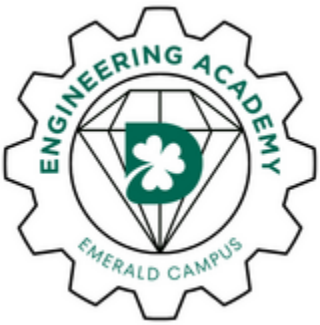

Dice Quality Control Lab Report

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Prepared for: Black Oak Workshop

Content: Verifying the Fairness of Dice

Date: 9/2/2025

Introduction:

This report concerns the group project that the Engineering Academy class was tasked with in relation to the company Black Oak Workshop. The group project was about testing various sets of dice to determine whether or not they were fair. To be counted as fair, each die needed to have each of its sides have a similar probability of appearing when being rolled. The engineering academy was separated into several groups, and the group this report is concerned with is the one that tested the blue *Black Death* dice. Detailed in this report is the method taken to determine the dice's fairness, the data that was taken, and the conclusions made about the set of dice. This report is written by the group's two members, Jacob Kreidler and Jack Turk.

Methods:

To determine the fairness of the dice, we conducted a chi-square goodness-of-fit test. This is a formula designed to determine whether or not the data we collect from the dice matches the expected predictions or if there is a significant deviation. The chi-square test has two hypotheses that are determined before testing.

Null Hypothesis (H_0): The dice are fair
Alternative Hypothesis (H_A): The dice are not fair

In the chi-square test, the goal is for the data to show that we failed to reject the Null Hypothesis, hence proving that the set of *Black Death* dice is fair.

Procedure:

Our procedure for getting the data was dropping each die 10 times per side, with every 10 drops having a different number facing up. We believed that 10 trials per side was enough, as we could be almost certain that each side would come up at least 5 times. Each drop was from a shoulder height onto the table. We nullified any roll that went off the table or hit anything but the table.

Our procedure met all of the conditions. It was random because we conducted an experiment, and data from experiments can be assumed as random. It was independent because every trial was independent of the other. Finally, it was normal as all expected counts were 10.

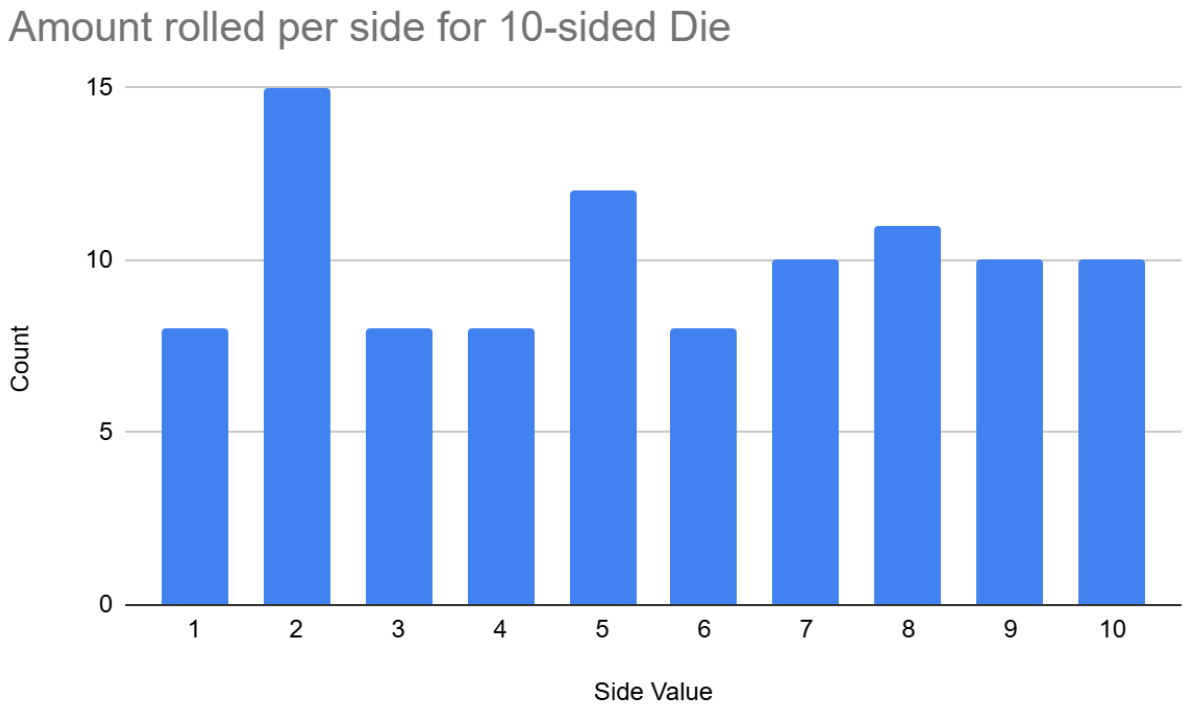
Results:

The data that we gathered was put into Google Sheets and converted into bar graphs demonstrating the type of die rolled and how many times each side showed up. The figures below represent the dice from the set that the data proved to be the fairest and least fair.

The die we determined to be the most fair was the 10-sided die, going from 1-10. A minimum of 10 rolls per side was needed to make sure that the data was the most accurate (100 rolls in total). The data table right below shows the sides and their corresponding roll counts for the 1-10 die.

Side Value	1	2	3	4	5	6	7	8	9	10
Count	8	15	8	8	12	8	10	11	10	10

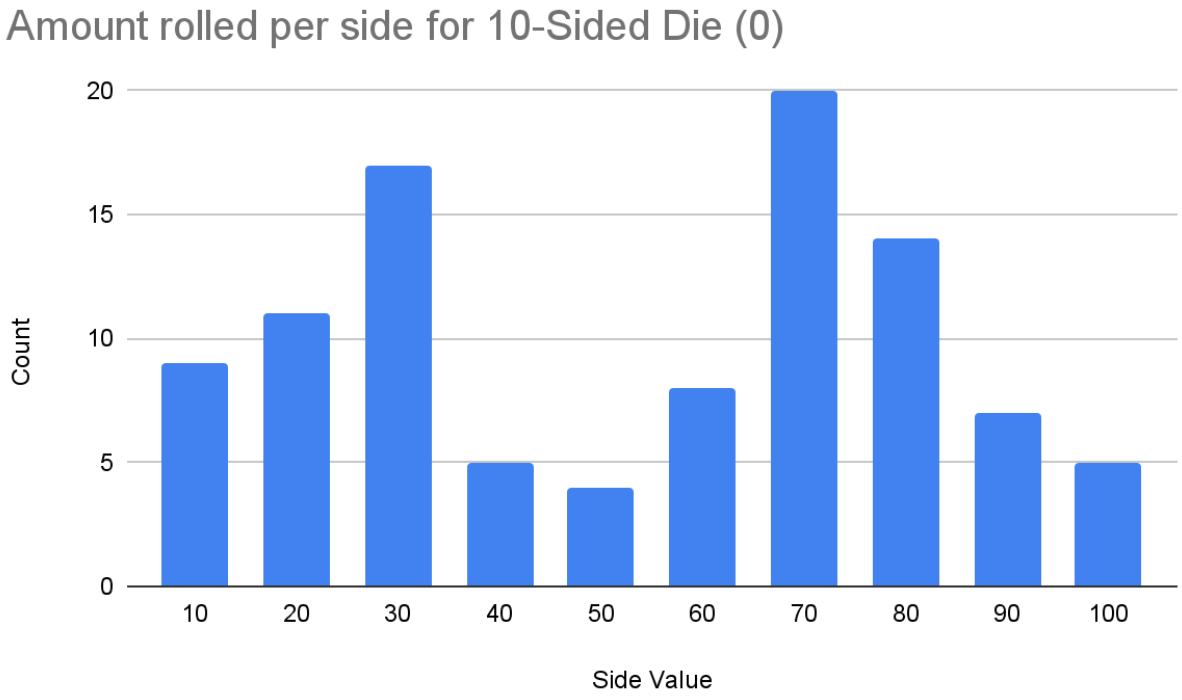
Taking all the values from the table and putting them into a bar chart shows up as the figure below:



The die we determined to be the least fair was the 10-sided die, going from 10-100. Again, a minimum of 10 rolls per side was needed to make sure that the data was the most accurate (100 rolls in total). The data table right below shows the sides and their corresponding roll counts for the 10-100 die.

Side Value	10	20	30	40	50	60	70	80	90	100
Count	9	11	17	5	4	8	20	14	7	5

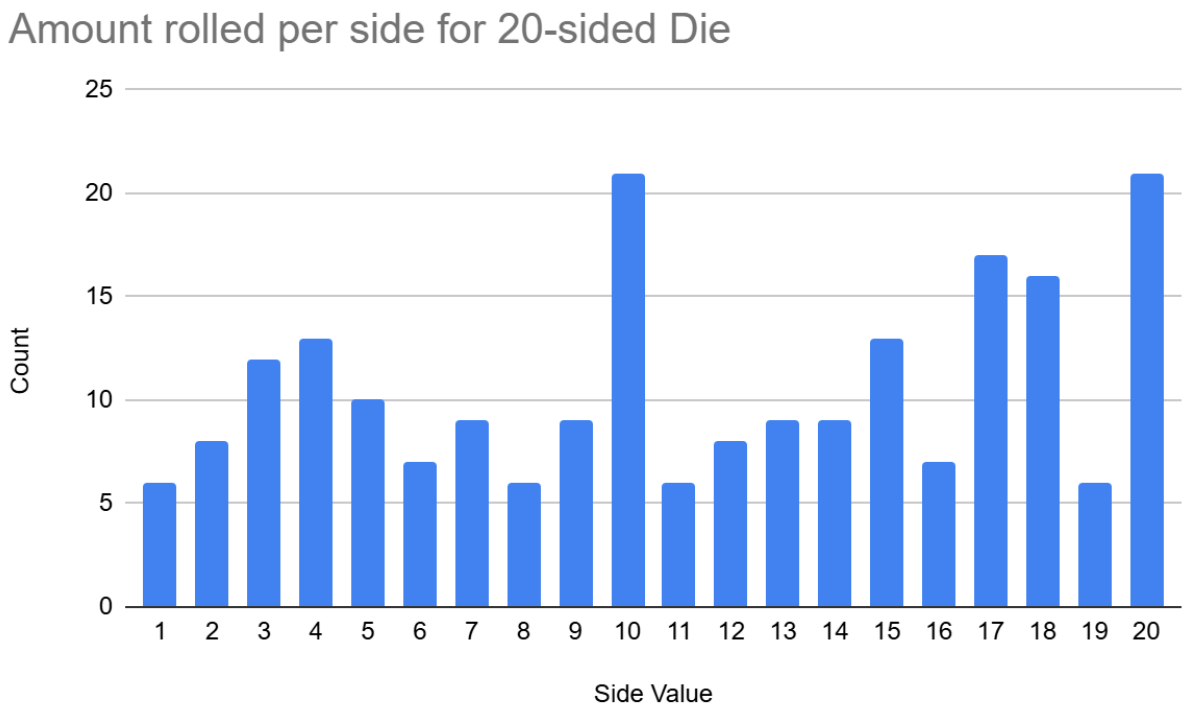
Taking all the values from the table and putting them into a bar chart shows up as the figure below:



The only other die that we determined to be unfair was the 20-sided die. With the only 200 rolls for a 20 sided die, it is possible that this happened due to chance and the die may not be truly unfair. Here is the data table.

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
6	8	12	13	10	7	9	6	9	21	6	8	9	9	13	7	17	16	6	21

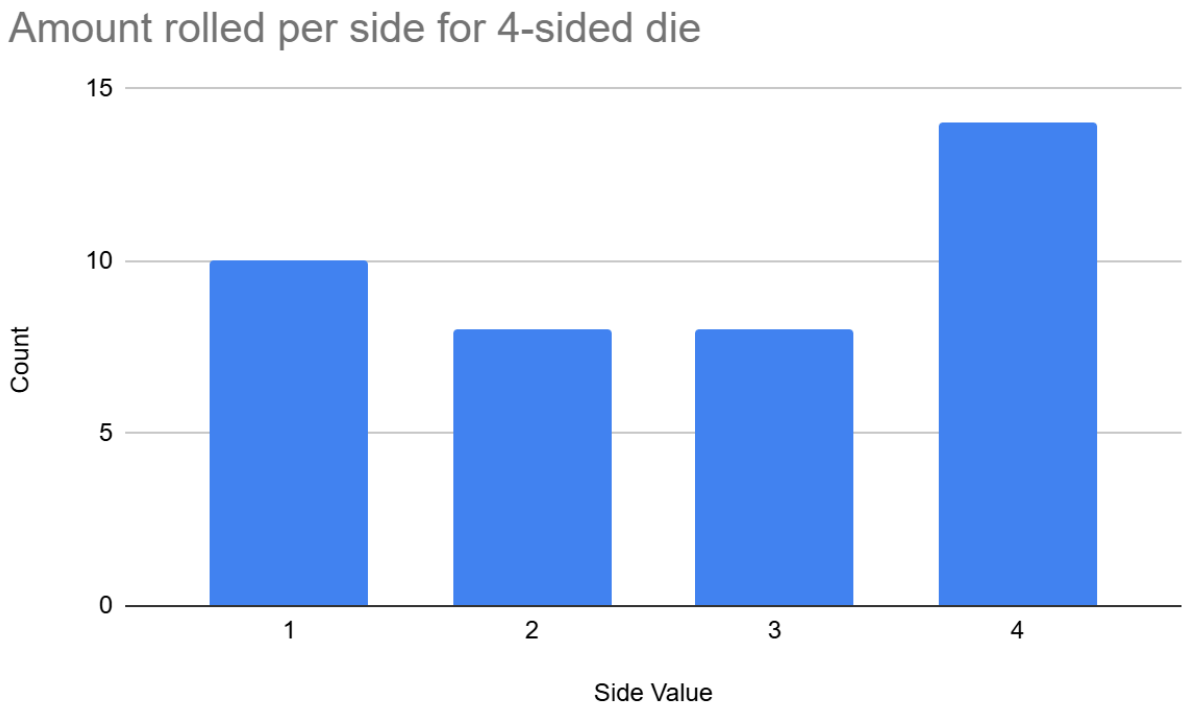
Taking all the values from the table and putting them into a bar chart shows up as the figure below:



Other than that, we determined every die to be fair. Here are the data tables and graphs for them.

4 Sided

Side Value	1	2	3	4
Count	10	8	8	14

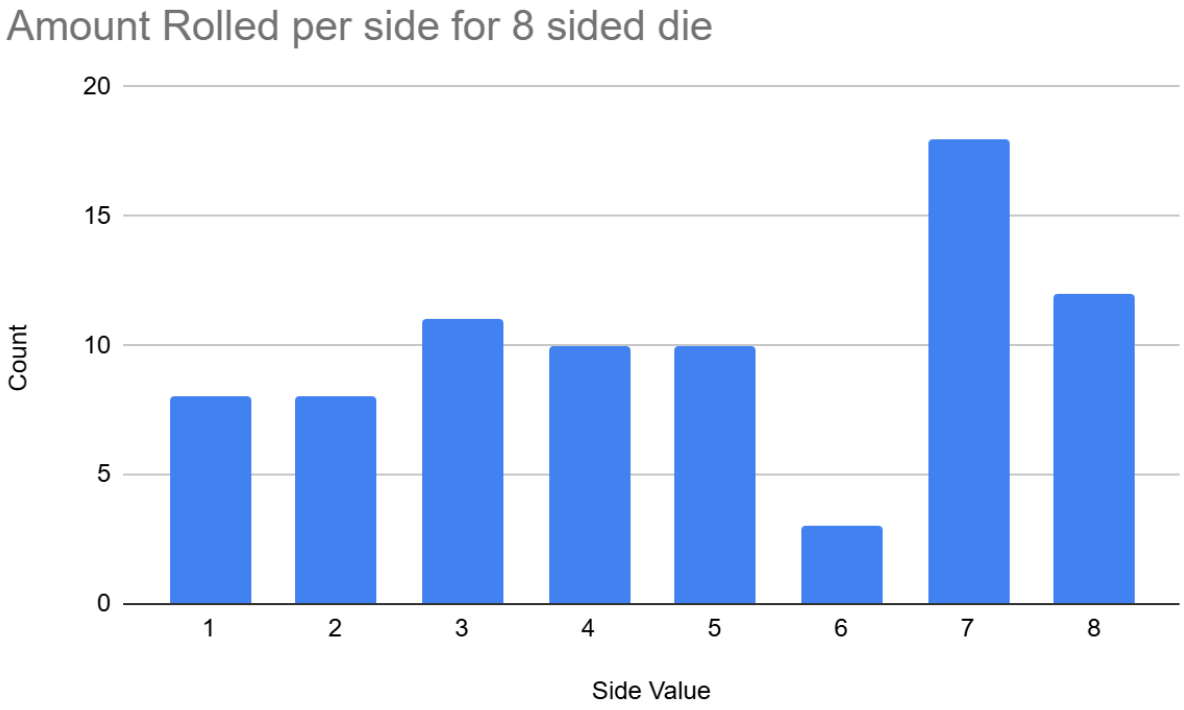


6 Sided

Side Value	1	2	3	4	5	6
Count	12	8	12	7	13	8

8 Sided

Side Value	1	2	3	4	5	6	7	8
Count	8	8	11	10	10	3	18	12

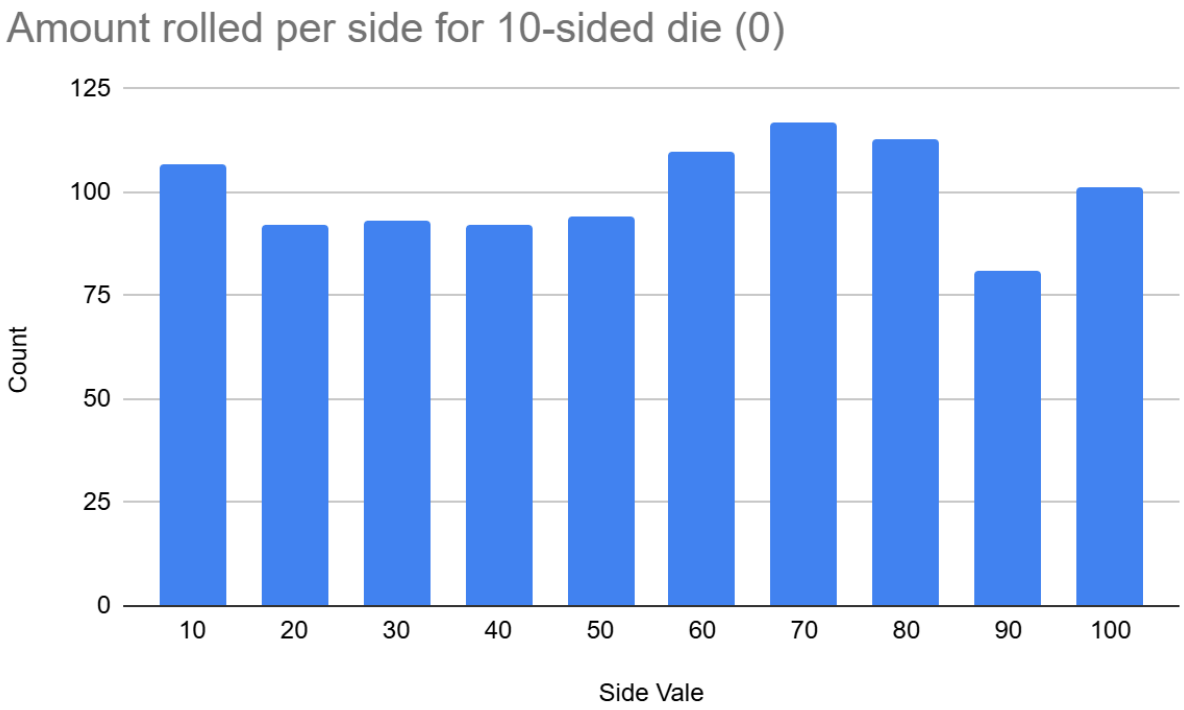


12 Sided

Side Value	1	2	3	4	5	6	7	8	9	10	11	12
Count	12	7	17	7	8	12	8	7	12	9	11	10

Finally, we were tasked with determining the fairness of the d10(0) die for the whole class. After everyone put their data into a sheet we did the same procedure and got this data.

Side Value	10	20	30	40	50	60	70	80	90	100
Count	107	92	93	92	94	110	117	113	81	101



Thus, with the sample size available we can be fairly certain that the d10 (0) die is fair.

Putting the data from all the dice into the chi-square test formula gives the resulting values in the table below.

4 Sided Die	$X^2 = 2.1$	p = .494	Fair
6 Sided Die	$X^2 = 3.4$	p = .639	Fair
8 Sided Die	$X^2 = 12.6$	p = .082	Fair
10 Sided Die	$X^2 = 4.6$	p = .868	Fair
10 Sided Die (0)	$X^2 = 26.6$	p = .001	Unfair
12 Sided Die	$X^2 = 9.8$	p = .548	Fair
20 Sided Die	$X^2 = 32.6$	p = .027	Unfair
Class 10 Sided Die (0)	$X^2=11.82$	p = .224	Fair

Discussion:

In the summary table, the important number to look at is the p-value. The p-value represents the chance that a data set could be as extreme or more extreme than the data set given. Any data set with a p-value less than or equal to .05 is statistically significant enough for us to reject our null hypothesis. Thus, we reject the null hypothesis and are 95% confident that the 10 Sided Die (0) and the 20 Sided Die are unfair. On the contrary, for all other dice, we fail to reject the null hypothesis, and thus there is not enough evidence to prove that those dice are unfair. A possible source of error in our experiment could be from the way we rolled the dice. Some rolls may not have been rolled with the right side facing up, possibly interfering with each roll's independence.

Conclusion and Recommendation:

After collecting the results from the chi-square test, our group has determined that the set of blue *Black Death* dice is overall fair. We failed to reject the null hypothesis for most of the dice with p-values that fell into the appropriate range. We can recommend Black Oak Workshop to ship out those dice. For the two dice that we determined to be unfair, with our smaller sample sizes, it may have been an extreme case that the dice were unfair. We recommend that further testing be done to ensure the fairness of those two dice.