MICE DICE FOR ELEMENTARY EDUCATORS

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ABSTRACT

Mice Dice is a classroom activity developed for use with Elementary Education majors at a 4-year regional institution; it could have reasonable application in any intro-level probability course. While mating mice (with dice), students are introduced to empirical simulations, foundational concepts for theoretical probability, and the basic structure and use of probability trees. The activity is designed to take 1-2 class days depending on the length of the class sessions, and to add complexity as students progress from one part to the next (generally working in small groups). Students are also encouraged to consider ways to modify the activity for actual use with 4th and/or 5th graders as a multidisciplinary activity that simultaneously incorporates both biological science and mathematics/statistics into their elementary classrooms.

GAISE II (PRE-K TO 12)

In addition to its role as part of the general education course for elementary educators, this activity is designed to target the following outcomes quoted from GAISE II[1] as well as the Kentucky Mathematics Standards[2]. **Bolding** indicates intersections with the activity (bolding used to illustrate intersections with the activity)

GAISE II highlights (from page 2 of the report):

1. The importance of asking questions throughout the statistical **problem-solving process** (formulating a statistical investigative question, collecting or considering data, analyzing data, and interpreting results), and how this process remains at the forefront of **statistical reasoning** for all studies involving data.

2. The consideration of different data and variable types, the importance of carefully **planning how to collect data** or how to consider data to help answer statistical investigative questions, and the **process of collecting**, cleaning, interrogating, and **analyzing the data**.

4. The **role of probabilistic thinking in quantifying randomness throughout all levels.**

Selected Kentucky Mathematics Standards

Grade 1: Organize and **represent data in a table/chart** with up to 3 categories.

Grade 3: **Identify a statistical question** focused on **categorical data**.

Grade 7: **Investigate chance processes** and develop, use, and evaluate **probability models**

High School: **Summarize, represent, and interpret data on a single count or measurement variable**. Use **conditional probability** to interpret data.

ACTIVITY PLAN

Potential Audiences

- K-12 Future Teachers (as developed)
- Grades 8-12 (potentially as developed)
- Grades 4-7 (reduce calculation difficulty appropriately)
- Intro Probability Course (potentially increase difficulty and/or add additional components)

Learning Objectives

- Use statistical ideas in context. Simulate a real-world process using available tools.
- Develop a plan to collect (simulated) data including a focus on unbiased (fairness).
- Implement data collection plan using dice for simulation.
- Construct Tally Charts for a sample.
- Calculate empirical probability estimates based on data (relative frequency).
- Calculate theoretical probability using tree diagrams.
- Summarize theoretical probabilities using a probability distribution table.
- Explain the impact of the Law of Large Numbers on the differences between the empirical estimates and theoretical probabilities.

Materials Needed

Students may be set to work individually or in groups. It is suggested that these materials are available for each individual student:

- Activity Handout
- At least two dice of different colors (to represent the father and mother mice)
- Calculator (optional)
- Class time: Approximately 75 minutes

The activity handout and teacher guide may be found at the website below (or scan the QR-code):

http://sappho.nku.edu/~nolanj1/

General Overview

Students may work individually or in groups as desired by the instructor. The activity is intended to be done in class, with frequent guidance as needed from the instructor. The following approximate timeline is typical for the activity as written.

1. Discuss background science / vocabulary as a class. In particular, students must have a basic understanding of the terms *allele*, *genotype*, and *phenotype*. (5 minutes, Page 1)

2. Simulation: using dice representing the mother and father, students "mate" their mice to produce children a total of 50 times. (10 minutes, Page 2)

3. Estimate probabilities based on the sample; calculate relative frequencies; n=50 makes this somewhat simple (5 minutes, Page 2)

4. Whole class review and discussion of these steps, as well as probability terminology (5 minutes, Page 2).

5. Construct tree diagram to represent the simulation in a theoretical manner and create appropriate probability distribution tables. **Individualized instructor assistance here!** (10 minutes, Page 3)

6. Whole class discussion of probability distributions and the three questions at the bottom of Page 3 (5 minutes)

7. Students complete Extension 1, followed by brief whole class discussion (15 minutes, Page 4)

8. Students complete Extension 2, followed by brief whole class discussion (15 minutes, Page 5)

POTENTIAL EXTENSIONS

Conditional Probability and Bayes Rule

This would be an ideal addition for an intro-probability course. Students will already be using trees, and one could easily imagine questions such as:

- A brown mouse is born. What is the probability that the mother of this mouse contributed the dominant allele?

- A brown mouse is born. What is the probability that this mouse has two dominant alleles?

Mating Groups (more than two mice)

- Ask students to think about how to accommodate 2 mothers / 2 fathers into their probability model using the dice; the mothers and fathers should have different rates of contributing dominant/recessive alleles.

Add Genetic Complexity (more than one gene)

- Make color based on two genes, so that there are three or four possible colors.

- Can do more but it gets complicated quickly!

Change the Dice

- D6's are used for the original activity but there is no reason one couldn't use D4, D8, D10, D12, or D20, which would require students to think further about setting up simulations.

Other ideas?

- If something comes to you please share!!!

ACKNOWLEDGEMENTS

1. Bargagliotti, A., Franklin, C., Arnold, P., Gould, R., Johnson, S., Perez, L., & Spangler, D. (2020). Pre-K12 Guidelines for Assessment and Instruction in Statistics Education (GAISE) report II. American Statistical Association and National Council of Teachers of Mathematics.

   https://www.amstat.org/asa/files/pdfs/GAISE/GAISEIIPreK-12_Full.pdf

2. Kentucky Department of Education. (2019). Kentucky Academic Standards: Mathematics.

   https://education.ky.gov/curriculum/standards/kyacadstand/Documents/Kentucky_Academic_Standards_Mathematics.pdf

3. https://tilthedayidice.tumblr.com/post/186448405617/dice-mice

4. Thanks to NKU faculty Marla Lemmon and Bethany Bowling who developed the original version of this activity and supported my desires to expand it and share it with others!