Comparison of Learning Outcomes from Traditional and Randomization-Based Inference Curricula in a Designed Experiment

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Dennis Lock, Miami Dolphins

Outline

- Comparing Inference Curricula
- Experimental Design
- Data Collection
- Model
- Results
- Conclusions

Comparing Inference Curricula

- Traditional Approach
  - Central Limit Theorem
  - Normal Based Inference
  - Normal Tables and Formulas
- Randomization-Based Approach
  - Bootstrap Confidence Intervals
  - Randomization/Permutation Tests
  - Tactile and Computer Simulation

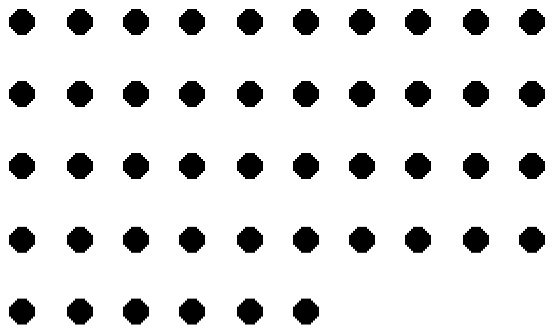
Comparing Inference Curricula

Week	Traditional Curriculum	Randomization-Based Curriculum
1	Introduction	Introduction
2	One Variable Descriptive	One Variable Descriptive
3	Two variable Descriptive	Two variable Descriptive
4	Linear Regression	Linear Regression
5	Experimental Design	Experimental Design
6	Probability	Probability
7	Binomial Distribution	Binomial Distribution
8	Midterm Exam	Midterm Exam
9	**Normal Distribution**	**Sampling Distributions**
10	**Sampling Distributions**	**Bootstrap Confidence Intervals**
11	**Central Limit Theorem (CLT)**	**Randomization Tests**
12	**Inference for single proportions**	**Normal Distribution and CLT**
13	**Inference for prop. and means**	**Inference for single proportions**
14	**Inference for single means**	**Inference for single means**
15	**Inference for two means**	**Inference for two means**
16	**Final Exam**	**Final Exam**

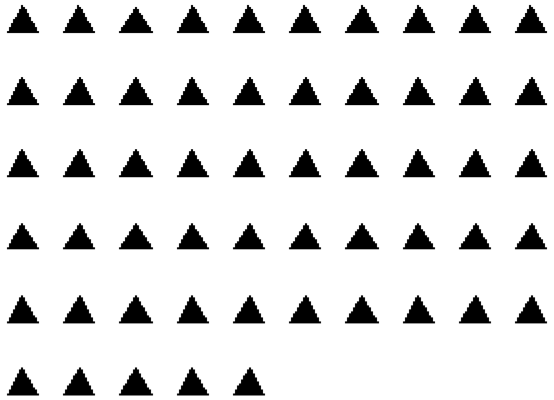
Experimental Design

- 116 Students enrolled into Stat 104
  - 4 Students dropped by week 2
- 112 Students randomly assigned to inference curricula beginning in week 9
  - 11 Students did not consent to data release
  - 101 Students consented to data release
- Experimental Design utilized co-teaching structure and room scheduling isolate curricula effect

46 Consenting Students in Section 1
Lecture TR 8:00-9:00
Lab F *8:00-10:00*



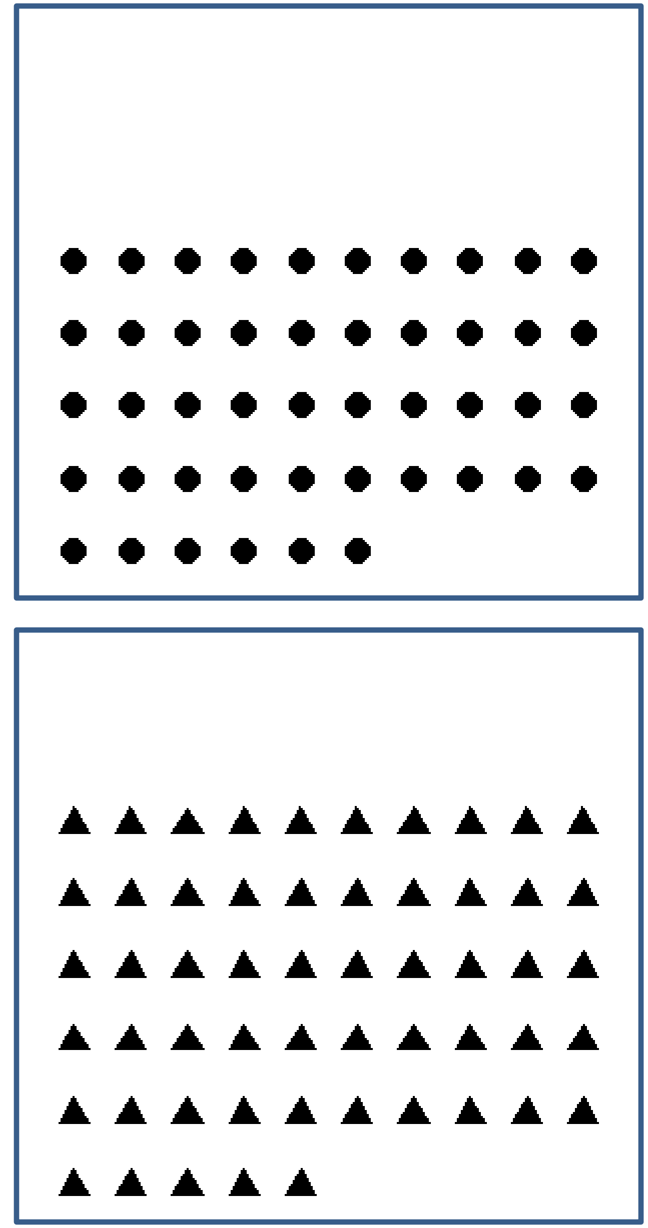
55 Consenting Students in Section 2
Lecture TR 8:00-9:00
Lab F *10:00-12:00*



Co-teaching Structure

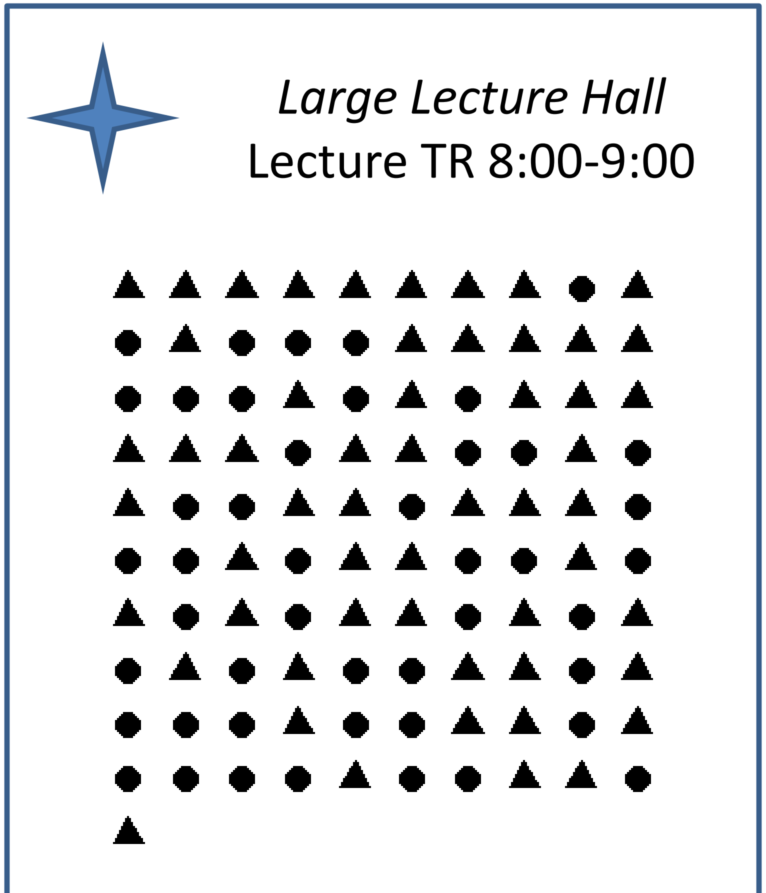
Instructor 1
(Dennis Lock)

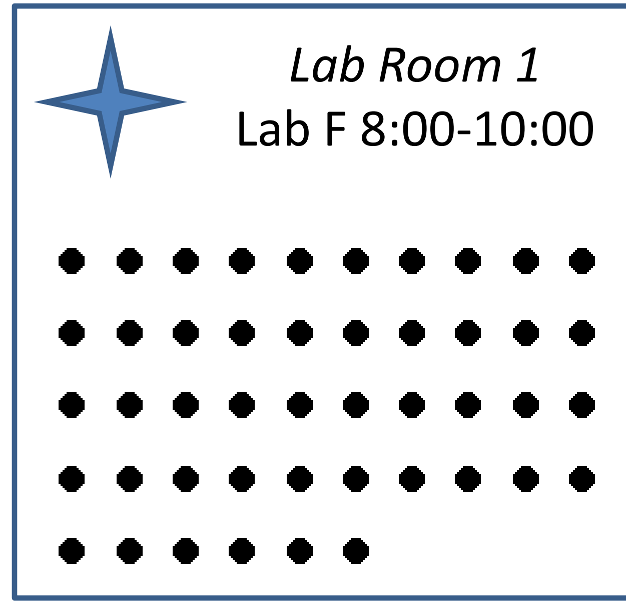
Instructor 2
(Karsten Maurer)

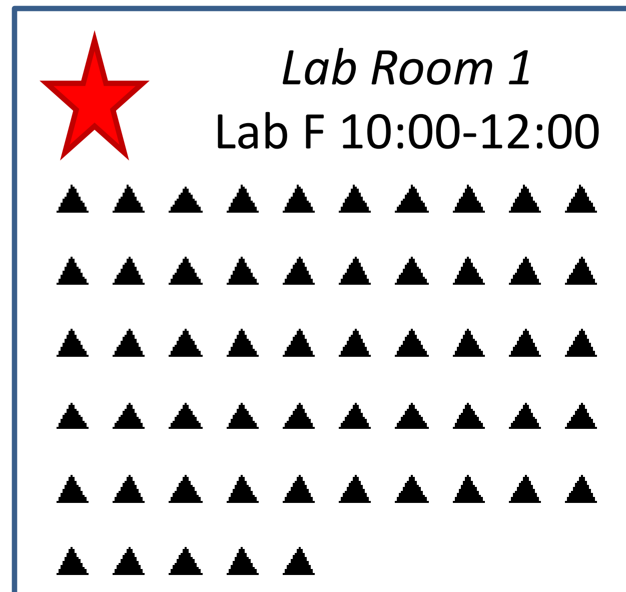


Week 1

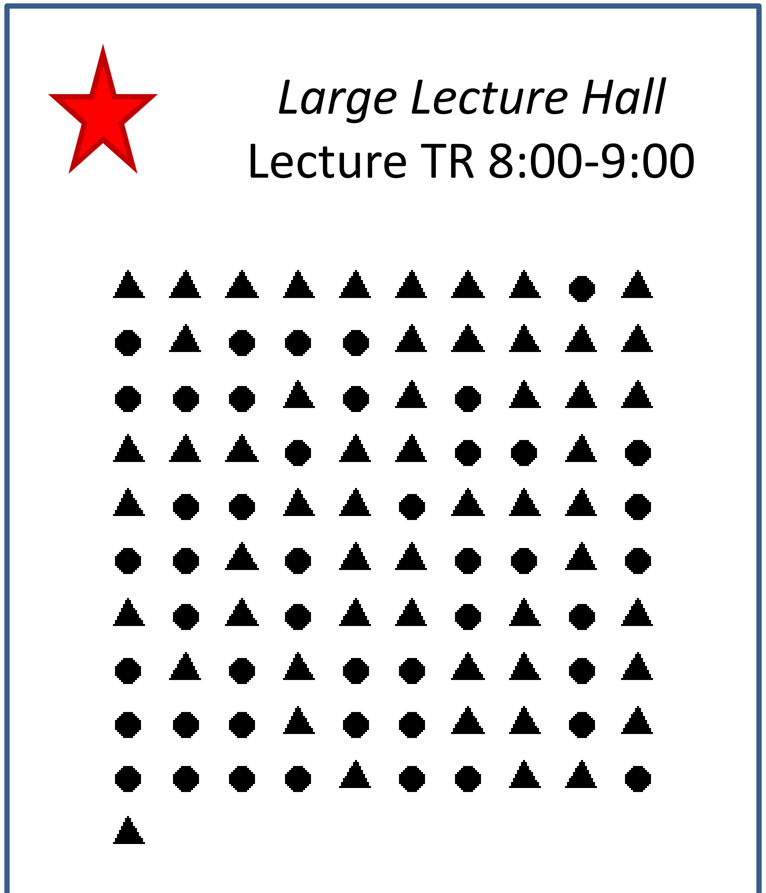
(Non-Inference Topics)

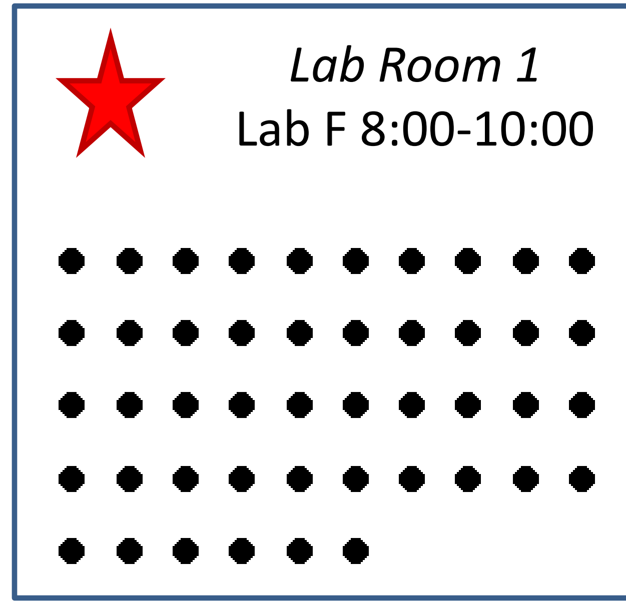


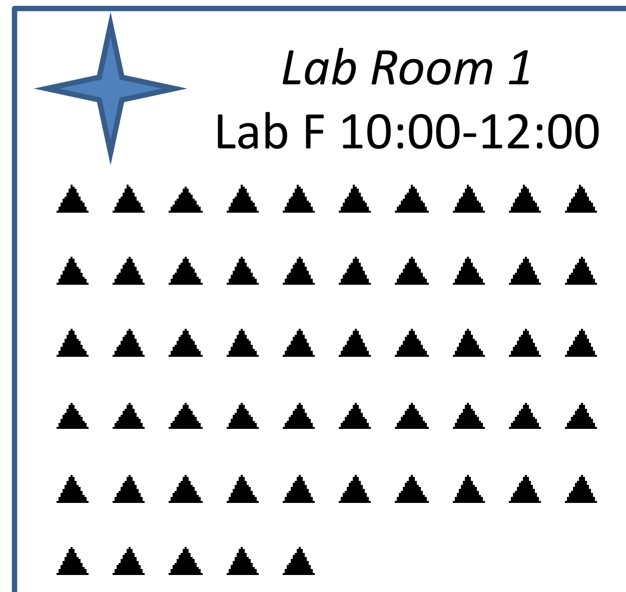




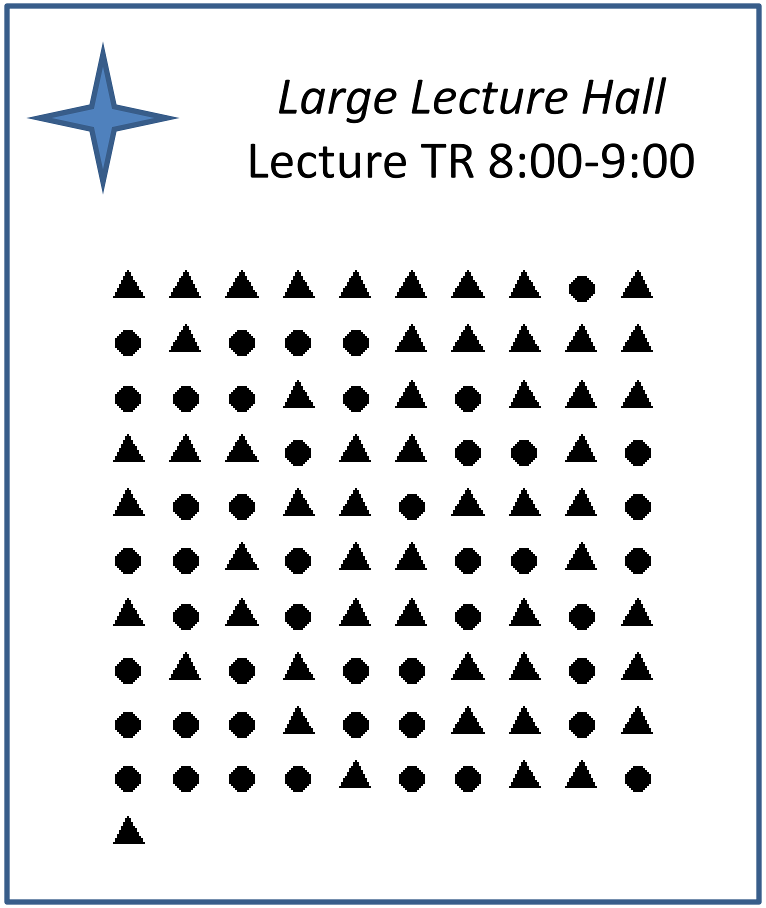
Week 2
(Non-Inference Topics)

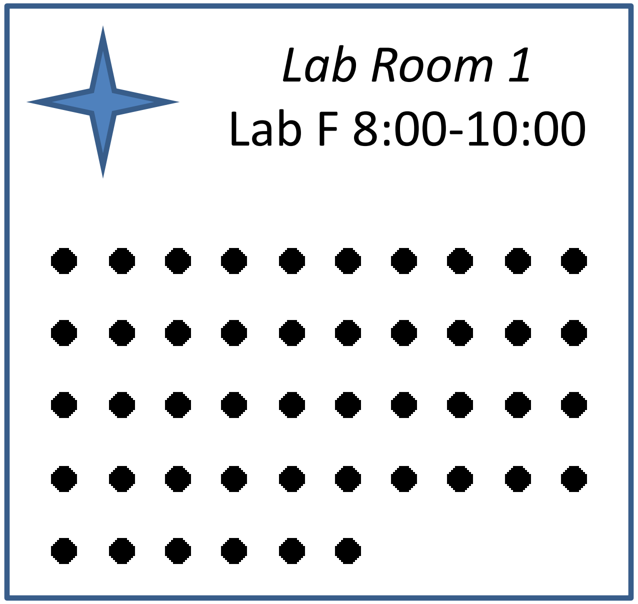


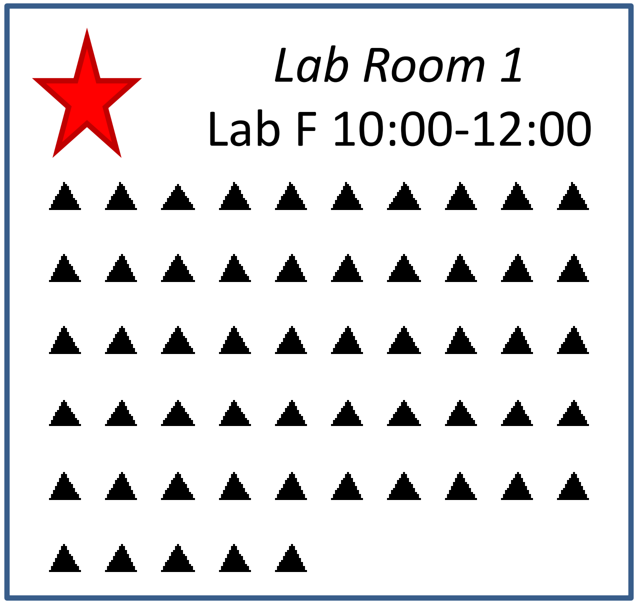




Week 1,3,5,7
(Non-Inference Topics)

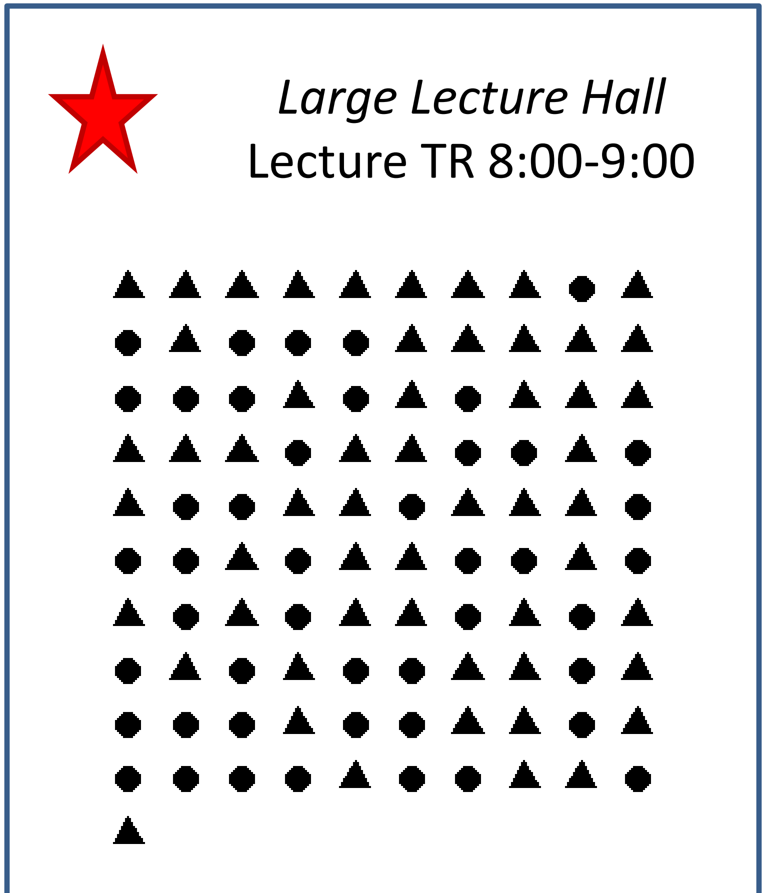


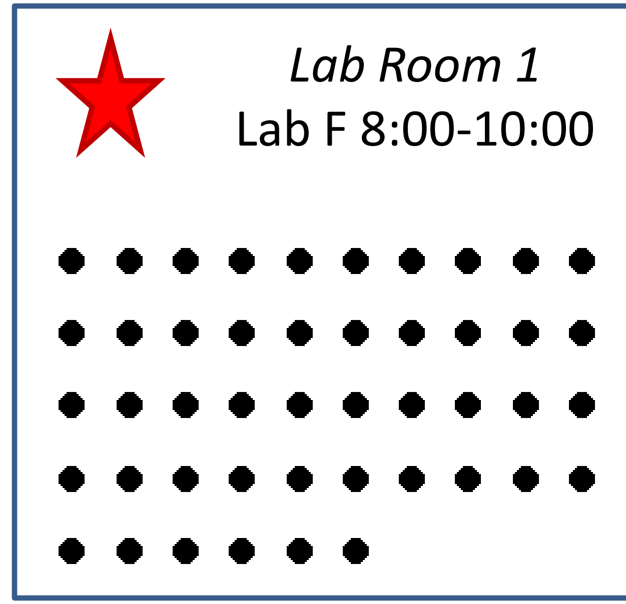


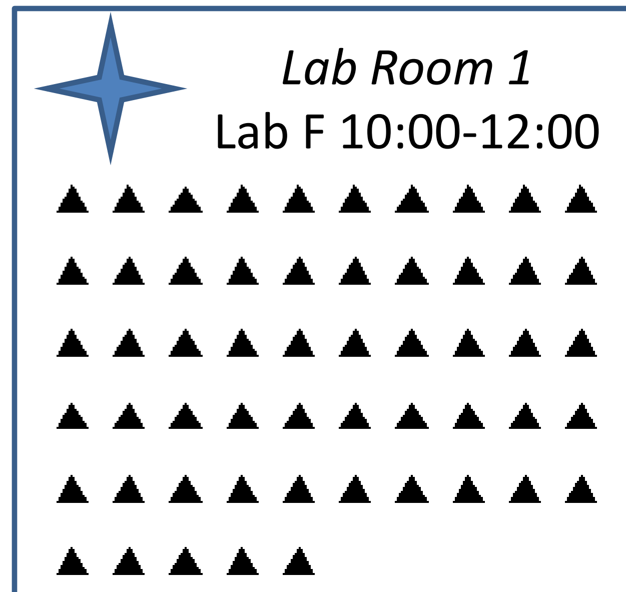


Week 2,4,6,8

(Non-Inference Topics)







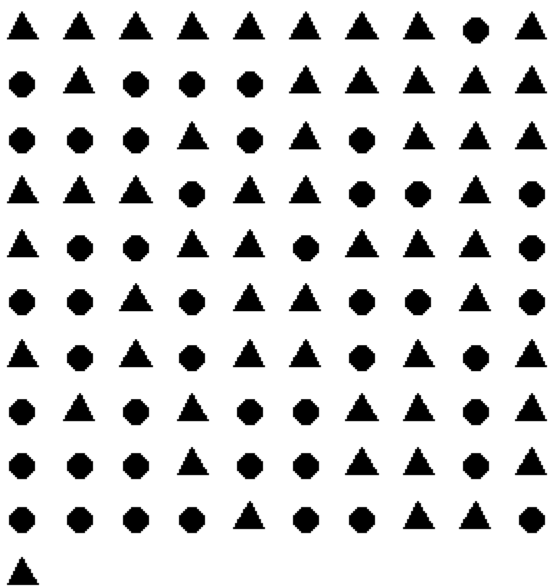
Random Assignment

Students to Inference Curricula

Needed for Weeks 9-16

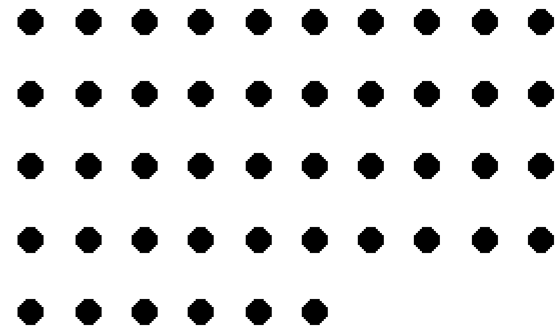
Large Lecture Hall

Lecture TR 8:00-9:00



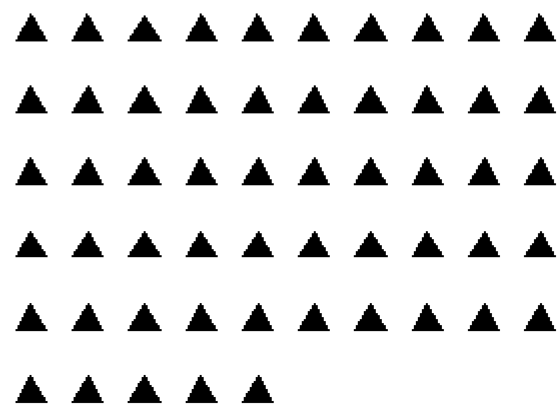
Lab Room 1

Lab F 8:00-10:00



Lab Room 1

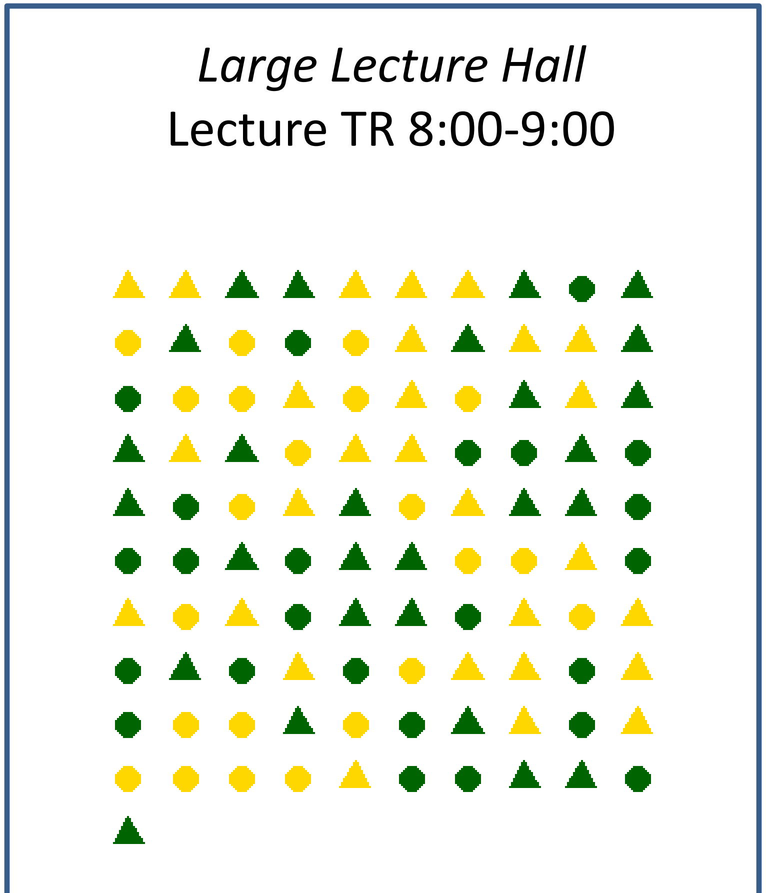
Lab F 10:00-12:00

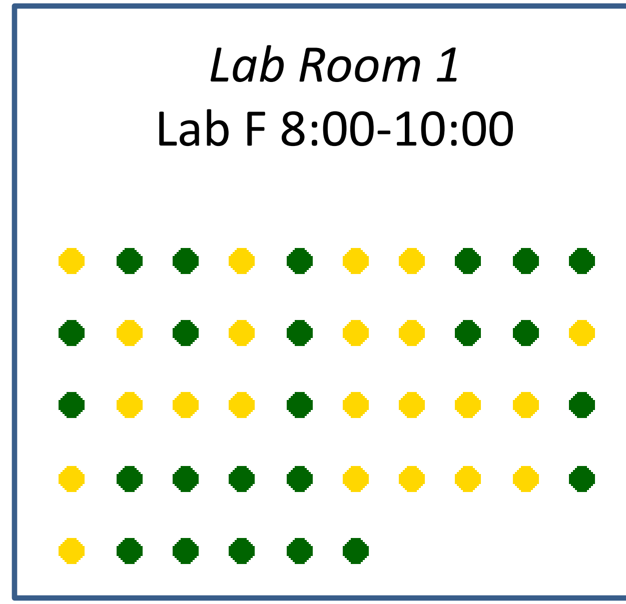


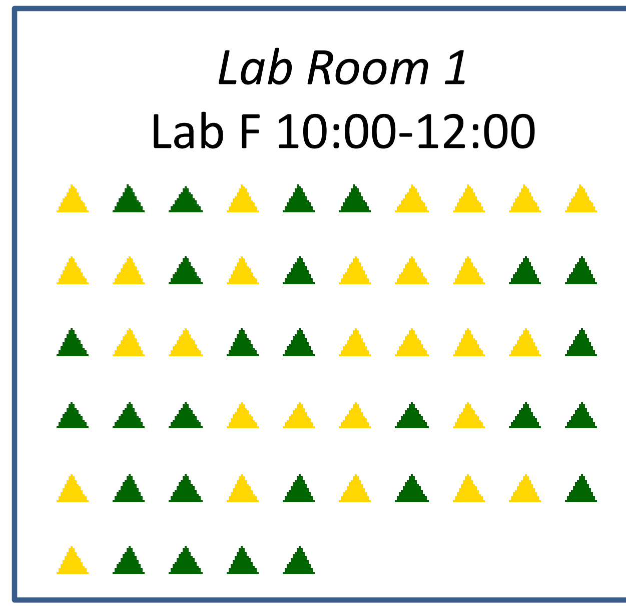
Random Assignment

Green = Traditional

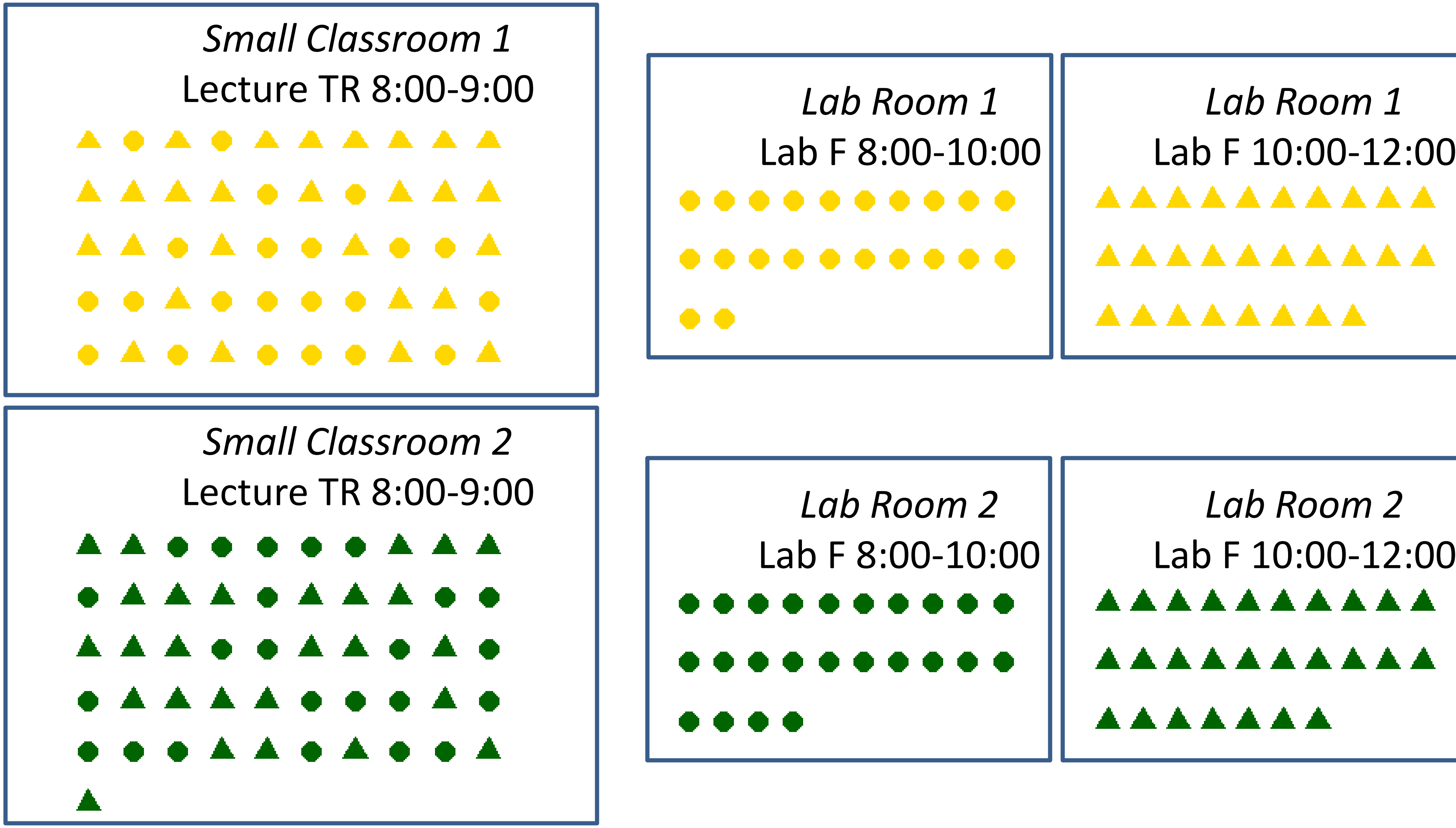
Yellow = Randomization-Based



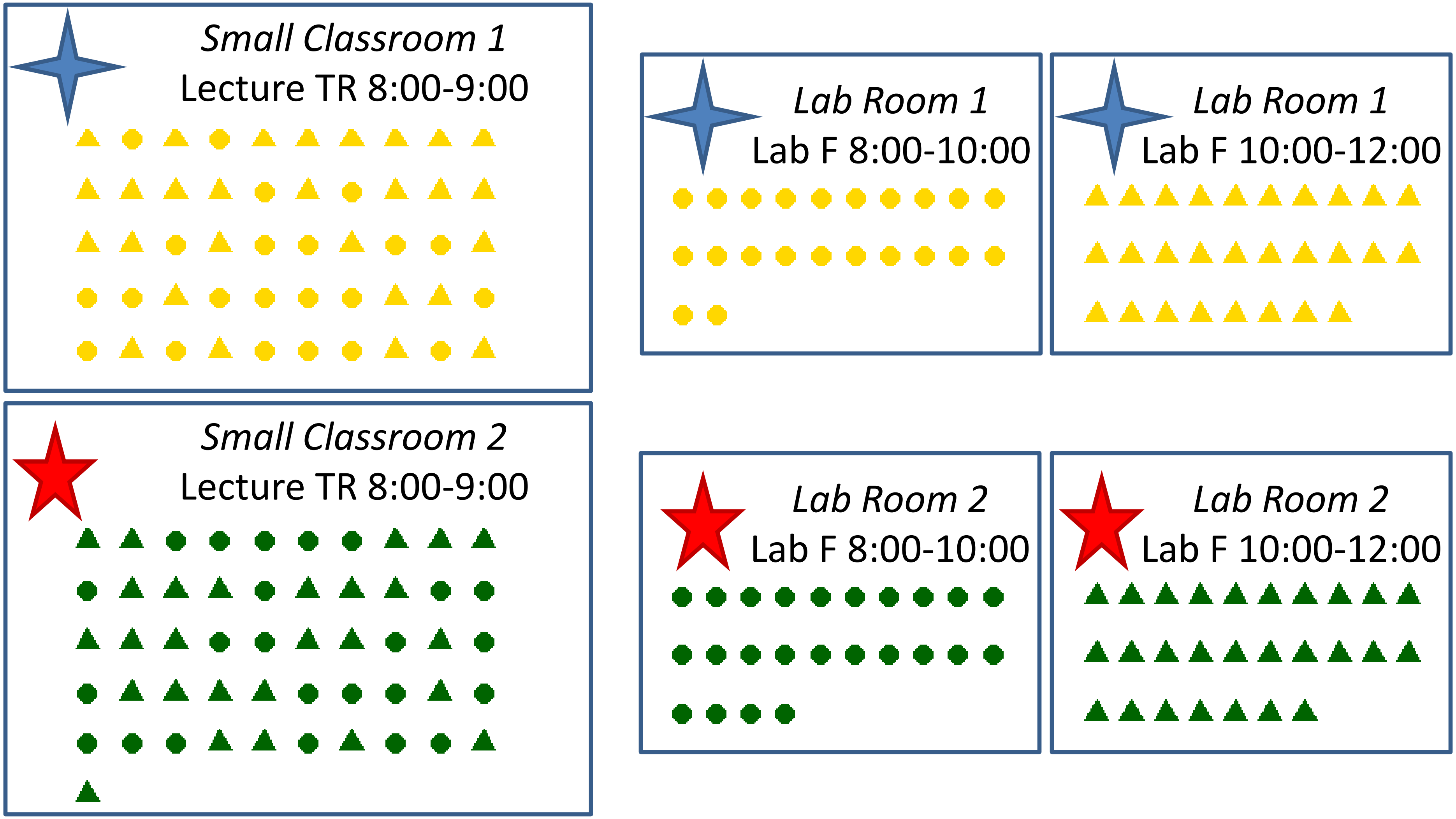




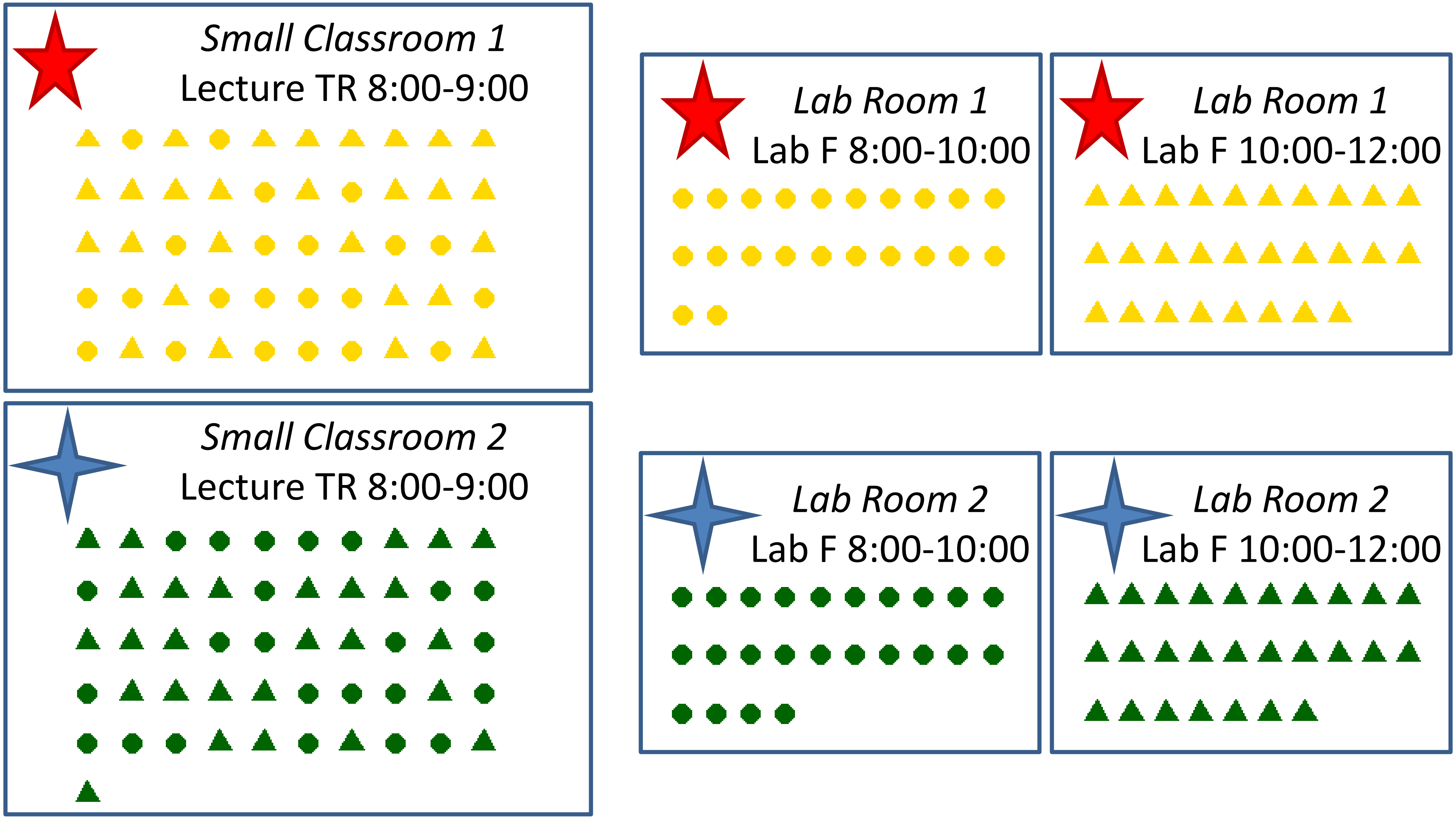
Split to New Rooms



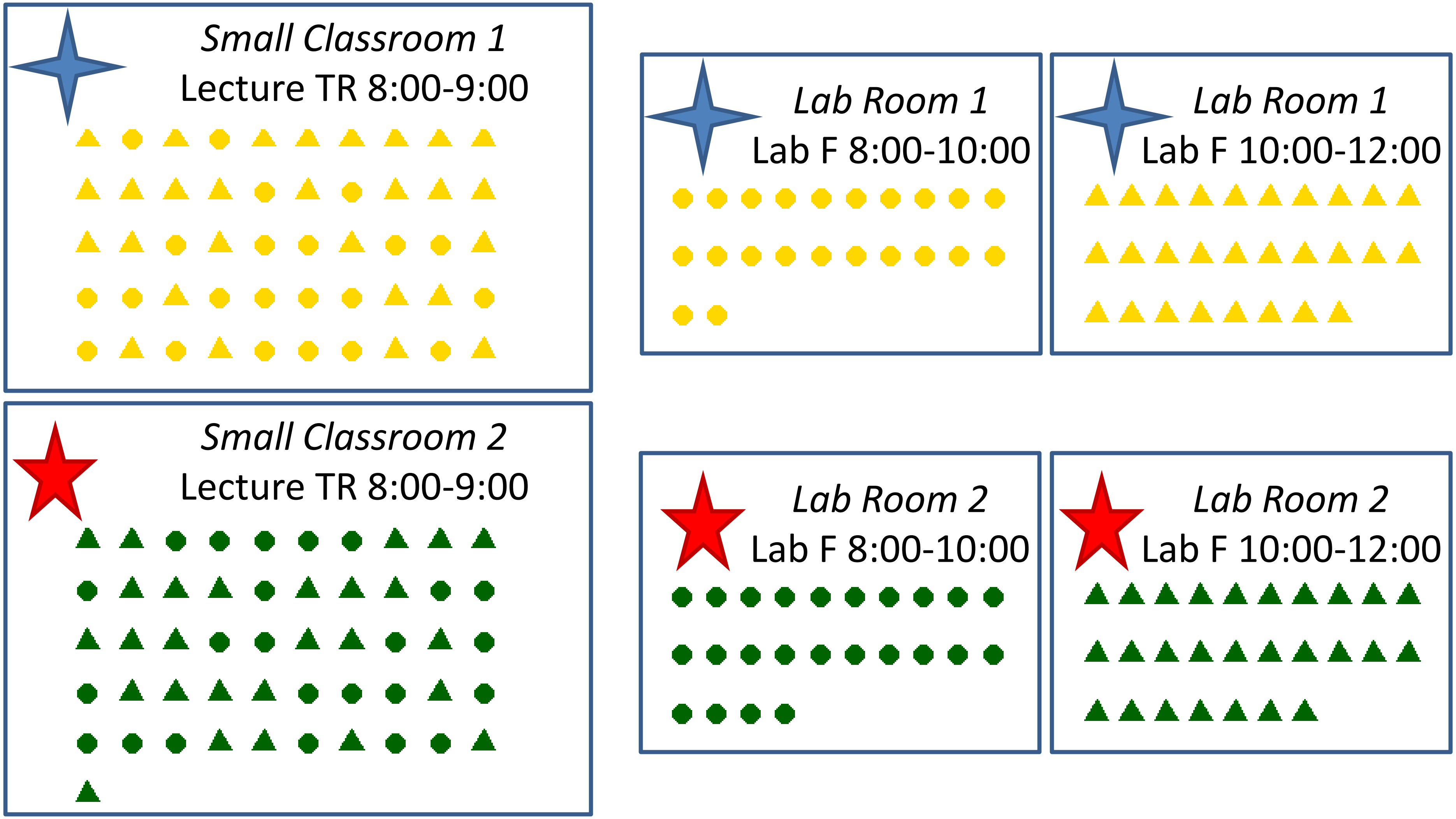
Week 9


Small Classroom 1
Lecture TR 8:00-9:00
Lab Room 1
Lab F 8:00-10:00
Lab Room 1
Lab F 10:00-12:00
Small Classroom 2
Lecture TR 8:00-9:00
Lab Room 2
Lab F 8:00-10:00
Lab Room 2
Lab F 10:00-12:00

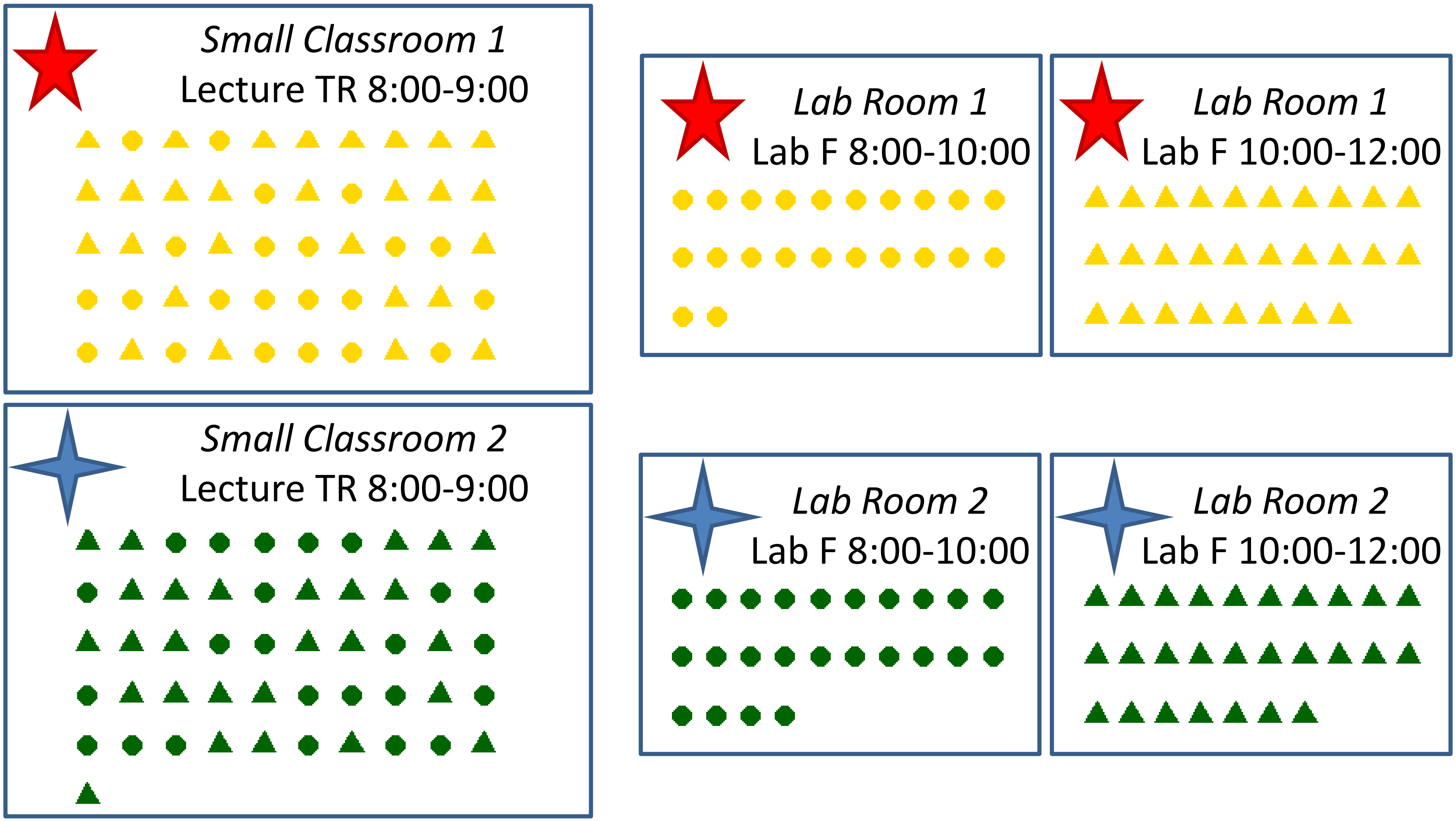
Week 10


Small Classroom 1
Lecture TR 8:00-9:00
Lab Room 1
Lab F 8:00-10:00
Lab Room 1
Lab F 10:00-12:00
Small Classroom 2
Lecture TR 8:00-9:00
Lab Room 2
Lab F 8:00-10:00
Lab Room 2
Lab F 10:00-12:00

Week 9,11,13,15



Week 10,12,14,16



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Data Collection

- Course Administration
  - Inference Curriculum Treatment
  - Enrollment Section
- Pre-Treatment Measures
  - Homework 1-7 Scores
  - Lab 1-7 Scores
  - Midterm Exam Score
- Learning Outcomes: ARTIST scaled question sets
  - Hypothesis Testing (HT score)
  - Confidence Intervals (CI score)

Model

- Student HT and CI scores are bivariate responses
- Use MANCOVA model to incorporate administrative and pre-treatment variables as covariates
- Start with full model including all covariates
- Backward stepwise selection based on AIC
- Final model reduced to three covariates:

  midterm score, Lab 5 score, curriculum treatment

Results

- Tests for Overall Covariate Significance

	Pillai’s Λ	Approx. F Stat	p-value
Midterm	0.2109	12.8277	< 0.001
Lab 5	0.0792	4.1261	0.0191
Curricula	0.0469	2.3605	0.0998

Results

- Model Coefficients

	HT coefficient (SE)	CI coefficient (SE)
Intercept	**2.1053 (1.0584)**	1.4648 (1.0135)
Midterm	**0.0386 (0.0118)**	**0.0477 (0.0113)**
Lab 5	0.8547 (0.6618)	**1.8274 (0.6337)**
Curricula	0.3050 (0.3532)	**0.7146 (0.3382)**

*__Bold__ indicates a significant effect at the $\alpha = 0.05$ level

Conclusions

- Randomization-based inference curriculum has a significant improvement in CI learning outcomes
- 7% improvement on the ARTIST scale for CI
- No significant effect of curricula on HT outcomes

- Consider causality and applicability of results
  - Experimental design allows for causal inference
  - Representative of all introductory students?
  - What about treatment lead to improved learning outcomes?

Thanks!

- Dennis Lock : Co-investigator
- Dr. Heike Hofmann: Study Advisor
- Dr. Bob Stephenson : Study Advisor
- All of you for attending

Any Questions?

- If time does not permit question:
  - Please look for publication (to be submitted next week)
  - Contact me (karstenm@iastate.edu)