INSTRUCTOR’S GUIDE

VIRTUAL LEARNING
EXPERIENCES

The **K20 CENTER FOR EDUCATIONAL AND COMMUNITY RENEWAL** is a statewide education research and development center which promotes innovative learning through school-university-community collaborations. Our mission is to cultivate a collaborative network engaged in research and outreach that creates and sustains innovation and transformation through leadership development, shared learning, and authentic technology integration.

The K20 Center's **VIRTUAL LEARNING EXPERIENCES** (VLE) development team is tasked with creating game-based learning experiences to be used in undergraduate courses at The University of Oklahoma. The experiences are designed and developed by a small team working with volunteer University professors.

The purpose of this guide is to support the effective integration of Potions! into your classroom teaching. This guide provides an overview of the game and instructions for how students will access the game in your Canvas classroom.

TABLE OF CONTENTS

5 **About the Game**
- 5 Purpose
- 5 Learning Objectives
- 6 Game Narrative
- 6 The Research

8 **Playing the Game: The Interface**

10 **References**

11 **Contact**

ABOUT THE GAME

PURPOSE

Potions! is intended to be used in college-level introduction statistics classes across multiple disciplines. The game can be used to facilitate discussion or used in place of a traditional classroom or homework assignment. By playing through the game, students will be introduced to concepts of inferential logic and hypothesis testing. The game provides the opportunity for students to interact with and apply these concepts within an authentic environment.

In Potions!, students select populations, choose potions to test, and then run t-tests. T-tests are used to compare the means of two groups on a single measure. T-tests can be one-sample or two-sample. Two-sample t-tests can be dependent for paired samples or independent. This game focuses on independent, two-sample t-tests. These tests are used when comparing the means of two independently measured samples.

Through Potions!, students will organize experiments to compare the effects of two potions, choose relevant parameters such as sample size and confidence interval, and interpret authentic results of their experiment. Potions! provides just-in-time feedback, allowing students to correct and learn from their mistakes as they make them.
After completing all five levels, students will have a more practical understanding of hypothesis tests and will be better equipped to overcome the common misconceptions associated with inferential reasoning.

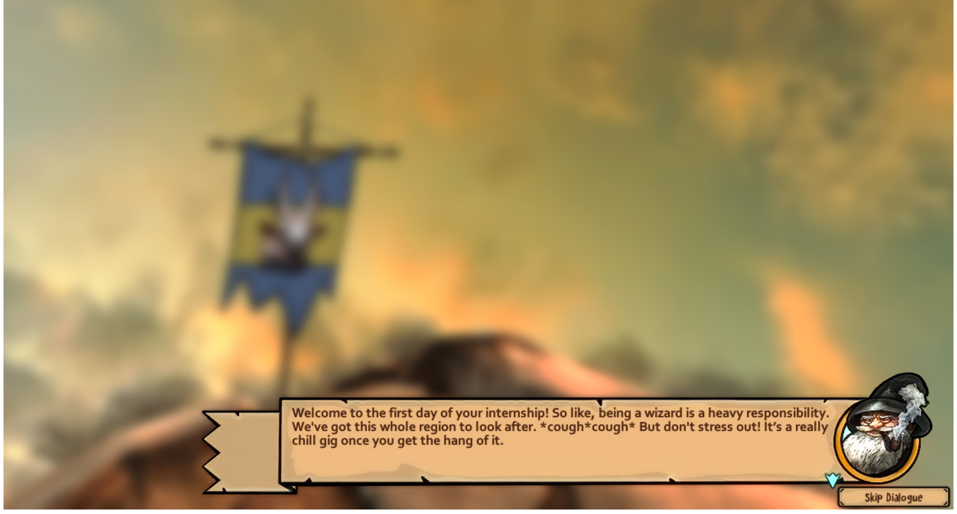
The fictional world of the game provides a low-risk, safe environment to aid in mitigating statistics anxiety and to allow students to learn from mistakes and failures without the threat of real-world consequences.

LEARNING OBJECTIVES

This instructional game endeavors to address the following objectives:

1. **Given an empirical problem and data, the student can perform a hypothesis test.**
   - **1.1.** The student can craft a null and an alternative hypothesis for that problem
   - **1.2.** The student can choose the appropriate directionality to test the hypothesis.
   - **1.3.** The student can choose an appropriate sample size to test the hypothesis.
   - **1.4.** Based on the results of a t-test, the student can determine if the null hypothesis is rejected.

2. **Given an empirical problem, the student can interpret what rejecting or retaining the null hypothesis means for that particular problem.**
   - **2.1.** The student can determine if a claim can be made based on the outcome of a hypothesis test.
   - **2.2.** The student can take effect size into account when drawing a conclusion or making a decision.
   - **2.3.** The student can identify Type I errors.
   - **2.4.** The student can identify Type II errors.



GAME NARRATIVE

The world of Potions! is populated with a wide variety of mythical creatures, and magic is seen as a real force. Magic is the domain of self-styled wizards whose skills come from training and experimentation. With these powers, they can do a variety of amazing things.

Wizards are rare, though, and tend to settle far from one another, each serving a different territory. Not all wizards are good. Some choose to serve the creatures in their area, protecting them from evils, but others seek to menace the populous for their own devious reasons.

In Potions!, students take the role of an intern taking on wizardly responsibilities for the first time. It is the intern’s job—with the help of a mentor—to protect the creatures of their region from magical threats. Presently, a number of local creatures have fallen ill to a mysterious curse. In theory, they can be cured with the right potions, but determining which potions are best for which creatures will take some experimentation. By conducting controlled trials on the affected populations, the intern will surely be able to determine (with a reasonable degree of certainty) which potions work best.

THE RESEARCH

Attitudes about statistics play a role in student academic achievement. Previous experience and achievement in statistics lead to more positive attitudes about statistics and higher future achievement (Ramierez, Schau, & Emmioglu, 2012). Students with more positive affect, cognitive competence, and value for statistics have higher achievement in statistics courses.

Statistics anxiety has also been identified as a key factor in achievement (Mustafa, 2003; Chew & Dillon, 2014). Games are known for increasing engagement in players (Boyle, Connolly, Hainey, & Boyle, 2012). Engagement is associated with a state of flow (Csikszentmihlyi, 1990) and lowered anxiety. This increase in flow is optimal when the difficulty of the game is matched with the skill of the player (Hamari et al., 2016). Additionally, the use of humor (Schact & Stewardt, 1990) and framing statistical problems within a fictional narrative have been shown to reduce statistics anxiety (D’Andrea & Waters, 2002).

Students are regularly able to carry out the mathematical manipulations necessary to perform a hypothesis test but often hold deep misconceptions about the interpretation of the results (Sotos, Stijn, Van der Noortgate, & Onghena, 2007; Chew & Dillon, 2014). Therefore, we propose that this instruction focus largely on the application of hypothesis tests and overcoming common misconceptions in their use.

Common Misconceptions about Hypothesis Testing

Sotos, Stijn, Van der Noortgate, and Onghena (2007) have identified several misconceptions about hypothesis testing that are considered particularly problematic for students:

- Many students neglect the role of sample size on the variance of the mean. Students holding this misconception will dismiss the variability of random events, assume that small samples are representative of the hypothesis, and overstate the reliability of hypothesis tests.
- Students often exchange null and alternative hypotheses for one another. Also, they often cannot craft adequate hypotheses to determine the results of an experiment. Students holding this misconception think that the null hypothesis and acceptance region are the same thing and believe that a hypothesis can reference both to a population and a sample.
- Confusion between significance level and p-value, often switching these two terms in the conditional probabilities is also a common misconception. Students often believe that the p-value is the probability that their decision to reject the null hypothesis is wrong. This leads to other misconceptions including the belief that the Alpha is the probability of making a mistake or the chance that the hypothesis is true.
- Students tend to consider hypothesis tests to be mathematical or probabilistic proof that a hypothesis is true or not. This means that students are falsely assuming that a hypothesis test is either deterministic or that the probability of an event reflects the probability of the premise from which it was drawn.
- Students tend to confound statistical significance and practical significance. Just because a hypothesis test produces statistically significant results doesn't mean that those results will have any real-world value.

Cognitive Biases

Research has shown that heuristic biases play a role in statistical reasoning. Representativeness bias (the belief that a small sample will reflect the qualities of a larger population) and equiprobability bias (the belief that all outcomes are equally likely) are particularly problematic (Morsanyi, Primi, Chiesi, & Handley, 2009). Morsanyi and colleagues compared biology and psychology students' bias reactions before and after having taken a statistics course. The results showed that, for psychology students, representativeness bias decreased with education while equiprobability bias increased. Education had no effect on bias for biology students. This difference is partially explained by differences in reasoning on different types of tasks. Both groups were more likely to elicit equiprobability bias on psychology content tasks (those dealing with the characteristics of people) than on tasks involving objects or natural phenomena. The increase in equiprobability bias is most likely a result of misconceptions about randomness and ignoring population base rates. Morsanyi and colleagues suggest that providing instruction to think logically and analytically about a problem can have an effect on reducing equiprobability bias.

PLAYING THE GAME: THE INTERFACE

MAIN MENU

Study Selection – Allow students to choose which level to play, these are unlocked sequentially as students play through the game.

Options – Allows for volume adjustment.

About – Provides information about the K20 Center.

The number beside the potion icon shows the total number of potions that can be brewed in the level. Can be of any type. Placebos do not use up inventory.

The student's score for the current level.

Hypotheses from tests are displayed here.

Each population with in a level will have a banner, clicking a banner will select that population for testing.

POPULATION SELECTION

THE LAB

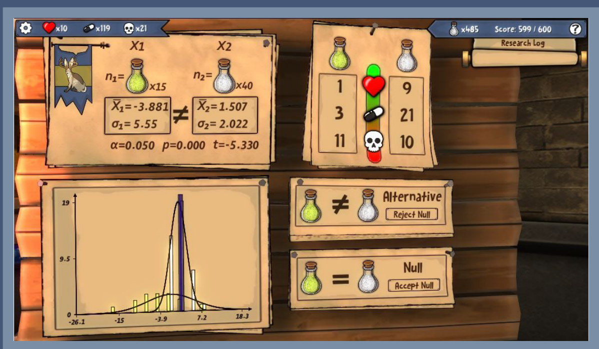
This banner shows the status of the currently selected population. It shows the number of currently healthy, sick, and dead.

Clicking the “Apply” and “Test” buttons allow players to cycle between testing and directly applying potions to the current population.

Potion testing Panel—Sample sizes and significance level are assigned here for testing.

Players can cycle through one-tail and two-tail tests by clicking the direction spinner between the test tubes.

Potions can be chosen for testing by dragging them to the test tubes.



Test Results screen—Test results are displayed on this screen, and players may accept or reject the null based on their analysis of the presented data.

Assessment Panel—At the end of each level, the player can see the true means and standard deviation for each potion and each population and compare it to their test results.

HOW SAMPLES ARE GENERATED

Each potion-creature combination has been assigned a constant mean and standard deviation by the game designers; these are effectively the population mean and standard deviation for that pairing. When students run a test with a particular creature-potion combination, n random numbers are generated along a normal distribution with the given population mean and standard deviation. These numbers form the sample distribution for that test. In this way, each test will be representative of the underlying population data but will contain a certain amount of variance.

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CONTACTS

DR. SCOTT WILSON
Associate Director; Director of Innovative Technology Partnerships
405-325-2608 scott.wilson@ou.edu

JAVIER ELIZONDO
DGBL Producer
405-325-0832 elizondoj@ou.edu

WILL THOMPSON
DGBL Instructional Game Designer
405-325-0832 will.thompson@ou.edu