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| Local Adaptation of Milkweed – *Data Analysis* |
| Introduction |
| This lesson guides students through data entry, representation, analysis, and interpretation. Students will submit data to be used as part of a larger, authentic distributed research project. They will also perform data analysis on the data they collect, and possibly data from other schools and past years; this will help them with their “data jam” that will be incorporated into their citizen science project at the end of the curriculum.  This lesson plan is a component of the *EXPLAIN* stage of the 5E Learning Model for the overall curriculum. |
| Objectives |
| After this lesson, students will be able to:   * ask questions and define which questions can be answered with their data, * enter data into a spreadsheet, * represent data through methods ranging from creating visual graphs to calculating means to performing a linear regression, and * make predictions about the implications of their results. |
| NGSS Performance Expectations Addressed |
| Standards  Middle School:   * MS-LS2-1. Analyze and interpret data to provide evidence for the effects of resource availability on organisms and populations of organisms in an ecosystem. [Clarification Statement: Emphasis is on cause and effect relationships between resources and growth of individual organisms and the numbers of organisms in ecosystems during periods of abundant and scarce resources.]   High School:   * HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales. [Clarification Statement: Examples of mathematical representations include finding the average, determining trends, and using graphical comparisons of multiple sets of data.] [Assessment Boundary: Assessment is limited to provided data.] * HS-LS4-3. Apply concepts of statistics and probability to support explanations that organisms with an advantageous heritable trait tend to increase in proportion to organisms lacking this trait. [Clarification Statement: Emphasis is on analyzing shifts in numerical distribution of traits and using these shifts as evidence to support explanations.] [Assessment Boundary: Assessment is limited to basic statistical and graphical analysis. Assessment does not include allele frequency calculations.]   Science and Engineering Practices   * (asking questions) * Developing and Using Models * Analyzing and Interpreting Data * Using Mathematics and Computational Thinking   Disciplinary Core Ideas   * LS2.A: Interdependent Relationships in Ecosystems * LS4.B: Natural Selection * LS4.C: Adaptation   Crosscutting Concepts   * Patterns * Scale, Proportion and Quantity |
| Information for Classroom Use |
| Approximate Duration for the Task  50-60 minutes or one class period.  Assumptions  Students should know or be familiar with:   * Excel functions * Terminology from the “Evolutionary Principles” lesson * Statistical calculations and/or tests ranging from calculating a mean to performing a linear regression, as appropriate for the class   Teachers should know or be familiar with:   * Statistical calculations and/or tests ranging from calculating a mean to performing a linear regression, as appropriate for the class   Additional Materials Needed   * Computers with Excel * Lab notebooks/folders   Supplementary Resources   * Tuva Labs: <https://tuvalabs.com/k12/> * Tuva Labs Graph Choice Chart: <https://tuvalabs.com/static/documents/Graph_Choice_Chart.pdf> * The Data Inquiry Framework is a graphic organizer that helps students work through analysis of any dataset. It may be used as a template for the specific process described below. * There is a Data Nugget lesson on Local Adaptation which could be useful as a transition or assessment:   <http://datanuggets.org/2016/10/winter-is-coming/> |
| Classroom Task |
| Context  Since students’ level of data analysis will vary between classes conducting this research, much of this lesson is left to the teacher’s discretion, such as the level of analysis and whether or not students will work individually or in groups to complete the data analysis activity. The main points all students should be taught include: data entry, connecting questions to data, appropriately representing data, and interpreting data. It is important to stress that most analysis will be done at the site level, and not the individual plant level. This means that the class will take average numbers across the plants originating from the same site. For students with more statistical knowledge, the class might perform statistical tests such as ANOVA or t-tests on the data. More advanced classes may wish to analyze a dataset that includes measurements from gardens at other sites in addition to their own.  *Prior to the analysis*, teachers should “clean” the data. This means that they should check over the data for any errors and remove any obvious mistakes. This is a good time to add in columns with Site Names and coordinates (lat. and longitude) to help students identify which are local and nonlocal plants. It will also be useful to add a column that identifies each plant as Local or Non-Local. The teacher may also wish to calculate averages of the 3+ measurements for each plant, which will make the analysis easier. If desired, you may select a limited number of measured, or response variables, to simplify the options for students.  Task Components  *ENGAGE*   1. Divide the class into 4 (or 8) groups, and ask each group to discuss the questions on one page in the Sample Data for Discussion. This will give students practice interpreting graphs related to the lab. 2. Connect the discussion to previous learning from the Risky or Not and Evolutionary Principles lessons.   *EXPLORE*   1. Have students follow the protocol for data entry prior to the “explain,” “elaborate” and “evaluate” portions of this lesson. This is protocol 5 in the “Protocols” section of the “Lab Materials” folder. 2. As a class, consider the following question: *what kinds of questions are answerable with our data?* Consider comparisons between groups (local vs nonlocal) and comparisons between measured variables (leaf number vs plant height) in this discussion.   *EXPLAIN*   1. At an appropriate mathematical level, explicitly teach or review: quantitative and qualitative variables, averages, variability. 2. Have students divide their data entry variables into quantitative and qualitative variables. 3. Choose one response variable (height, leaf number, etc.) and introduce students to graphing by showing and discussing example charts. Use the Tuva Graph Choice Chart to show possible ways to represent data with graphs and charts. Some example charts might include:    1. Plotting the chosen response variable against Position number in a scatterplot. This will allow you to observe the variability in measurements on the same plant.    2. Plotting the average response variable values between local and foreign plants in a bar graph. This would be a good way to discuss standard error (or variability among samples). The higher standard error would be expected for the local plants, which have a smaller sample size (n=4) than the foreign plants (n=12). 4. Have students choose a question that is answerable with the data.   *ELABORATE*   * + - 1. Have students use the Tuva Graph Choice chart to choose how to represent their data and answer their question.       2. Before graphing, students should make an analysis plan using Tuva Labs Graph Choice Chart, in which they outline the type of mathematical analysis and graph with which they plan to represent their data.       3. Encourage students to consider (and sketch graphs of) all possible outcomes.     *EVALUATE*   1. Students will make their chosen graph. 2. Some classes may choose to conduct statistical tests such as ANOVA or t-tests, if appropriate. As an additional extension, you may have your students calculate the local-foreign contrasts (the difference between the average measure for local population and the average across all the non-local populations). If you are analyzing the full dataset from many sites, you can also calculate the home-away contrast. 3. Students will interpret the data, either in a discussion or in their lab notebooks, answering questions such as the samples below:    1. What are the trends of your graph? (describe your results so they stand independently from the graph)    2. Use the data to answer the question you investigated.    3. How confident are you in your answer? Is there any error? Were there alternate hypotheses at play? Discuss potential sources of error.    4. What do your results mean in terms of local adaptation? (consider the graph analysis from the beginning of the lesson; connect back to Risky or Not? exercise)    5. What’s next? (make a suggestion for further analysis or experimentation) |
| Alignment and Connections of Task Components to NGSS Performance Expectations |
| Standards  Middle School:   * MS-LS2-1. *This standard could be addressed by having students compare milkweed size (resource availability) with insect/herbivory data to determine if herbivores respond to resource availability.*   High School:   * HS-LS2-2. *This standard is addressed by having students collect, represent, and analyze data to consider if local adaptation might affecting common milkweed.* * HS-LS4-3. *This standard is addressed by having students use statistical tests to analyze their data.*   Science and Engineering Practices   * Developing and Using Models – *This practice is addressed by having students use appropriate statistical tests and models to analyze their data.* * Analyzing and Interpreting Data – *This practice is addressed by having students use appropriate statistical tests and models to analyze their data.* * Using Mathematics and Computational Thinking – *This practice is addressed by having students use appropriate statistical tests and models to analyze their data.*   Disciplinary Core Ideas   * LS2.A: Interdependent Relationships in Ecosystems – *This idea is addressed by having students determine whether or not site location is important for the growth of common milkweed.* * LS4.B: Natural Selection – *This idea is addressed by having students determine whether or not local adaptation might be at play in common milkweed.* * LS4.C: Adaptation – *This idea is addressed by having students determine whether or not local adaptation might be at play in common milkweed.*   Crosscutting Concepts   * Patterns – *This concept is addressed by having students find patterns and trends in their data related to local adaptation of milkweed.* * Scale, Proportion and Quantity – *This concept is addressed by having students work with their data to answer questions related to local adaptation of milkweed.* |