Using Simulation to Present Complex Topics

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Introduction: Why Simulate?

Why Simulate?

Common Questions:

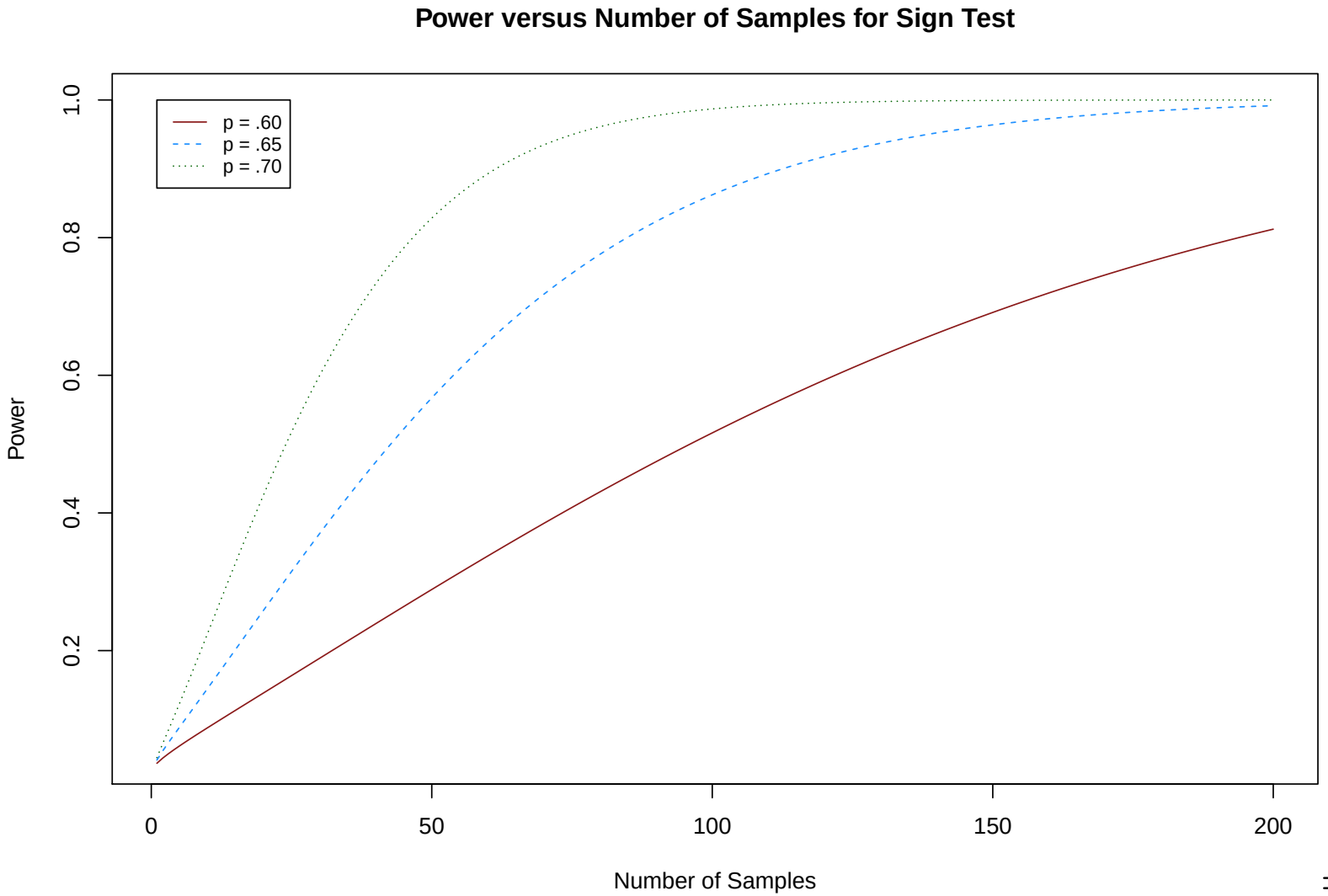
- Is it worthwhile to teach programming?
- Wouldn't writing a simulation be hard?
- Why not just use theorems and proofs and other such nonsense?

Why We Love Math

The Big Questions

- Why do we love math?
- What drives students to love math?
- How can we utilize this information to enhance student's learning?

Why We Love Math: GRAPHS



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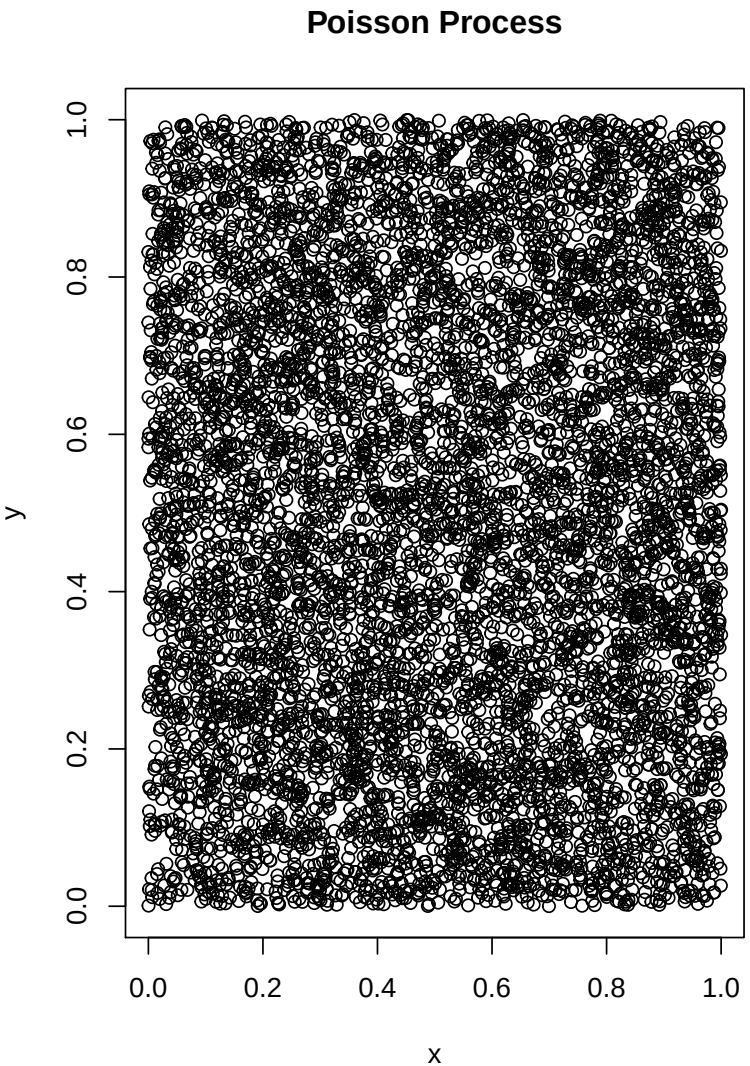
Why We Love Math: FUNctions and Equations!

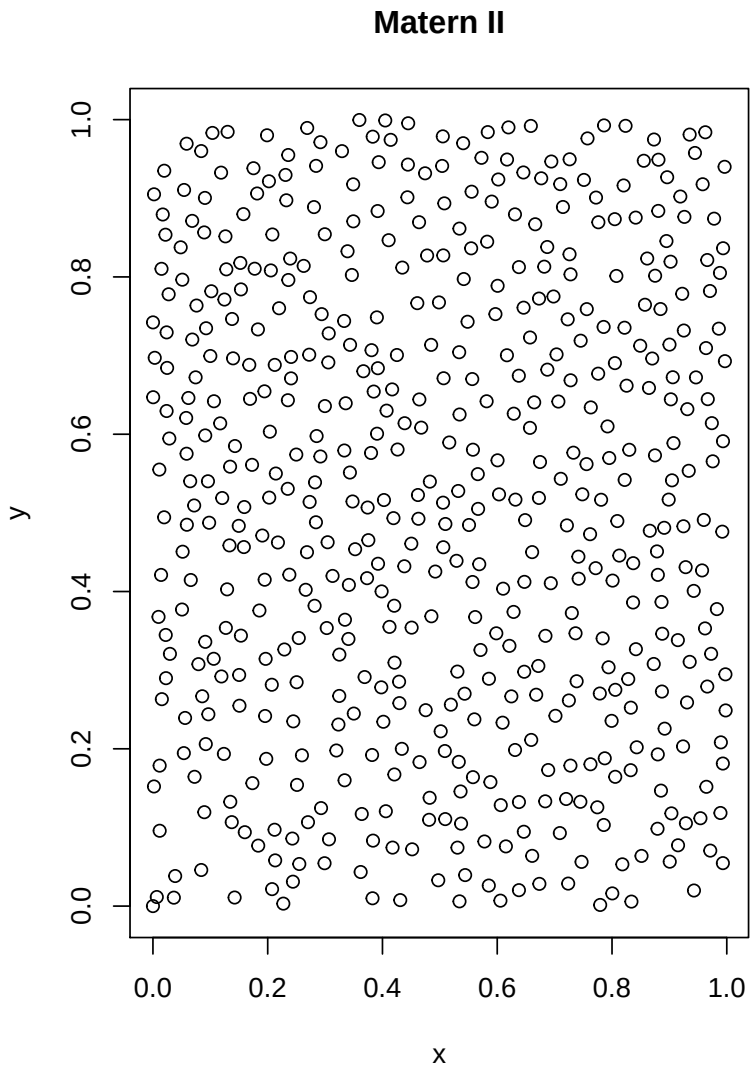
Senior Research Project

Assignment: Find the probability that a percolating cluster appears in Mat'ern II Point Process distributed Poisson(λ)

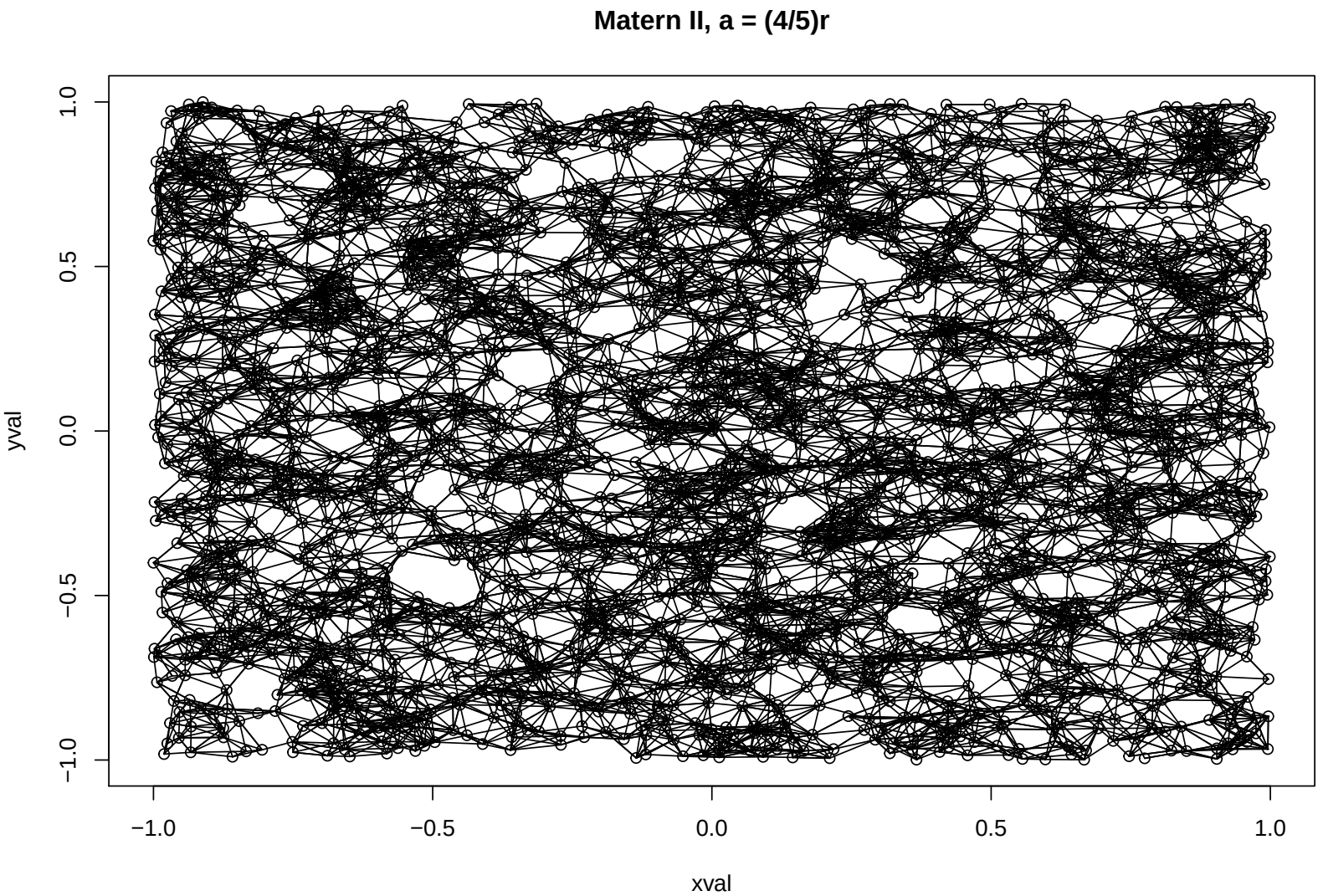
- What does it mean?
- How do I solve this?
- What's a Mat'ern?
- What's a percolating cluster?

Senior Research Project

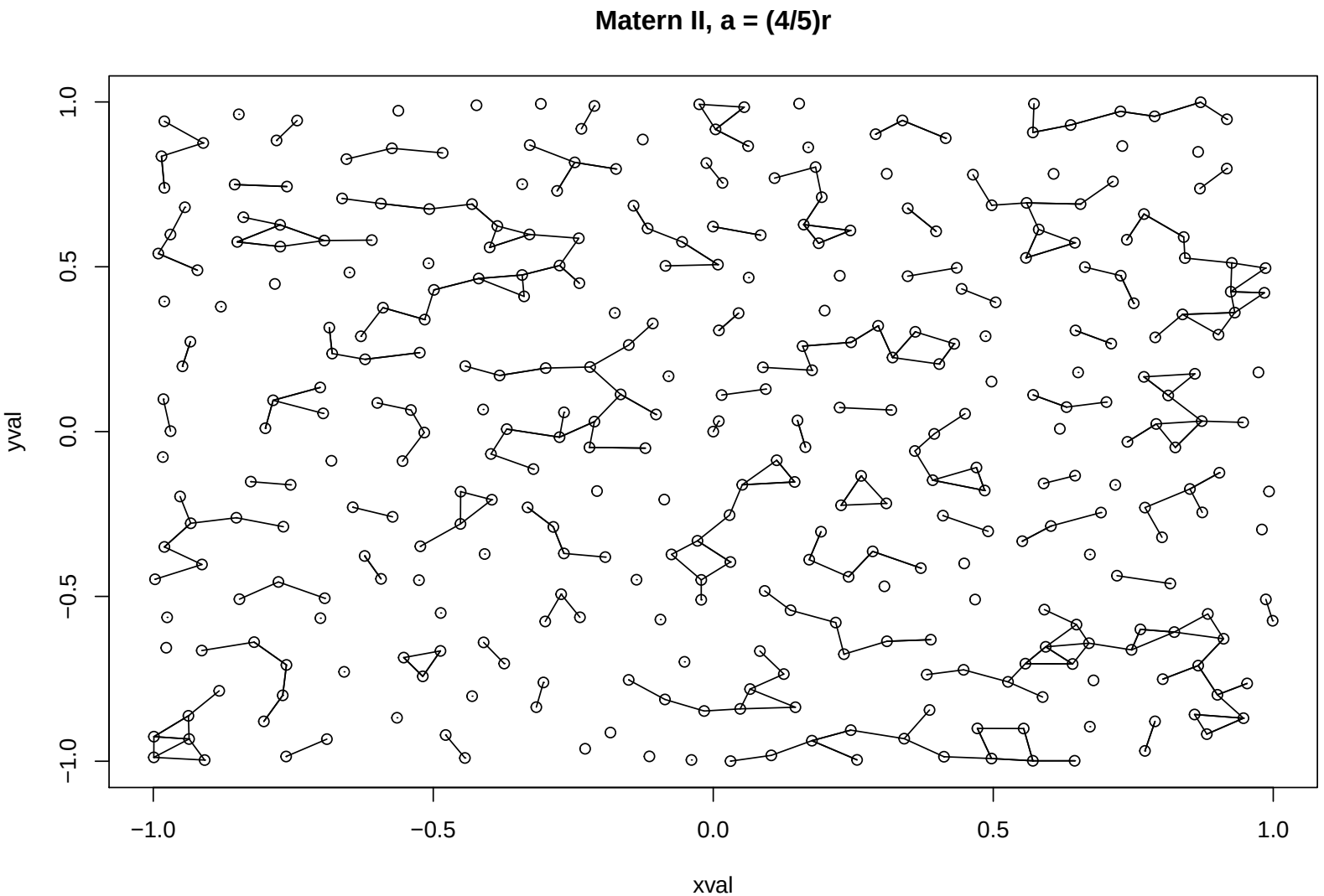




Senior Research Project



Senior Research Project



The "Traditional" Statistics Course

- Measures of Center
- Sampling
- Regression
- Hypothesis Testing

More Intense Problems

- Non-Normal Distributions
  - Poisson
  - Binomial
  - Exponential
- Central Limit Theorem

The "Traditional" Statistics Course

Measures of Center

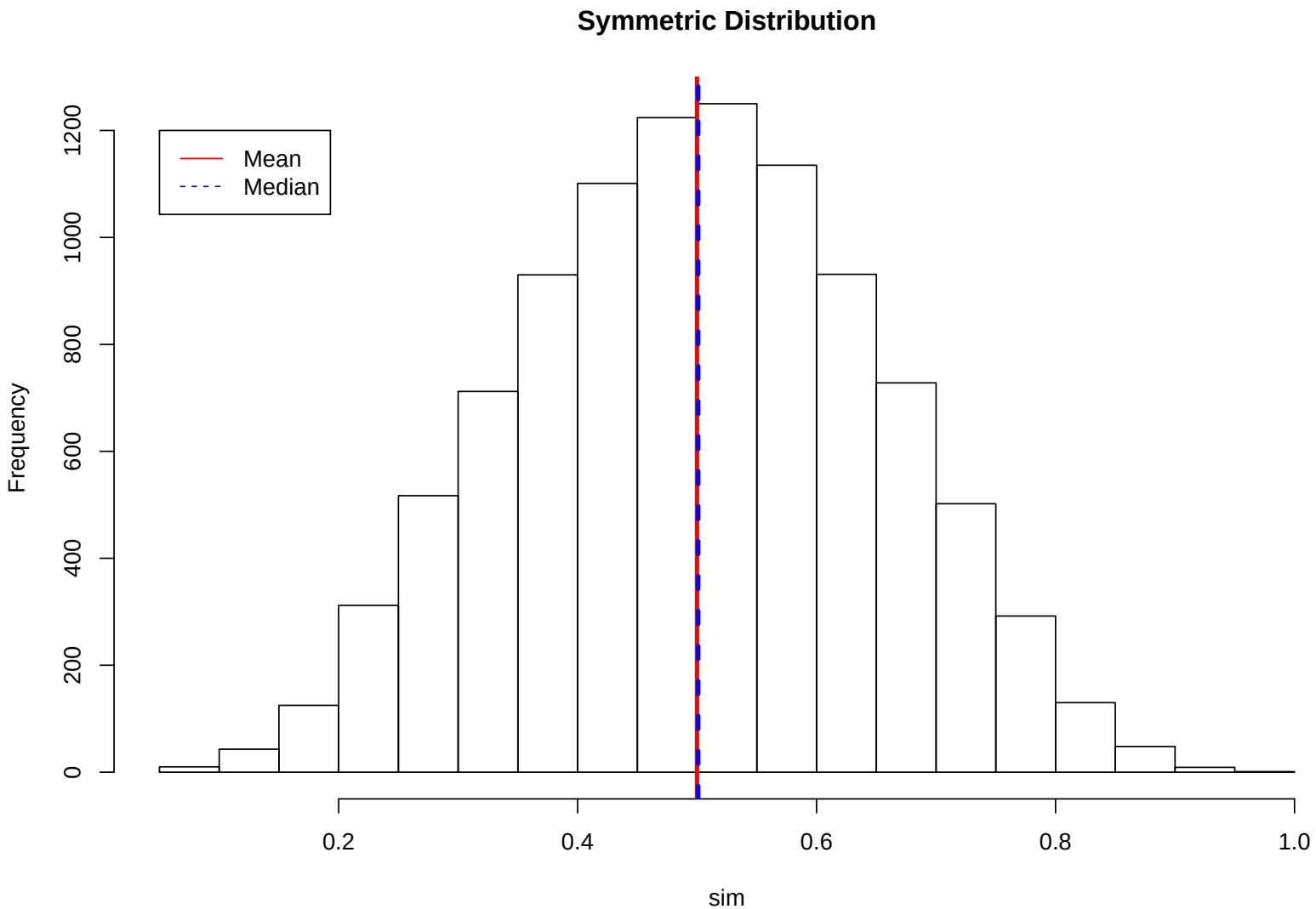
- Measures of center usually taught in respect to a symmetric distibution, left skewed distribution, and a right skewed distribution.
- How can we improve this information through simulation?
- More specifically, how can we show this without having data on hand?

Measures of Center on a Symmetric Distribution

The Simulation

```
sim <- rbeta(10000,5,5)
hist(sim, main = "Symmetric Distribution")
abline(v = mean(sim), col = "red", lwd = 3)
abline(v = median(sim), col = "blue", lwd = 3, lty = 2)
legend(0.05, 1200, c("Mean","Median"), col = c("red", "blue
```

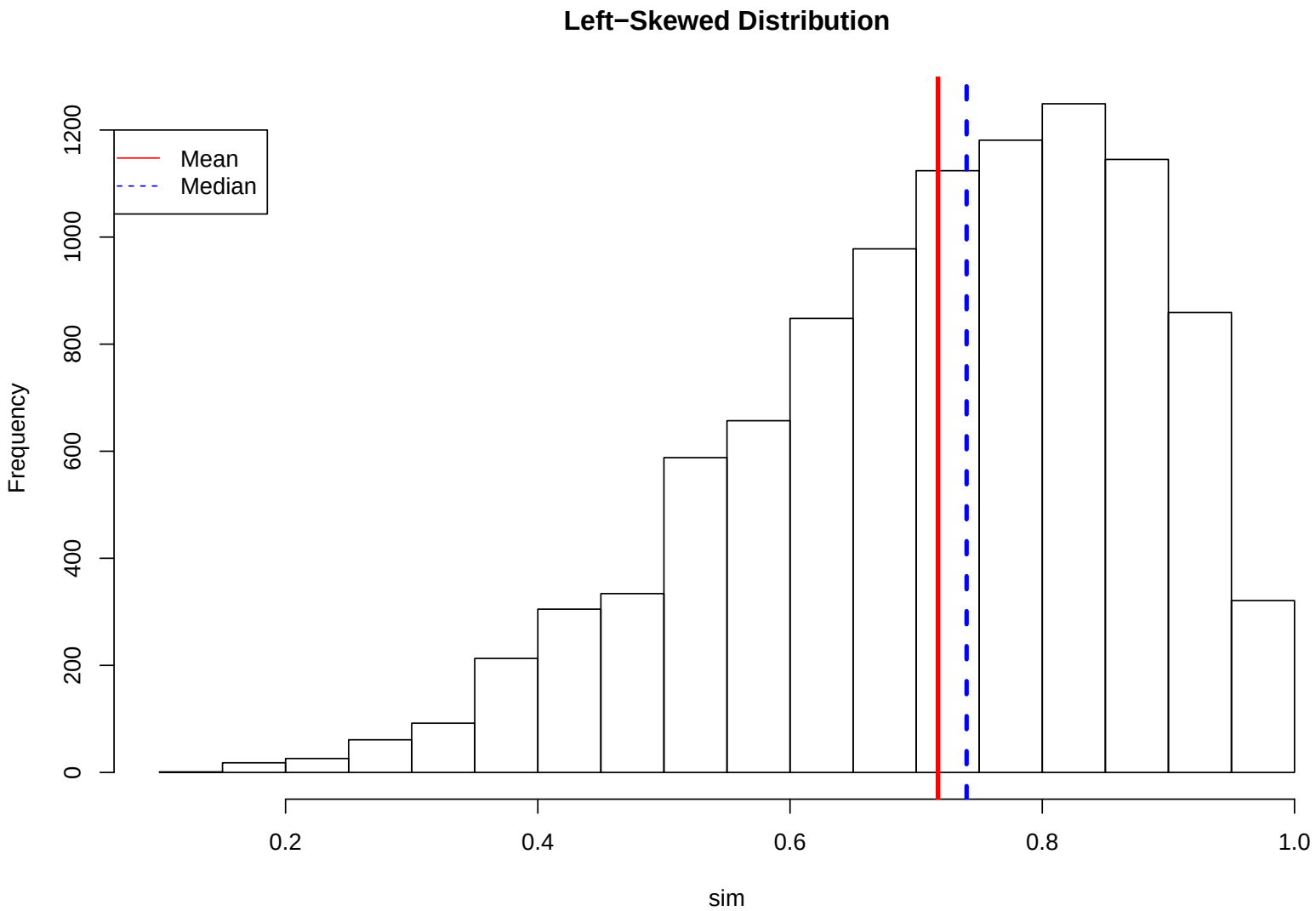
Measures of Center on a Symmetric Distribution



Measures of Center on a Left-Skewed Distribution

```
sim <- rbeta(10000,5,2)
hist(sim, main = "Left-Skewed Distribution")
abline(v = mean(sim), col = "red", lwd = 3)
abline(v = median(sim), col = "blue", lwd = 3, lty = 2)
legend(0.05, 1200, c("Mean","Median"), col = c("red", "blue
```

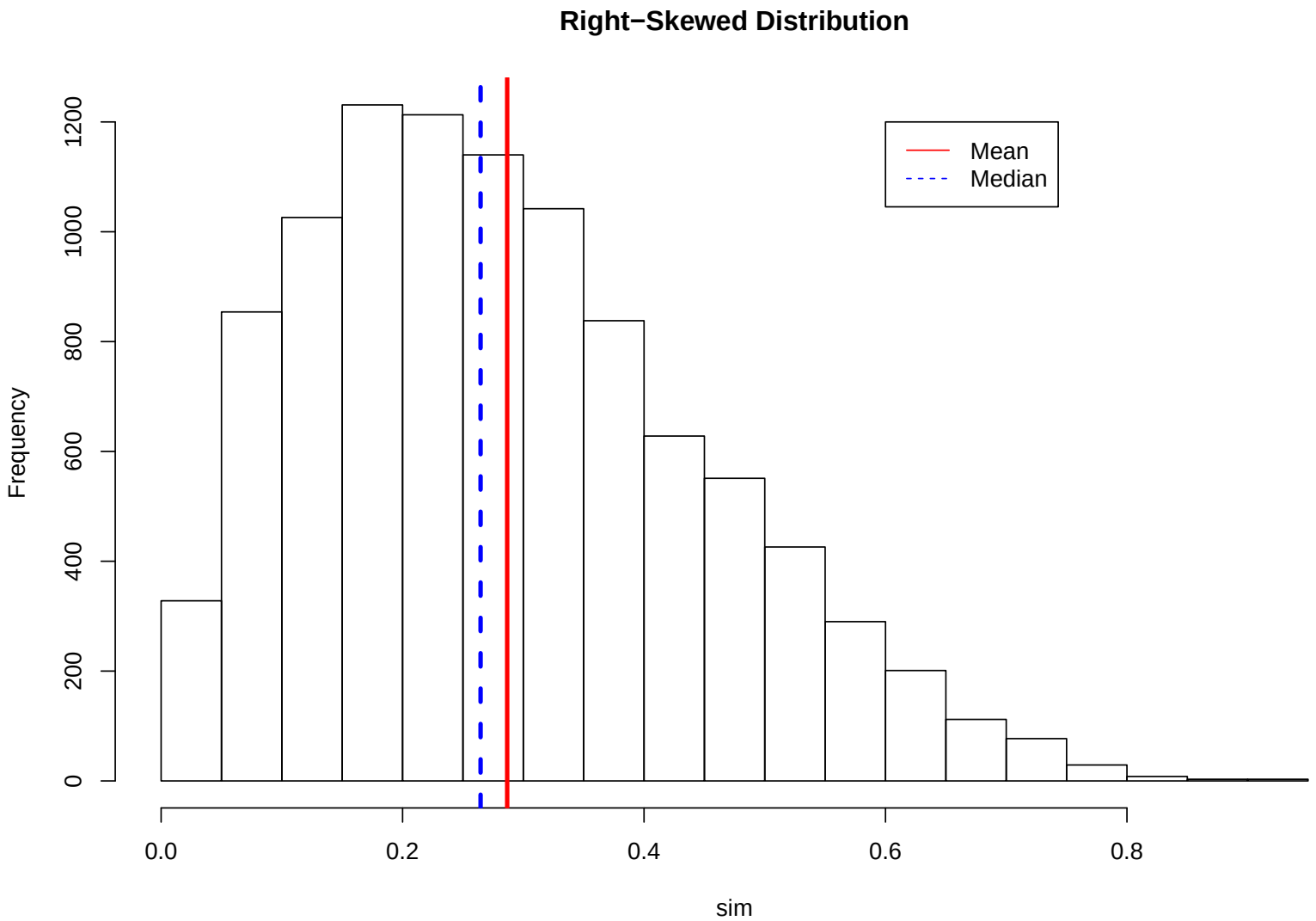
Measures of Center on a Left-Skewed Distribution



Measures of Center on a Right-Skewed Distribution

```
sim <- rbeta(10000,2,5)
hist(sim, main = "Right-Skewed Distribution")
abline(v = mean(sim), col = "red", lwd = 3)
abline(v = median(sim), col = "blue", lwd = 3, lty = 2)
legend(0.05, 1200, c("Mean","Median"), col = c("red", "blue
```

Measures of Center on a Right-Skewed Distribution



Sampling in R

The true bueaty of simulation lies in sampling (which is the core of most statistics).

- R can simulate from any notable distribution (and some non-notable!)
- R can then randomly sample from any of these distributions
- We can show elements of sampling empiracally to students through these two easily understandable parts of R

Sampling Examples

```
sim <- rnorm(10000)
cat("Mean of Simulation is:", mean(sim), "\n")
```

```
## Mean of Simulation is: 0.006586892
```

```
sim_sample <- sample(sim, 1000)
cat("Mean of Sim Sample is:", mean(sim_sample), "\n")
```

```
## Mean of Sim Sample is: -0.008006949
```

```
cat("Difference between Sample and Pop Mean:",
  abs(mean(sim) - mean(sim_sample)),"\n")
```

```
## Difference between Sample and Pop Mean: 0.01459384
```

Elevating the Statistics Course

Conclusion

Conclusion

Acknowledgements