Two Experimental Design Questions for Students

Many students struggle with experimental design questions when the topic is taught early in the year because they don’t know what the outcome of an experiment should be. While it’s true that early in the year students are unable to think about applying inferential tools to their data, they can think about how they would graph their data; and therein lies the secret to helping them focus their thoughts and create sensible experimental designs that aren’t overly complicated.

What follows are two experimental design questions that I and my colleague Julie Graves recently asked our students, followed by some student responses. We discussed the responses as a class, allowing the students to critique them and point out their strengths and weaknesses.

Question 1: Cut Flowers

Cut flowers in vases of water do not last forever, but people have different ways to try to make them last longer. The three we will consider here are putting a penny into the water, putting five drops of bleach into the water, and putting a packet of commercial "flower food" into the water.

Describe an experiment designed to compare these treatments to one another, and to estimate how effective they are at lengthening the "lifespan" of cut flowers in a vase of water. Your description should be fairly specific but not absurdly so. For example:

- Too vague: "Measure how long the flowers last." This needs to be more specific. What, exactly, is being measured, and how do you plan to measure it?

- Too specific: "Each vase should be made of glass, purchased from the same florist, and should hold one quart of water. To make up for evaporation of water, five ounces of water should be added to each vase each day." That is all unnecessary. It will suffice to say: "Vases should all be the same and filled with the same amount of water."

In addition to describing how the study will be conducted, you are also to determine how your data will be displayed graphically at the end of the study. Make up some fake data and use them to illustrate how your graphs might look. Be prepared to discuss what different graphical displays would indicate about the effects of the different treatments.
We start with 32 vases that are all the same and hold the same amount of water. All of the vases hold 3 fresh cut flowers from the same place. Eight vases are the control, and have only water. Eight vases hold the flowers being sustained by bleach, eight vases hold the flowers being sustained by a penny, and eight vases hold the flowers being sustained by flower food. We will measure the time it takes for all three flowers in a vase to die by routinely measuring the amount of oxygen they put out.
Question 1: Cut Flowers

Student Response B

- **Stats**
- **Controls for Experiment**
  - Same type of flower
  - Grown in same conditions
  - Same size and color
  - Same vase and amount of water and sunlight
  - Use same of 20 flowers for each treatment
- **When is flower “dead”**
  - 50 % of petals have fallen off
  - 50% of each leaf are brown
  - When the distance from the stem to the tip of the flower is 2/3 of what it originally was
- **Bleach**
  - 5 drops of bleach, about the size of a penny
  - Apply each day
- **Penny**
  - A penny a day, next to the root
- **Flower Solution**
  - 5 drops
  - Apply each day
- **Flower should be checked twice a day (every 12 hours)**
Question 1: Cut Flowers

Student Response C

Constants:

- Vase
- Water
- Sunlight
- Flower type
- Number of flowers per vase (5)

Independent variable: Treatment type

- Controlled
  - It is important to have a controlled group so that the result of the three treatments can be compared to it. This is the average “life span” of untreated cut flowers.
- Penny in the water
- Five drops of bleach
- Commercial “flower food”.

Dependant variable: number of petal that fall each day.

Procedure:

1. Put equal volumes of water in 4 vases. Vase “A” is controlled (just water) Vase B will contain a penny, vase C will contain five drops of bleach and vase D will contain commercial “flower food”. Place five flowers in each vase.
2. Observe flowers for 10 days. Record the number of fallen petal each day, at the same time.

Data Analysis:

Our data will be displayed on a line graph because a line graph reveals information about change over time. The cumulative number of petals fallen will be shown by different color lines (4 lines, one for each of treatment type, and one for the controlled.)

Sample Data table:

<table>
<thead>
<tr>
<th>Water (Control)</th>
<th>Pennies</th>
<th>5 Drops of Bleach</th>
<th>Flower Food</th>
<th>Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
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<tr>
<td>15</td>
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<td>25</td>
<td>11</td>
<td>10</td>
</tr>
</tbody>
</table>
Sample Graph:

Overlay Plot

Days

Y

Water (Control)  Pennies  5 Drops of Bleach  Flower Food
Question 2: Perception of Quality

Consider the hypothesis that people's perception of the quality of an object is influenced by its price; in particular we are interested in seeing whether people tend to think objects are of higher quality when they cost more.

We will here consider only manufactured chocolate chip cookies. Design a study to determine whether people's perception of the quality of manufactured chocolate chip cookies is influenced by what they believe to be the price of the cookies.

As with the cut flowers experiment, you should be fairly specific, but not absurdly so:

• Too vague: "Put a price tag in front of a bag of cookies and let volunteers taste them." What is on the price tag? Who are these volunteers? Where did this bag of cookies come from? These things are important to the experiment.

• Too specific: "Be sure that the cookies in all groups are arranged the same way on their plates so as not to influence people by the attractiveness of the display." (This may plausibly have an effect, but we can't get into that level of detail.)

In addition to describing how the study will be conducted, you are also to determine how your data will be displayed graphically at the end of the study. Make up some fake data and use them to illustrate how your graphs might look. Be prepared to discuss what different graphical displays would indicate about people's perception of the quality of chocolate chip cookies and how it relates to price.
In our experiment, we will have a stand holding 2 boxes of cookies, both the same type of manufactured cookies from an existing brand. However, both boxes will be made up brands, one in economical packaging (stacked loosely and quickly) and labeled as “Hitosan’s Super Box of Cookies”, the other box in “luxurious” packaging (each cookie in its own slot) and labeled as “Dove Blissful Cookies”. The economical box will have more cookies in it and be priced slightly less (per cookie) than the luxurious box. 100 people will be sampled, approximately, 20 people per day at random times throughout a 5 day period. They simply taste each cookie, in any order they choose, and then pick which brand they would be more likely to buy. If they opt for the “Dove” brand, then they are influenced by the price of the brand.
Question 2: Perception of Quality

Student Response E

Constants:
- Standard serving plates
- Initial number of cookies on each plate
- Type and brand of cookie (mid price cookies, preferably Pepperidge)
- Person handing out cookies

Independent Variables
- Control: no price next to all plates of cookies
- Non-control: price tags next to cookie plates
  - “$0.50 per cookie” sign
  - “$1.00 per cookie” sign
  - “$1.50 per cookie” sign

Dependent Variables:
- Consumer rating (scale from 1-10)

Experiment:
We will display three plates of cookies, all of which hopefully look the same since they are from the same brand. Our first experiment will be where none of the plates have price tags on them. The consumer will pick one cookie from each plate, taste test, and rank the cookies on a scale from 1-10. We will then perform the experiment to measure the effect of price tags on consumer perception of quality. The plates will have price values of $0.50, $1.00, and $1.50 (we are handing out the cookies for free). We then ask the consumers to rank a cookie from each plate in the same manner as in the control experiment. Even though all the cookies are technically the same, we are expecting differences between the ratings depending on cookie price.
Design:

We will give 100 random hungry individuals of all ages and genders each a piece of 20 different cookies of various brands. The cookies will be given in a different order to each person. 50 of the participants will try samples of 10 cookies of various brands that appear “cheap”—they will be in undecorated packaging and the people will be told they are cheap cookies. They will then be asked to rate these samples on a scale of 1-10, and the other 50 people will be asked to do the same for 10 different cookies in fancy after being told they are more expensive. Then, they will switch and the first 50 people will try the “expensive” kind and the other 50 will try and rate the “cheap” kind. For a control, we will have 100 different random hungry individuals of all ages and genders taste all 20 of the cookies and give a rating without being told anything or observing anything, just eating the cookie.
Question 2: Perception of Quality

Student Response G

Get two brands of chocolate chip cookies that are different enough that people won’t think they’re the same cookie, but similar enough that there would probably be some people who prefer one and some people who prefer the other. Call them Brand A and Brand B. For each subject (volunteers in a grocery store), decide on one of three treatments at random:

1. A high price ($3.69 a bag) on Brand A and a low price ($0.99) on Brand B.
2. A high price ($3.69 a bag) on Brand B and a low price ($0.99) on Brand A.
3. No price on either plate.

The people taste the cookies in a random order and then they say which one they prefer. After you have 100 subjects taste the cookies you compare the proportion who liked each brand better when they thought it was expensive or cheap to the proportion who liked it better when they didn’t know the price.

Note: this student solution was produced after a class discussion of the pros and cons of everyone’s first attempts.