**Weintrop et al.’s Data Practices (with Modeling added)**

**Creating**

“In many cases, scientists and mathematicians use computational tools to generate data. This is the case when investigating phenomena that cannot be easily observed or measured or that are more theoretical in nature. For example, to understand galaxy evolution, astronomers generate data using computer simulations as it is not possible to observe and measure a galaxy’s evolution in situ because the processes occur over billions of years. In this way, computational tools allow for data creation at scales that would otherwise be impossible. Students who have mastered this practice will be able to define computational procedures and run simulations that create data they can use to advance their understanding of the topic under investigation.”

**Examples:**

1. If we wanted to answer a question about tides and we lived near the ocean, we could go measure the height of the water at different times of the day with a pole. Computationally, we could attach an aqua meter or depth finder.
2. If we wanted to know how fast a toy car decelerates as it hits a foam barrier, we could use a slow-motion camera to record it crashing into the barrier.

**Collecting**

“Data are collected through observation and measurement. Computational tools play a key role in gathering and recording a variety of data across many different scientific and mathematical endeavors. Computational tools can be useful in different phases of data collection, including the design of the collection protocol, recording, and storage. Students who have mastered this practice will be able to propose systematic data collection protocols and articulate how those protocols can be automated with computational tools when appropriate.”

**Examples:**

1. Going to the NOAA website and getting some data on ocean levels. Sending depthfinder data to an online .csv file or even Google spreadsheet.
2. To collect data for #2 above, we measure the distance of the car to the edge of the barrier at each time interval and send store the data in a spreadsheet.

**Manipulating**

“In mathematical and scientific fields, it is essential to manipulate data in order to make meaning of them. Computational tools make it possible to efficiently and reliably manipulate large and complex datasets. Data manipulation includes sorting, filtering, cleaning, normalizing, and joining disparate datasets. These manipulations serve for both analysis and communication. Students who have mastered this practice will be able to manipulate datasets with computational tools, reshaping the dataset to be in a desired or useful configuration so that it can support further investigation.”

**Examples:**

1. Sort the tides data by date and time or by another factor (e.g., tide height). Filter the data by location, data, tide height, or moon phase.
2. Sort data collected on car regarding the car based on speed or time.

**Visualizing**

 “Communicating results is an essential component of any knowledge-building endeavor, and computational tools can greatly facilitate that process. In mathematics and science, creating visualizations is a powerful strategy for both analyzing and sharing data. There are a growing number of software tools available for designing and implementing data visualizations (Borner 2015). These tools include both conventional visualizations such as graphs and charts, as well as dynamic, interactive displays that allow the observer to interact with the data being displayed. Students who have mastered this practice will be able to use computational tools to produce visualizations that convey information gathered during analysis.”

**Examples:**

1. Plot moon phase and tide levels on the same page. Plot data from multiple locations on top of the same chart (time x height) and compare.
2. Plot the position of the car at consistent time intervals (on an XY axis plot).

**Analyzing**

“The true power of data lies in the information that can be gleaned from them through analysis. There are many strategies that can be employed when analyzing data for use in a scientific or mathematical context, including looking for patterns or anomalies, defining rules to categorize data, and identifying trends and correlations. Computational tools have become essential for conducting data analysis, as they make it possible to analyze data in a more reliable, effective manner and to conduct analysis on larger datasets than would otherwise be possible. Using computational tools to analyze data is becoming an especially important practice as we now live in an era of data-intensive science (sometimes referred to as ‘‘big data’’), where datasets routinely have billions of individual data points. Students who have mastered this practice will be able to analyze a given set of data and make claims and draw conclusions based on the finding from their analysis.”

**Examples:**

1. Look for patterns in the data (e.g., is there a relationship between tide height and moon phase). Determine if there is an observable relationship between variables. Look for outliers or unexpected results.
2. Analyze the relationship between position and time to try to determine the acceleration. Create an algorithm to determine acceleration.

**Reference**

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology*, *25*(1), 127-147.