Teaching Probability Through Play:

A High School Carnival Project Including Community Outreach

ILLINOIS

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Speaker Introduction

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What are you hoping to get out of this session?

University of Illinois Laboratory High School (Uni)

- 8^{th}-12^{th} grade students
- Selective Enrollment
- Public
- Math - Integrated curriculum
- This activity was completed in a Statistics course with 11^{th} -12^{th} graders

Overview

1. Overview of the class activity
2. Experience the activity through the eyes of the student
3. Outreach component
4. Student Feedback
5. Questions

Assignment

- Create a unique and appealing carnival game that will make the owner of the game money
- Based on probability- not skill
- Working in pairs
- Lots of flexibility – differentiation
- Use of makerspace
- Community outreach
- Reflection

GAISE II Framework

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

Specifically: *Students must interpret expected value. Students also reflect on their experiences*

3. The inclusion of multivariate thinking throughout all Pre-K–12 educational levels

Specifically: *Students are required to have multiple outcomes for their game*

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

Specifically: *Students use empirical or theoretical probability. Students are encouraged to incorporate items like spinners, dice, cards, that they have been exposed to in the course*

6. The enhanced importance of clearly and accurately communicating statistical information

Specifically: *Students must explain their game to a teacher, fellow students, and elementary students*

7. The role of assessment at the school level, especially items that measure conceptual understanding and require statistical reasoning involving the statistical problem-solving process

Specifically: *Students will be assessed using a rubric*

Example

Example: Suppose you run a Carnival Game called "Duck Pond." There are 25 rubber ducks in a pond, and each has a colored dot on the bottom which corresponds to a different prize. It costs $1 to play Duck Pond. The prizes and colors are described below:

10 yellow dots	Lose your money you paid to play
5 pink dots	You win a sucker (valued at $0.10)
5 red dots	You win a Hershey kiss (valued at $0.05)
3 green dots	You get your money back
2 blue dots	You win a teddy bear (valued at $3)

a. Create a probability distribution for the Duck Pond game.

From the player's perspective

x	p(x)
-1	10/25
-0.9	5/25
-0.95	5/25
0	3/25
2	2/25

b. Determine the expected winnings for someone playing the game $E(x) = -0.61$

c. Is the owner of the game making money? Explain

Because the expected value is negative for the player, the owner is making money

Working in groups of 2 (possibly one group of 3), you are to create a unique game (something different from the examples presented in class). You must have at least 5 different possible monetary outcomes. You will charge people "money" to play your game (you decide how much). Also, you decide how much each outcome is worth (win or lose). Make sure you are able to find the probability of each outcome (Hint: use dice, cards, coins, etc.). Students who chose more difficult probability computations (involving unions, intersections, binomials, or combinatorics) will have this reflected in their grade (see rubric). Your goal is to come up with an appealing game that people will want to play, but you still want to earn money in the end as the owner.

1. Title your game, explain the rules, and list the prizes.
2. Determine how many of each prize and their monetary value. You have a total budget of $30 for prizes.
3. Construct a probability distribution in chart form for your game, your random variable x should represent the player's monetary outcome (there should be at least 5 different x values).
4. Find the player's expected value of your game.
5. Create the game.
5. Be ready to explain how this game is going to make you money, but still be appealing enough for people to try to play.
6. After the activity, students will be asked to write an individual reflection.

For today, you can just estimate prize costs

Rubric:

	E-Exemplary	M-Mastery	R-Revisit and Reassess	X/0-Failure/did not complete
C1- oral communication	Explained game in a way that was engaging and easy to understand for all students	Presentation needed clarification in order to understand	Presentation was lacking in many areas	Did not complete
C2-Read and follow directions	All required items are listed in documents and explained/work shown		Did not follow all directions	Did not complete project
C3- Writing (individual reflections)	Format and organization make the reflection exceptionally clear	Few written errors (spelling, grammar, etc.) OR the flow of the writing is poor due to lack of formatting or organization.	Reflection is: written entirely in one paragraph, OR contains many spelling, grammar, and typing errors, OR difficult to read and follow, OR very little is said in explanation	Did not complete
C7-Collaboration	All group members worked together. Students listened respectfully to other groups present their games. Student has participated actively in all stages of the process. Student has served as a vital member of the group sharing in the work, especially in the research process and the statistical thinking.	Student is participating in group work but mostly focusing on "busy" work or "artistry" only. OR Student has participated in most of the process	Student has been disrespectful to others involved in the process. OR Student has not participated in discussions. OR Student has sabotaged their group. *Note th may al of othe*	
C8- Modeling	The game created could be a real carnival game, includes appropriate probabilities, and the owner of the game makes money Creativity is shown in design of game		Does n E colu	
U5.B- Probability	Student correctly uses the definition of probability and uses appropriate methods for calculations. Students who chose more difficult computations: 1-2 small errors could occur Examples of "more difficult computations": binomial/geometric, permutation/combination, addition AND multiplication rules	Basic computations: no calculation errors Example: addition OR multiplication rules but not both Difficult computations: 3-4 errors could occur	Basic computations: 1-3 small errors occur with probability calculations OR large errors occur with probability calculation. OR student choses a structure to their game that involves skill and therefore probability cannot be calculated correctly. It is clear that the student does not understand how to correctly calculate probability.	Student does not calculate probability
U6.A- Expected Value	Student is able to calculate, interpret, and understand expected value of a random variable	1-2 small errors occur	3 or more small errors, OR large errors occur with expected value calculation. OR student choses a structure to their game that involves skill and therefore expected value cannot be calculated correctly. It is clear that the student does not understand how to correctly calculate expected value.	

You try...

Developing Games

- Dice, Cards, Coins, Spinners
- Class worktime
- Meetings with teacher

Creating the Carnival Atmosphere

- Grant- prizes
- Students must budget
- Teacher purchased prizes and students “shop” from that selection.
- Location and time of day
- “Money” for others to play

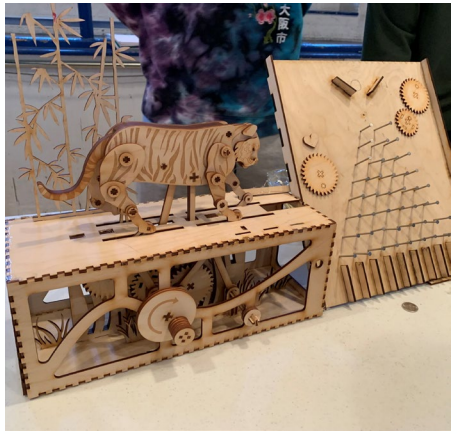
Buhnerkempe Bucks

Use this “ticket” to “purchase” plays on carnival games. As you play, the owner of the game will reduce the amount left on your “ticket” by crossing out the old amount and writing down the new amount you have remaining. Have fun!

Starting Value: $10


BEARS

Examples



Let's Play with Elementary Students!

- Do you need to modify your game to be played by younger students?
- How might you explain probability to a student who may not (fully) understand fractions?
  - Teacher tools:
    - 3rd or 4th grade (at least 4th recommended)
    - Share the Illinois Common Core State Standards

Community Outreach

Booker T Washington STEM Academy

3rd Graders

Nov. 2023

Community Outreach

Booker T Washington STEM Academy and Stratton Elementary

4th Graders

Nov. 2024

Student Interaction

Plinko

Student Comments

- One High, One Low
- Incorporating feedback and the process of pivoting

“The students were really engaged and got really into it.” – KM

“They were really good about working together to make a decision on how to play.” – SS

What portions of this project do you think you would like to implement in your own classes?

- What challenges do you anticipate?
- What modifications do you need to make?
- What do you plan to use as-is?

Too Big?

Poster Project

2014-2018

Class Carnival

2020-2021

School-wide

2022-present

Outreach

2023-present

Questions

- Emily Buhnerkempe
- emilyeb@illinois.edu

- Google folder with resources

THANK YOU!

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Extra resources/discussion

- Second video of student interactions at BTW- Leaf it to Chance
- 6 block workdays (could do less with modifications), 1 carnival day, 1 outreach day
- I wish… I could have students collect data during the school carnival to compare their empirical to their theoretical probability.