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| **Title** | **Project Based Learning with Greenhouses** |
| **Introduction** | The current world population is 7.4 billion (as of 2016) and is expected to reach 9.6 billion by 2050. As the population explodes, the need for a sustainable food supply will become an even bigger challenge. Agricultural scientists and farmers will be expected to grow more food on less land. In this project based learning experience, participants engage in a simulation in which they study how organisms interact in their ecosystem through the lens of agricultural science.  In this simulation, students work in cooperative learning groups forming a “nursery company” hoping to contract with Lowe’s Gardening Center. In order to earn Lowe’s business, they must have healthy plants ready for consumers before the planting season begins. The students conduct research on factors affecting plant growth (soil, water, light, and biotic factors). Then, students use a “choices handout” to guide decisions about how they will create their own desk-sized greenhouse. They will also design a blueprint of the greenhouse. They will use multimedia to present their solutions and justifications to an agricultural expert. After receiving feedback from the expert, teams will make any final changes and submit the greenhouse plan. Next, they will set up and maintain their greenhouses. The team with the tallest and healthiest plants (see scoring guide) will earn the business with Lowe’s to sell their plants.  Note: This simulation is purposefully designed to model competition within a market economy. A healthy spirit of competition can motivate participants while reinforcing economics concepts in fifth grade social studies.  **Steps in project**  Students will:  1. Research factors affecting plant growth through whole group instruction and independent internet research.  2. Make design choices and prepare multimedia presentations for greenhouse proposal to experts.  3. Present greenhouse proposal to agricultural experts for feedback.  4. Use feedback to finalize greenhouse design plan and to submit final plan.  5. Build and maintain greenhouse while evaluating the design.  Students are assessed through group discussions, the Choices Handout, exit tickets, and the Greenhouse Project Student Reflection at the end of the activity. A major theme in assessment in the justification of choices based on research, rather than the choice itself.  This project is open ended and requires students to take ownership of the process and the product. As the experience is designed for young participants, this guide includes resources, such as student research handouts, the Greenhouse Project Glossary, and “Choices Handout” to scaffold student independence. However, it is important to remember, there are multiple plausible solutions to designing an effective greenhouse and an experimental mindset is necessary for innovation. |
| **Real Science Application** | Crop Science research occurs both in university and industry settings world-wide as scientists work towards the goal of feeding a growing world population. The goal of Crop Science is to promote sustainable agriculture by helping farmers maximize yield. Experts in Crop Science promote best practices and innovate solutions, such as crop protection products, seed treatments, and transgenic plants.  Major themes in this lesson, such as manipulating factors affecting plant growth to determine best conditions for yield, creating and executing a plan for testing ideas, and developing solutions within a team are the foundation of Crop Science research.  Note: Crop Science is related to many other areas of science, including Biotechnology, Microbiology, Botany, Plant Pathology, and Cell Biology. |
| **Curriculum Alignment** | This PBL aligns directly with the 5th and 6th grade objectives listed below. Adaptations can be made to include other grade levels.  **Science Standards**  **North Carolina Essential Standards:**  **Fifth grade:**  5.L.2.2  Classify the organisms within an ecosystem according to the function they serve: producers, consumers, or decomposers (biotic factors).  5.L.2.3  Infer the effects that may result from the interconnected relationship of plants and animals to their ecosystem.  **Sixth grade:**  6.L.1.2  Explain the significance of the processes of photosynthesis, respiration, and transpiration to the survival of green plants and other organisms.  6.L.2.1  Summarize how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred within food chains and food webs (terrestrial and aquatic) from producers to consumers and decomposers.  6.L.2.3  Summarize how the abiotic factors (such as temperature, water, sunlight, and soil quality) of biomes (freshwater, marine, forest, grasslands, desert, tundra) affect the ability of organisms to grow, survive, and/or create their own food through photosynthesis.  **Next Generation Science Standards:**  **Fifth grade:**  5.LS.1.1  Support an argument that plants get the materials they need for growth chiefly from air and water.  5.ES.3.1  Obtain and combine information about ways individual communities use science ideas to protect the Earth’s resources and environment.  **Sixth grade:**  3-5.ETS.1.2  Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.  MS.LS.1.6  Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow of energy into and out of organisms.  MS.LS.2.2  Construct an explanation that predicts patterns of interactions among organisms across multiple ecosystems.  MS.ETS.1.2  Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.  **Common Core English Language Arts Standards**  **Fifth grade**  RI.5.1  Quote accurately from a text when explaining what the text says explicitly and when drawing inferences from the test.  RI.5.2  Determine two of more main ideas of a text and explain how they are supported by key details; summarize the text.  RI.5.4  Determine the meaning of general academic and domain-specific words and phrases in a text relevant to a grade 5 topic or subject area.  RI.5.7  Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently  RI.5.9  Integrate information from several texts on the same topic in order towrite or speak about the subject knowledgeably.  RI.5.10  By the end of the year, read and comprehend information texts, including history/social studies, science, and technical texts, at the high end of the grades 4-5 text complexity band independently and proficiently.  5.W.1B  Provide logically ordered reasons that are supported by facts and details.  W.5.2A  Introduce a topic clearly, provide a general observation and focus, and group related information logically; include formatting (headings), illustrations, and multimedia when useful to aiding comprehension.  W.2.B  Develop the topic with facts, definitions, concrete details, quotations, or other information and examples related to the topic.  W.2.D  Use precise language and domain-specific vocabulary to inform about or explain the topic.  W.5.6  With some guidance and support from adults, use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others  W.5.7  Conduct short research projects that use several sources to build knowledge through investigation of difference aspects of a topic.  W.5.8  Recall relevant information from experiences or gather relevant information from print and digital sources; summarize or paraphrase information in notes and finished work, and provide a list of sources.  [SL.5.1](http://www.corestandards.org/ELA-Literacy/SL/5/1/) Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.  [SL.5.1.A](http://www.corestandards.org/ELA-Literacy/SL/5/1/a/) 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.  [SL.5.1.B](http://www.corestandards.org/ELA-Literacy/SL/5/1/b/) Follow agreed-upon rules for discussions and carry out assigned roles.  [SL.5.1.C](http://www.corestandards.org/ELA-Literacy/SL/5/1/c/) Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.  [SL.5.1.D](http://www.corestandards.org/ELA-Literacy/SL/5/1/d/) Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.  [SL.5.2](http://www.corestandards.org/ELA-Literacy/SL/5/2/) Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.  [SL.5.4](http://www.corestandards.org/ELA-Literacy/SL/5/4/) Report on a topic or text or present an opinion, sequencing ideas logically and using appropriate facts and relevant, descriptive details to support main ideas or themes; speak clearly at an understandable pace.  [SL.5.5](http://www.corestandards.org/ELA-Literacy/SL/5/5/) Include multimedia components (e.g., graphics, sound) and visual displays in presentations when appropriate to enhance the development of main ideas or themes.  [SL.5.6](http://www.corestandards.org/ELA-Literacy/SL/5/6/) Adapt speech to a variety of contexts and tasks, using formal English when appropriate to task and situation.  **Sixth grade**  RI.6.1  Cite textual evidence to support analysis of what the text says explicitly as well as inferences drawn from the text.  RI.6.2  Determine a central idea of a text and how it is conveyed through particular details; provide a summary of the text distinct from personal opinions or judgments.  RI.6.4  Determine the meaning of words and phrases and they are used in a text, including figurative, connotative, and technical meanings.  RI.6.7  Integrate information presented in different media or formats (e.g., visually, quantitatively) as well as in words to develop a coherent understanding of a topic or issue.  RI.6.10  By the end of the year, read and comprehend literary nonfiction in the grades 6-8 text complexity band proficiently, with scaffolding as needed at the high end of the range.  W.6.1.A Introduce claim(s) and organize the reasons and evidence clearly.  [W.6.1.B](http://www.corestandards.org/ELA-Literacy/W/6/1/b/) Support claim(s) with clear reasons and relevant evidence, using credible sources and demonstrating an understanding of the topic or text.  W.6.2.B  Develop the topic with relevant facts, definitions, concrete details, quotations, or other information and examples.  W.6.2.D Use precise language and domain-specific vocabulary to inform about or explain the topic.  [W.6.2.E](http://www.corestandards.org/ELA-Literacy/W/6/2/e/) Establish and maintain a formal style.  [W.6.4](http://www.corestandards.org/ELA-Literacy/W/6/4/) Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.  W.6.6  Use technology, including the Internet, to produce and publish writing as well as to interact and collaborate with others  [W.6.7](http://www.corestandards.org/ELA-Literacy/W/6/7/) Conduct short research projects to answer a question, drawing on several sources and refocusing the inquiry when appropriate.  [W.6.8](http://www.corestandards.org/ELA-Literacy/W/6/8/) Gather relevant information from multiple print and digital sources; assess the credibility of each source; and quote or paraphrase the data and conclusions of others while avoiding plagiarism and providing basic bibliographic information for sources.  [W.6.9](http://www.corestandards.org/ELA-Literacy/W/6/9/) Draw evidence from literary or informational texts to support analysis, reflection, and research.  [SL.6.1](http://www.corestandards.org/ELA-Literacy/SL/6/1/) Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 6 topics, texts, and issues, building on others' ideas and expressing their own clearly.  [6.1.A](http://www.corestandards.org/ELA-Literacy/SL/6/1/a/) Come to discussions prepared, having read or studied required material; explicitly draw on that preparation by referring to evidence on the topic, text, or issue to probe and reflect on ideas under discussion.  [SL.6.1.B](http://www.corestandards.org/ELA-Literacy/SL/6/1/b/) Follow rules for collegial discussions, set specific goals and deadlines, and define individual roles as needed.  [SL.6.1.C](http://www.corestandards.org/ELA-Literacy/SL/6/1/c/) Pose and respond to specific questions with elaboration and detail by making comments that contribute to the topic, text, or issue under discussion.  [SL.6.2](http://www.corestandards.org/ELA-Literacy/SL/6/2/) Interpret information presented in diverse media and formats (e.g., visually, quantitatively, orally) and explain how it contributes to a topic, text, or issue under study.  [SL.6.4](http://www.corestandards.org/ELA-Literacy/SL/6/4/) Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes; use appropriate eye contact, adequate volume, and clear pronunciation.  [SL.6.5](http://www.corestandards.org/ELA-Literacy/SL/6/5/) Include multimedia components (e.g., graphics, images, music, sound) and visual displays in presentations to clarify information.  SL.6.6 Adapt speech to a variety of contexts and tasks, demonstrating command of formal English when indicated or appropriate.  **Common Core Math Standards**  **5th grade:**  5. MD.2  Make a line plot to display a data set of measurements in fractions of a unit (1/2, 1/4, 1/8). Use operations on fractions for this grade to solve problems involving information presented in line plots.  **6th grade:**  [6.SP.B.5](http://www.corestandards.org/Math/Content/6/SP/B/5/) Summarize numerical data sets in relation to their context, such as by:  A. Reporting the number of observations.  B. Describing the nature of the attribute under investigation, including how it was measured and its units of measurement.  C. Giving quantitative measures of center (median and/or mean) and variability (interquartile range and/or mean absolute deviation), as well as describing any overall pattern and any striking deviations from the overall pattern with reference to the context in which the data were gathered.  D. Relating the choice of measures of center and variability to the shape of the data distribution and the context in which the data were gathered. |
| **Learning Outcomes** | **Science:**  **5th grade**  \*The participant will classify organisms as producers, consumers, or decomposers in a graphic organizer.  \*The participant will infer the effects resulting from the interconnected relationship of plants and animals to their ecosystem using teacher-created note-taking guides.  \*The participant will support an argument that plants get the materials they need for growth chiefly from air and water using teacher-created note taking guides.  \*The learner will research and synthesize information about ways to use science ideas to protect the Earth’s resources and environment using internet resources.  \*The participant will generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem in small groups.  **6th grade**  \*The participant will explain the significance of the processes of photosynthesis and transpiration to the survival of green plants using teacher-created note taking guides.  \*The participant will summarize how energy derived from the sun is used by plants to produce sugars (photosynthesis) and is transferred within food chains and food webs from producers to consumers and decomposers using teacher-created note taking guides  \*The participant will summarize how the abiotic factors affect the ability of organisms to grow, survive, and/or create their own food through photosynthesis using real-life as examples.  \*The participant will construct a scientific explanation based on evidence for the role of photosynthesis in the flow of energy in organisms using illustrations and writing.  \*The participants will construct an explanation that predicts patterns of interactions among organisms in small groups.  \*The participant will evaluate competing design solutions to determine how well they meet the criteria and constraints of the problem in small groups.  **All learners:**  \*The participant will create a solution to a problem based on research in small groups.  \*The participant will be exposed to STEM careers and agricultural science through a simulation.  \*The participant will conduct scientific research and make choices based on the research in small groups.  \*The participant will justify design choices both verbally and in writing based on scientific reasoning in small groups.  **English Language Arts Learning Goals**  **(The specific objectives have been summarized here for brevity.)**  **Fifth grade**  Working both independently and in a group, I can read informational text from multiple sources to:  \*draw inferences  \*determine main ideas  \*summarize a text  \*determine the meaning of words.  \*locate an answer quickly/solve a problem  \*conduct short research projects  Working both independently and in a group, I can write while:  \*using logically ordered reasons that are supported by facts  \*introducing a topic clearly  \*including headings, illustrations, and multimedia  \*using key vocabulary  \*using technology to publish writing and collaborate with others  While discussing in a group, I can… \*be prepared to discuss a topic  \*follow agreed-upon rules for discussions and carry out assigned roles.  \*ask and answer questions thoroughly  \*draw conclusions based on knowledge gained from discussions  \*report on a topic, sequencing ideas logically and using details  \*speak clearly at an understandable pace.  \*include multimedia components and visual displays in presentations appropriately \*adapt speech to a variety of contexts, using formal English  **Sixth grade**  Working both independently and in a group, I can read informational text from multiple sources to:  \*cite textual evidence to support analysis  \*determine a central idea of a text and summarize it  \*determine the meaning of words used in a text  \*conduct short research projects to answer a question  \*gather relevant information from multiple sources and assess the credibility of each source  \*paraphrase the data and conclusions of others while avoiding plagiarism  Working both independently and in a group, I can write while:  \*integrate information presented in different media or formats  \*introduce claim(s) and organize the reasons clearly. \*use precise language and key vocabulary  \*maintain a formal style  \*produce coherent writing appropriate to task, purpose, and audience.  \*use technology to publish writing and collaborate with others  While discussing in a group, I can…  \*be prepared, having read or studied required material  \*follow rules for discussions and define individual roles as needed. \*pose and respond to specific questions with elaboration and detail \*present claims and findings, sequencing ideas logically and using pertinent facts  \*use appropriate eye contact, adequate volume, and clear pronunciation.  \*include multimedia components and visual displays in presentations to clarify information.  \*adapt speech to a variety of contexts, demonstrating command of formal English  **Math Learning Goals**  **5th grade**  I can make a line plot to display a data set of measurements in fractions using real data.  **6th grade** I can summarize and analyze data in context by reporting the number of observations., describing what the data means, and using median, mean, mode, and range using a calculator.  **Language objectives for the SIOP classroom**  \*The participant will read about factors affecting plant growth using active reading strategies, such as note taking.  \*The participant will orally describe and write a plan to create a greenhouse using teacher-created note-taking guides. |
| **Time Required and Location** | **Time required:** Days 1-9 and 30 are 45 minutes class periods; days 10-29 are 10 minutes observation times and the activities do not have to be done daily (recommended every other day).  **Location:** All activities can be done in the classroom. Mini-greenhouses should be placed on a long table or floor by the window. It is important they are placed in an area that will not be disturbed. |
| **Materials Needed** | **Supplies for greenhouses (days 9-30)**  \*Seeds (50-75 of the same type: recommended – lima beans or marigolds)  \*1 bag of seed starter mix  \*2 bags of potting soil  \*2 small bags of aquarium gravel (if students choose to use it at the bottom of the pots for drainage)  \*1 small bag of playground sand  \*50 paper cups  \*25 small paper bathroom cups  \*1 roll of paper towels  \*6 desk lamps with bulbs  \*6 timers for electrical outlets  \*25 gallon size Ziploc bags  \*Various size measuring cups  \*Optional: Small prizes for winning team (4-5 students in a group)  This [link](https://docs.google.com/document/d/1Bb014IUSPn_D_ZNtQIogc5sz1cud9ehRaUZ___NuJTk/edit?usp=sharing) includes a Google doc in which the teacher can copy and share with parents to have them donate supplies. When sharing the link, be sure to click “can edit” so parents can insert their name in the donor’s name section. The list includes all the supplies listed above and is based on a generous amount of materials for one class. If you teach more than one class, you will need to adjust the quantity.  Note: If students choose a “create your own option” from the Choices Handout, the teacher may require the group to obtain their own supplies. All solutions listed on the Choices Handout have materials listed above.  **Ancillary Materials included with this resource:**  Teacher PowerPoints (Soil, Light, Water, Biotic Factors)  Handouts (can be copied front and back and distributed to students as one packet at the beginning of the project)  -Greenhouse Project – Student Directions (1 pg)  -Greenhouse Project Company Information/Team Discussion Roles (2 pgs)  -Soil Research Handout (1 pg)  -Light Research Handout (1 pg)  -Water Research Handout (1 pg)  -Biotic Factors Research Handout (1 pg)  -Choices Handout (3 pgs)  -Here’s Our Plan (1 pg)  **-**Here’s My Feedback (only need copies for visiting experts)  -Greenhouse Project Student Data Sheets (5 pgs)  -Greenhouse Project Student Reflection (1 pg)  -Rubric of Evidence of 5th grade Science Learning Goals (1 pg) OR Rubric of Evidence of 6th grade Science Learning Goals (2 pgs)  -Rubric of Evidence of 5th grade ELA Learning Goals (2 pgs) OR Rubric of Evidence of 6th grade ELA Learning Goals (2 pgs)  -Collecting & Analyzing Greenhouse Data Using Line Plots (5th grade sheet -1 pg) OR Collecting & Analyzing Greenhouse Data Using Mean, Median, Mode, and Range (6th grade sheet - 1 pg.)  -Greenhouse Project Glossary (2 pgs)  **Note: Decide if you will provide additional copies of rubrics for students. Make extra copies of Greenhouse Project Glossary for experts.**  **Participant list:**  \*Graph paper (1-2 pages per group)  \*A copy of student handouts listed in the ancillary materials section above (1 per student)  \*1 manila folder or similar organizer for each student to house his/her research project papers  \*Computers for internet for research and presentation (one per participant is ideal, but at least one per group)  \*Headphones/ear buds for watching online videos associated with research  **Facilitator list/Other:**  \*Projector and computer for displaying presentations  \*Copies ofHere’s My Feedback handout (amount depends on how many experts visit, how many groups they hear present, and if the teacher has student groups give one another feedback)  \*Computer/iPad/device to use for internet research (ideally one per student, but at least one per group – days 2-7) |
| **Safety** | General science laboratory safety principles apply to this greenhouse project:  \*Never eat or drink in the lab.  \*Wash your hands after working in the lab.  \*Clean work spaces and equipment after use.  \*If students use desk lamps and timers use caution to minimize electrical hazards and reduce the risk of students tripping over cords.  \*Report any concerns to the teacher immediately.  \*Ensure students do not have allergies to the plant/seed type being used. |
| **Participant Prior Knowledge** | **Participants should be familiar with the following topics:**  \*examples of how organisms interact with their ecosystem (interdependence)  \*food chains/food webs  \*structure of plants (roots, leaves, etc.)  **Participants should be able to:**  \*take notes and identify main ideas in a passage |
| **Facilitator Preparations**  **Facilitator Preparations Cont.** | **Before the project begins:**  \*Prepare heterogeneous groups (4-5 students per group)  \*Arrange classroom to facilitate group discussion and greenhouse creation  \*Begin gathering supplies/send wish list to parents – link in Materials Needed section  \*Make copies of student handouts  \*Consider getting an extra set of hands for set-up day (day 9): parent volunteer, TA, resource teacher, etc. – can be same as one of the agricultural experts if he/she is willing to come in two days  \*Decide if/how to present prizes to winning team  \*Invite agricultural experts to volunteer on day 8 using the Volunteers Needed Flyer in the resources section; use the community engagement section for a list of ideas/contacts.  **Before the lesson:**  \*Become familiar with slideshows: day 2 - soil, day 3 - light, day 4- water, day 5 - biotic factors  \*Post links for daily research on class website: day 2 - soil, day 3 - light, day 4- water, day 5 - biotic factors (See links in resources section)  Ensure computer access for days 2-8  \*Organize supplies for greenhouse set up on day 9 |
| **Activities**  **Activities**  **Cont.**  **Activities**  **Cont.**  **Activities**  **Cont.**  **Activities**  **Cont.**  **Activities**  **Cont.**  **Activities**  **Cont.**  **Activities**  **Cont.** | **Lesson Outline**  Day 1: Introduce project  Day 2: Research soil  Day 3: Research light  Day 4: Research water  Day 5: Research biotic factors  Day 6-7: Outline plan for greenhouse (finalize research and review choices handout; create blueprint; prepare solutions/proposals multimedia presentation for experts)  Day 8: Present greenhouse proposal to agricultural experts (scientists; local gardeners, etc.) for feedback; use feedback to finalize greenhouse design plan and submit final plan  Day 9: Set up  Day 10-29 (exact number of days is flexible): Make daily observations; Build and maintain greenhouse while evaluating the design  Day 30 : Submit project results and write reflection; acknowledge “winners”  **Lesson Plans**  **Day 1: Introduce project**  **Part A:** Pass out the “Student Directions” handout for the project. Walk students through the directions and explain classroom expectations. Emphasize science learning goals and connections to other content areas, such as reading informational text. Be prepared to answer student questions or have them write them down on an index card and submit them for Q & A at a later time. Have students take the handout home to review with parents and return it with the parent signature.  Make Greenhouse research folders. Provide a place for all research materials to be stored, such as a manila folder. The “Student Directions” handout will be stored in this folder.  Next, distribute the Greenhouse Project Glossary to students. Have students read over the words and score the words 1, 2, or 3. 1 means “I have never heard of this word.” 2 means “I have some understanding of this word” 3 means “I know this word and can use it in a good sentence.” Then, briefly review the vocabulary with students. These words will be continually reviewed throughout the unit.  Lastly, tell students their groups and have them sit together for the remainder of the project. Tell students they will need to set “company values” for their team. What guidelines do they want to set for group discussion? What role should each member play? Have students complete the Company Values handout.  **Day 2: Research soil**  **Part A:** Distribute the Soil Research Handout and Choices Handout to each student. Tell students during the research process they are taking notes about each topic. They will need to choose what is important to write down. Ask: “How will we decide what information is important?” (Main ideas and key vocabulary words are important and anything that may help them make decisions about their greenhouses.) Emphasize each research handout is a note taking sheet and bullet points are an appropriate note-taking strategy, rather than complete sentences.  Read aloud each of the words in the important vocabulary section without explaining them. Then, activate prior knowledge by having students fill in the “What I already know about this topic” section (3-5 minutes). Have students share their ideas with a neighbor (2-3 minutes). Then, call on one or two students to ask what they already know about the topic.  Next, review the attached Soil slideshow with the class (15 minutes). This slideshow explains key ideas related to soil science and vocabulary terms. Encourage students to take notes in the “What did I learn from the teacher” section of the “Soil Research Handout.”  **Part B:** Direct students to conduct independent research using the soil links in the resources section of this document. (Post links on class website to help students access the links faster.) As they research, they take notes using the “What did I learn from my research?” section of their Soil Research Handout. (20 minutes) While students are conducting research, monitor student work by answering questions, helping students paraphrase main ideas, and asking probing questions. (Example: What have you learned from your research about soil types? How can you use that to help you choose good soil in your greenhouse?) Then, students get with their group members and share their research discussing how they can use the information to help them design an effective greenhouse. They record their group decisions and notes in the “How will I use this information in my greenhouse project?” section of their Soil Research Handout. Next, they will use the “Choices Handout” to record their decisions about soil. Direct the students to complete the “choices about soil” section on this sheet by reading and discussing the options with their team (5-10 minutes).  Remind students to store their “Soil Research Handout” and “Choices Handout” in their greenhouse research folder.  **Day 3: Research light**  **Part A:** Distribute the Light Research Handout to each student. Remind students to take notes on main ideas and information that may help them make good decisions about their greenhouse.  Read aloud each of the words in the important vocabulary section of the Light Research Handout without explaining them. Then, activate prior knowledge by having students fill in the “What I already know about this topic” section (3-5 minutes). Have students share their ideas with a neighbor (2-3 minutes). Then, call on one or two students to ask what they already know about the topic.  Next, review the attached Light slideshow with the class (15 minutes). This slideshow explains key ideas related to how plants use light to make food through the process of photosynthesis and relevant vocabulary terms. Encourage students to take notes in the “What did I learn from the teacher” section of the Light Research Handout.  **Part B:** Direct students to conduct independent research using the light links in the resources section of this document. (Post links on class website to help students access the links faster.) As they research, they take notes using the “What did I learn from my research?” section of their Light Research Handout (20 minutes). While students are conducting research, monitor student work by answering questions, helping students paraphrase main ideas, and asking probing questions. (Example: What have you learned from your research about light? Do plants grow better in some types of light than others? How could you use this information in your greenhouse?) Then, students get with their group members and share their research discussing how they can use the information to help them design an effective greenhouse. They record their group decisions and notes in the “How will I use this information in my greenhouse project?” section of their Light Research Handout. Next, they will use the Choices Handout to record their decisions about light. Direct the students to complete the “choices about light” section on this sheet by reading and discussing the options with their team (5-10 minutes).  **Day 4: Research water**  **Part A:** Distribute the Water Research Handout to each student. Remind students to take notes on main ideas and information that may help them make good decisions about their greenhouse.  Read aloud each of the words in the important vocabulary section of the Water Research Handout without explaining them. Then, activate prior knowledge by having students fill in the “What I already know about this topic” section (3-5 minutes). Have students share their ideas with a neighbor (2-3 minutes). Then, call on one or two students to ask what they already know about the topic.  Next, review the attached Water slideshow with the class (15 minutes). This slideshow explains key ideas related to how plants use water with relevant vocabulary terms. Encourage students to take notes in the “What did I learn from the teacher” section of the Water Research Handout.  **Part B:** Direct students to conduct independent research using the water links in the resources section of this document. (Post links on class website to help students access the links faster.) As they research, they take notes using the “What did I learn from my research?” section of their Water Research Handout (20 minutes). While students are conducting research, monitor student work by answering questions, helping students paraphrase main ideas, and asking probing questions. (Example: What have you learned from your research about water? How will you know when to water your plants? What type of water will you use for your plants?) Then, students get with their group members and share their research discussing how they can use the information to help them design an effective greenhouse. They record their group decisions and notes in the “How will I use this information in my greenhouse project?” section of their Water Research Handout. Next, they will use the “Choices Handout” to record their decisions about water. Direct the students to complete the “choices about water” section on this sheet by reading and discussing the options with their team (5-10 minutes).  **Day 5: Research biotic factors**  **Part A:** Distribute the Biotic Factors Research Handout to each student. Remind students to take notes on main ideas and information that may help them make good decisions about their greenhouse.  Read aloud each of the words in the important vocabulary section of the Biotic Factors Research Handout without explaining them. Then, activate prior knowledge by having students fill in the “What I already know about this topic” section. (3-5 minutes). Have students share their ideas with a neighbor (2-3 minutes). Then, call on one or two students to ask what they already know about the topic.  Next, review the attached Biotic Factors slideshow with the class (15 minutes). This slideshow explains key ideas related to how plants interact with other organisms in their ecosystem and relevant vocabulary terms. Encourage students to take notes in the “What did I learn from the teacher” section of the Biotic Factors Research Handout.  **Part B:** Direct students to conduct independent research using the biotic factor links in the resources section of this document. (Post links on class website to help students access the links faster.) As they research, they take notes using the “What did I learn from my research?” section of their handout (20 minutes). While students are conducting research, monitor student work by answering questions, helping students paraphrase main ideas, and asking probing questions. (Example: What have you learned from your research about how plants may be affected by other organisms? How will you use this information to grow healthy plants in your greenhouse?) Then, students get with their group members and share their research discussing how they can use the information to help them design an effective greenhouse. They record their group decisions and notes in the “How will I use this information in my greenhouse project?” section of their handout. Next, they will use the “Choices Handout” to record their decisions about biotic factors. Direct the students to complete the “choices about biotic factors” section on this sheet by reading and discussing the options with their team (5-10 minutes).  **Days 6-7 Outline plan for greenhouse**  Instruct students they will be using the next two days to finalize their greenhouse plans. Remind them they will present their plans to agricultural experts and will need to have a good understanding of what their greenhouse will be like so they can share their ideas with the expert. Write these four goals on the board as a to-do list for students:  1. Review/complete research and choices handouts  2. Create a blueprint of the greenhouse on graph paper  3. Complete the Here’s Our Plan handout  4. Create multimedia presentation for agricultural experts.  Explain each item to students in more detail:  1. Handouts: Tell students they can finish any part of their research or choices handouts they did not have time to complete previously. Also, they can continue to research any topic about which they still have questions or would like to learn more.  2. Blueprint: Pass out graph paper and tell the students they will be drawing a blueprint of what they what their greenhouse to look like. Explain that a blueprint is a detailed diagram of what something will look like. If necessary, use the LCD projector and display a picture of a blueprint from the internet.  3. Pass out the Here’s Our Plan handout. Explain to students how to use this sheet to prepare for tomorrow’s discussion with the agricultural experts.  Allow time for students to work in their groups. Monitor student work by rotating among the groups and asking probing questions, such as “Why have you decided to use/not use artificial light in your greenhouse?” Be sure to focus on the justification of the decision, rather than the decision itself. Encourage students to use vocabulary words from their “Greenhouse Project Glossary” whenever possible.  4. Lastly, tell the students they will be preparing a brief slideshow to use as they present to their agricultural experts (The presentation should be around 10 minutes). You may want to use the Google Slideshow in the resources section as a template/example for students. If students have Google accounts, they can use the slideshow link, make a copy, and then edit their slideshow to fit their needs. If students do not have Google accounts or access to Google Slideshow, they can use another presentation platform, such as PowerPoint and simply use the Google Slideshow as an example.  \*\*If time is short, the slideshow requirement can be deleted and students can use their research and choices handouts to guide their discussion with the experts.  **Day 8: Present greenhouse proposal to agricultural experts**  Remind students the goal of today is to present their greenhouse plan to agricultural experts in order to receive feedback and make adjustments to the plan. (See more information about how to obtain agricultural experts in the community engagement section of this document.) Remind students that receiving feedback and making adjustments is an essential part of participating in a scientific community. Set procedural and behavioral expectations while guests are in the class.  Introduce the experts to the “Here’s My Feedback” handout and encourage them to use it to facilitate effective communication between the students and the expert.  Allow students 5-10 minutes to set up and prepare presentations.  There are several options for how today’s lesson can be set up depending on the number of experts who are coming, needs of the students, and other classroom dynamics. Choose the option that works best for your environment.  \*Option 1: If you have at least one expert for every group (i.e. at least six experts and six groups), match up an expert with each group. Have groups present simultaneously to their experts around the room. After ten minutes, direct students to wrap up their presentations, and then allow five minutes for experts to give their feedback. Then, have experts rotate to a new group. With this option, students receive feedback from two experts. Note: Experts will need two copies of the Here’s My Feedback handout.  \*Option 2: A variation of the previous option, keep the same set-up as in option 1, but have the expert stay with the same group the whole time.  \*Option 3: If you do not have enough experts, match an expert with 2-3 groups. Have each group present to their expert. If you use this option, you could have the students fill out a Here’s My Feedback handout for the other group to keep them engaged while each group is presenting.  \*Option 4: If you only have one expert or if you do not have enough classroom space for the other options, you can have one group present to the entire class while the expert(s) listen and give feedback. Students can use the Here’s My Feedback handout to stay engaged while other groups present.  After groups have presented to the experts, allow some time for groups to reconvene and discuss any changes they need to make based on the expert’s feedback. By the end of the class, they should submit their final plans by updating their Here’s Our Plan handout. Be sure to emphasize a need to a specific list of supplies, since that is the list of supplies the facilitator will have available for students on Day 9: set up.  **Day 9: Set up**  Review procedural and behavior expectations for students as they set up their greenhouses. (How will students access their materials? What is an appropriate voice level? Etc.) Emphasize safety and appropriate lab procedures (See the safety section for more details.) Students should have their blueprints and Here’s Our Plan handout to refer to while building their greenhouse. You may choose to invite parent volunteers or experts to return to lend a helping hand. Allow students time to build their greenhouses. Ensure materials are put away and surface areas are clean before the end of the class period.  **Day 10-29: Make daily observations**  On day 10, distribute the Greenhouse Project Student Data Sheet weeks 1-5 handouts to students. Model how to fill in the sheet. Show students the [Youtube Bean Germination Video](https://www.youtube.com/watch?v=pB4ASdELBbQ&feature=youtu.be) to help them understand what germination is and what to expect in their greenhouse during the first week. During the next several weeks, allow students 10-15 minutes three times a week to observe their greenhouse, record data on the sheet, and maintain the greenhouse (i.e. watering, etc.) As students observe their greenhouse, they may see the need to make changes. Emphasize to students they must have any changes pre-approved. Example: If the plant is not growing as planned, the hours of artificial light can be increased.  **Day 30: Submit project results and write reflection**  Have students measure each of their plants’ height and record it on the board like this:   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Group 1 | Group 2 | Group 3 | Group 4 | Group 5 | Group 6 | | 5 cm  12 cm  2 cm  0 cm  6 cm |  |  |  |  |  |   Have them decide which two plants they will submit for the team evaluation. (Remind them to use the plant scoring guide on the Greenhouse Project Student Directions handout to make their choices of which plants to submit.) Next, distribute the Greenhouse Project – Student Reflection Sheet and the Collecting & Analyzing Greenhouse Data sheet appropriate for the grade level. (5th grade uses a line plot; 6th grade uses mean, median, mode, and range.) Allow students 30-40 minutes to complete the sheets. Meanwhile observe each groups’ plants submitted for review. Use the Plant Scoring Guide (see below) to determine the total number of points for each group.  **Plant scoring guide**  \*Each team will submit their two best plants to the judges.  \*Each of the 2 plants will be measured in centimeters and added together. You will earn 1 point per centimeter of height.  \*Each team will earn 1 point for each leaf of the two plants.  \*Each team will earn 3 points for a bud/flower on the plant.  Announce classroom winners and present prizes as appropriate. |
| **Assessment** | Rubrics are included in the ancillary materials to assess for science and ELA learning goals. The science rubric includes an “evidence” column so both teachers and students know how learning of these objectives is assessed. The ELA learning goals are broken down in sections based on the activity in which they occur. There is a section for research goals, group discussion goals and agricultural expert presentation goals (with subsections: multimedia and speaking goals). It is recommended the teacher organize student rubrics in a binder by groups (Example: All of group 1 members are in a section.) As the teacher rotates during research and discussion time, he/she can assess these objectives. If desired, students can also receive a copy of the rubrics and complete self-assessments at the end of each day or at the end of the unit. It is recommended that students receive a copy of the rubrics so they clearly understand how they are being assessed.  See the following rubrics at the end of the unit plan:  1. Rubric of evidence of 5th grade ELA learning goals  2. Rubric of evidence of 6th grade ELA learning goals  3. Rubric of evidence of 5th grade science learning goals  4. Rubric of evidence of 6th grade science learning goals  5th grade math learning goals are assessed by review of the handout entitled “Collecting & Analyzing Greenhouse Data Using Line Plots” Answers with vary.  6th grade math learning goals are assess by review of handout entitled “Collecting & Analyzing Greenhouse Data Using Mean, Median, Mode, and Range.” Answers will vary. |
| **Critical Vocabulary** | The Greenhouse Project Glossary is a student handout of an alphabetized list of words students will be exposed to during the unit with key vocabulary in bold. Pictures are used to aid English Language Learners and visual learners in their understanding of the concepts. |
| **Community Engagement**  **Community Engagement**  **Cont.** | A major component of the project is having students research factors affecting plant growth and make choices about their own greenhouses based on what they learn. As in real-world science, students need to share their ideas and receive feedback from experts. Be open-minded about who may be considered an “agricultural expert.” Remember there are often people who work in businesses related to plants and agriculture or those who garden as a hobby. These community members may not have a formal education in agricultural science, but can provide great, practical feedback to students, particularly students who have little to no previous experiences with ag science. Use the flyer in the resources section to communicate your need to potential volunteers.  **In order to engage agricultural experts, consider the following local resources:**  \*farmers  \*scientists (particularly with a background in biological sciences) and technicians from agricultural related businesses (such as crop science industry, nurseries, and gardening supply centers) Contact the Chamber of Commerce for information about these businesses.  \*parents, community members who garden as a hobby  \*community gardening clubs  \*county 4-H program  \*high school FFA (Future Farmers of America) club members  \*museums  \*county extension agents  \*universities (often universities have agricultural science programs/clubs and are more than willing to become involved) |
| **Extension Activities**  **Extension Activities**  **Cont.**  **Extension Activities**  **Cont.** | \***Collaborating via technology:** If you are having difficulty contacting local agricultural experts or if you would like to leverage technology further, consider contacting nation-wide or even world-wide agricultural experts for your class. Using technology such as Skype, FaceTime, and Google Share Features, students can collaborate with experts throughout the world without leaving the classroom!  \***Do not miss the opportunity to teach students how to interact in a professional setting.** Before agricultural experts arrive in your classroom, teach students how to introduce themselves, make appropriate eye contact, and shake hands. Model this behavior for students and have students practice with each other. Also consider having students dressing professionally when the experts visit the classroom. Dressing for success communicates respect to the guests and teaches students how to prepare for real-world presentations. Additionally, students gain more confidence and take the situation more seriously when dressed professionally. Show students a picture of two people one wearing a t-shirt and shorts and one dressed in a suit. Ask: Who do you perceive will give a better presentation? This option may not be appropriate for all settings, but can be a worthwhile experience for students if managed appropriately.  There are endless opportunities for extension/enrichment with this project. Here are just a few for each of the research topics. These could be completed after each day’s research on the topic.  **Soil science lab to supplement student research:**  --[Edibleschoolyard.org: pH Soil Testing Lab](https://edibleschoolyard.org/node/3172)  --[NSTA Online Connections](http://www.nsta.org/elementaryschool/connections.aspx): search for the November 2012 article called “Getting to Know Soil Student Activity Sheet 2”  --[Soil-net.com: The Jam Jar Experiment](http://www.soil-net.com/sm3objects/activities/Activity_JamJar.pdf) (shorter version of NSTA lab above)  **Light/Photosynthesis lab to supplement student research:**  ---[Kcedventures.com: How do Leaves Breathe?](http://www.kcedventures.com/blog/how-do-leaves-breathe-a-simple-science-experiment-for-kids): A very simple way for students to actually see evidence of photosynthesis!  **Water lab to supplement student research:**  --[NSTA: Up Goes the Water](http://science.nsta.org/enewsletter/2007-07/sc0404_47.pdf): Classic experiment to demonstrate how water travels through the xylem of a plant  **Biotic Factors labs:**  --[Woolly Adelgid Infestation Activity](https://drive.google.com/file/d/0B1nXDBqaAG2BV3JHUmMwZzFjZlE/view?usp=sharing) The Wooly Adelgid is a concern in forests in the Eastern US, such as the Great Smokey Mountains of NC. In this activity created by the greenhouse project author, students investigate how organisms interact with each other and the dangers of invasive species in a real-world situation. This activity also demonstrates how plants draw water through the xylem and symbiotic relationships. Students can research what role scientists are playing in managing the Wooly Adelgid.  For more information on the Woolly Adelgid:  --[Penn State: Hemlock Woolly Adelgid](http://ento.psu.edu/extension/factsheets/hemlock-woolly-adelgid)  --[Usda.gov: Woolly Adelgid](http://www.srs.fs.usda.gov/pubs/ja/2009/ja_2009_mcdonald_001.pdf)  --[Biologycorner.com: Earthworm observation lab](http://www.biologycorner.com/worksheets/earthworm_observation_living_key.html): Just as the greenhouse project focuses on how plants interact in their environment, this activity teaches how earthworms interact in their environment.  --[Virtual Earthworm Dissection](http://www.mhhe.com/biosci/genbio/virtual_labs/BL_14/BL_14.html) Great enrichment activity for students to understand the complexity of a seemingly simple organism  --The [Agclassroom.org Cheetos and Pollination Experiment](http://www.agclassroom.org/ID/teacher/doc/materials/pollination_experiment.pdf) is a great way to model interdependence between bees and plants.  **Investigating issues in Crop Science:**  \*Have students research the controversial issue of genetically modified foods. Discuss the importance of considering the author’s point of view when evaluating resources. Here a few resources to begin.  [Learn.genetics.utah.edu: GM Foods](http://learn.genetics.utah.edu/content/science/gmfoods/)  [World Health Organization: FAQ on GM Foods](http://www.who.int/foodsafety/areas_work/food-technology/faq-genetically-modified-food/en/)  [GMOanswers.com](https://gmoanswers.com/)  [Nongmoproject.org: What is a GMO?](http://www.nongmoproject.org/learn-more/what-is-gmo/)  Questions to consider:  --Why is there a need for transgenic plants? (emphasize urbanization and the growing world population)  --How could the technology of GM foods be used in other fields, such as health sciences?  --What are the ethical implications of alternating the DNA of an organism?  --How do transgenic plants compare with other methods of traditional breeding? (Consider factors such as efficiency and precision.)  \*Have students develop and conduct a blind taste test of organic vs. nonorganic foods. Emphasize the importance of controls and a fair test. Discuss appropriate data collection methods.  **Investigating world population**  \*Using the [Youtube: World Population video](https://www.youtube.com/watch?v=4BbkQiQyaYc) and the [National Geographic: 7 Billion Video](http://video.nationalgeographic.com/video/news/7-billion/ngm-7billion), discuss the current and projected world populations. What are the implications for health and agriculture? How do evolutionary concepts play a role in managing the human population (Consider factors, such as competition and natural selection.) Does industrialization, advanced healthcare, and the digital age override these factors?  \*Dinner for the World from Population Connection (available online): A simulation to show the inequitable distribution of food and resources. This is a lesson students won’t soon forget!  \*Supplemental lessons from [Population education](https://populationeducation.org/content/find-lesson)  **Agricultural Science: & Careers:**  \*Many students have the mindset that all people who specialize in agriculture work in a field and drive tractors. However, 22 million people work in agriculture in more than 200 careers. The [Wisagclassroom.org: Careers in Ag](http://wisagclassroom.org/wp-content/uploads/2015/10/An-Agricultural-Career-for-You.pdf)  resource introduces students to the numerous AG related careers.  \*This [University of Illinois Extension: Farming Infographic](http://www.farms.com/expertscommentary/infographic-us-agriculture-census-73807.aspx) shows US Census data related to agricultural.  **Other related enrichment:**  \*[Plant Phenotypes Activity](https://drive.google.com/file/d/0B1nXDBqaAG2BNFJFTFJROFZfdUU/view?usp=sharing): Students gain an understanding as plants as living organisms with unique genetic traits.  \*[Msichicago.org: Gardening in a Glove](http://www.msichicago.org/online-science/activities/activity-detail/activities/grow-a-garden-in-a-glove-1/browseactivities/4/): another option to help seeds germinate |
| **Modification**  **Modification**  **Cont.** | **Modification options for independent research/reading comprehension:**  \*Prior to the unit, use the Greenhouse Project Glossary to review key vocabulary with English Language Learners. Use realia and the internet to show students pictures of each word. Have students draw pictures beside each word to aid in their understanding of the word.  \*On Day 2, scaffold the independent research process by modeling for students how to conduct independent research. Choose one of the website links and show students how to differentiate between important information and details.  \*Print a copy of the PowerPoint for students so they can highlight main ideas as you present.  \*Form a small group of students who struggle with reading comprehension and have them read aloud one of the sources for each day’s research links. Ask questions to check for understanding. Discuss key vocabulary in context. Ask how the information might be used in the greenhouse project.  \*Use text-to-speech functions and headphone on participants’ computers for students who need read-aloud. Be sure they know how to pause it to take notes.  \*For students with writing difficulties, use tools such as talk to text features in Google Docs to replace traditional hard copy note-taking.  Note: Some supports are already in place for all students, such as the research handouts (guided notes) and Greenhouse Project Glossary.  **Modification options for discussions:**  \*To ensure equitable group discussion, provide each student with two tokens. When they make a comment or ask a question to their group, they must lay a token down. Once they have laid down both tokens, they cannot speak. Once every member has laid down both token, the process repeats.  \*If group members have difficulty with taking turns speaking, provide the group with a “talking stick.” Tell them only the person with the talking stick can speak. When they want to speak, they must place both palms up on the table. Then, the speaker can pass it to the next group member.  \*Print a copy of sentence stems to help students with special needs and English Language Learners communicate their ideas. These are helpful for both daily discussions and presenting to experts. Some examples include:   |  | | --- | | Something new I learned today was…  This reminds me of…  I think that…  I agree/disagree with \_\_\_\_\_, because…. |   **Modification options for assessments for students with learning disabilities or English Language Learners:**  \*Read aloud the assessment to students with reading difficulties  \*Have students dictate answers to a scribe or respond orally  \*Encourage students to draw pictures or diagrams to aid their written expression.  \*Allow students to use a word bank or their Greenhouse Project Glossary for written assessments. |
| **Resources/ Additional Information** | **Resources for teacher preparation:**  **\*Google Slideshow template** [link](https://docs.google.com/presentation/d/1Ky3l7_IXGtF-9uP0DLwXCvoW7e8ge0ycb8qsWs942u0/edit?usp=sharing):This slideshow is basic, but sets expectations for the type of information students should include in their multimedia presentation. If students have Google accounts, the teacher can make the shareable link available, and students can create a copy to use it as a starting point for their own work.  **\*Greenhouse Choices handout is also available as a Google Form** with this [link](http://goo.gl/forms/bmDQvEYd95). Create a similar form and edit as you see fit. Students can submit their responses electronically, and the teacher can view student responses in a spreadsheet format.  **\*Use this** [flyer](https://drive.google.com/file/d/0B1nXDBqaAG2BMXM0dzJSeUxiM1E/view?usp=sharing)to solicit agricultural experts to volunteer in your classroom. Edit as needed.  **Resources for more information:**  [Wake County, NC Extension Office](https://wake.ces.ncsu.edu/): Includes 4-H program information, contacts for county extension agents, etc. (Each county in NC has a cooperative extension agency which can be an invaluable tool for this project.)  [Holly Springs Garden Club](http://www.hollyspringsgardenclubnc.com/index.htm) (Town of Holly Springs, NC) – a simple Google search may help locate a similar club in the school community  [North Carolina Future Farmers of America](https://ncffa.org/):This organization is strong advocate for agricultural education. Each state/region has its own resources. Great website for research and contacts!  **Websites for student research:**  \*post on teacher website, so students can access them easily  **Soi**l:  [Slideshare: Properties of Different Kinds of Soil](http://www.slideshare.net/MMoiraWhitehouse/properties-of-soils-teach-9807299)  [Soil-net.com Factsheet: Soil Types](http://www.soil-net.com/sm3objects/activities/Factsheet_SoilTypes1.pdf)  [Soil-net.com Factsheet: Soil Components](http://www.soil-net.com/sm3objects/activities/Factsheet_SoilComponents.pdf)  [Soil-net.com Properties of Soil](http://www.soil-net.com/primary/ks2/topic6/topic6_factsheet.pdf)  [Youtube: Testing Soil for Clay Content](https://www.youtube.com/watch?v=hh211b8b5FE) (video seen in class)  [Scholastic Study Jams: Soil](http://studyjams.scholastic.com/studyjams/jams/science/rocks-minerals-landforms/soil.htm)  [Farmpretty.com: Sifting Through the Soil](http://farmpretty.com/2014/09/05/sifting-through-the-soil/)  [Composting for Kids](http://aggie-horticulture.tamu.edu/kindergarden/kidscompost/CompostingForKids.pdf)  **Water:**  [Gardener's Supply Company: When to Water](http://www.gardeners.com/how-to/when-to-water/8108.html)  [Gardening Know How: When to Water a Plant](http://www.gardeningknowhow.com/houseplants/hpgen/how-to-water-a-plant.htm)  [Kidsgardening.org: Teaching Kids About Water and Soil Conditions](http://www.kidsgardening.org/node/61046)  [Scholastic Study Jams: Roots and Stems](http://studyjams.scholastic.com/studyjams/jams/science/plants/roots-stems.htm)  [Colostate.edu: Guidelines for Watering Indoor Plants](http://www.colostate.edu/Dept/CoopExt/4dmg/Plants/guidline.htm)  [Powershow.com: Water and Plant Growth](http://www.powershow.com/view/122059-Y2ExM/Water_and_Plant_Growth_powerpoint_ppt_presentation) (higher-level enrichment text)  **Light:**  [Scholastic Study Jams: Photosynthesis](http://studyjams.scholastic.com/studyjams/jams/science/plants/photosynthesis.htm)  [Gardening Know How: What Light Affects the Growth of a Plant](http://www.gardeningknowhow.com/plant-problems/environmental/how-light-affects-the-growth-of-a-plant-problems-with-too-little-light.htm)  [Kidsgardening.org: Light](http://www.kidsgardening.org/school-greenhouse-guide/greenhouse-conditions/light)  [Photosynthesis: The Big Picture](http://www.hobart.k12.in.us/jkousen/Biology/phobig.html)  **Biotic Factors:**  [Kidsgardening.org: Pests and Disease](http://www.kidsgardening.org/school-greenhouse-guide/pests-diseases)  [Youtube: Beneficial Insects General Predators](https://www.youtube.com/watch?v=u-XoU4uZo-Y)  [Kidsgardening.org: Garden Buddies Making Friends with Beneficial Insects](http://www.kidsgardening.org/node/11528)  [McDonnell Nursery: Ladybugs](http://www.mcdonnellnursery.com/html/lady_bugs.html)  [Uncle Jim's Worm Farm: The Role of Worms in Our Ecosystem](https://unclejimswormfarm.com/the-role-of-worms-in-our-ecosystem/)  [Science Learning: Earthworms' Role in the Ecosystem](http://sciencelearn.org.nz/Science-Stories/Earthworms/Earthworms-role-in-the-ecosystem)  [Soil.net.com: Wormery](http://www.soil-net.com/sm3objects/activities/Activity_Wormery1.pdf)  **Other interesting links for extended student research:**  [Scholastic Study Jams: Plants with Seeds](http://studyjams.scholastic.com/studyjams/jams/science/plants/plant-with-seeds.htm)  [Kidsgardening.org: Hydroponics](http://sciencelearn.org.nz/Science-Stories/Earthworms/Earthworms-role-in-the-ecosystem)  [Kidsgardening.org: Seed Q&A](http://www.kidsgardening.org/node/96821#Q1)  [Ava's flowers: What is Botany?](http://www.avasflowers.net/the-study-of-plants-and-flowers-a-botany-guide-for-kids-and-stude) |
| **Comments** | **Choosing seeds and growing plants:**  When choosing a plant, keep in mind large seeds have the most energy and usually germinate the fastest. There are many possibilities for seed choices, with beans and marigolds being among the most popular. Dry beans are easily accessible and can be purchased at the grocery store throughout the year. For more information about choosing seeds and growing plants indoors, click [here](http://www.kidsgardening.org/node/96821).  **What if the seeds don’t germinate or the plants die?**  An important part of real-world science research and development is responding to failure. Educators tend to think negatively about failure. However, if the facilitator approaches a problem with a “What can we learn from this?” or “How can we change this to make it work?” attitude, the students will follow. As long as students are learning, it is not a failure.  “I haven’t failed. I’ve just found 10,000 ways that don’t work.” –Thomas Edison  **How does this project fits into the**  **4 Cs of 21st century learning skills?**   |  |  |  |  | | --- | --- | --- | --- | | **Communication** | **Collaboration** | **Creative thinking** | **Critical thinking** | | Communicating to agricultural experts builds students’ abilities to share ideas and listen to feedback in a real-world experience | Working in a team develops students’ skills as they consider the viewpoints of others, contribute meaningfully to discussions, and work towards a common goal. | Designing a greenhouse gives students the opportunity to propose unique solutions and create a product in response to a real-world problem. | Conducting research helps students analyze information, while designing a greenhouse requires students to consider multiple plausible solutions | |
| **Author Info**  **Author Info**  **Cont.** | **Kenan Fellow:**  Stacey Guerrero graduated with a BS in Elementary Education from Campbell University. She has taught both middle school and elementary for the last ten years. In 2011, she joined the staff at Holly Grove Elementary School in Holly Springs, NC (Wake County Public School System) as a fifth grade teacher with a focus on math and science. In 2010, Stacey received the Rising Star Teacher of the Gifted Region XII Award, and in 2011, she received her school’s Teacher of the Year award. In 2013, Stacey received her National Board Teaching Certification. She has worked with her district to create curriculum unit plans and common assessments. In 2015-2016, she worked as a Kenan Fellow at Bayer Crop Science in Durham, NC. Her favorite things about teaching are seeing the “light bulb” expression on the faces of her students as they are learning and witnessing the quirky things her students say and do to make every day unique! When Stacey is not teaching, she enjoys spending time outside on warm spring days, cooking new recipes, and soaking in quality time with family and friends.  Email: [sguerrero@wcpss.net](mailto:sguerrero@wcpss.net)  Twitter: @guerrerosclass  Website: [www.sguerrero.weebly.com](http://www.sguerrero.weebly.com)  **Mentor:**  Jeff Donald has nearly two decades of experience communicating on a wide variety of science, agriculture, and environmental topics. A passion for politics drove him to Washington, DC, where he served as deputy press secretary on the House Science Committee and political appointee at the National Oceanic and Atmospheric Administration dealing with issues, such as climate and Hurricane Katrina. Jeff left the public sector to manage communications for a global nuclear energy company, then called USEC to manage internal and external communications and develop the company’s social media strategy. Jeff returned home to North Carolina to advocate for agriculture with Bayer Crop Science, where he focuses on digital and social communications and media relations.  Jeff holds bachelors’ degrees in political science and communications from UNC Chapel Hill and a MBA from the George Washington University. When not buried in social media following his beloved Washington Nationals, Jeff can often be found by his smoker fueling his barbecue and home-cured bacon obsessions.  Email: [jeff.donald@bayer.com](mailto:jeff.donald@bayer.com)  **Other Crop Science mentors include:**  Danielle Mayber ([danielle.mayber@bayer.com](mailto:danielle.mayber@bayer.com))  The greenhouse staff led by Kurt Boudonck ([kurt.boudonck@bayer.com](mailto:kurt.boudonck@bayer.com)) and the innovation team led by Brian Vande Berg ([brian.vandeberg@bayer.com](mailto:brian.vandeberg@bayer.com)) |