Example Context Elaboration: Water Taste Test

Focus: Experimental design

Achievement objective S8-1

In a range of meaningful contexts, students will be engaged in thinking mathematically and statistically. They will solve problems and model situations that require them to:

Carry out investigations of phenomena, using the statistical enquiry cycle:

A conducting experiments using experimental design principles, conducting surveys, and using existing data sets

B finding, using, and assessing appropriate models (including linear regression for bivariate data and additive models for time-series data), seeking explanations, and making predictions

C using informed contextual knowledge, exploratory data analysis, and statistical inference

D communicating findings and evaluating all stages of the cycle.

Introduction to experimental design

This activity focuses on developing an understanding of how to design good experiments. Students first participate in an experiment with intentional flaws in its design to stimulate discussion about its inadequacy to answer the problem posed. The intention is that, through participating in this experiment, the students are able to construct most of the guidelines necessary for designing quality experiments. They will also be introduced to the generally accepted vocabulary used to describe the plan for their experiment. Please note that the design for this experiment is more complex than what is required at this level, and is simplified later in this activity.

Problem

The overall theme for this investigation is measuring taste – various liquids/foods could be used for a similar experiment e.g. chocolate, types of cola etc.

Discuss labeling of foods and price differences. Students need to have informed contextual knowledge about area of interest so they can define relevant problems. Try to pull out from the students' interest about the investigation and let them lead you towards a suitable problem that can be investigated through an experiment. Give the students an open ended question – what is the importance of labels when people choose food?

Problem

Go onto supermarket websites and look at price differences for food between budget/no label products and more exclusive brands.

- Do people buy the label foods because they taste better or because of the brand?

  Could discuss that in some cases the food is exactly the same!

- Do you think you are influenced by labels?

- Would you rate a food item better just because of its label?

- Do you think that Year 13 students would say bottled water tastes different to tap water just because they know the water has come from a bottle?

For this activity, the investigative problem is: How do Year 13 students perceive the taste of tap water, filtered water or bottled water?

Plan

You will need a large bottle of water, plastic cups, and a jug of chilled filtered water for the experiment. Leave the label on the bottle of water.

Tell the students that they are going to investigate the problem and that they are going to take part in a taste test experiment. Listen carefully for what students say throughout the experiment (see below).

Tell the students to go to the nearest tap or water fountain and to fill up their cup with water. Don't tell them how much water to collect.

When they return to the classroom, ask them to drink all of the tap water and then rate the taste of the water on a scale from 1 to 5, where 1 is unbearable and 5 is fantastic.

Next, get the students to try the chilled filtered water, telling them where it was taken from e.g. the teacher's staff room. This time, pour out a small amount into each student's cup and get students to rate the taste.

Finally, pour varied amounts of the "fantastic still spring water" into the students' cups. This should be at room temperature – try to make a big deal about what great quality water it is (you can read off the label about where the water is from). Students rate this water as well on the scale from 1 to 5.

As this is an activity where we want students to construct guidelines for planning good experiments, listen carefully to what they say during the experiment, and use these observations when outlining the principles of experimental design later.

Students might question aspects of the experiment:
Shouldn't we all have got water from the same tap?
What does 3 mean?
Do we have to drink the whole cup?
Maybe you shouldn't tell us which one is which?

Students might also discuss with each other the taste of the tap water while they do their ratings:
What if it is psychological?
What if you have the taste of the other water?
The chilled water tastes the best, don't you think….

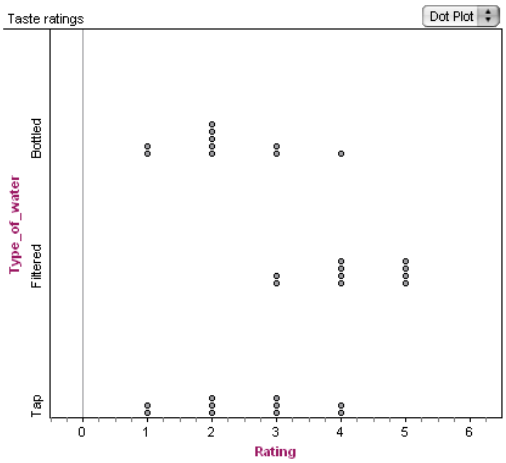
Data

The rating for each student for each type of water can be collated directly onto three parallel dot plots. The focus of the analysis for this activity is for students to consider the variation of the taste ratings, and to also consider other sources of variation in the ratings in addition to the type of water (so they can control possible sources of variation in the design of their experiment).

Analysis

Students should be encouraged to make observations about what they see in the dot plots, focusing on variation, although they will probably refer to shift as well:
e.g.
I notice there is variability in the ratings for each type of water
I notice that the ratings for the filtered water are higher and slightly more similar/less varied than the other types of water

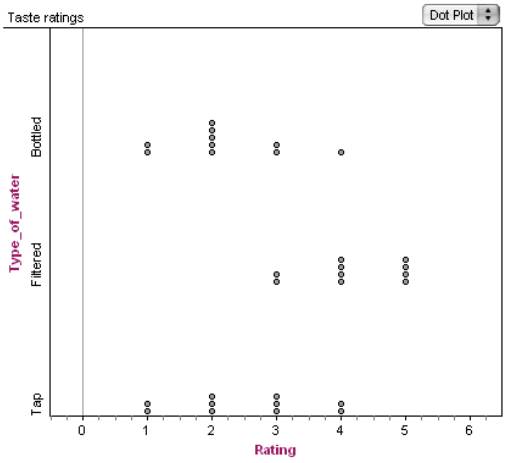
This display gives the impression that the type of water is an "independent" variable.



Analysis

Using the same dot plot, now get students to draw lines between ratings from the same people (link up ratings).

Ask students what they notice about the variability in ratings for each person as they taste each type of water
e.g.
I notice that nearly everyone increased their rating for filtered water compared to tap water, and then lowered their rating for bottled water.



Conclusion

Reflection

Why is the design of the experiment so important? We want to design an experiment that measures what we need to answer our problem. For this example, we want to measure the differences/variation in taste ratings (if there are any) that are caused by changing the type of water.

- Ask students what they think are some variables that might affect the taste ratings for the different types of water.
- Explain that there will be variables that we can control and others that we can't control.
- Ask them to sort the variables they have brainstormed in to "can control" and "can't control".
- Encourage discussion as to whether these are variables that need to be considered in the design of the experiment.
- These variables could cause variation in the taste ratings.
- We only want to measure the changes in the taste ratings caused by the different types of water.

e.g. Variables we can control: Knowing what type of water you are tasting, temperature or freshness of the water, order of drinking the different types of water, amount of water your drink, what type of cup you drink from

e.g. Variables we can't control: Personal taste preferences, sensitive teeth, thirst, gender

e.g. Important variables? Gender, ethnicity – will these affect how you rate taste of water? Do you think attributes such as ethnicity, gender, and age would affect the taste ratings for water? How could you alter the design of your experiment to account for gender?

e.g. Possible solutions:
We could make sure all the types of water are served at the same temperature and serve the water in cups with no labels so that people don't know what type of water they are drinking.

We could make everyone drink the same amount and in the same way, we could only have them taste one type of water. We can minimise the affect of other factors, such as thirst, that we can't control by randomly assigning which type of water they taste. If thirst does affect taste, there should be a balance of thirsty people in for each type of water being tasted, so they'll affect the results in the same way.

Extension activity

Students should be able to offer up some guidelines for designing experiments at this point. They might not use the right vocabulary, but should have some of the key ideas. How could we do this differently next time? What were the big problems with the experiment?

Brainstorm ideas from groups onto a piece of A3 paper, then combine by grouping the criticisms (e.g. sampling ideas, controlling variables, measuring variables/measurement bias etc.) – try to come up with informal guidelines for designing an experiment/writing a plan for an experiment.

An example of a plan that simplifies the design of the water taste-testing experiment is given below. For the revised experiment, participants will taste only one of the three types of water.

Example
Do Year 13 students at this school tend to give higher ratings for the taste of tap water, filtered water or bottled water?
The response variable is the rating given for the taste of the water. The rating will be a score for the taste of the water on a five-point scale (1 = unbearable to 5 =fantastic). Students will need to rate the taste immediately after tasting the water to ensure consistent ratings (e.g. after taste might develop with time).
The explanatory variable for this experiment is the type of water. There are three treatments – tap, bottled and filtered water. *Each student will taste only one type of water to create three independent groups for analytical purposes. Each student will be randomly assigned the type of water they taste. Randomly assigning the type of the water tasted should balance other factors such as gender, age, ethnicity, thirst, personal taste preference etc. that might affect the ratings for taste.*
Students will not be allowed to eat for one hour before the experiment (to control affect of food eaten on perceived taste of water), the water will have labels unknown to the students and to the person who carries out the experiment (i.e. a ***double blind*** *experiment so that the experimenter doesn't unwittingly convey to the students what type of water is in each cup), the temperature of all three types of water will be the same, the water will be presented in the same types of cups, the volume of water in each cup will be the same, and the students will be asked to drink the water in the same way (swirl in mouth and then swallow).*