Bioinformatics Bite #1: Intro to p-values

Worksheet
Teacher Materials

OVERVIEW

This worksheet is part of set of short lessons to help students become familiar with relevant vocabulary for introductory statistics.

KEY CONCEPTS

- **Statistical p-values are used to evaluate the difference between samples/populations.**
- **Experimental design is based on a null hypothesis and its counterpart alternate hypothesis.**

OBJECTIVES

- **Students will be able to define and identify a statistical p-value**
- **Students will be able to differentiate between statistical hypotheses**
- **Students will be able to self-assess progress associated with learning aims**

TEACHING TIPS

- **This lesson is designed with high school age students (grades 9-12) in mind.**
- **This lesson is part of a set of short lessons that can be up to 20 minutes long, and either taught contiguously in an hour-long class period or as short daily introductions.**
- **Several additional teaching tips are included in red text throughout this teacher version of the document.**
- **MATERIALS NEEDED FOR PART 4**
  - **Pennies or other similar coins/objects that can be flipped**

Part 1: I hypothesize…

One of the biggest misunderstandings that students walk into science classes with is the idea of the singular "If….then…" hypothesis. You'll probably see a lot of variations of this in this brainstorm. This section is designed to help bring up these misconceptions and make them visible, so that they can be directly addressed and corrected.

Hypotheses are testable, falsifiable explanations. They are based on previous work and evidence (to ensure that the hypothesis is novel). They are specific, relevant to the problem, and clear. Although the if/then idea is an integral relationship of a hypothesis, they are NOT written in that format, instead being written as direct statements.

If you were designing an experiment, how many hypotheses would you have? Why?

What makes a good hypothesis (or hypotheses)?

Design a sample hypothesis (or hypotheses).

Part 2: Wait, there's two of them?

There are actually two hypotheses when designing an experiment!

Read the text in the box below, highlight what you consider to be important (or want to ask your teacher about), then answer the items that follow.

"The actual test begins by considering two hypotheses. They are called the null hypothesis and the alternative hypothesis. These hypotheses contain opposing viewpoints.

*H*0: The null hypothesis: It is a statement of no difference between sample means or proportions or no difference between a sample mean or proportion and a population mean or proportion. In other words, the difference equals 0.

*H*a: The alternative hypothesis: It is a claim about the population that is contradictory to *H*0 and what we conclude when we reject *H*0.

Since the null and alternative hypotheses are contradictory, you must examine evidence to decide if you have enough evidence to reject the null hypothesis or not. The evidence is in the form of sample data.

After you have determined which hypothesis the sample supports, you make a decision. There are two options for a decision. They are "reject *H*0" if the sample information favors the alternative hypothesis or "do not reject *H*0" or "decline to reject *H*0" if the sample information is insufficient to reject the null hypothesis."

Text from https://opentextbc.ca/introstatopenstax/chapter/null-and-alternative-hypotheses

Have a discussion with your students about what it means to write a definition in their own words. Encourage them to research more on null and alternative hypotheses if they feel stuck!

Define a null hypothesis in your own words

Using your own words, define the "null hypothesis".

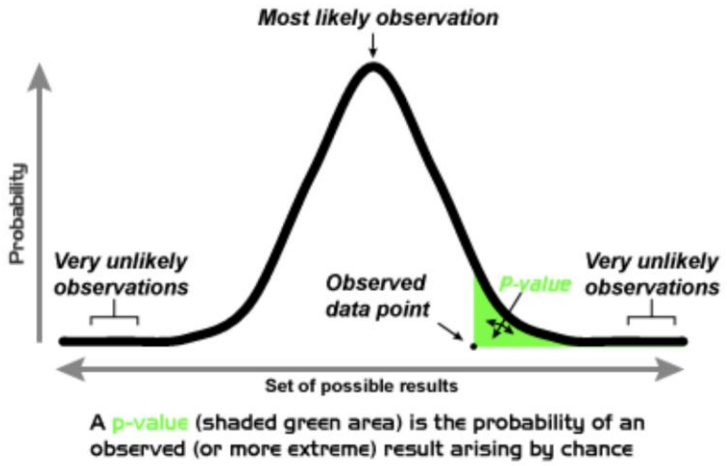
How do is it determined whether to reject the null hypothesis or not?

Guide students towards discussing the strength of the sample data/evidence being what makes us confident enough to reject the null hypothesis or not. Transition the discussion to Part 3.

Part 3: How do we know if the evidence is strong enough or not?

Text from https://opentextbc.ca/introstatopenstax/chapter/null-and-alternative-hypotheses

Look at the graph and read the text below, highlight what you consider to be important (or want to ask your teacher about), and then fill out the highlighted table and question below!



https://upload.wikimedia.org/wikipedia/en/0/00/P-value_Graph.png

The *p*-value reflects the strength of evidence against the null hypothesis. Accordingly, we'll encounter two situations: the strength is *strong enough* or *not strong enough* to reject the null hypothesis.

Generally, we use 0.05 as a threshold. If $p > 0.05$, we say that the evidence against the null hypothesis is not strong enough, and we can't reject the null hypothesis. If $p < 0.05$, we say that the evidence against the null hypothesis is strong enough, so we reject the null hypothesis and accept the alternative hypothesis.

	p>0.05	**p<0.05**
What does this mean for the null hypothesis?	We cannot reject the null hypothesis.	We can reject the null hypothesis and accept the alternative hypothesis.

Based on the graph and the text, how would you define a p value?

Student answers will vary but may say "A p value indicates how likely the result occurred by chance" or "a p value is probability of obtaining a result greater than or equal to the results we got."

Part 4: Application Time!

Using pennies or other coins design a quick test with a partner, meeting the highlighted requirements below!

Be sure to ask your teacher to look over your plan and explain how to do the calculation step (*)!
Encourage students to work with their partner first to troubleshoot questions/confusion, research additional resources, and use their work from this assignment. Roam the room to monitor progress and provide support if partnerships reach a sticking point. When partnerships are ready to present to you, evaluate their plans and then make sure they know how to do the calculations (and show them if necessary).

Here are two resources for your refreshment on penny p-value experiment calculations:

https://library.unimelb.edu.au/__data/assets/pdf_file/0006/1924161/p_value.pdf
https://s4be.cochrane.org/blog/2016/03/21/p-value-in-plain-english-2/

Null Hypothesis:

Alternative Hypothesis:

Plan for Experiment:

Data:

***Calculation of P-Value/P-Value:**

Reject or accept the null hypothesis and why:

Part 5: Learning Aims and Evaluation

Talk to students about the importance of metacognition ("thinking about your thinking") and reflecting on their learning and where they are at with what they are learning. It may feel strange to students, but it is very important for their growth and helps them see learning aims as not something to simply "glaze over" at the beginning of the assignment but tools to see what they have learned. Encourage them to be honest, letting them know that rating themselves below a 4 for any or all of these learning aims does not correlate with losing points for this section.

Please rate where you personally are at, with regards to the learning aims, at the end of the lesson and why.

Rating Scale

1- I do not understand it at all yet.

2-I understand parts of it, but I need my teacher and/or classmates' support to answer questions.

3-I understand it and can complete an assignment by myself.

4-I understand it so well I can teach others and apply my knowledge to new situations.

Learning Aim #1: Students will be able to define a null hypothesis and alternative hypothesis and the role that p values play in rejecting or accepting them.

My Evaluation of Learning Aim #1 and Explanation:

Learning Aim #2: Students will understand what a p value is and be able to demonstrate that understanding through the creation of their own definition of a p value.

My Evaluation of Learning Aim #2 and Explanation:

Learning Aim #3: Students will demonstrate their understanding of the topics of this lesson by designing a simple and quick experiment with pennies.

My Evaluation of Learning Aim #3 and Explanation:

Additional References

Tran Quang Hung. March 2016. Key to statistical result interpretation: P-value in plain English. https://s4be.cochrane.org/blog/2016/03/21/p-value-in-plain-english-2/

Tanu Seth. January 2020. How to understand p-value in layman terms? https://towardsdatascience.com/how-to-understand-p-value-in-layman-terms-80a5cc206ec2

Null and Alternative Hypotheses. BCCampus. https://opentextbc.ca/introstatopenstax/chapter/null-and-alternative-hypotheses/

Probability Value (p-value). Helpsheet by Giblin Eunson Library. https://library.unimelb.edu.au/__data/assets/pdf_file/0006/1924161/p_value.pdf

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