Mystery Dice: A Game of Inferences

Joel Schwartz & Therese Block

Purpose

This lesson focuses on two main aspects of scientific research: plotting data with software to visualize and help understand relationships, and hypothesizing the mechanism that generated trends (or absence thereof) in data to begin with. This is approached in the context of an author-created game Mystery Dice, which has both simple rules to play and complex behavior to reason out. While the first portion is intended for those unfamiliar with making computerized graphs, the remaining activities are applicable to any ability level from Middle School upward.

Overview

The format and rules of Mystery Dice will be covered first, after which students will break into groups of (ideally) 4 to play through the game. Group members will share numerical data with one another, using instructions for Google Spreadsheets to create a graph displaying all of their collected information. After seeing and discussing each member's behavior during the game, a much more involved inference scenario (and friendly competition) will be undertaken by all groups which utilizes the full extent of Mystery Dice. After each group has deliberated/reasoned their choices, the true behavior can be compared to all hypotheses simultaneously on another specially constructed Google Spreadsheet. A class discussion on the utility of data, graphs, and inference to both scientific and everyday situations will conclude the lesson.

Student Outcomes

Students will be able to:

- Follow oral & written directions to play & understand the unfamiliar game Mystery Dice.
- Construct graphs in Google Spreadsheets using detailed written instructions.
- Make reasonable guesses as to the strategy of each group member during the game.
- Apply visual & numerical data towards reasonable inferences about a collection of gameplays.
- Assess their hypotheses before & after learning the actual rule-outcome pairings involved.
- Describe their ideas on uses & limits of inference from graphs/data for real situations.

Standards Addressed

MS-ETS1-2 (Evaluate competing solutions systematically to determine applicability to problem)
MS-ETS1-3 (Analyze data to determine similarities and differences between solutions)

Time

Approximately two 90-minute class sessions (between 2-3 hours)

Reach for the Stars is a GK-12 program supported by the National Science Foundation under grant DGE-0948017. However, any opinions, findings, conclusions, and/or recommendations are those of the investigators and do not necessarily reflect the views of the Foundation.

Level
Middle School Science/Math (as described; game & inference portions applicable to more advanced levels as well)

Materials and Tools
- Dice (at least 1 per student)
- Computers/laptops for using Google Spreadsheets
- Mystery Dice game supplements:
  - Data Worksheet (pdf)
  - Graph Instructions (pdf)
  - Graph Template (spreadsheet)
  - Sample Graph (spreadsheet)
  - Lettered Goals (png)
  - Inference Worksheet (pdf)
  - Auto Answer Template (spreadsheet)
  - INFERENCE ANSWER KEY (spreadsheet)

Preparation
Have dice ready to pass out before the first session begins. Print copies of Data Worksheet, Graph Instructions, Lettered Goals, and Inference Worksheet for each student. Also print a few extra copies of the Lettered Goals and cut them out, so that you have at least one rule slip per student (there will be multiple slips per rule, which is fine.) No special prep is needed for computers other than having the electronic version of the supplemental documents available.

Prerequisites
Familiarity with basic parts of a graph is advised, as well as with creating simple plots by hand. No prior computer graphing experience necessary.

Background
Have you ever seen an item in a store with no price tag and wondered how much it costs? How about overheard a sentence from another conversation and tried to figure out what the people were talking about? If so for these and similar situations, you have almost surely tried finding an answer for what was going on, which can be really wild sometimes!

Now, ever noticed the Moon seeming larger in the sky near the horizon and being curious as to why that is? What about having watched cells divide in two and wondered how they know when to start and stop? Surprisingly these are really the same kind of questions as before- they all require a certain logic called inference. But wait, what does that mean?

Inference is where you try to find an explanation for something using the evidence available and your ability to think about the situation. It is not always easy, but inference is a vital tool for both science and our everyday lives. In fact, you probably use it *all the time* without even realizing it! Perhaps we can change that for the better…

Today we will try to flex our inference-power about our friends with a game called Mystery Dice, which as you will soon see is much more subtle than meets the eye! Figuring things out from dice numbers alone can be a little tricky, so we will also be learning how to use computers to create pretty graphs automatically. These visual tools are great for helping us see the trends in numbers we might otherwise miss (a lot more common than you think!)

As we go through our activity, keep these ideas in mind:

- What does using inference look/seem like to you?
- Can you describe a specific time that inference was very helpful for you or someone you know?
- Is inference ever a bad thing or something to be careful with?
- What tools/ideas/practices can make us better at using inference well?

Rolls away!

Teaching Notes

Before describing anything else, the rules and gameplay of Mystery Dice come first:

A single game of MD covers 10 rounds and uses 4 dice, so (ideally) there are four players. There are also 15 “secret goals” or “secret rules” in play, one of which is selected (usually at random) by each participant before starting- hopefully no duplicates within each game. In each round everyone rolls 1 of the dice and places it in the middle of the table. Each player must choose 2 out of the 4 dice to add together, based on their “secret rule” they got earlier. For example, if the dice rolls are [2, 2, 4, 5] and the rule is “pick the two middle dice,” the player would choose a 2 and the 4 to get the sum 2 + 4 = 6. Each player writes down the sum they selected, and the process is repeated for the next round. Importantly, none of the players should tell each other *what pair they chose* or *why* just yet. Once all ten rounds have been rolled, the players then exchange their selected sums with one another. The game is not over at this point, though, and continues with players trying to figure out what the others were doing the whole time! (Other parts of this lesson work towards deciphering this.)

The nice thing about MD is that the gameplay is simple enough for anyone to follow along, but can create a lot of depth when trying to reason out the “secret goal” of each participant. That also means higher grades and/or advanced students can acquire just as much (if not more) benefit from the activity with minimal changes to the lesson plan described here.

Start with a simple introduction about inference (see “Background” for suggestions), and have students break into groups of 4 (3 and 5 are OK as needed, too.) Pass out data worksheets and 4 dice to each group, plus randomly hand each student one the rule slips cut out earlier. *Let them know to keep their rule a secret from everyone else!* Next go over the flow of MD and have each group play through an entire game, exchanging selections with each other at the end. You can have students share some initial impressions here about what their partners were doing from the numbers they are given. Explain that a next step towards figuring this out is visualizing the data, so pass out the graph instructions and have students get computers.

Show the practice sample graph and discuss it briefly so students know the form they will be constructing, then have them begin working through the instructions using the graph template file in Google Spreadsheets. The graph instructions are detailed at each step and will help students build up a full plot of their group’s data. Using the new graphs with the numerical lists, each group should discuss what the lines could be showing and (with appropriate exclusions) what each player may have been doing during the game. At some time here it would be helpful to pass out the lettered goals sheet to each student, so they know what possibilities exist- but waiting a bit at first should keep their discussions more open. You can eventually transition into a class discussion, where different groups share their graphs and reasoning. Have players reveal their “secret rules” during this time and compare them to the guesses, talking with everyone about what are reasonable and unreasonable choices.

******This is a good point for splitting the activity into two days******

After participating in an entire *single* game, students are ready to tackle a more involved inference scenario. Pass out the inference worksheet (plus lettered goals grid again, if needed) and overview it with the class. Contained here are data tables and graphs for 5 games of 3 players each, where all of the 15 “secret goals” have been used *exactly one time.* These games are real gameplays of MD, which were done without author knowledge of the correct goal-graph pairings. The answers are in the inference answer key supplement, but should remain hidden so the instructor can participate honestly in the deduction process. After all, the real world has no cheat sheet ahead of time! This is an excellent situation for friendly competition as follows: break students into numbered groups of 4 (same or different from before, as desired) and allow ample time to have them discuss/debate what pairings generated these graphs/tables. Inform them that the group(s) with the most correct predictions are awarded a prize (left to discretion of instructor!)

It is encouraged that the instructor makes a prediction set of their own, while rotating between each group to check progress. Some helpful suggestions that can be gradually shared with students (no order):

- Look for patterns in the graphs (one of the games looks like an especially good place to start.)
- Think about limits of the data (for example, where would the “lowest two dice” line fall?)
- Use process of elimination to get simpler pairings first; work on ones that look harder later.
- The number tables are useful, certainly to check that the graphs are being read properly.
- There will naturally be many combinations that seem reasonable, which is OK- this is exactly how the real world works almost all the time!

Once all groups have their pairing selections, compile them into the auto answer template and enter the true answers from the supplemental document in the “goal key” column. This should be done in front of the class, one at a time- the template highlights correct selections (with conditional formatting), totals the score for each group (using a number table off to the right side), and highlights the leading group(s) (again with conditionals.) After congratulating the winners, conclude with a class discussion about how inferences, graphs, logic, etc. can be helpful to both science and everyday life, plus what some of their limitations might be. Students likely have new ideas about these after participating in this extended inference game.

Assessment

- Check students’ graphs for quality/information accuracy, individually and with the sample.
- Discuss reasonable and unreasonable choices as a class, asking students to share their opinions.
- Survey students about their ideas for hypothetical graph-rule pairings (both simpler and subtler.)
- Tabulate all group hypotheses on the accompanying Auto Answer Template, which is done together as a class.

Additional Information

Feel free to modify Mystery Dice to add new layers to the game. Maybe individual players could choose which “secret goal” they would like to use, or whole groups might select a set of goals they believe would be difficult for others to deduce. The number of total dice, number of summed dice, and alternate "secret goals" may also make for interesting situations. Think of this as a basic game and get creative!