

## Using CODAP to Tell Different Stories

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### Overview of Lesson

This lesson considers students favorite outdoor spaces and walks students through the statistical problem-solving process from beginning to end where they develop and expand a statistical investigative question and create a single survey to collect data. After administering the survey to their class, they work in small groups to answer the statistical investigative questions by analyzing and interpreting the results. They review work of their peers to more deeply understand the meaning of the data and potential implications. In addition to multiple choice questions (e.g., How do you usually get to this space?) that result in quantitative and categorical variables, the survey includes a question with an open-ended response and a request for a photograph. The open-ended response and photograph are used to further explore how students get to their favorite outdoor space and CODAP (Common Online Analysis Platform), a free web-based educational software for data analysis is used to analyze the data and develop statistical concepts.

This lesson was written to demonstrate how students might engage in the Statistical Investigation Cycle at Level B as detailed in the *preK-12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II)* (Bargagliotti et.al., 2020). This lesson also connects to two other STEW lessons written by Leticia Perez and Pip Arnold, both of which explore different ways teachers might help students use data to tell stories about their favorite outdoor spaces. *Using technology to create data elements* dives deep into collecting data from the photograph itself, including pixel color proportions. *Questioning through the statistical problem-solving process* emphasizes the role of questioning throughout the investigation process.

### Type of Data

- More than two variables, both quantitative and categorical
- Non-traditional data (photographs)
- Open-ended responses
- Data generated or collected as a class

### Learning Objectives

Use the statistical problem-solving process and software such as CODAP to create and answer a statistical investigative question while considering relationships of multiple variables and questioning throughout the process. The data include an open-ended response and a non-traditional source of a photograph. This includes (but is not limited to) the following standards:

- HS.ID.B.5 - Summarize, represent, and interpret data on two categorical and quantitative variables
- 6.SP.B.4 - Display numerical data in plots on a number line, including dot plots, histograms, and box plots.
- 6.SP.B.5 - Summarize numerical data sets in relation to their context

### Audience

- GAISE Level B - middle school students and GAISE Level C - early high school students
- Prior to this lesson, students should have experience with descriptive statistics for one variable (mean, median, proportion), comparing groups, and some basic graphing skills in CODAP.

- If the students are not yet familiar with the statistical problem-solving process, it is important they recognize that it includes more than calculating statistics and creating graphs. Prior to this lesson, the teacher might direct them to complete a [Desmos Activity introducing the statistical problem-solving process](#).

### **Time Required**

Approximately 3 class periods (with 55 minutes) Or 2 class periods (with 90 minutes), although extensions could be included for block scheduling to cover 3 class periods of 90 minutes each.

### **Technology and Other Materials**

- Guided Notes printed for each student or available electronically (optional)
- Student access to computer (individual or groups)
- Technology similar to [CODAP](#) (Common Online Data Analysis Platform, a free software available at <https://codap.concord.org/> to analyze data and develop statistical concepts. For an overview of CODAP see Pip Arnold's [Getting Started with CODAP](#) or [ESTEEM's Introduction to CODAP](#).
- Google Forms or other electronic survey methods
- Digital camera (including a phone camera) or internet access to retrieve a photograph – note the format of the photograph should be of a type that can be imported to Google Slides.
- Access to printer to print graphs for poster

## Lesson Plan

Traditional data are quantitative and categorical, however with advancements in technology data is now available in different formats such as pictures and videos. Pictures and video often include geospatial data, where the time and geographical location are included data elements. This lesson uses data collected through a class survey and includes a photograph, a non-traditional data source. The survey is aimed to gather data about students' favorite outdoor spaces, and it is one of three different lessons developed from this prompt. This lesson could be adapted to include a different prompt, for example considering favorite meals or places to shop.

The general format of this lesson follows the [GAISE II](#) four-step statistical problem-solving process: formulate a statistical investigative question, collect or consider data, analyze data, and interpret results. This lesson is broken down into three traditional class periods (55 minutes), allowing time for students to design their study and collect data on the first day, analyze and interpret the results on the second day, and participate in a Gallery Walk on the third day to consider different approaches to analysis and identify implications and possible future studies. Alternatively, a block schedule might allow two days for this investigation or three days with extensions included.

### **DAY 1: Create Statistical Investigative Question and Data Collection Tool**

The first day includes the first two phases of the statistical problem-solving process. The students complete the survey they design in class as a homework assignment.

#### **Formulate a statistical investigative question**

##### Step 1 - Introduce the Lesson (5-10 minutes)

On the first day of the lesson, the teacher might show a video about the importance of spending time outdoors (e.g., [Video about the importance of spending time outdoors – 52 seconds](#)). The teacher asks students to think about their favorite outdoor space. All students are asked to close their eyes and imagine they are at their favorite place. The teacher asks some questions to encourage the students to visualize:

- What do you see?
- What do you hear?
- Is there a certain smell or sound when you are in your favorite outdoor space?
- Is this somewhere you are alone, or are other people with you?

##### Step 2 - Identify and discuss a favorite Outdoor Space (10-15 minutes)

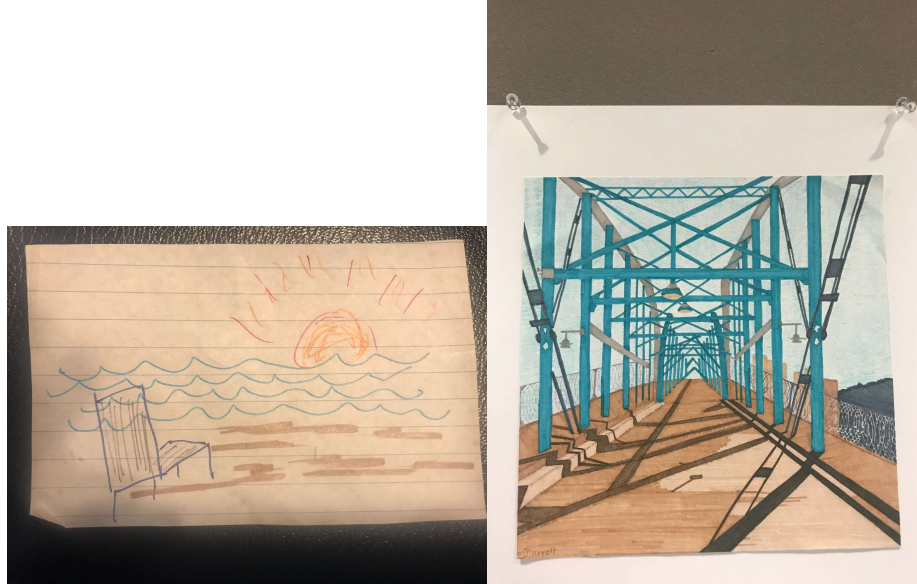
The teacher explains they will be studying favorite outdoor spaces and the students will need to take or find a picture of their favorite outdoor space. Depending on the class, the teacher might want to place restrictions on the photographs (e.g., no people in pictures, no inappropriate material). The students are next given some [Guided Notes](#) for this activity and some individual time (about 5 minutes) to describe and draw their favorite outdoor space. The teacher circulates to preview work and to encourage students to draw. Teachers might emphasize that students are making a rough draft drawing, sketching some of the important features of their favorite outdoor space. With rough draft drawing, the emphasis is on getting ideas down on paper and not on the artistic quality of the finished product.

- You are not expected to create an artistic masterpiece, a rough draft drawing to get an idea of key features of your favorite space is the goal.

Alternatively, a more formal art lesson might be an interdisciplinary approach and an extension that could be used when using 3 separate 90-minute class periods.

**Figure 1**

***Examples of Rough Draft Drawing and Formal Artwork for Student's Favorite Outdoor Space***



After thinking about and drawing their favorite outdoor space, the students are encouraged to share information about their favorite outdoor space with one another in pairs or groups of three for about five minutes. The teacher can circulate during this time, encouraging discussion, listening, and noting some interesting information to include in a class discussion. For example, maybe some students have similar outdoor spaces that include mountains, a body of water, a sport, or another activity. After about five minutes, the teacher facilitates a whole-class discussion to learn about some key features about the students' favorite outdoor spaces.

- What are the key features of your favorite outdoor space?
- How many of you have \_\_\_\_\_ (e.g., man-made objects, bodies of water, sports) in your favorite space?
- What are similarities among favorite outdoor spaces?
- If we surveyed the entire school, do you think the favorite outdoor spaces would have similar features?
- What about if we surveyed other schools in the state, country, or world?

### Step 3 - Begin the Statistical Problem-Solving Process (10-15 minutes)

The teacher discusses features of a good statistical investigative question (Arnold & Franklin, 2021). If the class previously completed the [Desmos activity defining the statistical problem-solving process \(Johnson, 2021\)](#), the teacher might remind them about it, highlighting the following:

- A statistical investigative question is one that can be answered with data.
- A statistical investigative question is one that specifies a population, as well as the variables that are being considered.

The teacher guides the students to consider their class of students as the population of interest, and reminds them to include this population in their questions by saying something like the following:

- Because our class of students is the population, your statistical investigative question should include a reference to our class.

Using the [Guided Notes](#), students are challenged to each create three statistical investigative questions about favorite outdoor spaces of students in their class. The teacher circulates and helps students who might be struggling to create a question.

#### Step 4 - Identify the Class's Initial Statistical Investigative Question and more (10-15 minutes)

The teacher asks some of the students to share their initial statistical investigative questions and together they brainstorm a list of possible questions (Note: not all of the questions posed will be statistical investigative questions - questions we ask of the data. Some might be survey questions - questions we ask to get the data, or analysis questions - questions we ask about displays as we describe the data). Through discussion, possible statistical investigative questions are considered and refined. The teacher should ensure the resulting statistical investigative question is a good question (Arnold & Franklin, 2021). For example, a student's statistical investigative question might not identify the population that is being considered or might not anticipate data that varies. The class decides on an initial statistical investigative question to explore. For the purposes of this investigation, we will be working with the following initial statistical investigative question:

“How do students in our class get to their favorite outdoor space?”

Whereas a surface-level response to this statistical investigative question might only require one survey question and a display might be limited to a one-variable bar graph showing the ways students get to their favorite outdoor space, the statistical problem-solving process encourages students to remain curious and ask interrogative questions throughout the process. This leads to a more in-depth response that incorporates additional variables. For example, how they get to their favorite outdoor space might depend on how often they go there or how natural the space is. The teacher encourages the students to generate other variables besides mode of transportation that might help provide a deeper insight into how people get to their favorite outdoor space. The resulting variables are listed on the board or electronically.

- What other possible variables could we explore to answer this statistical investigative question in a more meaningful way?
- What might influence how you get to your favorite outdoor space?
- Is there something about a person or their favorite outdoor space that might help us predict how they get there?

Other statistical investigative questions might emerge, resulting in different data being collected, analyzed, and interpreted, but the statistical problem-solving process and questioning throughout the process remains the same.

Additional class discussions at this point might include anticipating how the statistical problem-solving process might play out.

- What data will we need to answer this statistical investigative question?
- How will we gather this data, through an observational study or a survey?
- What survey questions will we need to ask?
- What variables could be compared to comprehensively answer this initial statistical investigative question?
- Is there a particular graphical display that would be helpful to create when conducting this investigation?

## Step 5 - Create a Survey (10-15 minutes)

### **Collect or Consider the Data**

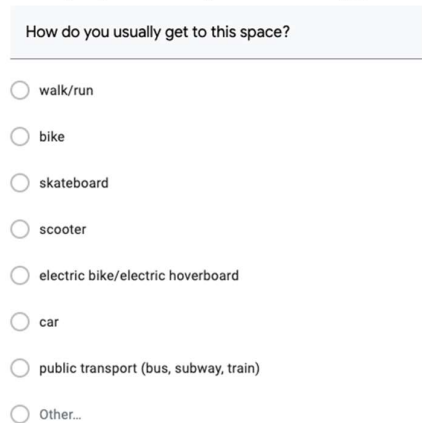
The teacher guides the students in creating a single survey in order to answer their statistical investigative question, “How do students in our class get to their favorite outdoor space?” Using Google Forms, the teacher can project the creation of a new form that will be emailed to all students in the class to complete. The survey should request each respondent to include a photograph of their favorite outdoor space as well as a survey question to determine how they get there. This survey question about how they get there could be open-ended, allowing for free-form entry or multiple-choice, restricting answers to a list. Possibly the class has participated in the [Census at School](#) and remembers the options given for the similar survey question of “How do you get to school?” The teacher might create both types of questions on the Google Form and guide discussion to consider the benefits of each type of survey question:

- How might you respond to an open-ended question?
- What do you think the typical responses from students in our class might be?
- How would responses differ if they are limited to multiple choice?
- Which type of response will be easier to analyze?

Noting that analysis will be easier with a multiple-choice question where there are predefined categories and noticing that Google Forms allows for multiple choice questions with an “Other...” category that includes a free form entry to explain, the class might decide on the following:

**Figure 2**

#### ***Survey Question for Mode of Transportation***



How do you usually get to this space?

- ☐ walk/run
- ☐ bike
- ☐ skateboard
- ☐ scooter
- ☐ electric bike/electric hoverboard
- ☐ car
- ☐ public transport (bus, subway, train)
- ☐ Other...

Recalling the additional variables they identified, the teacher encourages students to think about additional survey questions they might want to ask. Some guiding questions might include:

- What were the other variables we identified?
- What survey questions do we need to ask to gather this data?
- Should these be open-ended survey questions, or multiple choice?
- If multiple choice, what should the options be?

The survey questions will depend on the variable the class identified. For example, some additional survey questions might include:

- How many of the last seven days did you enjoy your favorite outdoor space?
- How far from your home is your favorite outdoor space?
- What is your preferred method of transportation to your favorite outdoor space?



The teacher creates the survey with input from the class. Here is a link to a sample survey in Google Forms that can be copied and modified: [Google Form for Favorite Outdoor Space](#). The students complete the survey as a homework assignment and include a photograph of their favorite place.

## **DAY 2: Use the survey results to answer the Statistical Investigative Question**

The second day allows the students to consider the data they collected with the survey and analyze the data in a way that answers the statistical investigative question through continued questioning to guide their statistical reasoning.

### Step 1 - Consider the Survey (5-10 minutes)

When the survey has been completed, the collected data can be considered. As a warm-up question, the teacher might ask the students about their experience taking the survey they designed.

- Did you have any problems completing the survey?
- After you completed the survey, did you think of changes you would want to make if you were to give it again?
- Were there additional survey questions you wished we had asked?
- Were there survey questions you would like to rephrase?

It is important to reflect on their experience of taking the survey. The first survey given is often just a prototype and the importance of piloting surveys to improve their design can be discussed.

### Step 2 - Consider the Data (10 minutes)

Prior to analyzing the data, it is important to review the results and determine if any of the data need to be cleaned. The teacher first has the whole class look at the survey responses (Google Forms allows a spreadsheet view of the collected data). This could be shared electronically, printed, or projected.

- How does the data look, what do you notice?
- Is there a response for each student in the class?
- Are there duplicate records that might need to be removed from the data?
- Are there incomplete responses?
- Are measures reported with the same unit?
- Are the survey respondents available to complete any missing data?

The difference between a sample and a census can be discussed here. It is important to note that the original responses should remain in an unedited file, and as the data is cleaned, carefully crafted notes should accompany any edited version. Data scientists often keep a data dictionary (centralized repository of information about data such as meaning, relationships to other data, origin, usage, and format) to track the changes to the data and variables.

Next, the students look at the data and begin Part 2 of the [Guided Notes](#) to record their noticings and wonderings (Fetter, 2011). The Google Sheet resulting from the survey can be printed or shared with students in the class so they can view the results on their computer. Additionally, the teacher can project the results for students to see.

- What do you notice?
- What do you wonder?
- What's going on with this data?

A Think-Ink-Pair-Share strategy might be used here to allow students to individually look at the data (think), write down their own answers to the questions first (ink), then talk with a classmate (pair), and finally have a class discussion (share). The teacher might consider setting a timer for two to three minutes for each part of the Think-Ink-Pair-Share. This Part 2 of the [Guided Notes](#) can be used to make notes throughout the analysis process as well.

Additional discussions might target a possible follow-up survey. Would we want to further separate walk/run as separate categories? Do we want to add “mass transit” as a category? Might we want to know the time of day people visited their favorite place? Constantly questioning not only the data, but what additional information we might want to learn in order to answer the statistical investigative question will allow us to see beyond the data at hand, develop new meaningful survey questions, and ultimately create a story with the data.

## Analyze the Data

### Step 3 - Interrogate the Data (15-20 minutes)

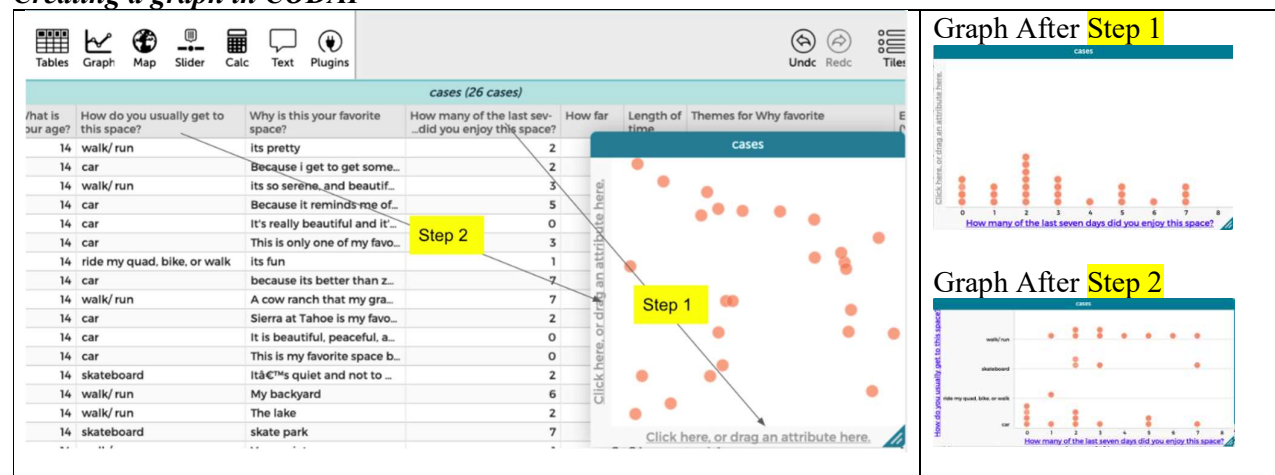
Using CODAP or other software to visualize data and develop statistical concepts, the teacher guides the students through analyzing the data. The teacher informs the students they will need to include information from the photograph and the open-ended question in their analysis. Students work in pairs or groups of three and as a class, they each import the data and create a graph and also create new variables from the photograph and the open-ended question.

*Importing the Data* - From Google Sheets, a .csv file can be created (File-Download-Comma-separated values (.csv, current sheet)) and this file can be imported into CODAP (Create New Document, then Import from the three bars on the top left of the screen). If possible, the teacher can project this as well as verify that each group has completed importing the data.

*Creating a graph* - Once the data table is imported, graphs can easily be created in CODAP for various variables by dragging and dropping the column headings into a graph object. The teacher projects creating a graph and encourages students to select any two variables to create a bivariate plot of their own.

**Figure 3**

### Creating a graph in CODAP



CODAP recognizes the type of variable (quantitative or categorical) and creates the appropriate type of display (dot plot, scatterplot, two-way table) so it is easy for students to visualize the data. Students should be encouraged to remain curious and play with the data to discover additional statistical investigative questions and ultimately uncover a story they can tell.

*Creating Additional Variables* - The teacher reminds the students that their analysis will need to include both information from the photograph and the open-ended question. They work through creating a new

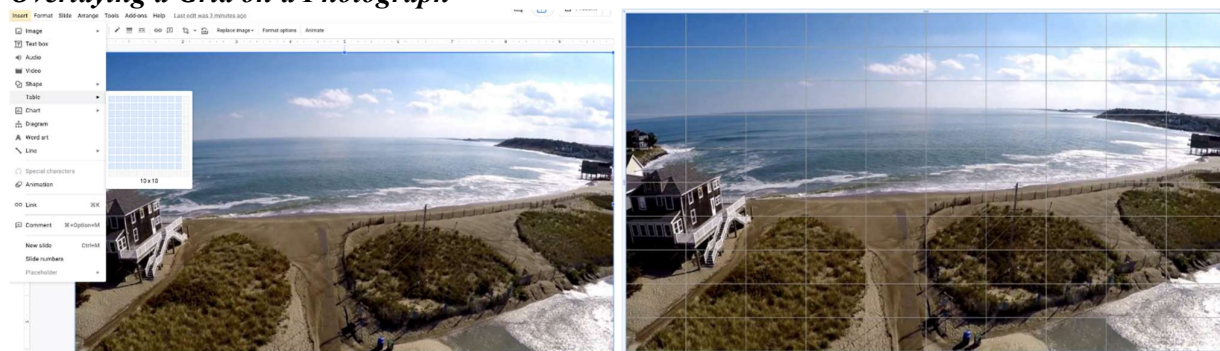


variable for each. Students are informed they can add additional variables and choose the information they want to use.

For the photograph, the teacher might walk the class through computing the percentage of sky in the photographs. This can easily be done by importing each photograph into Google Slides (Import-Image) and overlaying a 10x10 table on top (Insert-Table-select 10x10 and resize the table to cover the photograph). It is worthwhile to note that it doesn't matter whether the boxes of the grids are squares or rectangles, because if they are each the same size they represent 1% of the total area. Thus counting the boxes for the photograph below that include sky gives an estimation of the percent of sky in the photograph (30%).

The teacher projects the example of creating a Google Slide for the students and then shares the file with the class and has each student import their photograph and overlay a grid. Thus, this shared file can be used by students to create additional variables other than percentage sky (e.g. percentage of trees, water, or human-made objects).

**Figure 4**  
**Overlaying a Grid on a Photograph**



To add a variable to the table in CODAP, clicking on the “+” on the top right of the table (see Figure 5) will create a new column. The teacher can ask each of the students to compute their percent Sky for their photographs and enter the numbers.

**Figure 5**  
**Creating an additional Variable in CODAP**

cases (26 cases)		Click on “+” --->	
How do you usually get to this space?	Why is this your favorite space?	newAttr	
walk/ run	A cow ranch that my gra...	To add a new column	
car	Sierra at Tahoe is my favo...		
car	It is beautiful, peaceful, a...		
car	This is my favorite space b...		

cases (26 cases)		
How do you usually get to this space?	Why is this your favorite space?	Sky
walk/ run	A cow ranch that my gra...	50
car	Sierra at Tahoe is my favo...	37
car	It is beautiful, peaceful, a...	80
car	This is my favorite space b...	8

For the open-ended question, the teacher might point out that the responses are strings of words that are all different. To analyze the responses a new variable can be created, and the original responses are coded for the new variable. The teacher first has the students read through the responses and then identify some major themes they see repeated.

- What do these responses have in common?
- Is there something you see repeated in these responses?

They identify *beautiful*, *people*, and *exercise* as some of the themes, add a column (new variable) to the table, and start classifying the responses. However, as they are classifying each response, they notice some of the responses belong in more than one category (e.g., beautiful and exercise). Anticipating

difficulty in analyzing the data, the teacher guides the students to create a separate Boolean variable for each category (e.g., beautiful: Y/N, exercise: Y/N).

**Figure 6**

**CODAP Display showing “Themes for Why favorite” created from *Why is this your favorite space?***

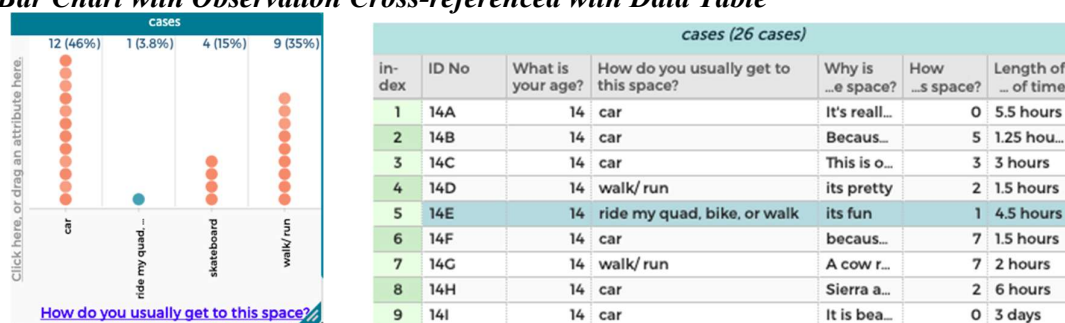
cases (26 cases)			
Exercise (Y/N)	Beautiful Y/N	Themes for Why favorite	Why is this your favorite space?
N		beautiful	its pretty
N		people	Because i get to get some type of social activity
N		beautiful	its so serene, and beautiful.
N		people	Because it reminds me of my grandfather
Y		beautiful, exercise	It's really beautiful and it's a great hike.

The students are given time to work in their groups to analyze the data and create a poster summarizing their findings. What follows here is one example of what a data analysis might look like. However, since the statistical problem-solving process is iterative and not linear, as the students interrogate the data, groups of students might consider different variables and ask diverse analysis questions throughout, thus a variety of analyses will emerge.

We begin by considering our main statistical investigative question “*How do students in our class get to their favorite outdoor spaces?*” and the survey question “How do you usually get to this space?”, which results in a categorical variable that specifies the mode of transportation. In only two clicks (creating a new graph and dragging the column heading to the graph), CODAP will automatically create an appropriate display based on the variable selected. Level B students become attuned to the different types of variables that exist and what standard graphical displays are available. To get an understanding of the distribution of the responses across categories, it is helpful to first look at the dotted bar chart that was created in CODAP. In the dotted bar chart each observation is represented with an equal sized dot (see Figure 7). One of the benefits of software like CODAP is that highlighting a dot on the graph will cross-reference it with the data table.

**Figure 7**

**Dotted Bar Chart with Observation Cross-referenced with Data Table**



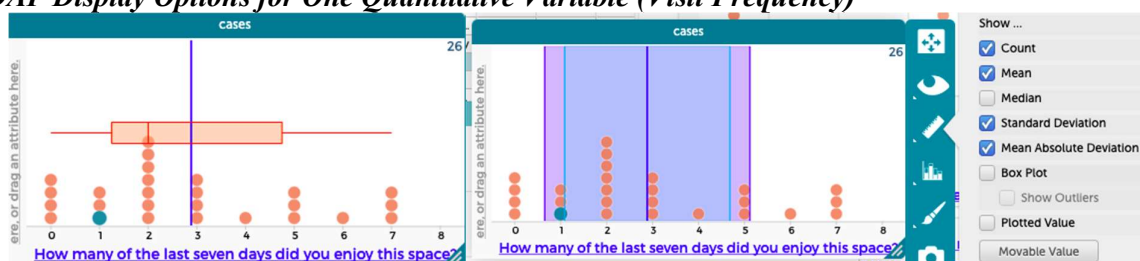
It is interesting to note there is only one “other” response and when we look at the free-form entered data, the description “ride my quad, bike, or walk” includes “bike” and “walk” which are two separate categories. At this point, when a group finds an interesting conundrum, the teacher can have a class

discussion. Here the discussion is about potentially combining the categories for the analysis by re-categorizing this response from “other” to “bike” or “walk”. Since the data is primary data and was collected in the class, the survey respondent might be able to clarify which category is the best fit. For the purposes of this analysis, the students choose to leave it as a separate category, but you can see how different student groups might diverge, resulting in unique analyses and interpretations. This is an example of why the Gallery Walk at the end of this lesson is a useful pedagogical approach here because students can consider the different approaches of their peers.

Level B students broaden their skills with graphical, tabular, and numerical summaries introduced at Level A. Allowing them to create a variety of displays on data they created is one way to broaden these skills. Students should be encouraged to consider variability in their analysis. According to GAISE II, Level B students represent variability with appropriate displays such as box plots, using key features of distributions (center, variability, and shape), and by reasoning about distributions to compare groups based on quantitative variables.

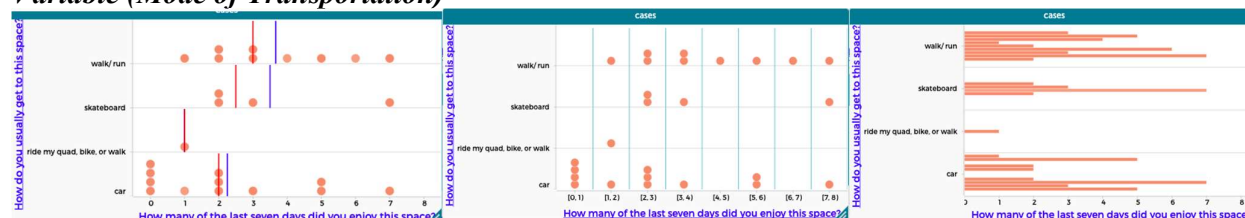
As the students consider the data collected from the survey, they may wonder if the number of days in the last week a student enjoyed their favorite space might differ based on how they got there. Considering the data overall, we can look at the distribution of the visit frequency by using a dot plot (see Figure 8). There are a variety of display options available in CODAP including adding a box plot, measures of center, and ranges for the standard deviation and mean absolute deviation (MAD). Decisions about which of these measures to use will depend on what has been focused on previously with the class.

**Figure 8**  
**CODAP Display Options for One Quantitative Variable (Visit Frequency)**



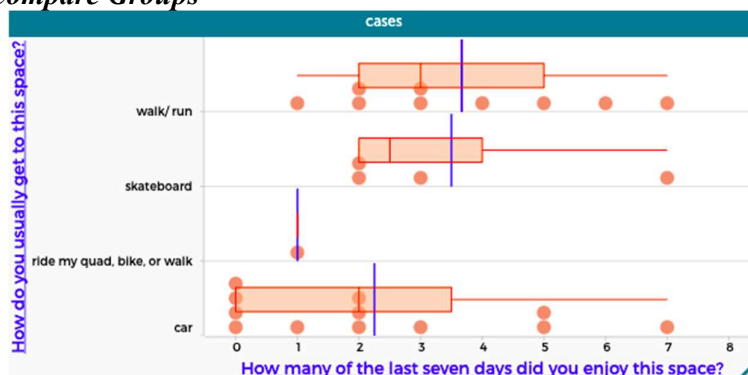
Comparing these quantitative measures for different groups (e.g., how they traveled to their favorite outdoor space) can easily be accomplished with technology. Before looking at the distribution of the visit frequency separated by mode of transportation, the students might make a guess as to what they expect. Students might think that if the mode of transportation is a car, the number of times they enjoyed the space in a week will be lower, since these younger students would have to find a ride in order to get there. Dragging the mode of transportation to the vertical axis of the graph creates comparative plots and CODAP allows for different displays (points, group into bins, bar for each point) allowing both the mean and medians to be marked with the “points” option. In Figure 9, both the mean and median values for “car” are lower than “skateboard” or “walk/run”.

**Figure 9**  
**CODAP Display Options for One Quantitative Variable (Visit Frequency) and One Categorical Variable (Mode of Transportation)**



Additionally, when the points option is selected a box plot can be added so that we can look at the median of one group in comparison with the IQR of another group. Level B students should consider this additional information to determine if there is a meaningful difference in measures of center.

**Figure 10**  
*Using Box Plots to Compare Groups*

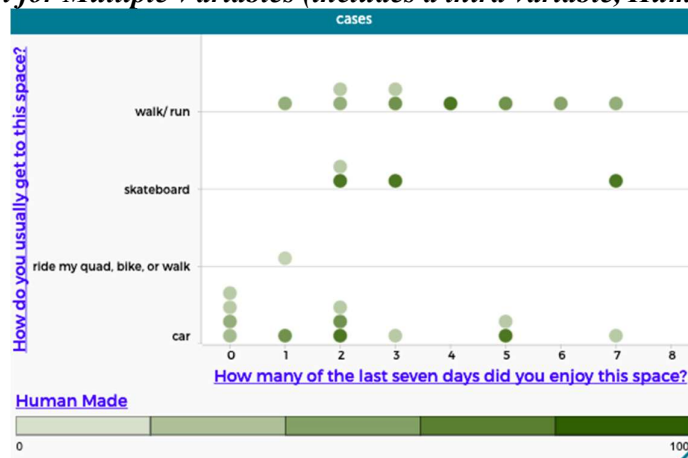


As the analysis progresses, the data is further interrogated and additional analysis questions are asked. Some of these analysis questions might include another variable. Additional analysis questions might incorporate statistical investigative questions from a non-traditional data source such as a photograph. For example, a student might wonder how the proportion of human made items in the photograph might be related to the other two variables.

Some statistical investigative questions are broader than others and they can subsume other investigative questions. When one statistical investigative question is broader, it is possible that an underlying analysis question can be a statistical investigative question that is of a smaller scope. For example, “How do students in our class get to their favorite outdoor space?” is broader than “How does the number of days a student enjoyed their favorite space in the last week differ based on how they got there?” In addition, it is important to note that initial statistical investigative question may be modified as the process develops.

A third variable can easily be added to the graph in CODAP by dragging the variable from the table to the plotting area. In the following graph, the percentage of human made items in the photograph has been added as a third variable. Note the base graph remains the same, yet the dots are color coded and a scale is added to include information related to this third variable. The students can use CODAP to investigate different analysis questions with multiple variables, discovering patterns and relationships.

**Figure 11**  
*CODAP Display Option for Multiple Variables (includes a third variable, Human Made)*

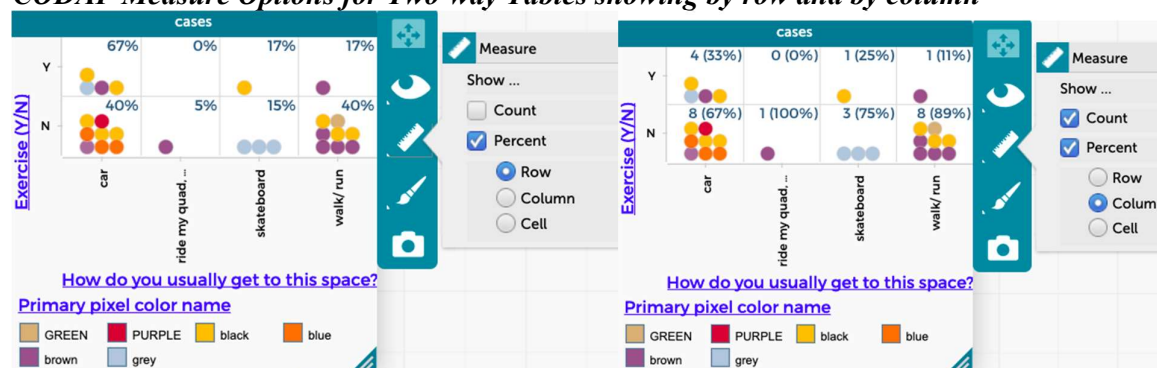




Level B students also begin to consider possible associations between two categorical and two quantitative variables. If the two variables are quantitative, students can use a scatter plot to look at the data visually and the quadrant count ratio (QCR) to determine if there is a likely association. However, when the two variables are categorical, they can use a variety of visual displays (bar charts, mosaic plots, etc.) and compare conditional proportions across categorical variables.

The students might wonder if there is an association between exercise and how they get to their favorite outdoor space. When CODAP is used to compare categorical variables, a two-way table is created where each observation is represented with a dot that similar to any other graph can be cross referenced to the table by simply clicking on it. The two-way table has options to include percentages based on rows or columns and can also include the count. Additional variables such as the primary pixel color name of the photograph can be added.

**Figure 12**  
**CODAP Measure Options for Two-way Tables showing by row and by column**



## Interpret the Results

Once the analysis has been completed, it is important to use the results to answer the statistical investigative question. The teacher should provide some general guidance and review drafts of student answers by walking around and checking in on the groups to ensure their answers are comprehensive. The students should use the graphs from the analysis to tell a story about the data, including numbers, context, meaning, and potential implications. The following are some guiding questions that the students can answer to help them in telling a story about the data from their analysis.

- What is the statistical investigative question and why is it important?
- What graphs are important to include?

It is important they present the analysis of the data in a way that answers the statistical investigative question. Whereas there is not one correct answer, their interpretations of the analysis should align with the graphs they created. For example, students who get to their favorite place by car visit fewer times per week (mean of 2.25, median of 2.0) when compared with students who walk or run (mean of 3.67, median of 3.0). This is a meaningful difference according to the box plots (Figure 6), since the median for those who get to their favorite spot by car is at the outer edge of the IQR (2.0 to 5.0) for those who walk or run.

Different final products can be used (e.g., a report, a presentation, an infographic, or a poster) to communicate the results of their analysis. For this example, students create a poster that can be displayed in person. Each poster should include the statistical investigative question and a data visualization that includes data from the photograph and a data visualization that includes data from the open-ended question. Alternatively, electronic posters or pictures of posters are an option for virtual students. As homework, students can put any finishing touches on their poster in preparation to share with the class during a Gallery Walk the following day.

Level B students acknowledge that looking beyond the data is feasible. Although the statistical investigative question focuses on the class in which the data is collected, Level B students recognize that their class data might be used to make inferences about a larger population such as their grade. As part of their interpretation, the teacher should guide them to consider the limitations of their class as a sample. Since there was no random selection, there will be bias. Is the make-up of the class different than that of the school? For example, is there a larger percentage of athletes in their class and might this contribute to the proportion of those who walk or run to their favorite space?

### **DAY 3: Gallery Walk**

The third day allows the students to communicate their results through a Gallery Walk where they consider the work of their peers and synthesize the results to better define potential implications. With paper posters in the classroom, students can walk around to each project/poster while discussing in their small groups and comment using sticky notes or writing on large poster paper next to the project/poster. Alternatively, especially if this is a virtual class, students can complete a Google Form to give feedback and the resulting Google Sheet can be shared with the class. The Gallery Walk can either be silent with individual feedback, or the students can be encouraged to discuss projects/posters. Based on the number of groups and the total time of the class, the teacher might allow 10 minutes at the beginning of class for set-up and last minute-questions and 15 minutes at the end of the class for a class discussion to summarize and synthesize the project results. The remaining time can be allocated across the number of projects so students can review the work of their peers.

#### Step 1 - Set-up Final Products (10-15 minutes)

At the beginning of class the students are allowed to set-up their work. They might have some last-minute questions and the teacher might choose to start the day with a reminder about the importance of spending time outdoors. In highlighting the statistical investigative question and non-linear process of the statistical problem-solving process, the teacher should remind the students of the fact there is no one right way to answer this question. As different groups interrogate the data, they are likely to notice different things and choose alternative graphs to represent the data. Reminding students they are developing their data science and statistical literacy while they read other reports, in addition to creating reports might be helpful.

The teacher might prepare some sort of feedback form for the students to complete (paper or electronic) while they are reviewing each project or alternatively might choose to assign a reflection after the class discussion. If the feedback form is shared with the students, there is an opportunity to guide students to begin with a positive remark, identifying something about the work that is excellent or admirable and also provide some constructive criticism as to how the work can be improved. Additionally, asking the students what they wonder about after reading the work of their peers might be helpful in providing initial thoughts for a summative discussion.

#### Step 2 - Review work of other students (25-35 minutes)

After the posters are set up, the teacher defines a path for the students to follow and might elect to use a timer in order to allow equal time. As the students rotate around the room, the teacher can listen to their conversations. The teacher could elect to have the students complete a feedback form for each group, (see [Guided Notes](#), Part 3). If a group of students is silent or distracted, the teacher might point to an interesting feature of the work and ask what it means. Pointing out examples of good work where an interpretation is based on the data presented in the graphs and answers the statistical investigative question might help promote good discourse and feedback.

#### Step 3 - Summarize and Synthesize (10-15 minutes)

After the students have had a chance to look at each other's work, the teacher facilitates a class discussion to summarize and begin to synthesize the important collective findings. Encouraging the students to share new wonderings can move their interpretations so they extend beyond the analysis to consider



implications and possibly even prompt some community action. Maybe the class finds students are having to travel long distances to their favorite space and through class discussion they reveal the lack of nearby spaces with a low percentage of manmade objects. The teacher could have the students write letters to their local government representatives using their data to argue for more green space.

### Attached Materials

- [Desmos Activity](#) for the Statistical Problem-Solving Process
- [Google Form](#) for Favorite Outdoor Space Survey
- [Guided Notes](#) for this activity in a Google Doc (also included as an Appendix)

### Reflections and Additional Recommendations (optional)

- See associated STEW lessons that also have using photographs as data as the starting point, but with different approaches to the investigation
  - *Using technology to create data elements*
  - *Questioning throughout the statistical problem-solving process*

### References

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## Appendix A – Guided Notes

### Guided Notes Part 1- Using CODAP to tell different stories

#### What is your favorite outdoor space?

Drawing of my favorite outdoor space:

Description of my favorite outdoor space:

After talking with your classmate about their favorite outdoor space, what do you wonder about other student's outdoor spaces?

The statistical problem-solving process often begins with a statistical investigative question that can be thought of as a research question. Recall the [Desmos Activity](#) about the statistical problem-solving process and that good statistical investigative questions include a population of interest and require data that vary in order to answer them. Write down three statistical investigative questions you could ask about favorite outdoor spaces.

1.

2.

3.

## Guided Notes Part 2 - Using CODAP to tell different stories

What do you notice?

What do you wonder?

What's going on with this data?

## **Guided Notes Part 3, Gallery Walk Feedback - Using CODAP to tell different stories**

For each of the projects, answer the following questions:

What specifically about this project was excellent or admirable?

What suggestion do you have to improve this project?

After reviewing this project, what new ideas do you have that might help answer the statistical investigative question?