

Simulation Example: Physical Model versus Fathom Model

The ages of ten hourly workers involved in the second round of layoffs at Westvaco were 25, 33, 35, 38, 48, 55, 55, 55, 56, and 64. The ages of the three workers who were laid off were 55, 55, and 64, with average age 58. Use simulation to estimate the probability that three workers selected at random for layoff would have an average age of 58 or more.

Assumptions

Each of the ten workers has the same chance of being laid off.

Workers to be laid off are selected at random without replacement.

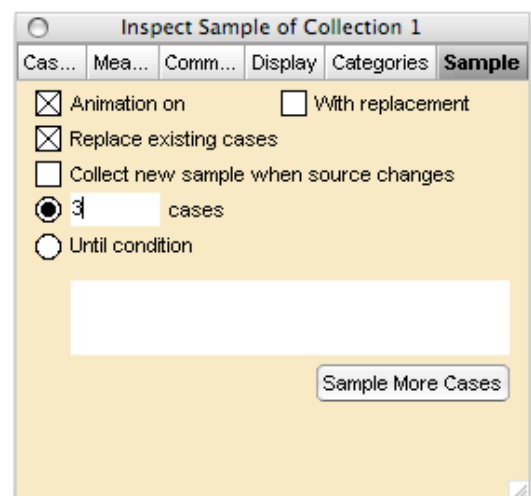
Physical Model

1. Write the ages of the ten workers on ten identical pieces of paper.
2. Mix them and select three pieces of paper without replacement. The selected pieces of paper represent the ages of the workers that are laid off in a single run of the simulation.
3. Find and record the average of the ages of the three workers laid off.
4. Replace the three selected pieces of paper and repeat this process many times.
5. Plot the distribution of average ages for many runs of the simulation.

Fathom Model

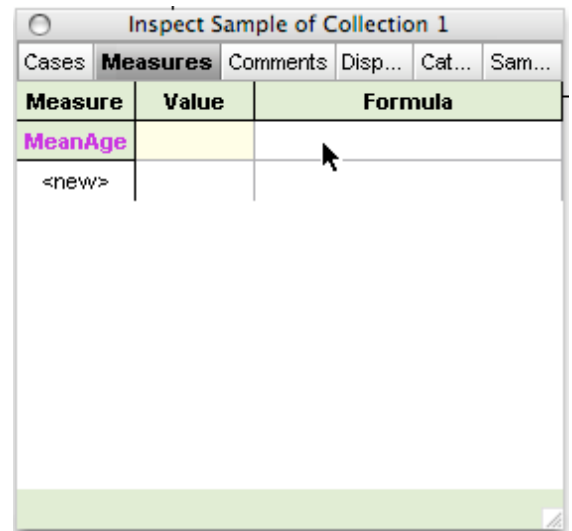
1. Create a collection of the ten workers:
 - Drag down a new case table from the tool shelf.
 - Create an attribute called *Age* and enter the ten ages.
 - Click once on the column title to select it and choose **Table | Use As Caption**.
[This is equivalent to writing the ten ages on the identical pieces of paper.](#)
2. Create a sample of three workers:
 - Select the collection box (not the case table) and choose **Collection | Sample Cases**. A new collection box with blue balls appears called **Sample of Collection 1**
 - In the open sample inspector (shown at right), deselect “With replacement” so that a worker can only be selected once. Change the number of cases to 3 and click **Sample More Cases**.
 - Select the **Sample of Collection 1** box so it has a blue frame. Grab the lower right-hand corner of the frame and expand the window to see the three workers that were laid off. The **Use As Caption** command in the last step results in the icons being labeled by the ages.

[This is equivalent to selecting three pieces of paper for one run of the simulation.](#)

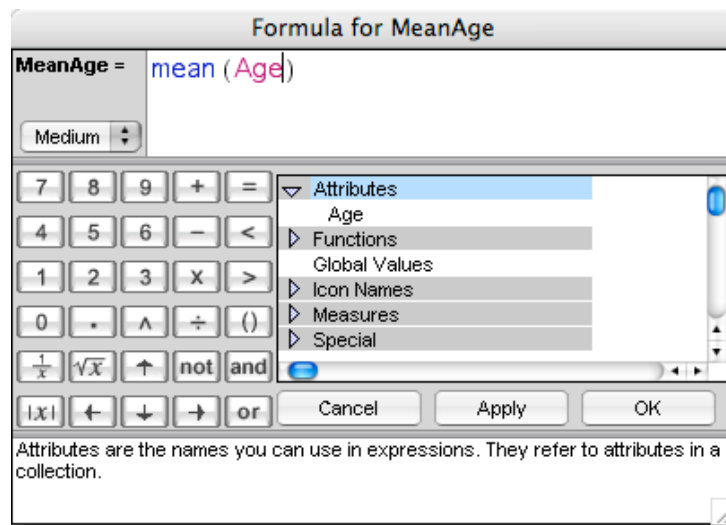


3. Create a measure of the sample that is the average of the three ages:

- The inspector for the **Sample of Collection 1** should still be open. Otherwise, double-click somewhere inside the **Sample of Collection 1** window near the blue icons.
- Click on the **Measures** tab.
- Click where it says <new> and type in the measure **MeanAge**. Then double-click inside the Formula cell, as shown at right.
- In the **Formula Editor** that opens, type in the formula **mean(Age)**, as shown below. Note that the colors change as Fathom recognizes a command or attribute. Click **OK**.



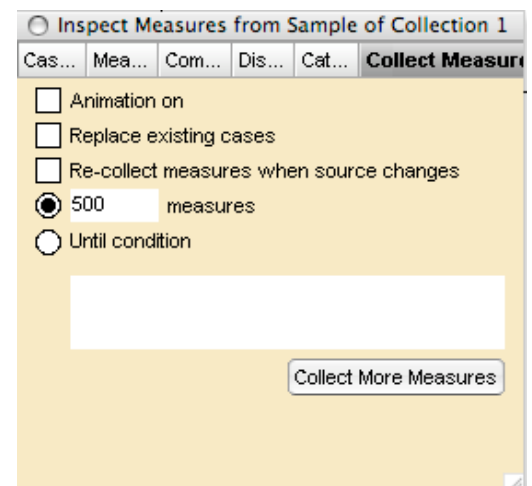
This is equivalent to finding and recording the average of the three numbers that were selected.



4. Create a new collection of measures from the sample:

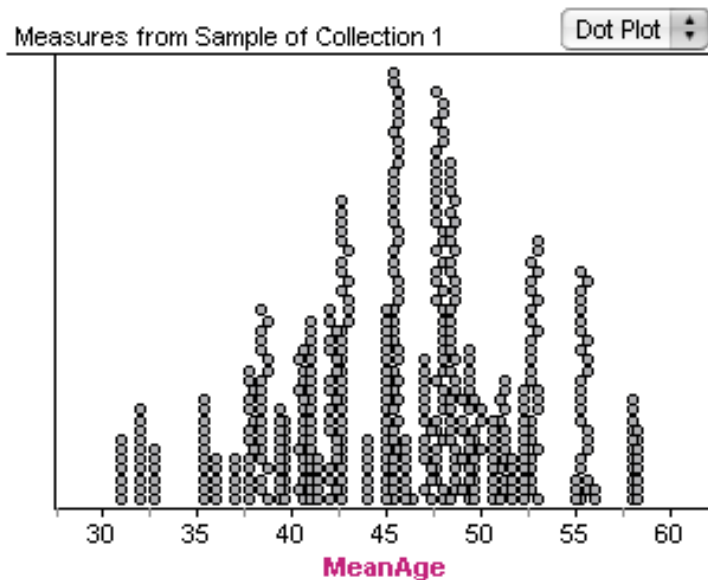
- Select the **Sample of Collection 1** box and choose **Collection | Collect Measures**.
- A new collection box with green balls appears called **Measures from Sample of Collection 1**.
- Deselect “Animation on” and change the number of measures to a much larger number, as shown at right, and then click **Collect More Measures**.
- The samples are represented by green balls in the collection box.

This is equivalent to repeating the process of selecting three pieces of paper many times.

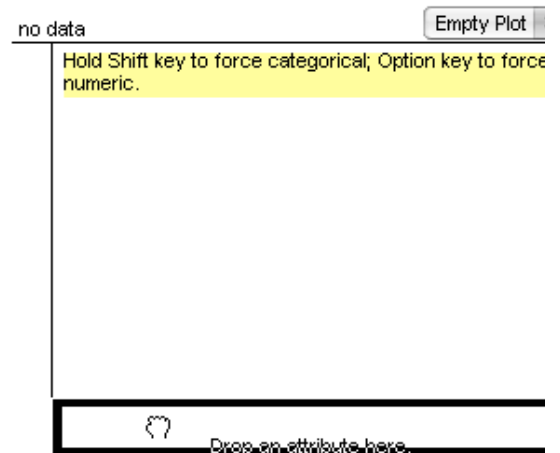


5. Create a dot plot of the collection of measures:

- Drag down a new graph from the tool shelf.
- Click on the **Cases** tab in the inspector of the collection of measures. Click and hold on the attribute name *MeanAge* in the inspector and drag it to the horizontal axis on the graph, as shown at right.
- The resulting dot plot will be similar to the one shown directly below.
- To see the probability that the average age of a simulation is 58 or more, drag a new summary table from the tool shelf.
- Drag *MeanAge* from the graph to the row title cell in the table. Double-click the formula and change it to `proportion(MeanAge ≥ 58)`, as shown at bottom-right. To access the \geq symbol, hold down Ctrl (Windows) or Option (Mac).



Inspect Measures from Sample of Collection 1		
Cases	Measures	Comments
Attribute	Value	Formula
MeanAge	39.6667	
<new>		



This is equivalent to plotting the distribution of average ages for many runs of the physical simulation.

Conclusion

Based on 500 runs of the simulation, the estimated probability of getting an average age of 58 years or more if you pick three workers at random is 3.8%. This probability is fairly small, so it is unlikely that the process Westvaco used for layoffs in this round was equivalent to picking the three workers at random.

Measures from Sample of Collection 1	
MeanAge	0.038
S1 = <code>proportion(meanAge ≥ 58)</code>	