Baseball Simulation

The goal of this activity is to use the computer program Excel to simulate a baseball player’s distribution of hits.

During the 2007 season, Matt Holliday’s hitting average was .340. As the third hitter in the lineup, Holliday typically has four at bats in a game. Assume that each time Holliday bats, his chance of getting a hit is .340 and that each at bat is an independent event. Simulate an entire 162 game season to determine the distribution of the number of hits Holliday gets each game.

1. In cells A1 to E1, enter the column titles 1, 2, 3, 4, and Total.

2. Enter Holliday’s batting average in cell F1.

3. To simulate whether Holliday gets a hit or not in his first at bat in game 1, enter the following formula in cell A2.

   \[ \text{IF}(\text{RAND()}<$F$1,1,0) \]

4. Highlight cell A2 and select Copy (in the Edit menu). Then highlight cells B2, C2, and D2 and select paste (in the Edit menu) to copy and paste the formula to simulate the rest of his at bats in game 1.

5. To count the number of hits Holliday had in game 1, enter the following formula in cell E2;

   \[ \text{COUNTIF}(A2:D2,1) \]

6. Highlight cells A2 – E2 and copy and paste the cells in rows 3 through 163 to simulate the remaining 161 games of the season.

7. To create a probability distribution, first enter the table headers “x” in cell G1 and “P(x)” in cell H1.

8. In the “x” column (cells G2 – G6) enter the possible number of hits Holliday can hit in a game: 0, 1, 2, 3, and 4

9. To determine the probability of getting zero hits per game in the season, enter the following formula in cell H2.

   \[ \text{COUNTIF}($E$2:$E$163,G2)/162 \]


11. Save the file as \textit{Holliday}.

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The baseball situation in the simulation is a binomial experiment. Use Holliday’s batting average as the probability of success for the following items.

12. Determine the probability that Holliday will get four hits in a game when he bats four times.

13. Determine the probability that Holliday will get no hits in a game when he bats four times.

14. Determine the probability that Holliday will get a hit in his first at bat and none for the rest of the game. Determine the number of ways Holliday can get one hit when he bats four times in a game. Determine the probability that Holliday will get one hit in a game when he bats four times.

15. Determine the probability that Holliday will get two hits in a game when he bats four times.

16. Determine the probability that Holliday will get three hits in a game when he bats four times.
Binomial Probability Distribution

The goal of this activity is to understand how to use a formula, a table, and a calculator to determine the probability of a binomial experiment.

### Binomial Probability Distribution Function

The probability of obtaining \(x\) successes in \(n\) independent trials of a binomial experiment, where the probability of success is \(p\), is given by

\[
P(x) = \binom{n}{x} p^x (1 - p)^{n-x}, \quad x = 0, 1, 2, \ldots, n
\]

Example: Determine the probability of obtaining 2 successes in 4 independent trials of a binomial experiment with probability of success 0.35.

#### Using the Formula

Calculate \(P(2)\) with \(n = 4\).

#### Using Table II

Most statistics books include a table of binomial probabilities, such as Table II in the Appendix (pages A-2 to A-4). Look down the \(n\) column to find 4 and then down the \(x\) column to find its corresponding 2. Scan across that row until you reach the column for the probability \(p\) of 0.35.

In a binomial experiment with \(n = 4\) and \(x = 2\), \(P(2) = \underline{\phantom{0.000}}\)

| \(n\) | 0.00 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 0    | 0.960 | 0.914 | 0.868 | 0.823 | 0.780 | 0.740 | 0.703 | 0.670 | 0.640 | 0.613 | 0.589 | 0.567 | 0.547 | 0.529 | 0.513 | 0.499 | 0.486 | 0.474 | 0.463 |
| 1    | 0.039 | 0.086 | 0.138 | 0.191 | 0.249 | 0.312 | 0.379 | 0.451 | 0.527 | 0.607 | 0.701 | 0.798 | 0.898 | 0.998 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 2    | 0.960 | 0.914 | 0.868 | 0.823 | 0.780 | 0.740 | 0.703 | 0.670 | 0.640 | 0.613 | 0.589 | 0.567 | 0.547 | 0.529 | 0.513 | 0.499 | 0.486 | 0.474 | 0.463 |

| \(n\) | 0.00 | 0.05 | 0.10 | 0.15 | 0.20 | 0.25 | 0.30 | 0.35 | 0.40 | 0.45 | 0.50 | 0.55 | 0.60 | 0.65 | 0.70 | 0.75 | 0.80 | 0.85 | 0.90 | 0.95 |
|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 3    | 0.990 | 0.986 | 0.981 | 0.976 | 0.972 | 0.968 | 0.964 | 0.960 | 0.957 | 0.954 | 0.951 | 0.948 | 0.945 | 0.942 | 0.940 | 0.937 | 0.934 | 0.932 | 0.930 |
| 4    | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 | 0.990 |

#### Using Technology

The binomial probability distribution function is located in the DISTR menu above the VARS key. The syntax of the function is given below.

\[
\text{binompdf}(n, p, x)
\]

Use the calculator to find the probability.
Characteristics of a Binomial Experiment

The goal of this activity is to understand the mean and standard deviation of the binomial probability distribution.

On your computer, recall the Excel file Holliday.

The following will determine the mean and standard deviation of the baseball simulation.

17. Calculate the values of \( x \cdot P(x) \) in cells I2 – I6.

18. Use these values to calculate the value of the mean of the probability distribution in cell I7.

19. Calculate the values of \( x^2 \cdot P(x) \) in cells J2 – J6.

20. Use these values to calculate the value of the standard deviation of the probability distribution in cell J7.

<table>
<thead>
<tr>
<th>Mean (or Expected Value) and Standard Deviation of a Binomial Random Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>A binomial experiment with ( n ) independent trials and probability of success ( p ) has a mean and standard deviation given by the formulas</td>
</tr>
<tr>
<td>[ \mu_x = n \cdot p \quad \text{and} \quad \sigma_x = \sqrt{n \cdot p \cdot (1 - p)} ]</td>
</tr>
</tbody>
</table>

21. Calculate the mean and standard deviation of the binomial random variable of the number of hits in four at bats for Holliday in cells I8 and J8, respectively.

22. Compare these values with the values found for the simulation.