Tomato Trouble: What’s Going On In The Garden?

A Problem-Solving Investigation

Hannah Barkley

CBLI Project

ENV 307 Fall 2010

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Abstract

School Garden Science and Language Arts Lessons Plans for Grade 4
Hannah Barkley, ENV307 F2010

School gardens are becoming increasingly popular as parents and educators attempt to reunite children with nature. Although garden-based learning benefits students’ academic performance, lifestyle choices, and environmental awareness, a major obstacle in the growth of school gardens is the difficulty in integrating the use of gardens into curriculum standards. To solve this problem, a series of seven garden-based lesson plans for grade 4 were created to fulfill state standards in science and language arts.

The sequence of lessons asks students to solve a mystery in the garden: the tomato plants are not growing. The first two lessons provide necessary background information: the first lesson teaches students about plant biology and the second discusses what plants need to grow. The third lesson introduces the tomato problem. Students brainstorm possible reasons for the lack of growth and then analyze each in subsequent lessons. The third lesson asks students to use graphs and tables to decide whether water, sunlight, or temperature is responsible for the problem. In the fourth lesson, the students learn about soil and conduct experiments to figure out whether the health of the soil is at fault. The students learn that insects are responsible in the fifth lesson and conduct independent research to determine which insects are helpful and harmful to garden plants. In the sixth lesson, groups of students use evidence to identify the insect culprit (the tomato hornworm) and in the seventh lesson the students learn about the life cycle of the hornworm to solve the problem.
Background Information

School gardens have become increasingly popular in elementary schools across the country. While the concept of school gardens is far from new, school gardens have undergone a resurgence in the past two decades as concern has increased that children are becoming increasingly separated from the natural world. In response, parents and teachers have created and maintained school gardens at the local level and employed garden-based learning strategies in an attempt to bridge the divide between children and nature (Bucklin-Sporer and Pringle 2010). While the model for learning in association with a garden varies considerably from school to school, Desmond et al. generally define garden-based learning as any instructional strategy that uses a school garden as a teaching tool (2002).

The value of school gardens is immeasurable. Numerous studies have reported the undeniable benefits that elementary school children gain by participation in garden-based learning. Academic studies have demonstrated that the use of school gardens increases the academic achievement of students. Klemmer et al. (2002) showed that the use of school gardening programs increased science achievement in elementary school students, and Lieberman and Hoody (1998) demonstrated that students who took part in garden-based learning performed better in standardized tests in math, reading, language, and spelling than students who did not. School gardens are particularly conducive to interdisciplinary studies in all areas of learning, and they cater to a variety of different student learning styles (Fornier). In addition, school gardens promote healthy lifestyles and proper nutrition, encourage the careful stewardship of environmental resources, and allow students to develop a sense of community and place (Bucklin-Sporer and Pringle 2010).

Despite the great benefit that students derive from outdoor learning, a fundamental difficulty associated with the use of school gardens is the disconnect between the availability of lesson plans that use the garden and the fulfillment of state curriculum standards (Fornier). Teachers may struggle to integrate garden-based lesson plans if the lessons do not teach skills that are directly tested in rigorous state examinations, which emphasize competence in mathematics and language arts literacy. Furthermore, changing curriculum standards pose significant problems for teachers. In New Jersey, this problem has become increasingly complicated in the past few years, as the New Jersey Department of Education has recently altered curriculum standards for public schools. In addition to revising the Core Curriculum Content Standards in 2009, the New Jersey State Board of Education adopted a resolution in June 2010 that called for districts to align their curriculum standards in math and language arts literacy with the national Common Core Standards in 2011 (New Jersey Department of Education 2009, New Jersey School Boards Association 2010). Major changes in curriculum requirements can be difficult for teachers, who frequently must adjust their familiar teaching routines to match the new, often rigid standards (Amimo 2008). While these revised curriculum standards may present a stumbling block for teachers attempting to integrate their lessons into school gardens, they may also provide an opportunity for teachers to construct and use new lesson plans that unite the curriculum requirements with garden-based learning.

Thus, the motivation for this project is the need to integrate the use of school gardens with the revised New Jersey state curriculum standards. By doing so, I hope to have made garden-based lessons that both fulfill New Jersey education standards and are accessible to teachers. Through these lessons, I hope to engage students in their environment and promote an enthusiasm and appreciation for the incredible natural world in which they live.
Lesson Plan Summary

This lesson series is based on a mystery: the tomato plants in the school garden are not growing, and the students must figure out the reason for the lack of growth. Through a sequence of seven separate lessons, the students will learn about plant biology and investigate potential reasons for the problem. At the end of the unit, the students will discover that the tomatoes are not growing because tomato hornworms are eating the fruit and leaves. The students will then develop solutions to prevent this problem.

I developed my sequence of lessons so that each lesson would allow students to explore in depth a potential reason for the lack of growth. In developing these lessons, I tried to create exercises and experiments that fulfill the grade four curriculum standards for both science and English Language Arts. While I created the lessons with fourth grade curriculum standards in mind, these lessons could easily be used in other grade levels. I tried to develop lessons that combine a variety of different teaching and learning techniques to engage students in the material, including demonstrations, videos, collaborative problem solving, experimental investigations, and independent research. These plans intend to integrate the New Jersey curriculum standards into the use of a school garden by both referring to plants and animals in the garden and allowing students to have the opportunity to physically interact with the garden environment. The following is a brief summary of each lesson plan:

The first lesson teaches students about the four main parts of the tomato plant: roots, stem, leaves, and flowers. Students will learn about the role of each part and why it is important, as well as what would happen if the part was missing. This lesson plan sets the stage for the rest of the unit by providing students with baseline information needed to solve the plant problem.

The second lesson builds on an understanding of the parts of the plant and teaches students about the things that plants need to grow. Students will watch The Magic School Bus Gets Planted, which demonstrates all of the things that plants need to make food and grow. Students will discuss as a class how the plant’s environment determines its ability to thrive.

The third lesson introduces the problem that will define the rest of the lessons for this unit: the tomato plants aren’t growing, and it’s the students’ job to figure out why. The students will brainstorm potential solutions based on what they have already learned about plants. These ideas will become the topics of the next lessons: water, sunlight, temperature, soil, and insects. This lesson then examines the first set of potential problems in the environment: water, sunlight, and temperature. Students will discuss why each of these factors could cause the plants not to grow and will examine a set of graphs and tables to determine whether the lack of plant growth is due to a lack of water or sunlight or due to incorrect temperature levels.

The fourth lesson looks at the second potential problem: soil health. Students will learn about soil formation and composition, the different types of soil (sand, silt, clay), and the soil conditions that plants need to grow. Students will conduct an experimental investigation to look at soil permeability and pH and will observe the content of organic materials in the soil. Finally, students will examine soil samples from the garden to determine whether poor soil is at fault for the poorly growing tomato plants.
The fifth lesson looks at the final potential problem: insects in the garden. Students are provided pictorial evidence that insects are responsible for the tomato plant problem because they are eating the leaves of the tomato plant. The teacher then gives the students a list of insects that have been spotted recently in the garden, and the students must conduct independent research to determine which insects are good for the garden and which insects are bad.

The sixth lesson asks students to use evidence to determine which insect is responsible for eating the tomato plant leaves. Since students have already narrowed down the potential insect culprits to those that are bad for the garden, they use information provided by the teacher to pick the insect that has harmed the tomato plants (the tomato hornworm).

The seventh lesson teaches students about the insect lifecycle using the tomato hornworm as a model organism. Students then use this knowledge to determine the best way to stop the hornworms from harming the tomato plants.
# State Curriculum Standards Addressed

The table below documents the curriculum standards that are addressed in the following lesson plans.

<table>
<thead>
<tr>
<th>Content Area</th>
<th>CPI#</th>
<th>CCR Anchor Strand/ Content Statement</th>
<th>CPI</th>
<th>Lesson Plan #</th>
</tr>
</thead>
<tbody>
<tr>
<td>English Language Arts (ELA)</td>
<td>RI.4.7</td>
<td>Integrate and evaluate content presented in diverse media and formats, including visually and quantitatively, as well as in words.</td>
<td>Interpret information presented visually, orally, or quantitatively (e.g., in charts, graphs, diagrams, timelines, animations, or interactive elements on Web pages) and explain how the information contributes to an understanding of the text in which it appears.</td>
<td>3</td>
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<tr>
<td></td>
<td>W.4.7</td>
<td>Conduct short as well as more sustained research projects based on focused questions, demonstrating understanding of the subject under investigation.</td>
<td>Conduct short research projects that build knowledge through investigation of different aspects of a topic.</td>
<td>5</td>
</tr>
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<td></td>
<td>W.4.8</td>
<td>Gather relevant information from multiple print and digital sources, assess the credibility and accuracy of each source, and integrate the information while avoiding plagiarism.</td>
<td>Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>SL.4.1</td>
<td>Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others’ ideas and expressing their own clearly and persuasively.</td>
<td>Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grade 4 topics and texts, building on others’ ideas and expressing their own clearly.</td>
<td>1, 2</td>
</tr>
<tr>
<td></td>
<td>SL.4.1a</td>
<td>Prepare for and participate effectively in a range of conversations and collaborations with diverse partners, building on others’ ideas and expressing their own clearly and persuasively.</td>
<td>Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.</td>
<td>6</td>
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<td></td>
<td>SL.4.2</td>
<td>Integrate and evaluate information presented in diverse media and formats, including visually, quantitatively, and orally.</td>
<td>Paraphrase portions of a text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.</td>
<td>2, 3, 6</td>
</tr>
</tbody>
</table>
### Science

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1.4.B.1</td>
<td>Building and refining models and explanations requires generation and evaluation of evidence.</td>
<td>Design and follow simple plans using systematic observations to explore questions and predictions.</td>
</tr>
<tr>
<td>5.1.4.B.2</td>
<td>Tools and technology are used to gather, analyze, and communicate results.</td>
<td>Measure, gather, evaluate, and share evidence using tools and technologies.</td>
</tr>
<tr>
<td>5.1.4.B.3</td>
<td>Evidence is used to construct and defend arguments.</td>
<td>Formulate explanations from evidence.</td>
</tr>
<tr>
<td>5.1.4.C.2</td>
<td>Revisions of predictions and explanations occur when new arguments emerge that account more completely for available evidence.</td>
<td>Revise predictions or explanations on the basis of learning new information.</td>
</tr>
<tr>
<td>5.1.4.D.1</td>
<td>Science has unique norms for participation. These include adopting a critical stance, demonstrating a willingness to ask questions and seek help, and developing a sense of trust and skepticism.</td>
<td>Actively participate in discussions about student data, questions, and understandings.</td>
</tr>
<tr>
<td>5.1.4.D.2</td>
<td>In order to determine which arguments and explanations are most persuasive, communities of learners work collaboratively to pose, refine, and evaluate questions, investigations, models, and theories (e.g., scientific argumentation and representation).</td>
<td>Work collaboratively to pose, refine, and evaluate questions, investigations, models, and theories.</td>
</tr>
<tr>
<td>5.1.4.D.4</td>
<td>Organisms are treated humanely, responsibly, and ethically.</td>
<td>Handle and treat organisms humanely, responsibly, and ethically.</td>
</tr>
<tr>
<td>5.3.4.A.2</td>
<td>Essential functions required for the well-being of an organism are carried out by specialized structures in plants and animals.</td>
<td>Compare and contrast structures that have similar functions in various organisms, and explain how those functions may be carried out by structures that have different physical appearances.</td>
</tr>
<tr>
<td>5.3.4.D.1</td>
<td>Plants and animals have life cycles (they begin life, develop into adults, reproduce, and eventually die). The characteristics of each stage of life vary by species.</td>
<td>Compare the physical characteristics of the different stages of the life cycle of an individual organism, and compare the characteristics of life stages among species.</td>
</tr>
<tr>
<td>5.4.4.C.1</td>
<td>Rocks can be broken down to make soil.</td>
<td>Create a model to represent how soil is formed.</td>
</tr>
</tbody>
</table>
Tomato Trouble: What’s Going On In The Garden?

Lesson Plans

Lesson 1: Plant Structure and Function
Lesson 2: What Do Plants Need To Grow?
Lesson 3: What’s Wrong With The Tomato Plants?
Lesson 4: It’s All About The Soil
Lesson 5: Garden Helper or Pesky Pest?
Lesson 6: Bugs on Trial!
Lesson 7: The Life and Times of The Tomato Hornworm
Tomato Trouble: What’s Going On In The Garden?

Lesson 1: Plant Structure and Function

Objectives: Students will learn the structure and function of the four main parts of a plant (roots, stems, leaves, and flowers/fruit).

NJ Core Curriculum Content Standards: ELA SL.4.1; Science 5.3.4.A.2

Opening: Place an apple (flower/fruit), a celery stalk (stem), a carrot (root), and a head of lettuce (leaves) on a table. Ask the students to identify each item on the table and discuss the similarities and differences between the different fruits and vegetables. Try to bring the discussion to the fact that all of the fruits and vegetables are from plants and each represents a different part of the plant.

Content/Procedure: Display a live plant (preferably a tomato plant) and a poster or illustration showing the different parts of a plant at the front of the room. Using the fruits and vegetables as a guide, ask the students to identify which structure each fruit or vegetable is on a plant and have the students point out the corresponding parts of the plant on the live plant and on the poster. As the students point out each structure, explain and discuss the function of each part:

Roots:
- Take in water, minerals, and nutrients from the soil
- Store nutrients for the plant
- Transport food and water to other parts of the plant
- Hold the plant in the soil

Stems:
- Support the plant
- Expose the leaves to sunlight
- Transport food and water to other parts of the plant
- Sometimes conduct photosynthesis to produce food

Leaves:
- Conduct photosynthesis (take in carbon dioxide and release oxygen to produce food)
- Conduct respiration (take in oxygen and release carbon dioxide to produce energy for the plant)

Flowers:
- Sexual reproduction
- Flowers can be divided into four basic parts: sepals, petals, carpels, and stamen
  - The sepal is the outer green part that is at the base of the flower and protects the flower before budding.
  - The carpel is the female part of the flower. It is made up of the ovary, which holds the eggs, the style, and the stigma, which is at the top of the style and is the part that receives pollen.
- The petals are the colorful pieces of the flower that attract insects
- The stamen is the male part of the flower that produces pollen
- Can also discuss how flowers become fruits that animals eat and thus transport seeds

Alternatively, the teacher could conduct the lesson outside in the garden and use different plants in the garden to point out the different parts. This is particularly useful in the spring if garden plants are flowering, and could allow for cross comparison between different plant species.

**Assessments:** Ask students to write a short paragraph about what would happen to the plant if one of its parts were not working correctly. For example, what would happen to the plant if the leaves were removed or the flowers were cut off? Students’ answers should reflect an understanding of both what each part of the plant does and, therefore, why the plant would be unable to function without the each part.

**Closure:** Have students share their answers to the previous question with the class. Emphasize the fact that each part of the plant is important, and the plant cannot survive and/or reproduce with one of its parts removed.

**Homework:** Students should complete plant parts word search (attached).
Parts of a Plant Word Search

Next to each clue, write the correct part of the plant. Then, find the word in the puzzle.

Word Bank
Root
Stem
Leaves
Sepal
Carpel
Ovary
Stamen
Petal
Stigma

Takes in water and nutrients from the soil _________________________
Takes in sunlight and produces food for the plant _____________________
The part at the top of the style that receives pollen ____________________
Supports the plant and transports water _______________________________
Female part of the flower _________________________________________
Male part of the flower ____________________________________________
Colorful part of the plant that attracts insects _______________________
Part of the carpel that holds eggs ___________________________________
Outer green part that protects the flower ______________________________
Parts of a Plant Word Search

**Answer Key**

<table>
<thead>
<tr>
<th>Word Bank</th>
<th>Root</th>
<th>Ovary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stem</td>
<td>Stamen</td>
<td></td>
</tr>
<tr>
<td>Leaves</td>
<td>Petal</td>
<td></td>
</tr>
<tr>
<td>Sepal</td>
<td>Stigma</td>
<td></td>
</tr>
<tr>
<td>Carpel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Takes in water and nutrients from the soil</th>
<th>Root</th>
</tr>
</thead>
<tbody>
<tr>
<td>Takes in sunlight and produces food for the plant</td>
<td>Leaves</td>
</tr>
<tr>
<td>The part at the top of the style that receives pollen</td>
<td>Stigma</td>
</tr>
<tr>
<td>Supports the plant and transports water</td>
<td>Stem</td>
</tr>
<tr>
<td>Female part of the flower</td>
<td>Carpel</td>
</tr>
<tr>
<td>Male part of the flower</td>
<td>Stamen</td>
</tr>
<tr>
<td>Colorful part of the plant that attracts insects</td>
<td>Petal</td>
</tr>
<tr>
<td>Part of the carpel that holds eggs</td>
<td>Ovary</td>
</tr>
<tr>
<td>Outer green part that protects the flower</td>
<td>Sepal</td>
</tr>
</tbody>
</table>
**Tomato Trouble: What’s Going On In The Garden?**

**Lesson 2: What Do Plants Need To Grow?**

**Objectives:** Students will learn the factors and inputs that all plants need to grow.

**NJ Core Curriculum Content Standards:** ELA SL.4.1, SL.4.2; Science 5.3.4.A.2

**Opening:** Ask students to spend about five minutes independently writing down what they already know about what plants need to grow.

**Content/Procedure:**

The class will watch *The Magic School Bus Gets Planted* (approximately 20 minutes). This video can be found online at [http://www.gamequarium.org/cgi-bin/search/linfo.cgi?id=9681](http://www.gamequarium.org/cgi-bin/search/linfo.cgi?id=9681) or a VHS copy can be ordered at [http://www.amazon.com/Magic-School-Bus-Planted/dp/B00005BCOT](http://www.amazon.com/Magic-School-Bus-Planted/dp/B00005BCOT).

This video is a good introduction to this lesson and the rest of the lessons in this unit as it highlights what environmental conditions and nutrients plants need to grow and produce food. This video also sets the stage for the problem with the lack of growth in the tomato plants that will form the basis of the next few lessons because the students in the video similarly attempt to figure out why a plant is not growing.

After students have watched the video, ask the students to add to their initial list of what plants need to grow based on what they have learned. The teacher should then lead a class discussion that focuses on the information presented in the video. Ask students what the video says plants need to grow, and encourage students to add their own ideas to the discussion. Make a list of these things on the board or on poster paper and save the list for later discussions.

The class discussion should emphasize the major points presented in the video:

- The plants’ roots gather water that is then transported to the rest of the plant.
- The plants’ leaves take in air (carbon dioxide) to produce food for the plant.
- The plants’ leaves need sunlight in order to produce food.

The teacher should also discuss the other factors that plants need to grow. These should include the factors that are part of subsequent lesson plans, such as healthy soil (for nutrients and minerals for the plant), adequate air temperature, beneficial garden insects (pollinators and insects that eat those that harm plants), etc.

An optional extension of this lesson could be to take students out into the garden and to have the students examine the plants in the garden and the different environmental inputs that are important for them to grow. The teacher can point out how water, sunlight, soil, and insects are necessary for plants in the physical setting of the garden.
Assessments: Base student understanding off of responses to class discussion.

Closure/Homework: Have students write a short response answering the prompt: “What would you do if you found out that a plant in the garden wasn’t growing? What are possible reasons that plants might not grow, and what would you do to fix the problem?”
Tomato Trouble: What’s Going On In The Garden?

Lesson 3: What’s Wrong With The Tomato Plants?

Objectives: Students will be presented a problem with the tomato plants in the garden and will brainstorm possible reasons for the problem; students will learn about how water, temperature, and sunlight contribute to plant growth and will work in small groups to determine whether these factors are responsible for the plant problem.

NJ Core Curriculum Content Standards: ELA RI.4.7, Science 5.1.4.D.2

Opening: Ask students to share their homework responses from the previous night with their neighbor (“What would you do if you found out that a plant in the garden wasn’t growing? What are possible reasons that plants might not grow, and what would you do to fix the problem?”).

Content/Procedure:

First, present the problem to the students. Tell the students that yesterday afternoon a student realized that there was a problem with the tomato plants in the garden. Like Phoebe’s beanstalk in The Magic School Bus, the tomato plants aren’t growing. The student has been measuring the height of the tomato plants every day and has discovered that they haven’t grown any taller in the past month. Assuming that it is now the height of the tomato growing season (this lesson can be conducted throughout the year, although the tomato growing season is May through June), it does not make any sense that the tomato plants are not growing. Tell the students that it is up to them to figure out what the problem is and to determine how to fix it.

First, based on the knowledge that students have gained from the past two lessons about what plants need to grow and the initial discussion, have students brainstorm potential reasons why the tomato plants might not be growing. Among other answers that the students might provide, make sure that students add the following to the list: lack of water, lack of sunlight, inadequate temperature, poor soil, and pest problems. These will form the basis for the next lessons.

After students have created a list of potential problems, they will address each one. The students will start by looking at water, sunlight, and temperature. The teacher should first remind students why each of these factors is important for plant growth. Then, dividing students into smaller groups (3-5 students), have students fill out the following worksheet.

Students are provided with three types of data: a table that shows the amount of water the tomato plants have received in the past month, a bar graph showing the amount of sunlight the plants have received, and a line graph showing the temperature every day for the past month. Students are also provided information about how much water and light tomato plants need and the ideal temperature for tomato plant growth. Using this information, students are asked to read the table and graphs and then decide whether any of these problems is responsible for the lack of growth in the tomato plants. The students should conclude that none of these factors is responsible for the lack of growth because the tomatoes have received enough water and sunlight, and the temperature has been in the appropriate range in the past month.
Once the small groups have completed the worksheet, have the groups share and defend their answers in the larger group. The teacher should have the class conclude that none of these potential problems is responsible for the lack of growth in the tomato plants.

This lesson can easily be divided into multiple sessions depending on the length of discussion and the time it takes students to finish the worksheet. For example, the teacher could present the problem with the plants and have students brainstorm potential reasons on one day and then have students complete the worksheet on the second day. Teachers could also take students outside to see tomato plants in the garden to help with brainstorming potential solutions to the problem.

Assessments: Collect student worksheets to evaluate understanding of the material.

Closure: Have students start an investigation journal in which they document their findings and evidence for the tomato plant problem. After this lesson, have students write what they have learned about water, sunlight, and temperature, why these things are important to the tomato plant, and how the student knows that these are not at fault for the lack of growth.

Homework: None.
Tomato Trouble: What’s Going On In The Garden?

Something is wrong with the tomato plants in the garden, and it’s your job to figure out what it is! There are a number of reasons why the tomato plants might not be growing, but we will first look at factors in the plants’ environment that are important for the tomato plants to grow. We know that all plants need water and sunlight to grow larger and produce food. We also know that plants cannot grow if it is too hot or too cold outside.

Fortunately, an observant student has recorded the daily temperature, the amount of water the tomatoes have received, and the number of hours of sunlight that tomatoes have gotten in the past month. From this information, we can determine whether any of these factors are responsible for harming the tomatoes.

**Water:** Tomatoes need 1 liter of water a day.

With your group, look at the table on the next page. In the left column, the student has written the day of the month, and in the right column the student has written the amount of water that the tomato plants received on that day.

What was the minimum amount of water that the tomato plants received on a day? _______________________

What was the maximum amount of water that the tomato plants received on a day? _______________________

If tomatoes need 1 liter of water per day, have the tomatoes received enough water every day during the past month? _________

----------------------------------------------------------------------------------------------------
Sunlight: Tomatoes need 6 hours of sunlight a day.
Now look at the bar graph. This graph shows the number of hours of sunlight that the tomato plants have received every day over the past month.

What was the minimum amount of sunlight that the tomato plants received on a day? ______________________

What was the maximum amount of sunlight that the tomato plants received on a day? ______________________

If the tomatoes need 6 hours of sunlight every day, have the tomatoes received enough sunlight every day during the past month? _________

Temperature: Tomatoes need temperatures that are above 50°F and below 90°F.
Finally, look at the line graph. This graph shows the temperature for every day during the past month.

What was the minimum temperature during the past month?
__________________________

What was the maximum temperature during the past month?
__________________________

If tomatoes need temperature between 50°F and 90°F, have the tomatoes been in the right temperature during the past month? _________

Based on the information from these graphs, are water levels, number of sunlight hours, and/or temperatures responsible for the problems with the tomatoes? Why or why not?
## Tomato Water Levels For The Past Month

<table>
<thead>
<tr>
<th>Day</th>
<th>Amount of Water (L)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>2</td>
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<tr>
<td>2</td>
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Hours of Sunlight For Tomato Plants

Day

Hours of Sunlight

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
Temperatures For The Past Month
Something is wrong with the tomato plants in the garden, and it’s your job to figure out what it is! There are a number of reasons why the tomato plants might not be growing, but we will first look at factors in the plants’ environment that are important for the tomato plants to grow. We know that all plants need water and sunlight to grow larger and produce food. We also know that plants cannot grow if it is too hot or too cold outside.

Fortunately, an observant student has recorded the daily temperature, the amount of water the tomatoes have received, and the number of hours of sunlight that tomatoes have gotten in the past month. From this information, we can determine whether any of these factors are responsible for harming the tomatoes.

**Water:** Tomatoes need 1 liter of water a day.

With your group, look at the table on the next page. In the left column, the student has written the day of the month, and in the right column the student has written the amount of water that the tomato plants received on that day.

What was the minimum amount of water that the tomato plants received on a day? 1 Liter

What was the maximum amount of water that the tomato plants received on a day? 2 Liters

If tomatoes need 1 liter of water per day, have the tomatoes received enough water during the past month? Yes
**Sunlight:** Tomatoes need 6 hours of sunlight a day.
Now look at the bar graph. This graph shows the number of hours of sunlight that the tomato plants have received every day over the past month.

What was the minimum amount of sunlight that the tomato plants received on a day? 6 Hours

What was the maximum amount of sunlight that the tomato plants received on a day? 10 Hours

If the tomatoes need 6 hours of sunlight every day, have the tomatoes received enough sunlight during the past month? Yes

**Temperature:** Tomatoes need temperatures that are above 50°F and below 90°F.
Finally, look at the line graph. This graph shows the temperature for every day during the past month.

What was the minimum temperature during the past month? 68°F

What was the maximum temperature during the past month? 80°F

If tomatoes need temperature between 50°F and 90°F, have the tomatoes been in the right temperature during the past month? Yes

Based on the information from these graphs, are water levels, number of sunlight hours, and/or temperature responsible for the problems with the tomatoes? Why or why not?
No, water levels, sunlight hours, and temperature are not responsible for the decrease in tomato growth because they have been supplied in sufficient quantities over the past month.
Tomato Trouble: What’s Going On In The Garden?

Lesson 4: It’s All About The Soil

Objectives: Students will learn about the different types of soil. They will create hypotheses and conduct experiments to test their hypotheses. Students will use their experimental results to determine whether soil conditions are responsible for the tomato problem.

NJ Core Curriculum Content Standards: Science 5.1.4.B.1, 5.1.4.B.2, (5.4.4.C.1)

Opening: If possible, collect soil from the garden before class. Try to obtain as many layers of the soil as possible, including the organic matter and humus on top. Using the soil as a model, ask the students what they know about soil, how it is made, and what it is made of. Write their responses on the board.

Content/Procedure:
Depending on the previous knowledge of the students, the teacher could first explain the soil formation process. The teacher should explain that wind and water break down parent rock (bedrock) into small particles. Over time, the small rock particles are mixed with organic matter to form soil. Teachers may also discuss the different layers in the soil and the composition of each layer.

After students understand the soil formation process and composition of soil, the teacher should introduce the fact that soil contains three types of material: sand, silt, and clay. These different types of material are defined by the size of the particles. Soil also contains air spaces, water, and decaying organic material (humus). The combination of all of these factors determines the characteristics of different types of soils.

Discuss with students what types of soil are the best for plants to grow and why. Most plants need well-drained soils that are rich in organic materials.

Students will then conduct simple experiments to learn about the permeability, pH, and humus content of different soils.

First, students will determine how permeable different types of soils are. The teacher should set out a sample of the three types of soil in Styrofoam cups with holes cut in the bottom. In their journals, the students should write predictions for how well water will travel through each of the types of soil based on their knowledge of each soil type. Then, have students pour a measured amount of water into each cup of soil and collect and measure the amount of water that drains through the cup in a graduated cylinder. Soils that hold about half of the added water (i.e. if the students pours in 10 mL of water, 5 mL drain out of the bottom of the cup) are the best for plant growth because the soil holds enough water to support the plants but does not hold too much and, therefore, drown the plant. Based on the results, have students evaluate their hypotheses and determine which types of soil are the best for plants to grow.
Second, students will determine the pH of different soils. pH can be determined using a cabbage indicator ([http://www.vickicobb.com/scienceyoueat.html](http://www.vickicobb.com/scienceyoueat.html)) or litmus paper. Allow students to measure the pH of different soils and compare the results with those obtained by measuring the pH of known acidic or basic materials (such as lemon juice).

Third, discuss the importance of organic materials (humus) in the soil. Explain why plants need organic materials and nutrients and how they might be added to the soil.

After students have conducted the experiments and discussed the importance of soil permeability, pH, and organic matter, students will evaluate whether the soil in which the tomato plants have been growing is sufficient for plant growth. Tomato plants grow best in rich, loamy, well-drained soil between pH 6.2 and 6.8 and with organic matter and nutrients. Students will use this knowledge as a basis to determine whether the soil is conducive for plant growth.

The teacher should either take soil from the garden or create a soil that is well-drained, slightly acidic, and contains organic material (the teacher should ensure beforehand that the soil passes these tests). Tell the students that tomato plants need well-drained, slightly acidic soils with organic material. The students will first conduct a permeability test in the same manner as before and write down their observations. Next, the students will measure the pH of the soil. Finally, the students will observe the amount of organic material in the soil. Based on their observations, the students should conclude that the soil is conducive to tomato plant growth and is not responsible for the lack of tomato plant growth.

This lesson may be spread over a couple of days depending on the students’ previous knowledge concerning the properties of soil. Teachers may need additional time to explain the soil formation process or properties of soil, and students may need extra time to complete the experiments.

**Assessments:** There is no formal assessment, but teachers should evaluate student understanding by their formation of hypotheses and response to experimental data.

**Closure:** Students should continue to write in their investigation journal. They should document what they have learned about soil, what makes soil good for plant growth, and why soil is not at fault for the lack of tomato plant growth.

**Homework:** The students have now concluded that abiotic factors are not responsible for harming the tomato plants. For homework, have the students answer the following question: “How can living organisms affect the growth of plants? What kinds of other living things can interact with plants, and what effect might they have on plant health?”
Tomato Trouble: What’s Going On In The Garden?

Lesson 5: Garden Helper or Pesky Pest?

Objectives: Students will learn about different insects that are common in a garden, categorize them into helpful and harmful insects, and decide which of the common garden insects may be responsible for the tomato problem.

NJ Core Curriculum Content Standards: ELA W.4.8, Science 5.1.4.B.3

Opening: Display the attached picture of a tomato plant at the front of the room. The picture shows a tomato plant branch that is missing its leaves and also has leaves with holes (circled in the picture). Tell the students that a fellow student has taken a picture of the unhealthy tomato plant leaves and has asked the class for help in determining the problem. Ask students to examine the picture and to write down what is wrong with the plant and what they think may be the problem based on the picture.

Content/Procedure:
Ask the students to share their responses to the picture. First, remind the students and then discuss as a class why it is important for plants to have their leaves, and why the lack of leaves would cause plants not to grow. Students should understand that the reason the tomato plants have been unable to grow is because they do not have leaves to produce food. Then, have the students discuss what may be causing the problem with the plant as pictured. Students should eventually come to the conclusion that something is eating the plant. Then, tell the students that based on the fact that no animals that eat leaves (such as deer) have been spotted in the garden in the past month, insects in the garden must be to blame for this problem.

Next, tell the students that once they realized that insects were probably eating the leaves of the tomato plant, went out into the garden and wrote down every insect they saw. In the attached worksheet, the names of each of the ten different types of insects spotted in the garden have been provided. The students now need to figure out which of these insects may have been responsible for eating the tomato leaves; however, some of the insects on the list are beneficial for the plants in the garden while others are harmful. The worksheet asks students to differentiate the helpful and harmful insects based on outside research.

Students should use books and internet sources to conduct their research (depending on what sources are available). There are a number of ways for students to complete this worksheet. The student can either research all ten insects, or the teacher can assign each student an insect and then have the student share his/her results with the class. Students will research the role of each insect in the garden and then determine whether it is helpful or harmful to the plants in the garden. Finally, students should cite their sources in the proper format (citation style may vary by school). Depending on the available time, students may complete this worksheet during class time or finish it at home. After the students have completed the worksheet, the teacher should lead a class discussion to share answers.
One potential way for the teacher to assemble resources is to create a webquest that students can access. Websites, such as http://www.zunal.com/, allow users to create webquests for free. For example, the following links could be integrated into a list of potential sources:

- Honeybee - http://www.biokids.umich.edu/critters/Apis_mellifera/
- Praying Mantis - http://kids.nationalgeographic.com/kids/animals/creaturefeature/praying-mantid/
- Spicebush Swallowtail Butterfly - http://www.biokids.umich.edu/critters/Papilio_troilus/
- Grasshoppers - http://www.biokids.umich.edu/critters/Acridiidae/
- Aphid - http://www.biokids.umich.edu/critters/Aphididae/
- Stink Bug - http://www.pestworldforkids.org/stinkbugs.html

An optional extension of this activity is to have students go in to the garden to search for garden insects on their own. Students can list and identify any insects they find and then similarly research whether these insects are helpful or harmful to the garden. Teachers can also use this activity as a means to teach students about the way to humanely handle insects that the students find in the garden (Science Standard 5.1.4.D.4).

Assessments: The teacher should collect the worksheet to evaluate student understanding.

Closure: Once students have completed the worksheet, they should continue to document their findings in their journals. Students should write about how insects may affect the plants in the garden, how we can tell that insects are eating the leaves, and which insects may be responsible for eating the tomato leaves based on their independent research.

Homework: Students should complete the worksheet at home if they have not completed it during class.
Insects: Garden Helper or Pesky Pest?

Now that we have figured out that an insect is eating the leaves of the tomato plants, we need to find out which insect is responsible. To do so, you decide to go out into the garden to look at all of the insects in the garden. You find and identify 10 different insects. Now, you need to decide which insects are helpful for the plants in the garden and which ones are harmful. Below is a list of the insects you found. Using books and relevant websites, research these insects. Write down what each one does in the garden and then decide whether it is helpful or harmful to the garden. Cite your sources.

<table>
<thead>
<tr>
<th>Spicebush Swallowtail</th>
<th>Honeybee</th>
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<tbody>
<tr>
<td>Aphid</td>
<td>Hornworm</td>
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<tr>
<td>Grasshopper</td>
<td>Green Lacewing</td>
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<tr>
<td>Lady Bug</td>
<td>Praying mantis</td>
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<tr>
<td>Japanese Beetle</td>
<td>Stink bug</td>
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<th>Garden Helper</th>
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<td>Insect</td>
<td>What It Does In The Garden</td>
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<td>Spicebush Swallowtail</td>
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<td>Aphid</td>
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<td>Grasshopper</td>
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<td>Japanese Beetle</td>
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<td>Praying mantis</td>
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<td>Stink bug</td>
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Write down the sources you used for your research:
ANSWER KEY

Insects: Garden Helper or Pesky Pest?

Now that we have figured out that an insect is eating the leaves of the tomato plants, we need to find out which insect is responsible. To do so, you decide to go out into the garden to look at all of the insects in the garden. You find and identify 10 different insects. Now, you need to decide which insects are helpful for the plants in the garden and which ones are harmful. Below is a list of the insects you found. Using books and relevant websites, research these insects. Write down what each one does in the garden and then decide whether it is helpful or harmful to the garden. Cite your sources.

<table>
<thead>
<tr>
<th>Garden Helper</th>
<th>Pesky Pest</th>
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<tbody>
<tr>
<td>Spicebush Swallowtail</td>
<td>Aphid</td>
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<td>Aphid</td>
<td>Hornworm</td>
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<td>Grasshopper</td>
<td>Green Lacewing</td>
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<td>Lady Bug</td>
<td>Praying mantis</td>
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<td>Japanese Beetle</td>
<td>Stink bug</td>
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Spicebush Swallowtail
Aphid
Grasshopper
Lady Bug
Japanese Beetle
Honeybee
Hornworm
Green Lacewing
Praying mantis
Stink bug
<table>
<thead>
<tr>
<th>Insect</th>
<th>What It Does In The Garden</th>
<th>Garden Helper or Pesky Pest?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spicebush Swallowtail</td>
<td>Pollinates garden plants</td>
<td>Garden Helper</td>
</tr>
<tr>
<td>Aphid</td>
<td>Pierces stems and leaves of plants and sucks out fluids</td>
<td>Pesky Pest</td>
</tr>
<tr>
<td>Grasshopper</td>
<td>Chews on leaves and flowers of garden plants</td>
<td>Pesky Pest</td>
</tr>
<tr>
<td>Lady Bug</td>
<td>Eats aphids, mites, and mealybugs</td>
<td>Garden Helper</td>
</tr>
<tr>
<td>Japanese Beetle</td>
<td>Eats leaves, fruits, and roots of plant</td>
<td>Pesky Pest</td>
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<tr>
<td>Honeybee</td>
<td>Pollinates garden plants</td>
<td>Garden Helper</td>
</tr>
<tr>
<td>Hornworm</td>
<td>Feeds on leaves and fruits of garden plants</td>
<td>Pesky Pest</td>
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<tr>
<td>Green Lacewing</td>
<td>Eats aphids, white-flies mites, and lacebugs</td>
<td>Garden Helper</td>
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<tr>
<td>Praying mantis</td>
<td>Eats aphids, grasshopper, fruit flies, moths, and crickets</td>
<td>Garden Helper</td>
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<tr>
<td>Stink bug</td>
<td>Attacks fruits and vegetables</td>
<td>Pesky Pest</td>
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Tomato Trouble: What’s Going On In The Garden?

Lesson 6: Bugs on Trial!

Objectives: Students will work together to use evidence and information on five different species of garden insects to determine which insect is responsible for eating the tomato plants.

NJ Core Curriculum Content Standards: ELA SL.4.1a, SL.4.2; Science 5.1.4.C.2, 5.1.4.D.2, 5.1.4.B.3

Opening: The teacher should display images of five insects on the board (attached). Either remind the students of the previous lesson in which they researched the insects that are helpful and harmful to the garden, or ask the students if they know what the insects represent. Tell the students that based on their previous research, we know that the insects pictured on the board are all harmful to the garden, and they are now on trial for damaging the tomato plants. We now need to figure out which insect is to blame. Tell the students that they will examine the evidence for and against each type of insect, and then based on that information, they will decide which one has been eating the tomato plants.

Content/Procedure:
Divide the students into smaller groups (3-5 students, 4 is ideal). Hand out copies of the insect information sheets (attached). Each sheet provides information on the appearance, life cycle, and suspicious activity (type of damage) of each insect. The students should carefully read the information on each insect. Then, hand out copies of the evidence (attached) to each student. Cut out and distribute the “cards” so that each student in the group has a different piece of evidence. Do not initially distribute the final evidence card (with the picture of the moth). Then, have each student use the insect information sheets and evidence card to eliminate potential suspects. Each card should allow the students to eliminate one or more of the insects. Once each student has evaluated his/her own evidence, the group should then discuss their findings. As a group, the students should decide on the most likely choices.

The first clue (the insect’s coloration allows it to blend in with its environment) should allow students to eliminate the multi-colored Japanese beetle and the brown stink bug. The second clue (the insect has chewed on the leaves of the tomato plant) eliminates the aphids, which suck fluids from the stem, and stink bug, which attacks the fruit. The third clue (the insect can easily be seen with the naked eye) also eliminates the aphids, which are very small and unlikely to be visible to the naked eye. The fourth clue (the insect has left behind dark droppings on the leaves) should eliminate everything but the hornworm and grasshopper, both of which—the information sheets say—leave behind droppings on the leaves.

Once the groups have discussed the evidence, tell them that another piece of evidence has been uncovered, and then hand out the final evidence card. Allow the groups time to evaluate the final piece of evidence. The final piece of evidence, which says that the insect is in the larval stage and shows a picture of an adult moth, eliminates the grasshopper. The students should conclude that the hornworm is the culprit.
Each group should then write a short paragraph explaining why they have picked the insect they did. Then, allow the groups to put the insects “on trial” with the teacher as the judge. Each group should present their analysis of the evidence provided and then, based on the evidence, decide who they think is to blame for eating the tomato plants. The class can either vote on which insect they think is responsible, or the teacher can serve as the judge and pick the culprit.

**Assessments:** The teacher can collect the paragraphs that each group has written based on the evidence and can evaluate student understanding based on student presentations of the evidence.

**Closure:** Ask students to continue writing in their evidence journals. They should explain why they picked the insect they did and how the hornworm affects the tomato plants.

**Homework:** None.
**Aphids**

**Appearance:** The tiny aphid is less than $\frac{1}{4}$ inch long. These soft-bodied insects can be green, yellow, brown, or black, and are pear-shaped with long legs and antennae. Most aphids do not have wings, but a few winged adults allow aphids to spread between plants.

**Life Cycle:** Aphids reproduce very quickly. Some aphids can reproduce asexually, and female aphids give birth to live offspring. The young aphids do not have a pupal stage, and instead they grow straight into adult aphids. Aphids may also mate and reproduce sexually.

**Suspicious Activity:** Aphids usually live in large groups on the leaves and stems of plants. The aphid has a small mouth that allows it to pierce the stems and leaves of plants and suck out plant fluids. Large groups of aphids can cause leaves to curl, turn yellow, or change shape.
Japanese Beetle

**Appearance:** The Japanese beetle is about \( \frac{1}{2} \) inch long and has a metallic green thorax and bronze wing covers. The beetle has white hairs along the side of its abdomen. The beetle's body has an oval shape with short antennae.

**Life Cycle:** Adult beetles lay eggs in the soil. The eggs hatch into white larvae that become pupae that are brown in color. The pupae then hatch into adult beetles.

**Suspicious Activity:** The Japanese beetle feeds on leaves and flowers. The beetles eat around the veins of the leaf, leaving behind visible holes in the leaves.
Hornworm

Appearance: The hornworm is pale green with white and black markings, and it is called a “hornworm” because of the black projection on the end of its body. Fully-grown hornworms are 3-4 inches in length.

Life Cycle: The hornworm is a caterpillar. An adult moth lays eggs that hatch into the larval hornworms. Once the larva has matured, the caterpillars drop into the soil and form a pupa. The pupa emerges from the soil as a moth, which is sometimes known as the sphinx moth. The moth then lays an egg on the underside of a leaf.

Suspicious Activity: The hornworm feeds on plant leaves, leaving behind black droppings. The younger caterpillars eat parts of leaves while older caterpillars can eat entire leaves and fruit.
Grasshopper

Appearance: Grasshoppers range from about $\frac{1}{2}$ inch long to several inches. Most are brown or green in color and have large hind legs for jumping and wings for flying. Grasshoppers have short antennae and large eyes.

Life Cycle: Female grasshoppers lay eggs in egg pods in the leaf litter. Eggs hatch into larvae, which molt and increase in size to become adults. Adults then develop wings and are mature after about 11 months.

Suspicious Activity: Grasshoppers eat a variety of different plants and chew holes in the leaves of plants. Grasshoppers may also leave behind dark droppings on the leaves.
Stink Bug

Appearance: The stink bug is a little less than 1 inch long and is brown in color. The stink bug is triangular in shape with a small head, and the insect gets its name from scent glands on the underside of the thorax.

Life Cycle: Adult stink bugs lay eggs on the underside of leaves. The eggs hatch into small red and black larvae that undergo five molts to become adults.

Suspicious Activity: Stink bugs eat a wide variety of garden plants. The insects mostly attack the fruits, leaving behind indentations and brown spots in the fruit.
The insect culprit’s coloration allows it to blend in with the leaves and stem of the tomato plant.

The insect culprit has chewed the leaves of the tomato plant.
The insect culprit can easily be seen with the naked eye.

The insect culprit has left behind dark droppings on the tomato plant leaves.
The insect culprit is a larva. This is what the adult insect looks like:
Tomato Trouble: What’s Going On In The Garden?

Lesson 7: The Life and Times of The Tomato Hornworm

Objectives: Students will learn about the life cycle of insects using the tomato hornworm as a model organism. Based on this knowledge, students will devise ways to solve the hornworm pest problem.

NJ Core Curriculum Content Standards: Science 5.3.4.D.1

Opening: Remind students about the culprit, the tomato hornworm. A fun visual could be to place the picture of the hornworm “behind bars” at the front of the room. Tell the students that now that they have caught the culprit, they still need to figure out what to do to solve the problem so that the tomato plants will once again grow. In order to rid the garden of pests, they first need to understand the life of the hornworm.

Content/Procedure:
The students are already familiar with the larval form of the hornworm. However, tell the students that the caterpillar is only one phase in the animal’s growth. Using posters or pictures as visuals, explain the different phases in the hornworm’s life cycle and try to connect the information about the life cycle of the hornworm to the tomato plants and the garden:

- The adult moth lays a small, round, green egg on the underside of leaves.
- The eggs hatch to form a caterpillar (the hornworm). As we have already discovered, the caterpillar eats the leaves of plants, such as the tomato plant, to grow bigger.
- The caterpillar then drops into the ground to form a hard pupa. The caterpillar stays underground as a pupa over the winter.
- The pupa then emerges from the ground as an adult moth. The moth lays a single egg and dies.

The students should complete the attached worksheet, which asks them to identify and describe the different life stages of the tomato hornworm.

There are many ways to extend this lesson beyond only describing the life stages of the hornworm. The students could raise butterflies and/or moths in the classroom from eggs or caterpillars into adults and identify the different stages of growth. In addition, the teacher could describe the life cycles of the other insects in the previous lesson and compare these to that of the hornworm. Finally, the teacher could also teach the students about the different stages of plant growth (the life cycle of the tomato plant would be particularly relevant) and compare the plant life cycle to the insect life cycle.

Finally, ask the students how they would solve the hornworm problem based on their knowledge of its life cycle. Most people tend to address problems with hornworms by simply plucking them off the leaves, but students could come up with equally effective and creative solutions.

Assessments: Collect student investigation journals (see below) and homework.
Closure: Students should write their last entry in their investigation journals. They should write about what they have learned about the life cycle of the tomato hornworm. Based on their understanding of the life cycle, how would they attempt to solve the problem of the tomato plants? Finally, the students should write what they have learned about plants, insects, and the garden environment from solving the tomato plant problem. If available, the teacher could also provide students with tomatoes from the garden to eat as a reward for solving the problem.

Homework: Complete the worksheet of the stages of the tomato hornworm life cycle (attached).
**Tomato Hornworm Life Cycle**

In the box under each picture, label the stage of the life cycle. Then, on the next page, rewrite and describe the characteristics of an insect in each phase.
# Tomato Hornworm Life Cycle

<table>
<thead>
<tr>
<th>Life Cycle Stage</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.</td>
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</table>
Tomato Hornworm Life Cycle  ANSWER KEY

In the box under each picture, label the stage of the life cycle. Then, on the next page, rewrite and describe the characteristics of an insect in each phase.

1. Egg

2. Larva/Caterpillar

3. Pupa

4. Adult/moth
## Tomato Hornworm Life Cycle

<table>
<thead>
<tr>
<th>Life Cycle Stage</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1. Egg</td>
<td>A small, round egg is deposited by an adult moth on the underside of leaves.</td>
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<tr>
<td>2. Larva</td>
<td>The green larva (caterpillar) hatches from the eggs. The caterpillar feeds on leaves to grow larger.</td>
</tr>
<tr>
<td>3. Pupa</td>
<td>The caterpillar goes into the ground to form a pupa, which is a brown, hard case that surrounds the caterpillar. The caterpillars can spend the winter in the pupa state.</td>
</tr>
<tr>
<td>4. Adult</td>
<td>The pupa emerges from the ground as an adult moth. The adult moth is several inches long and has two sets of wings. The moth hatches an egg and then dies.</td>
</tr>
</tbody>
</table>
Applications

My intention in writing this set of plans was to create a sequence of lessons that could both stand alone and be easily integrated into a larger unit about plants, the garden, or basic ecology. These lesson plans address both the revised 2009 New Jersey Core Content Curriculum Standards for science and the national Core Curriculum Standards for English Language Arts. Thus, these lessons provide teaching material that uses the school garden as a tool to fulfill some of the revised New Jersey learning requirements. In addition, these lessons attempt to integrate the science and language arts curriculum standards. This will hopefully allow teachers to teach science while still fulfilling the requisite literacy knowledge on which students are tested during standardized tests.

I constructed this set of lessons based on a specific story arc, beginning with a basic introduction, then presenting a problem-solving mystery, exploring possible explanations, and finally developing solutions for the problem. While the progression of the lessons reflects this framework, teachers can easily use individual lessons to teach specific material. In addition, teachers could increase or decrease the difficulty level of the lessons or substitute lessons that are more appropriate for the knowledge or the ability of their particular students. While I wrote this with fourth grade standards in mind (and discussed the appropriateness of the material for fourth grade with elementary school teachers), the material may easily be transferred to other grade levels depending on progression of learning in a specific school system.

While this sequence of lessons already contains a lot of material, there are multiple lessons that teachers could add to this story arc that fulfill other curriculum standards or learning requirements. For example, the first lesson teaches students about the parts of a plant. The teacher could extend this idea to discuss pollination, the life cycle of a plant, the different types of plants, etc. The second lesson on what plants need to grow could easily include a discussion of photosynthesis or respiration. The third lesson on water, sunlight, and temperature could include a lesson on the water cycle or plotting and reading different types of graphs. The fourth lesson, which discusses soil, might facilitate discussion on the rock cycle, soil formation, or composting. In the fifth, sixth, and seventh lessons on insects, the teacher could teach students about the parts of an insect and different types of insects and their life cycles. The overall problem-solving goal of this set of lessons is conducive to the addition of other material and provides an interesting and engaging framework through which students can learn material that may be less engaging in isolation.

While these lesson plans do not require the explicit use of plants or animals in the garden, all the lessons provide the opportunity for students to interact with the garden environment (individual lessons reference potential ways for students to use the garden). While the teacher does not need to take students outside to complete this plan, outdoor learning would likely increase the effectiveness of the lesson. For example, students could examine the tomato plants in the garden to learn about their abiotic and biotic environment, or they could catch, identify, and classify different species of insects that are common in the school garden.

I hope that lessons such as these will be effective teaching tools because, at their core, they are fun. These lessons include hands-on activities, experiments, and group discussions that hopefully will capture student interest in addressing a real-world problem. Through the process of solving a mystery, I hope that students will also learn skills, such as teamwork and problem solving, which cannot be fully quantified by curriculum standards. I believe that these are the skills, far more than the ability to recall specific facts, that are ultimately the most important.
References

**Background Information**


**Lesson 1**

Lesson 2

Lesson 3


Lesson 4


Lesson 5


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Lesson 6


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Lesson 7
Image Citations

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