# **TITLE: Predict This!:** Using models to observe correlation and improve predictions

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**Field tested with:** 12th grade AP Statistics, Watsonville High School, Watsonville, CA, Spring, 2014. (*content intended for algebra or algebra II students)*

**Module Type:** Classroom lab activity

**Duration:** 2 hour class period

**Key materials:**

- Large bag of raw beans
- Large jar of marbles (teacher should know the number of marbles)
- Scale (for measuring in grams)
- Small tare containers to keep marbles and beans from rolling off the scale
- Ruler or straight edge
- Calculator (or cell phone if students can handle staying on task)
- Worksheet (Predict This!)

**Concepts:** Prediction, metric system, patterns, models, correlation

**Skills:** Taking measurements, graph creation & interpretation (data visualization), understanding prediction, making arguments based on evidence

**Science Education Standards:**

- **National:** Science as Inquiry
- **California:** Investigation and Experimentation
- **NGSS-**Crosscutting concepts: patterns; systems & system models; scale, proportion & quantity**.** Practices: 5. Using mathematics and computational thinking, 2. Developing and using models; 4. Analyzing and interpreting data

## Overview:

This project is an opportunity for students to learn:

- How models can be used to predict what we cannot measure
- How correlation can be used to construct a simple yet practical model (i.e. making life easier, estimating, etc)
- How patterns can be recognized, defined, and used to make predictions
- How simple trends can be used to predict more complex ones
- To make graphs to depict data and begin assessing patterns
- To use evidence to support an argument/claim

**Navigate:** Background Materials &Time Starting Point Procedures Standards Supplemental

## Background for Teachers

**Why this matters:**

Being able to observe, describe and quantify patterns is an incredibly valuable skill for all scientific disciplines (and many non-science disciplines as well). Developing simple models that begin to describe more complex phenomena is a core cross-cutting concept in the new NGSS standards, and the application of this broad conceptual framework is nearly endless. This simple MiniModule can be a quick foray into this transferrable life skill.

**Assumed background:**

- Basic scatterplot with linear trendline (slope, intercept…y=mx + b)
- Basic plotting skills (differentiating axes, dependent vs independent variable, etc)
- Proper use of small scale to weigh bean mass
- Metric system (ex: bean mass in grams)

**Special context:**

This activity has been intentionally designed to be simplistic (e.g. estimating the number of beans or marbles based on their masses) so that its concepts are easily adapted to the class needs. We suggest that the instructor stresses to the students that today's activity will provide an important concept that spans a variety of disciplines (rather than conveying trivial facts about bean mass).

**Scaffolding supplements:**

No PowerPoint is necessary for this mini-module, but the instructor may introduce the topic by "hooking" the students attention with some neat examples of how models can be useful in making predictions for things we cannot measure (ex: a Watsonville farmer going to the market who needs to fill fifty sacks with 10,000 beans each…). Students will generate several plots based on data they collect (bean count and mass) as a means of visualizing a correlation within easy-to-measure data.

## Module Description

### Materials:

- Scale (to measure mass in grams)
- Small tare containers to keep beans/marbles from rolling off the scale
- Bag of raw, uncooked beans (enough for~50 per group of two students)
- Large jar of marbles (need mass of jar before and after the addition of marbles)
- Worksheet: "Predict this!"
- Optional: prize for student whose 'guess' was the closest to the number of actual marbles – should show work to prove it was a prediction based on data rather than an random guess

## Preparation:

- Count actual number of marbles placed in large jar (which students will estimate)
- Have small tare containers (large enough to fit approx. 50 beans) near scales
- Separate piles of roughly 50 beans for each student pair
- Students can work in pairs to weigh materials but should complete the worksheet independently

## Timeline:

1. Introduction to the activity (provide basic premise about predictions (give examples), materials, distribute worksheet) - 10 min
2. Student worksheet/activity time - 45min
3. Group discussion - 15min
4. Clean up - 5min

## Starting Point for Inquiry:

Scientists use their observations of the natural world to generate hypotheses and predictions for their topic of interest (ex: how species interact, why planets rotate the way they do, and why rain falls in one area but not another). There are infinite ways to measure the natural world and it is impossible to measure every phenomenon. Therefore, scientists (and economists, ecologists, doctors, etc) constantly measure what they can in order to predict what they cannot.

## Detailed Procedure:

1. Introduction to the activity - 15 min
    a. Provide basic premise about correlation& prediction (their generality, applicability, etc)
    b. Provide examples of how prediction is used in daily life, science, etc
    c. Distribute worksheet
    d. Walkthrough the sections of the worksheet while showing where to find materials (be sure to remind students to tare/zero the containers they are using to contain beans/marbles on the scale).
2. Student worksheet/activity time - 45min
    a. Part 1: Measuring Beans: solving a problem using estimation
        i. ***Students should work in pairs or groups of three *maximum* to ensure all group members are following along, contributing, synthesizing the material, etc.
        ii. In Table 1, students record the mass of one and various handfuls of beans (sm, med, lg), then count the number of beans in each handful
        iii. These values are plotted on the provided graph paper/grid
        iv. Basic linear properties (ex: slope, y-intercept) are extracted and used to create an equation (basic linear model)
        v. This equation is used to estimate the mass of more beans than the students are given and to estimate the approximate number of beans for a given mass.
    b. Part 2: Don't Lose your Marbles! (optional extension activity)
        i. The inquiry portion of the Predict This! activity…
        ii. Students are provided with the materials (and minimal scaffolding on the worksheet) and are encouraged to both guess & predict the number of marbles in a large jar by incorporating their understanding of building a

model (Part 1)

1. Obviously the number of marbles in the jar must be counted prior to this activity
2. Teacher makes data table on board with each student's name and his/her best guess for the number of marbles in the jar (Columns = "Name," "Guess," "Estimate")
3. Students estimate the number of marbles (using the same weighing technique they used for beans). This marble count estimate is recorded in the class data table
4. Average the estimates of several groups
5. Which are closest to the real number of marbles? Discuss…this presents an opportunity for the teacher to demonstrate how (hopefully) the student's marble estimates, derived from weighing marbles and creating a linear model, is a *better predictor* for the actual number of marbles in the jar than a guess. Models can allow for more accurate predictions!

iii. The student/group whose estimate is closest to the actual value (after showing work that their estimate was a prediction based on data) wins the activity (and potentially a prize).

3. All-class discussion - 15min
   a. Recap the insights gleaned from each of the 2 parts of the student worksheet (ex: how did measuring bean mass help you predict the mass of more beans than you were given? How did the farmer benefit from using your bean counting technique?).
   b. We recommend the teacher provide several additional "real-life" examples of how generating simple models can be valuable predictive tools which save time/effort.
   c. Discuss any concerns/issues students had with the process of using simple, known measurements to forecast unknown ones
4. Clean up - 5min
   a. Return materials
   b. Complete (ex: filling in name, period, etc) & turn in worksheet

## Assessment Methods:

The final marble estimation provides short-term feedback on assessing the student's comprehension of the concept. If students simply *guess* the number of marbles in the container without doing any measuring/calculations, then the concept of predicting based on prior measurements clearly wasn't absorbed or assimilated. Ideally, marble jar estimates from students reflect the true marble count better than the guesses; this simply illustrates the predictive power of models over blind guessing. Perhaps another assessment method could be to include a count-prediction type question on an exam in which the students need to use a similar strategy to appropriately answer the question.

## Possible pitfalls:

Individual bean and marble size (mass) can vary, and therefore students will derive unique regression equations. Rather than a pitfall per se, this provides an opportunity for the teacher to discuss *variability* in a population, and how accounting for that variability (or failing to do so) can influence a model's accuracy and predictive power.

## Glossary:

Model: in this context, the mathematical relationship between two or more parameters/variables

Linear trendline: when the best-fit model for a given relationship is a straight line (a straight line explains the most variance between variables)

Prediction: a statement about what will happen in the future (may or may not be based on prior knowledge/data)

Correlation: a mutual relationship between two or more variables (note: NOT causal necessarily)

## Science Education Standards Addressed

**National Science Standards (NSES)**

A. Science As Inquiry (p.175-176)

**California Public Schools Standards (SCSCPS)**

Higher Mathematics Standards. Modeling (p. 131-132)

Investigation and Experimentation, 1. Scientific progress is made by asking meaningful questions and conducting careful investigations. As a basis for understanding this concept and addressing content in the other four strands, students should develop their own questions and perform investigations. Students will:

**a**. Select and use appropriate tools and technology (such as computer-linked probes, spreadsheets, and graphing calculators) to perform tests, collect data, analyze relationships, and display data.

**c**. Identify possible reasons for inconsistent results, such as sources of error or uncontrolled conditions.

**Next Generation Science Standards (NGSS)**

Cross-cutting concepts- patterns; systems & system models; scale, proportion & quantity

NSES (http://www.nap.edu/catalog/4962.html)
SCSCPS (http://www.cde.ca.gov/be/st/ss/documents/sciencestnd.pdf)
NGSS (http://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL%20edited%204.10.13.pdf)

## Guide to supplemental materials

**Lectures**

See Detailed Procedure above, specifically Introduction to the activity - 15 min

**Graphics**

**Sack of beans from:** http://www.shutterstock.com/pic-12495298/stock-photo-coffee-beans-in-canvas-sack.html
Sack of pinto beans from : http://www.samsclub.com/sams/peak-pinto-beans-50-lb-bag/155402.ip
Clipart figure from MS Word 2010.

**Worksheets:**

Predict This!

**Assessment Materials**

As mentioned above, perhaps including a count-prediction type question on an exam in which the students need to use a similar strategy to appropriately answer the question