigated affected plant growth. Developing scientific claims supported by empirical evidence introduces students to the Empirical Nature of Science (NOS). This tenet refers to the notion that science is based on observations and data collected from natural phenomena and that scientific claims are interpretations of these observations. This serves as the foundation for the Explanation phase, where students construct a scientific explanation based on valid and reliable evidence obtained from their experiment. Their explanations for plant growth in response to light color is showcased in student presentations, where student groups construct arguments with empirical evidence and scientific reasoning to support their claims. Additionally, students address the empirical NOS when they engage in the peer review process during group presentations.

Learning Objective Addressed in the Explanation Phase: Students use collected and analyzed data to make a claim supported by evidence.

Time in Minutes: 150

Evidence Statements Addressed during the Activity:

- 1. Articulating the explanation of phenomena.** As students create their presentations, they also articulate a claim that relates the light color they investigated to plant growth; this statement includes how both environmental and genetic factors could influence how plants grow. To support their claims, students use evidence collected during their investigation to explain their plant's growth in response to a specific color of light.
- 2. Evidence.** Students are tasked to identify and describe the evidence they used to support their scientific claims while they are presenting their research to peers. Their evidence draws from the data collected and observations made during their experiments. The evidence students identify is the environmental factor of light (more specifically, the color of light) and its influence on plant growth.
- 3. Reasoning.** With evidence selected, students support their claims explaining how plant growth changed during their experiment. These explanations – occurring during whole-class discussions – also include the possible environmental and genetic influences on plant growth. To connect their evidence to their scientific claims, students describe their chain of reasoning by explaining how their plants could be influenced by both environmental and genetic factors.

Materials

Student Materials: StudentHandoutExplanation1_Presentation
StudentHandoutExplanation2_PeerFeedback
StudentExplanationHandout3_ExitTicket1
StudentHandoutExplanation4_ExitTicket2
StudentHandoutExplanation5_Letter
Technology (personal devices, school-provided devices, or computer lab access)

Teacher Materials: TeacherHandoutExplanation1_Presentation
TeacherHandoutExplanation2_Rubric

Procedure – Part 1: Presentation Workspace

After students analyze their data and developed graphs to display their data, they begin to interpret their data in the *Research Presentations* activity. With data in a format that is easier to identify patterns, students construct and present an oral argument, supported by empirical evidence and scientific reasoning. Students use selected data as evidence to support or refute their claim for plant growth in response to different colors of light.

I transition into the next activity with the following narrative: Dr. Doust wants to see what you have learned during your experiments about plant growth! He suggests that you develop a presentation to showcase your investigation and findings.

Using laptops or iPads, student groups create presentations showcasing their research projects. Student presentations include the following information (a scoring rubric for presentations is available in TeacherHandoutExplanation2_Rubric):

- Research question
- Hypothesis
- Independent variable, dependent variable, and controls
- Materials used (focus on plant species used and the colored cellophane they used)
- Data collected (including graphs)
- Claims made
- Evidence to support claims
- Explanation if claims supported or refuted their hypothesis

At the end of each class period, I provide students with StudentExplanationHandout3_ExitTicket1 and StudentHandoutExplanation4_ExitTicket2, respectively. Below are answers to the exit ticket questions.

Exit Ticket 1: If you wanted to show the difference in number of leaves among three plants, which of the following figures would more clearly display your data?

- (a) Scatter plot
- (b) Bar graph**
- (c) Pie chart
- (d) Line graph

Exit Ticket 2: Jamie wants to test her claim that plants watered with distilled water grow better than plants watered with rainwater. After learning that the plant watered with distilled water has fewer secondary shoots and grows shorter than the plant watered with rainwater, she wants to collect more data to determine if distilled water could be a possible cause for the plant growing less successfully. What are two pieces of data she could record to study the effect distilled water has on plant growth?

- *Answers will vary, but should mention some of the aspects below:
Jamie can compare distilled water and rainwater on more plant species. She can also collect more types of data, such as measuring number of leaves, the size of roots, or the size of leaves. Jamie can also test other watering mediums, such as tap water, and compare to her previous data.*

Procedure – Part 2: Presentations and Peer Review

Once students have finished creating their research presentations, I draw team numbers from a hat to determine the presentation order. I continue the narrative: Now that you have developed your presentations, Dr. Doust suggests displaying your research to a group of your peers. This way, your findings can undergo peer review, and in turn, your project can be improved!

Before the first presentation, students are provided with StudentHandoutExplanation2_PeerFeedback forms. I instruct the class to fill out a form for each group. As one group presents, I task their peers to note anything they found interesting, confusing, and/or misleading, as well as any changes they think could help strengthen the project. Before presentations begin, I emphasize two things:

1. While presenting your research, do not rush through your presentation; speak slow and clear.
2. As your classmates make their research presentation, take notes on your feedback forms over their presentations. Be constructive in your feedback; your suggestions can help your classmates to strengthen their future research presentations!

Grade each PowerPoint presentation using the rubric found in TeacherHandoutExplanation2_Rubric. Students are graded on a 0 to 4 point scale: Below Average Performance (0-1), Average Performance (2-3), and Above Average Performance (4). Each category of criteria is weighted differently with the greatest weight applied to students' scientific claim.

Once each student group has presented, distribute the peer review forms completed for each group. Then, engage students in a whole-class discussion about their projects. Be sure that at least one student from each group shares their questions, comments, and/or concerns that was noted while watching the group's presentation. Engage and navigate students in their discussion, including topics such as:

- Whether students agree or disagree with the claims made in one of their peers' presentations, followed by their reasoning for why/why not
 - I reference student commentary during this conversation, allowing students to reference build upon the ideas of their classmates
 - Example: "*Student A* thinks that their claim is correct because of _____. *Student B*, ... can you build off of their reasoning? ... do you agree? ... etc.
- Any questions that arose during presentations
 - Student questions can either be specific to one group's presentation or an overall question for all student groups
 - I sometimes follow one student's question by asking another student to rephrase their peer's question
- Ideas to help strengthen a project or to provide further insight about the research question
 - Students could suggest ideas such as collecting different types of data, testing more plant species, etc. ... I ask them to provide reasoning as to how their suggestion could help further understanding about the research question

Once the class shares their notes and commentary, I task students to review the feedback provided by their peers. Using their findings and peer feedback, each group is tasked with writing a short report to Dr. Doust describing why and how they would revise their presentation (which they record in StudentHandoutExplanation5_Letter.) I like to wait until the next class period to collect this assignment from students; this way, students have enough time to consider and review the commentary provided by their classmates.

Procedure – Part 3: Summative Discussion

After distributing StudentHandoutExplanation5_Letter (and before students begin working on the letter), I hold discussion with the class to reflect on their experiments and draw connections between each group's scientific claims. Rather than discussing their **presentations** and projects as a whole, students are reflecting on the **natural phenomena** they observed during their experiments. Because students are comparing different experiments (each with different variables, data collected, results, etc. ...), students consider how different environments affect plant growth in different ways. This discussion helps students to develop the relationship between light color and plant growth. Furthermore, students observe how different species grow over time, in addition to environmental influences.

During this discussion, my students have an opportunity to reflect on both the genetic and environmental conditions that could potentially impact the growth of a plant. Students first recall their own claims concerning the color of light they investigated and its effect on plant growth. Then, they compare their claims with the claims of their peers. With this comparison, students discuss which color or colors resulted in the most plant growth. This allows students to recognize how light color served as an environmental factor during their experiments, and that their plants grew in response to this factor.

I serve as the facilitator during the whole-class discussion. To keep discussions moving, I introduce new questions for students to discuss. Below are examples of questions I ask my class:

- Let's recall Group A's and Group B's experiments. Group A tested blue light on mung beans, while Group B tested blue light on radish plants.
 - What was Group A's claim? What about Group B? **How do their claims similar and how are they different?**
 - Which plant grew taller in blue light? What do you think may have caused this?
 - **Place emphasis on differences in species causing differences in growth.** Bring up examples such as desert plants versus rainforest plants.
 - **Direct students to discuss the causes behind genetic differences.** Explain how different plant species inhabit different environments. Plants respond to the light available in their environment, which could influence the plant's genetics to be more successful in an environment. So, we should expect differences in growth between two plants in the same environment because each species responds differently to light, caused by their difference in genetics (one plant simply growing faster, one plant needing more/less light, etc.)
 - **Elaborate on environmental differences.** Explain that, although two plants may be from different species, their genetics are not always the cause for differences in growth! Environmental differences, such as rain or soil type, can also influence a plant's growth.
 - Did Group A's experimental plant grow toward or away from the window? What about Group B? **What do you think this means?**
- Who can draw a connection between their scientific claim and another group's claim? What do you think the two claims mean?
 - Does this connection reflect a pattern in light color and plant growth?
 - (After one student connects two claims) Who agrees with their statement? Why/why not?
- Within your own experiments, did both of your experimental plants grow the same? Or did they grow differently? **Why do you think this happened?**
 - Why did we plant two of the same plant when conducting this experiment? Why do plant biologists plant more than one plant in their studies?
 - Discuss intra-species variation and emphasize that plants within the same species can also have differences in genetics. Similar to how some students may have blue or brown eyes or blonde or brown hair, or how some students may be tall or short, plants also differ in their characteristics. An organism's individual genetics can result in some plants within the same species to be more successful than others.

Use the above discussion to reiterate students' recognition of patterns within their data sets and graphs, as well as the recognition of relationships between plant growth responses and available light colors. The use of patterns and relationships continues in the Elaboration phase, where students are once again tasked to develop arguments to support explanations, based on empirical evidence and scientific reasoning.

Explanation Phase: Presentation Rubric

Students: _____ Group #: _____

Criteria	Below Average Performance (0-1)	Average Performance (2-3)	Above Average Performance (4)	Weight	Points Awarded
Research Question	Information is incomplete or written incorrectly; research question is not related to variables of light and/or to plant growth.	Research question provides correct and complete information; question is related to variables of light and plant growth.	Research question provides correct and thorough information; clearly articulates the variable of light and its relation to plant growth.	__ X 2	
Hypothesis	Hypothesis is missing or incomplete; hypothesis is unclear or only implied elsewhere.	Hypothesis relating variables to predicted results is basic/general; hypothesis is based on flawed logic; hypothesis does not/is loosely related to research question.	Hypothesis clearly and reasonably states relationship between variables and predicted results. Hypothesis directly connects to research question.	__ X 2	
Experimental Variables	Variables incomplete or written incorrectly; description is incomplete and/or Independent, Dependent, and/or Control Variables identified incorrectly.	All of the following variables included: research question, hypothesis, data, results, and final claim	Included all variables; correctly and clearly highlighted variables	__ X 1	
Materials Used	Materials are not listed; materials list is incomplete.	All of the following materials used are listed: choice of colored gel light	All materials are listed; reason for using each material	__ X 1	

		filter, choice of seed, and an image with all materials in use (including general materials such as CD cases, sand, cardboard, and zip lock bags)	is addressed/discussed.		
Data Collected	Data is incomplete or missing. Data does not relate to research question at all. Graphs displaying data are incorrect or missing variables (title, key, etc.)	Data are shown and loosely relates to research question. Two graphs display recorded data.	Displays qualitative and quantitative data that directly addresses research question; Two graphs clearly display results and trends in data.	__ X 1	
Claim	Claim is incomplete and/or scientifically inaccurate; does not adequately address research question.	Claim is scientifically accurate/partially accurate; completely/partially addresses research question.	Claim is scientifically accurate and completely addresses research question.	__ X 3	
Evidence	Data used as evidence does not relate to or support claim at all; evidence for claim is not provided.	The data relates to the claim, but not scientifically appropriate. Data is basic and/or general; could have collected stronger data to address claim.	Selects scientifically appropriate data to support claim. Data are thorough; provide enough details and evidence is provided.	__ X 2	
Reasoning	Reasoning is insufficient or does not connect evidence to claim. Does not show scientific understanding and/or understanding is limited.	Reasoning adequately or loosely connects evidence to claim. Relates to science principles, but weakly supports claim. Reasoning is more general rather than specific.	Reasoning clearly links evidence to claim. Shows how data serves as evidence based on scientific principles. Makes clear connections between claim and evidence.	__ X 2	

Presentation	Presenters are unprepared and unenthusiastic about their presentation. They do not articulate their understanding of the topic. Slideshow is unorganized and/or incomplete.	Presenters are generally prepared. Demonstrate basic understanding of their research. Slideshow displays required information.	Presenters are prepared and enthusiastic about their presentation. Demonstrate full understanding of topic and discuss openly with audience. Slideshow is visibly appealing and accurate.	__ X 1	
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Total Points Awarded	/60
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Student name: _____ Date: _____

Research Presentations

Purpose:

Now that you have collected and analyzed your data, you will share your research with your classmates. In a slideshow presentation, display and discuss the following information with your peers

- Research question
- Hypothesis
- Independent variable, dependent variable, and controls
- Materials used (focus on plant species used and the colored cellophane they used)
- Data collected (including graphs)
- Claims made
- Evidence to support claims
- Explanation if claims supported or refuted their hypothesis

Presentation Rubric

To help you address all required aspects of your presentation, below is the scoring rubric that will be used to grade your research presentation.

Students: _____ Group #: _____

Criteria	Below Average Performance (0-1)	Average Performance (2-3)	Above Average Performance (4)	Weight	Points Awarded
Research Question	Information is incomplete or written incorrectly; research question is not related to variables of light and/or to plant growth.	Research question provides correct and complete information; question is related to variables of light and plant growth.	Research question provides correct and thorough information; clearly articulates the variable of light and its relation to plant growth.	___ X 2	
Hypothesis	Hypothesis is missing or incomplete; hypothesis is unclear or only implied elsewhere.	Hypothesis relating variables to predicted results is basic/general; hypothesis is based on flawed logic; hypothesis does not/is loosely related to research question.	Hypothesis clearly and reasonably states relationship between variables and predicted results. Hypothesis directly connects to research question.	___ X 2	
Experimental Variables	Variables incomplete or written incorrectly; description is incomplete and/or Independent,	All of the following variables included: research question, hypothesis, data, results, and final claim	Included all variables; correctly and clearly highlighted variables	___ X 1	

	Dependent, and/or Control Variables identified incorrectly.				
Materials Used	Materials are not listed; materials list is incomplete.	All of the following materials used are listed: choice of colored gel light filter, choice of seed, and an image with all materials in use (including general materials such as CD cases, sand, cardboard, and zip lock bags)	All materials are listed; reason for using each material is addressed/discussed.	__ X 1	
Data Collected	Data is incomplete or missing. Data does not relate to research question at all. Graphs displaying data are incorrect or missing variables (title, key, etc.)	Data are shown and loosely relates to research question. Two graphs display recorded data.	Displays qualitative and quantitative data that directly addresses research question; Two graphs clearly display results and trends in data.	__ X 1	
Claim	Claim is incomplete and/or scientifically inaccurate; does not adequately address research question.	Claim is scientifically accurate/partially accurate; completely/partially addresses research question.	Claim is scientifically accurate and completely addresses research question.	__ X 3	
Evidence	Data used as evidence does not relate to or support claim at all; evidence for	The data relates to the claim, but not scientifically appropriate. Data is basic and/or	Selects scientifically appropriate data to support claim. Data are thorough; provide enough	__ X 2	

	claim is not provided.	general; could have collected stronger data to address claim.	details and evidence is provided.		
Reasoning	Reasoning is insufficient or does not connect evidence to claim. Does not show scientific understanding and/or understanding is limited.	Reasoning adequately or loosely connects evidence to claim. Relates to science principles, but weakly supports claim. Reasoning is more general rather than specific.	Reasoning clearly links evidence to claim. Shows how data serves as evidence based on scientific principles. Makes clear connections between claim and evidence.	__ X 2	
Presentation	Presenters are unprepared and unenthusiastic about their presentation. They do not articulate their understanding of the topic. Slideshow is unorganized and/or incomplete.	Presenters are generally prepared. Demonstrate basic understanding of their research. Slideshow displays required information.	Presenters are prepared and enthusiastic about their presentation. Demonstrate full understanding of topic and discuss openly with audience. Slideshow is visibly appealing and accurate.	__ X 1	

Total Points Awarded	/60
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Peer Review: Feedback Form for Group #_____

[illegible]

Student name: _____ Date: _____

Exit Ticket 1:

Complete and submit this assignment before the end of class!

Q. If you wanted to show the difference in number of leaves among three plants, which of the following figures would more clearly display your data?

- a. Scatter plot
- b. Bar graph
- c. Pie chart
- d. Line graph

Student name: _____ Date: _____

Exit Ticket 2:

Complete and submit this assignment before the end of class!

Q. Jamie wants to test her claim that plants watered with distilled water grow better than plants watered with rainwater. After learning that the plant watered with distilled water has fewer secondary shoots and grows shorter than the plant watered with rainwater, she wants to collect more data to determine if distilled water could be a possible cause for the plant growing less successfully. What are two pieces of data she could record to study the effect distilled water has on plant growth?

Student name: _____ Date: _____

Letter to Dr. Doust

Instructions: Review the peer feedback forms that your classmates provided you. What did they say about your project? Based on these comments, how would you change your experiment, and why? In the space below, write a letter addressed to Dr. Doust discussing how you would revise your presentation based on the commentary you received. Discuss the strengths and weaknesses that your peers identified in your project, as well as any suggestions or ideas to improve upon your project's weak points.
