The Causality Lab

Application: www.phil.cmu.edu/projects/causality-lab

Web Version: http://oli.web.cmu.edu

- Create New Account
- Course admit code: **csrdemo05**

Outline

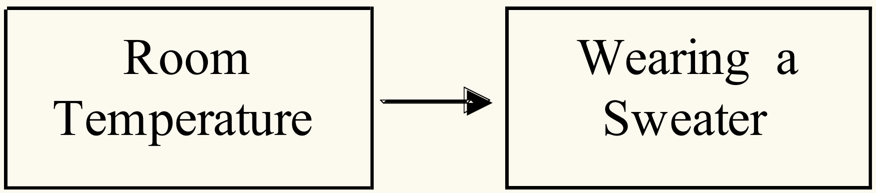
Yesterday

1. The Curriculum
2. The Online Course
   - Modules
   - Causality Lab
   - Case Studies
3. Learning Studies

Today

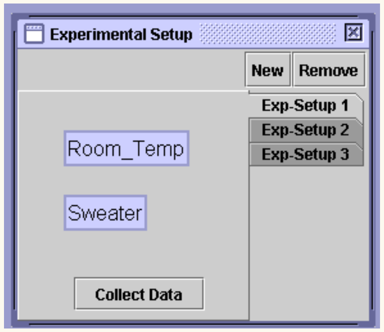
1. The Causality Lab in Detail
2. Hands On Work
   - Doing Exercises
   - Authoring Exercises
3. Pilot Studies

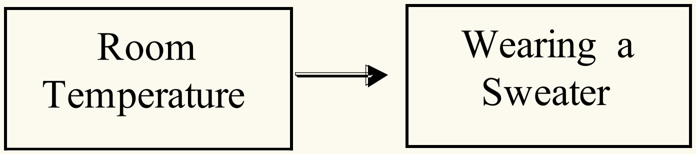
Simple Bayes Net



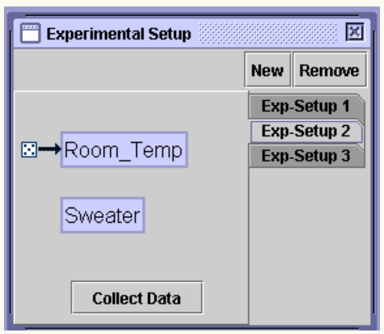
$P(RT = <55) = .1$
$P(RT = 55\text{-}85) = .8$
$P(RT = >85) = .1$
$P(\text{Wearing a Sweater} \mid RT < 55) = .98$
$P(\text{Wearing a Sweater} \mid RT = 55\text{-}85) = .5$
$P(\text{Wearing a Sweater} \mid RT > 85) = .04$

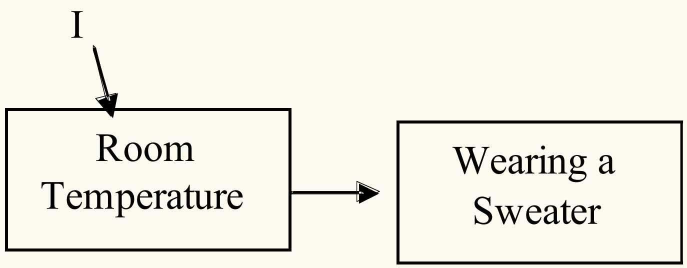
Exp. Setup | Manipulated Graph | Population



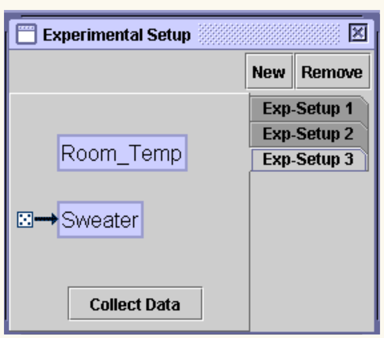


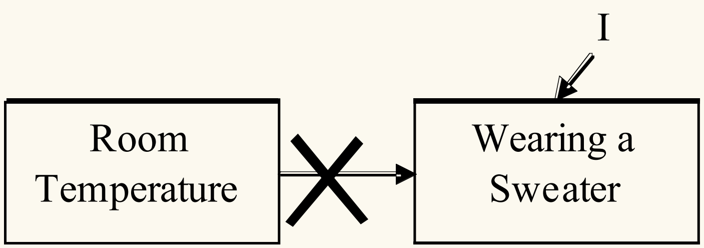
P(RT = <55) = .1
P(RT = 55-85) = .8
P(RT = >85) = .1
P(Wearing a Sweater | RT < 55) = .98
P(Wearing a Sweater | RT = 55 -85) = .5
P(Wearing a Sweater | RT > 85) = .04





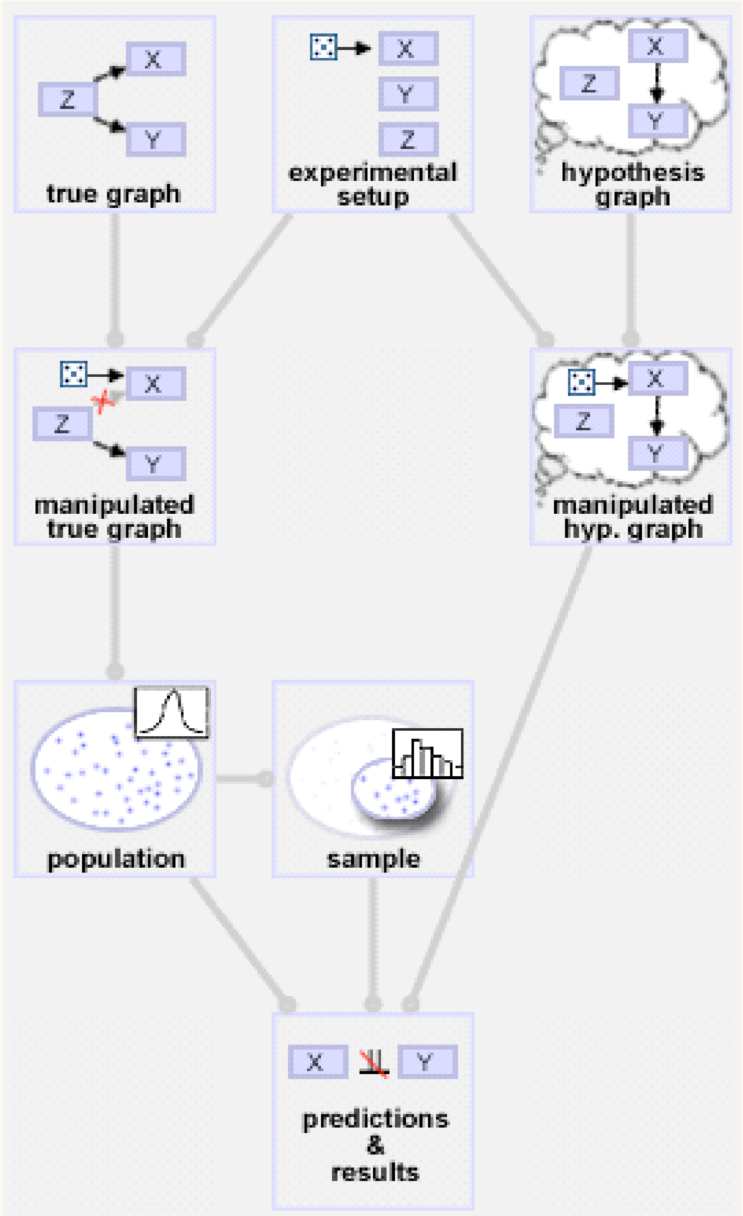
P(RT = <55 | **I**) = **.33**
P(RT = 55-85 | **I**) = **.33**
P(RT = >85 | **I**) = **.33**
P(Wearing a Sweater | RT < 55) = .98
P(Wearing a Sweater | RT = 55 -85) = .5
P(Wearing a Sweater | RT > 85) = .04





P(RT = <55) = .1
P(RT = 55-85) = .8
P(RT = >85) = .1
P(Wearing a Sweater | **I**) = **.5**

Causality Lab: Navigation Panel



Causality Lab – Pilot Studies

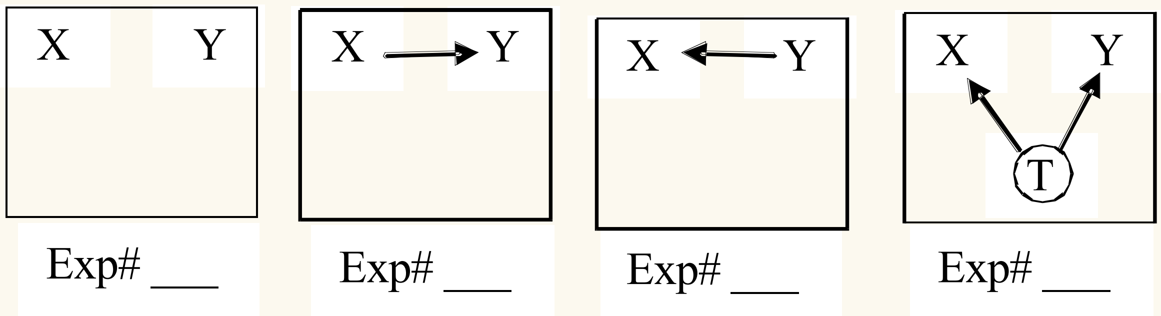
- Carnegie Mellon class (15 students): Causation and Social Policy
- 4-weeks so far through online course
  - Causal graphs,
  - Independence and Conditional Independence
  - d-separation
- No exposure to equivalence classes or methods for discovering structure

Causality Lab – Pilot Studies

- Students given set of possible true models
- Students setup experiments
- Given independence results directly
  - no sample data
  - no statistical inference needed
- Tasks:
  - Infer correct model in minimum number of experiments
  - Infer set of models consistent with experiments so far

Training Experiment

True Model **one of:**

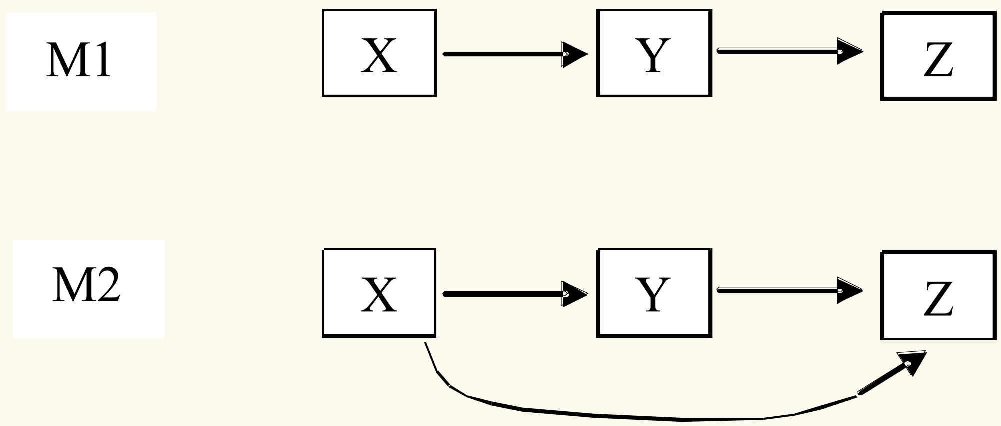


***Student Task*:**

- **Do Passive Observation First – eliminate inconsistent models**
- **Discover True model in fewest possible experiments after that**

Experiment 1

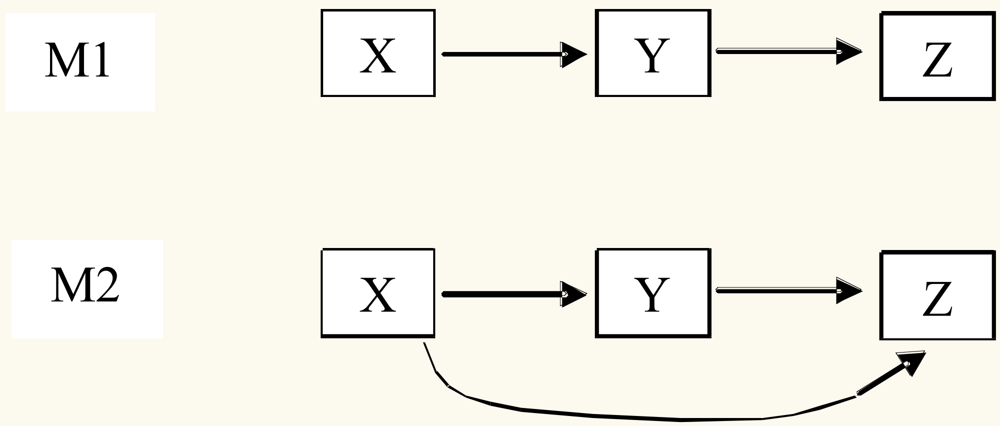
***True Model* one of:**



***Student Task*:**

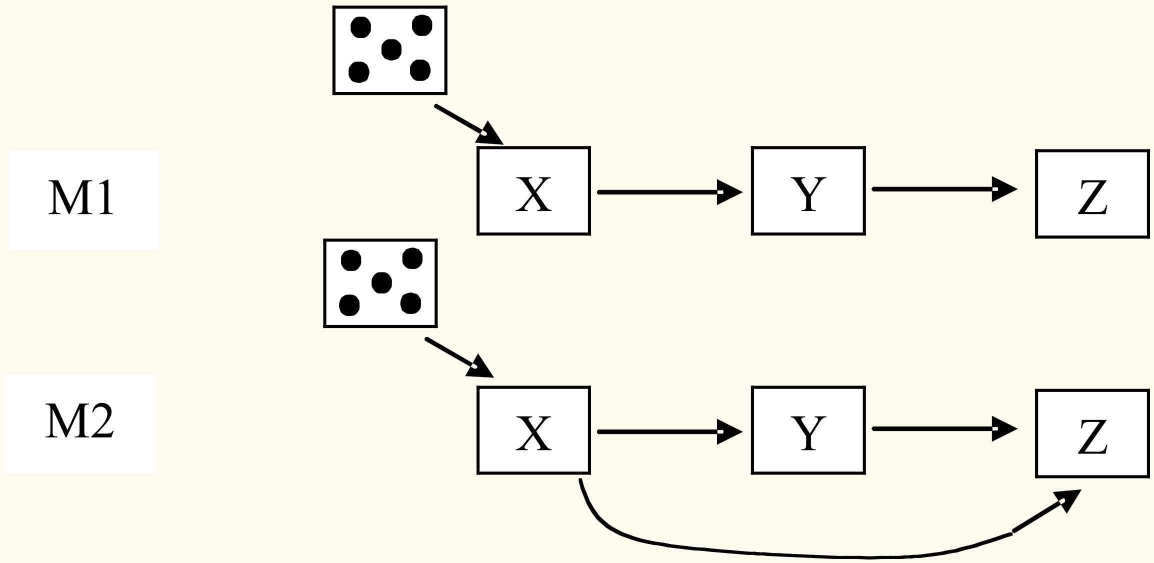
Discover True model in fewest possible experiments

Experiment 1



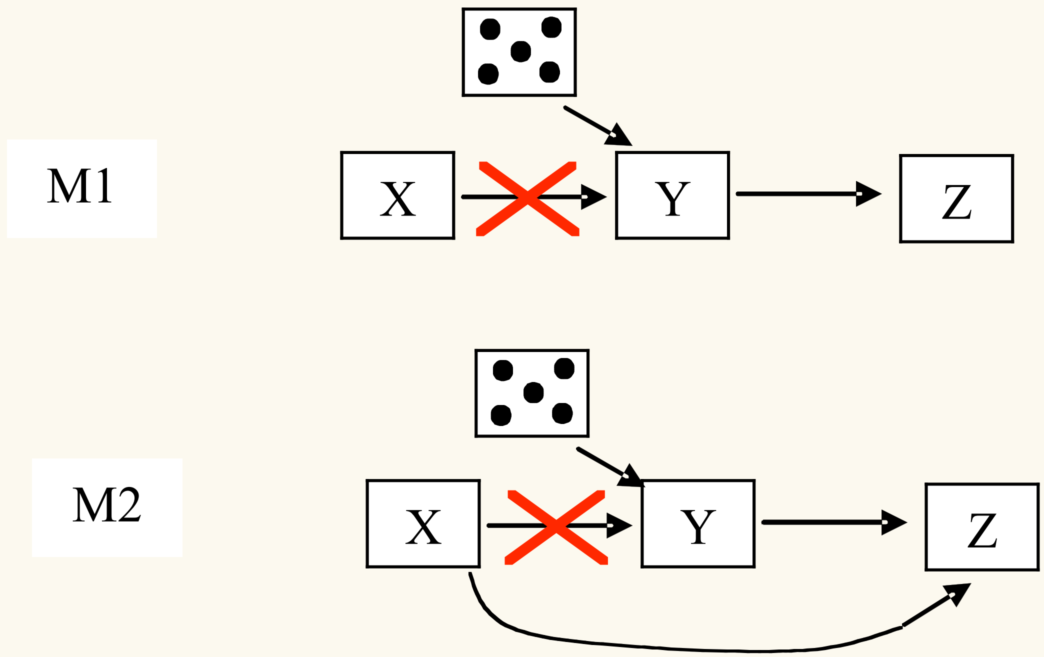
***Passive Observation*:** **X _||_ Z | Y ?**

Experiment 1



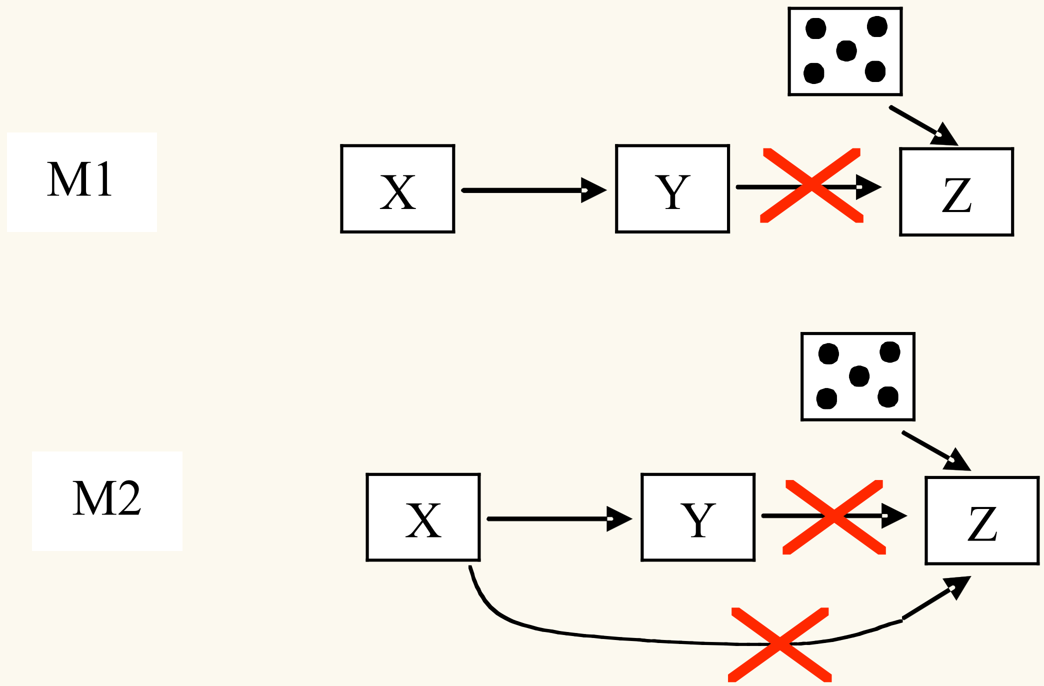
***Intervene on X*:** **X _||_ Z | Y ?**

Experiment 1



***Intervene on Y*:** **X _||_ Z ?**

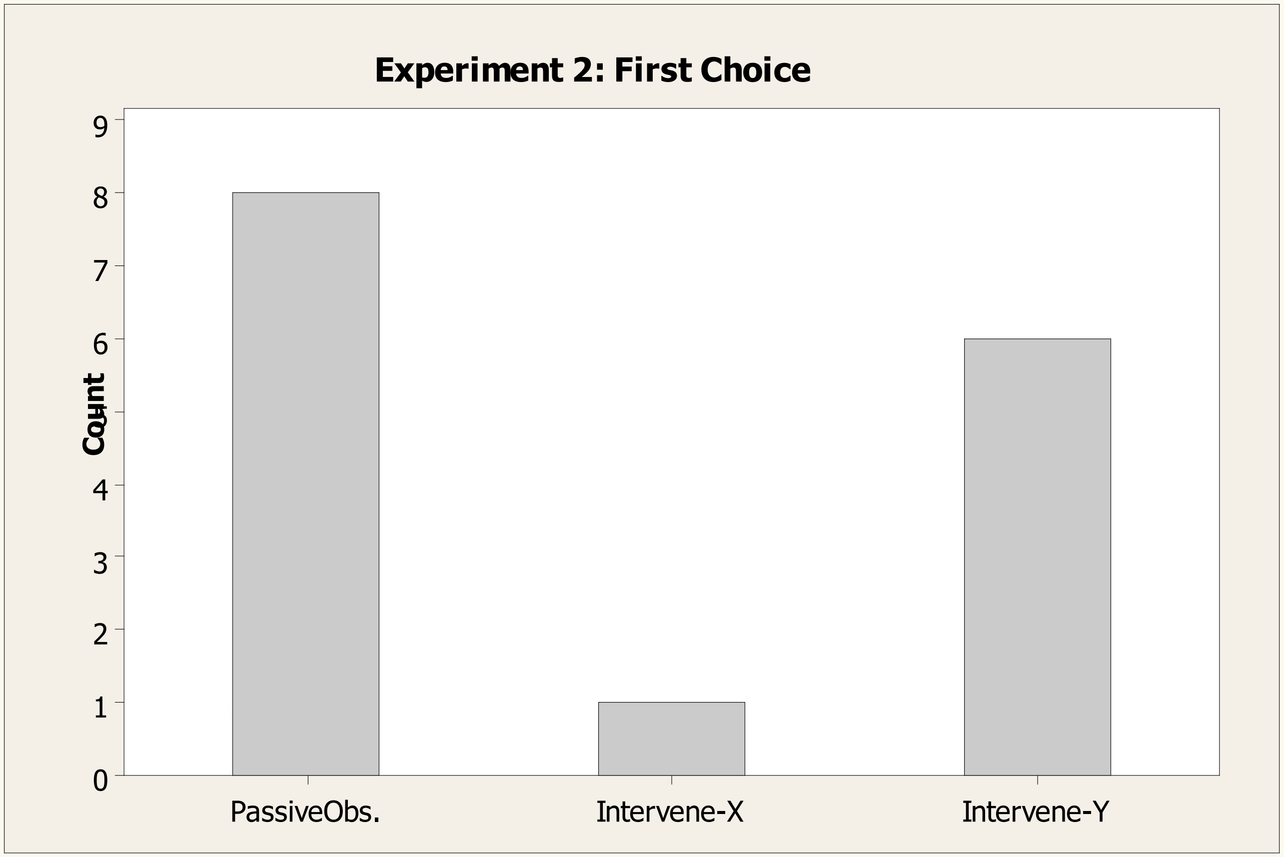
Experiment 1



Intervene on Z: **Indistinguishable Models**

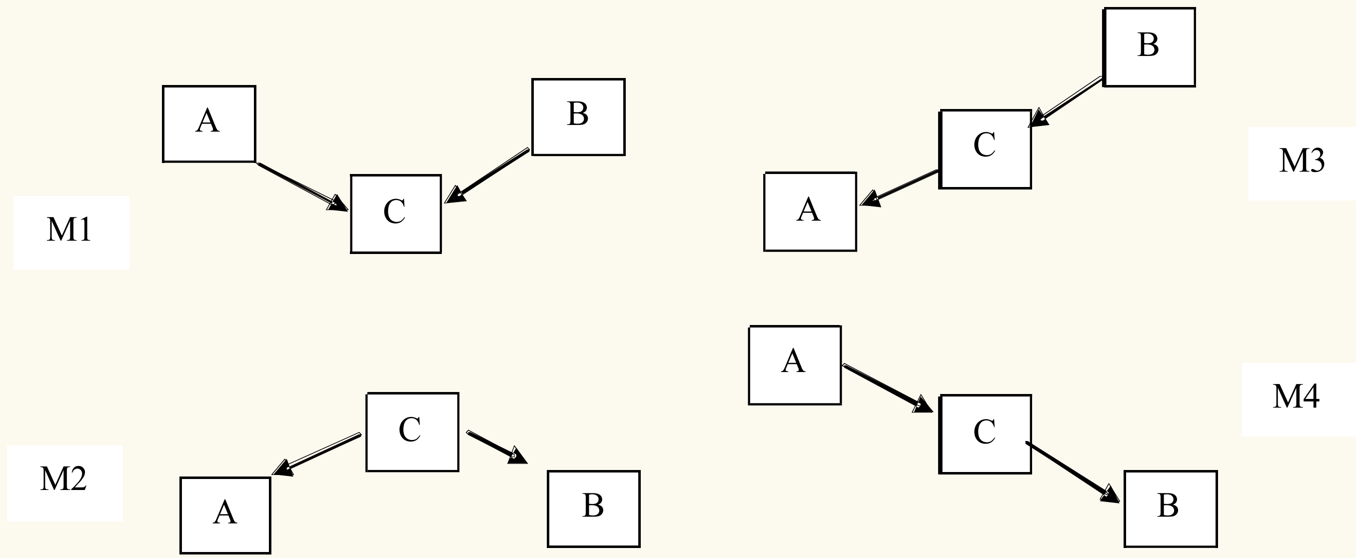
Experiment 1: Results

Correct Answer: 15/15



Experiment 2

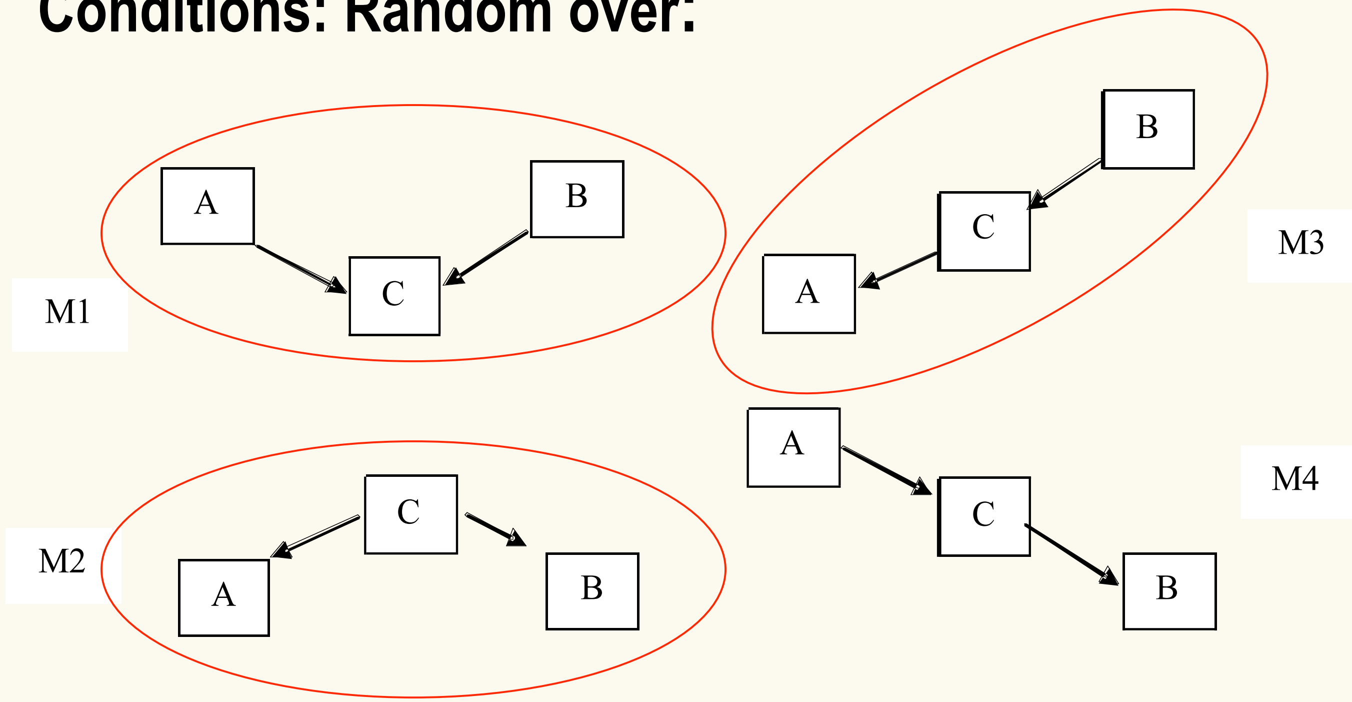
True Model one of:



Task: Discover True model in fewest possible experiments

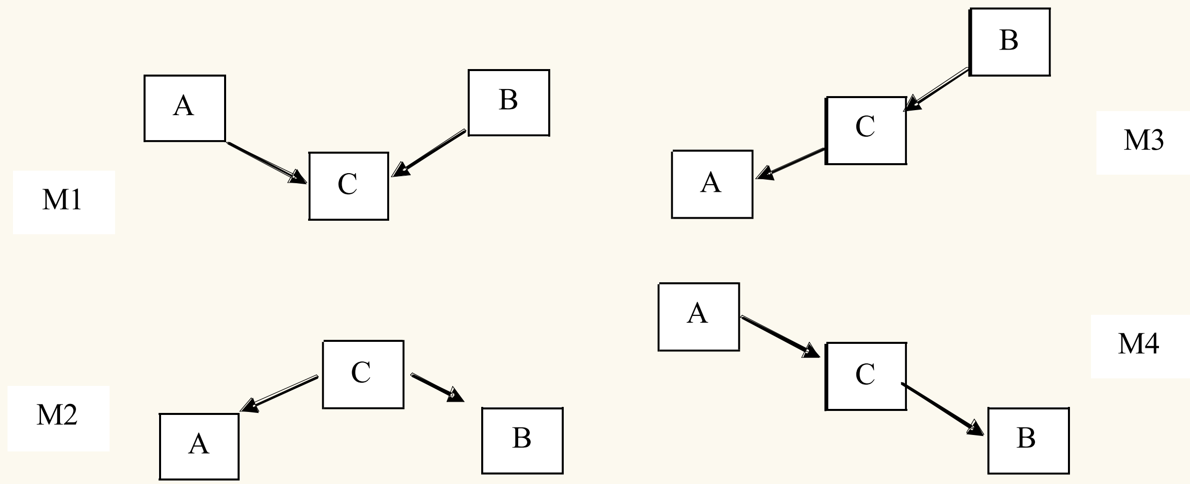
Experiment 1

Conditions: Random over:



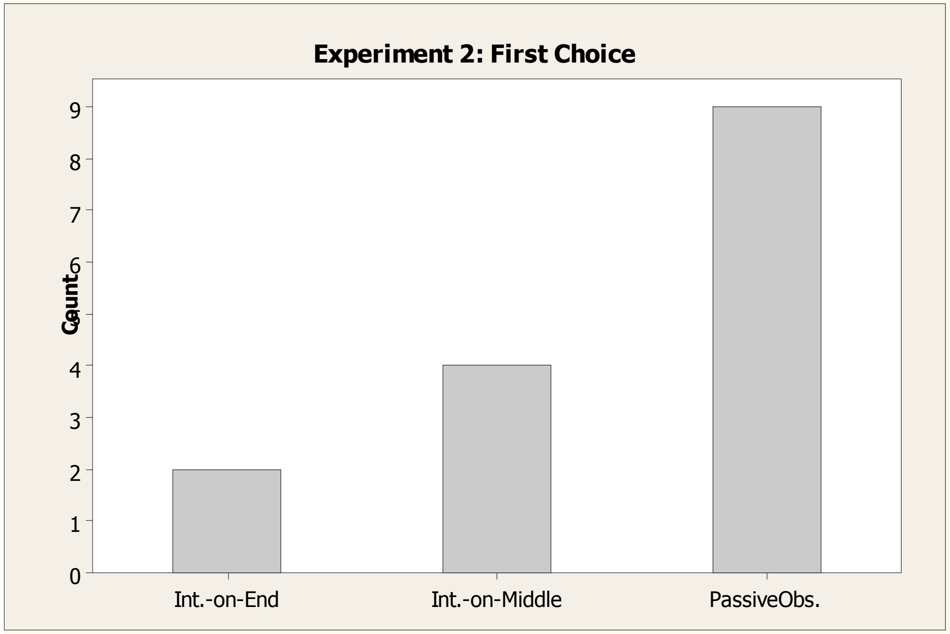
Experiment 2

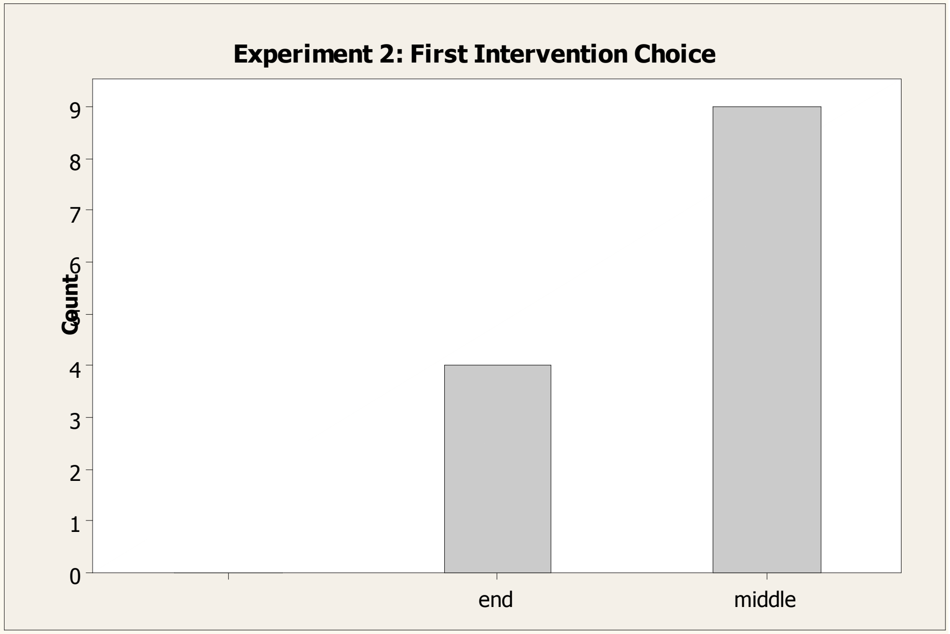
Experimental Setup	Distinguishable?
Passive Observation	M1 from {M2, M3, M4}
Randomize A	M1 from {M2, M3} from M4
Randomize B	M1 from {M2, M4} from M3
Randomize C	M1 from M2 from M3 from M4



Experiment 2: Results

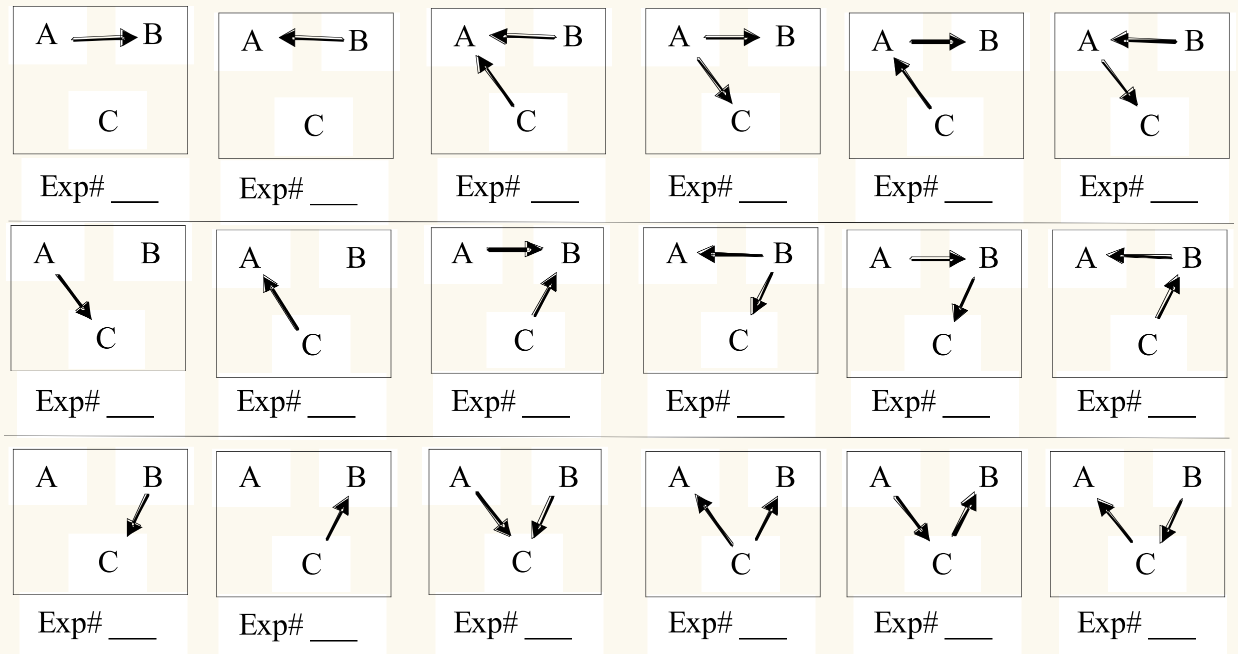
Correct Answer: 14/15





Experiment 3

***True Model* one of:**

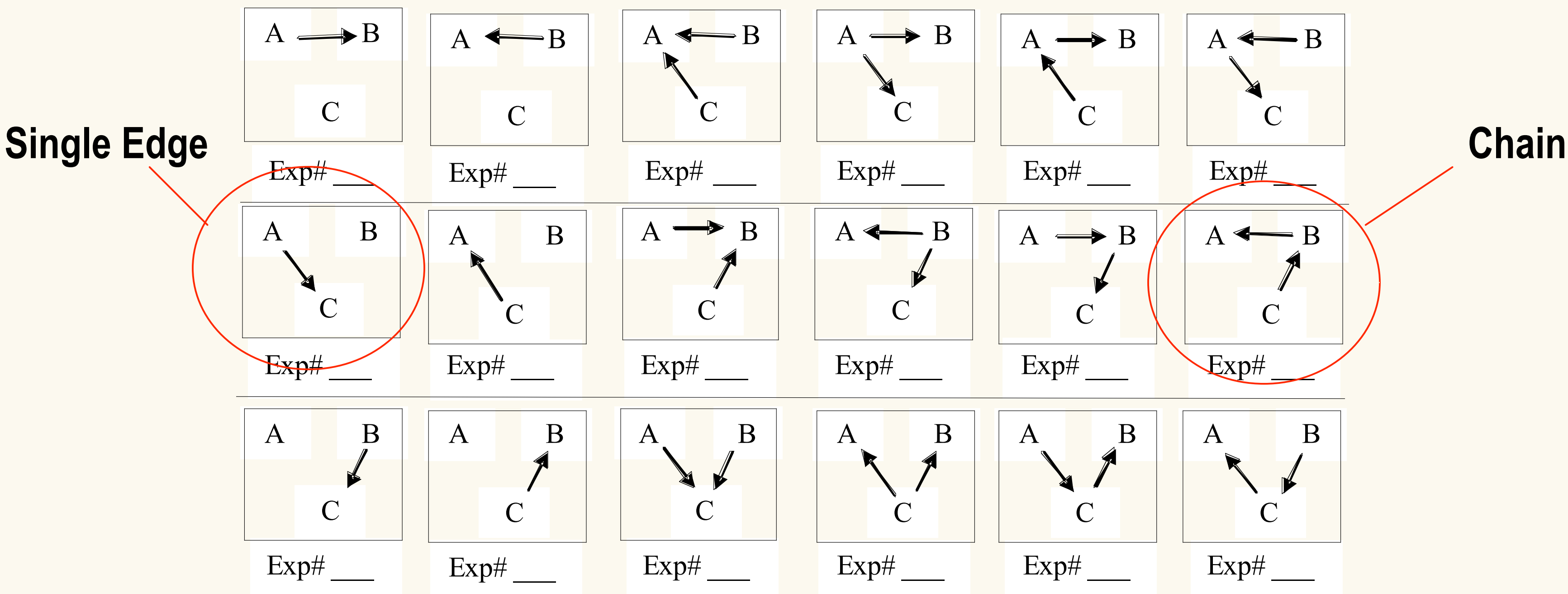


***Student Task*:**

1) Passive Observation: eliminate inconsistent models

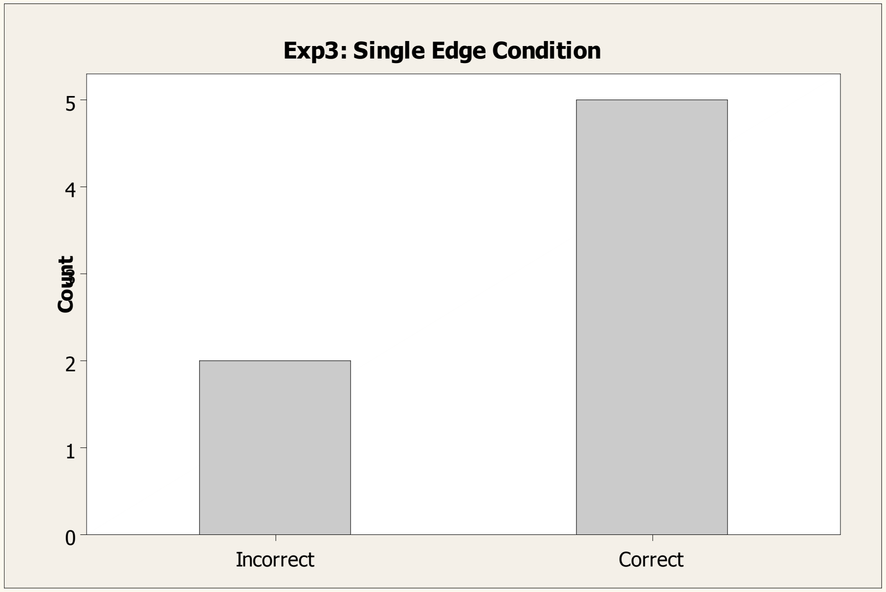
2) Discover True model in fewest possible experiments thereafter

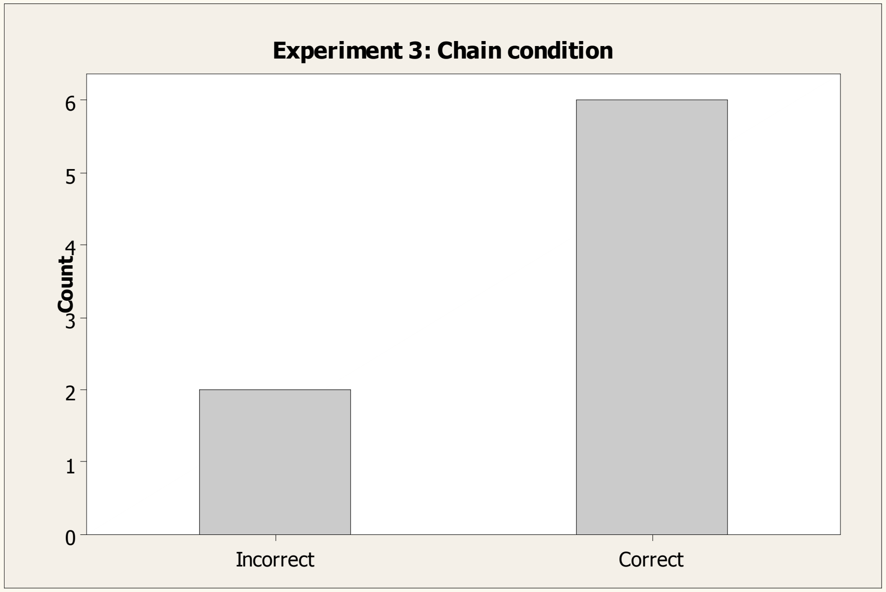
Experiment 3: Conditions



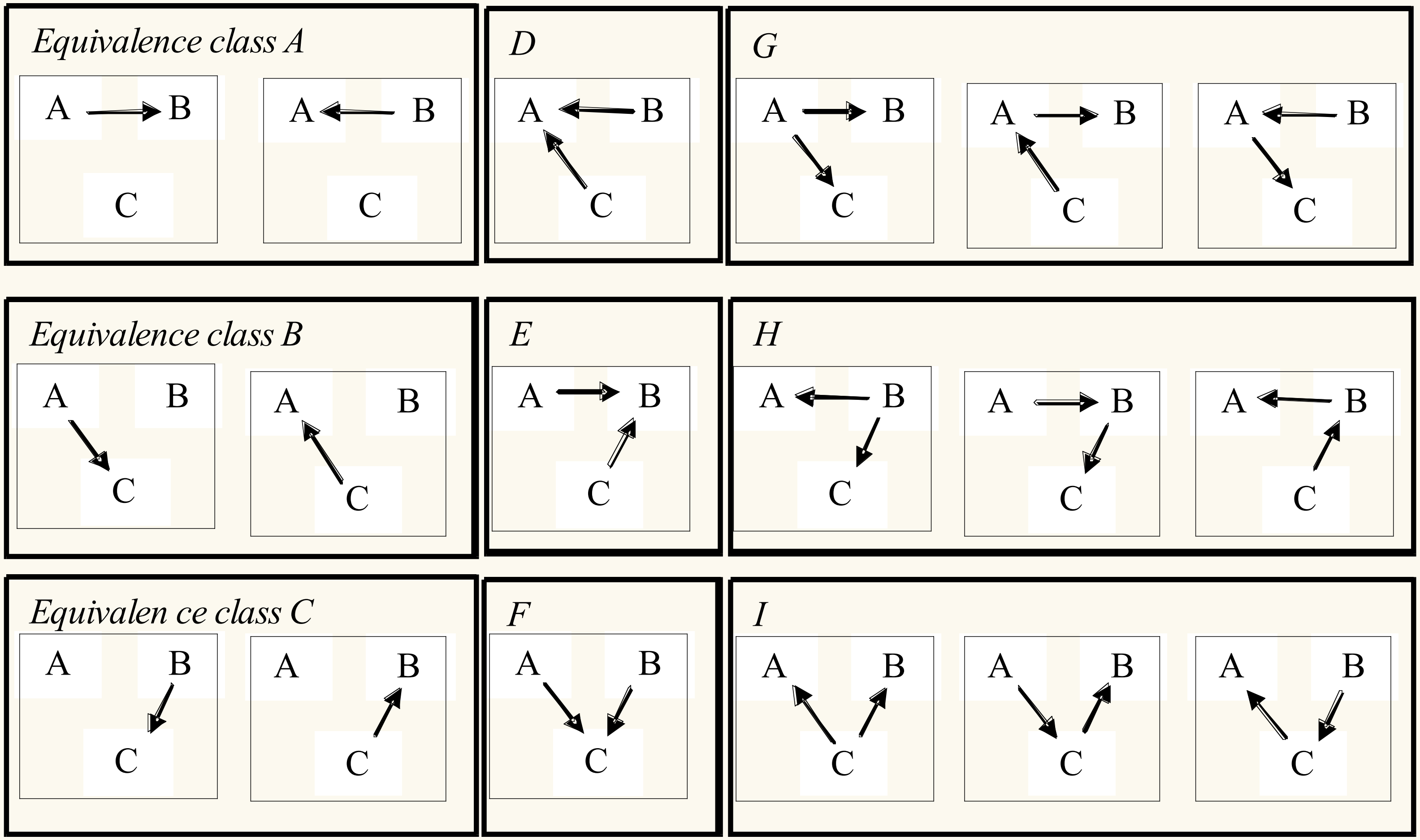
Experiment 3: Results

Overall Success

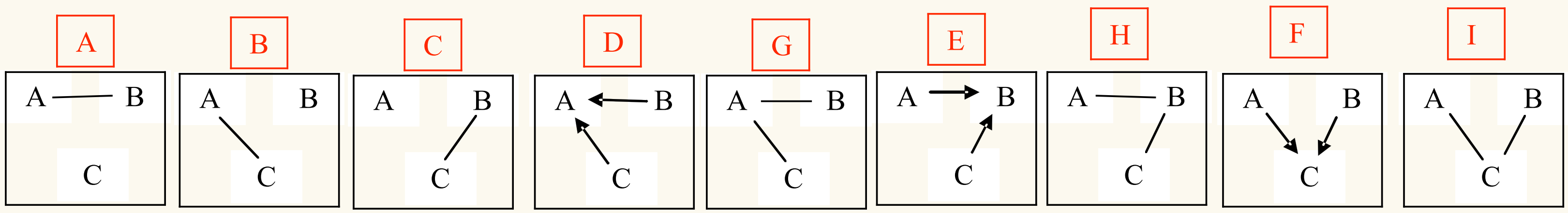




Experiment 3 : Equivalence under Passive Observation



Experiment 3: Equivalence Class Integrity



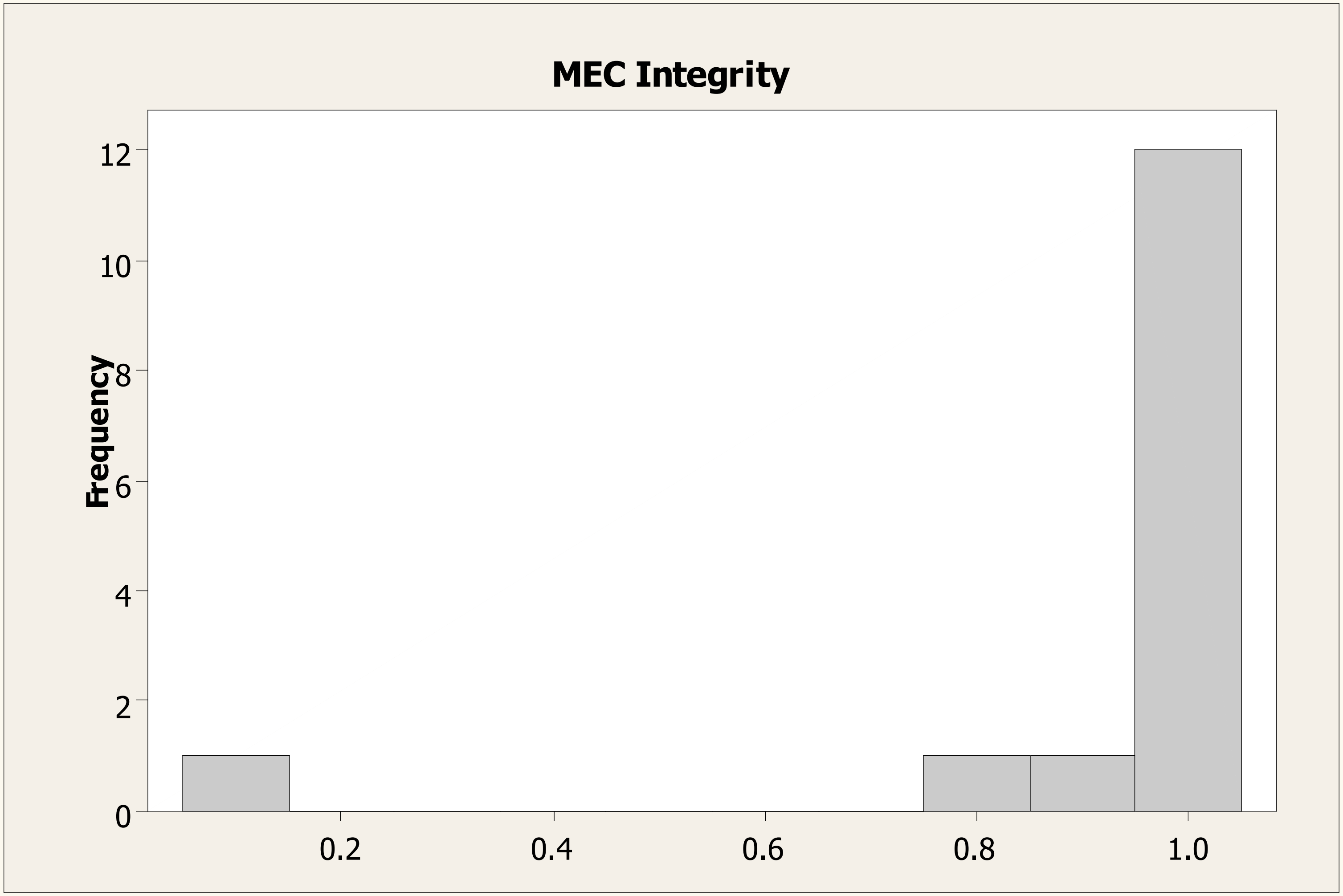
After Passive Observation:

Students who understand equivalence should either

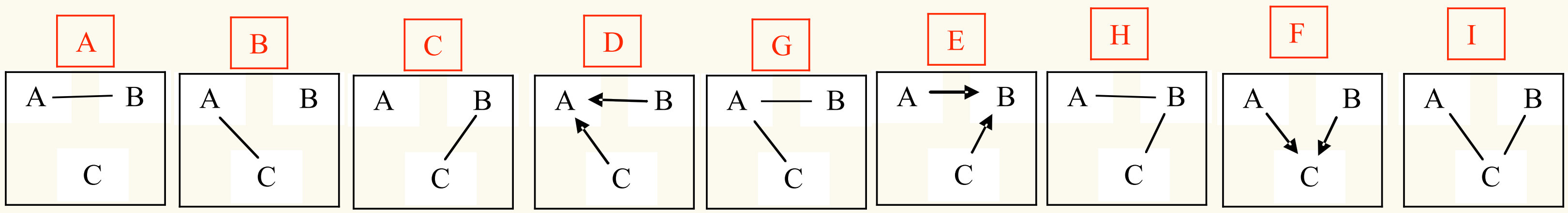
- Keep all models in an equivalence class, or
- Remove all models in an equivalence class

$$\textit{MEC-Integrity} = \frac{\displaystyle\sum_{mec \in \{A,B,C,G,H,I\}} \begin{cases} |\mathbf{mec}| : \text{if all models in mec were included or all excluded:} \\ \mathbf{0} \quad : \text{otherwise} \end{cases}}{15}$$

Experiment 3: Equivalence Class Integrity Results



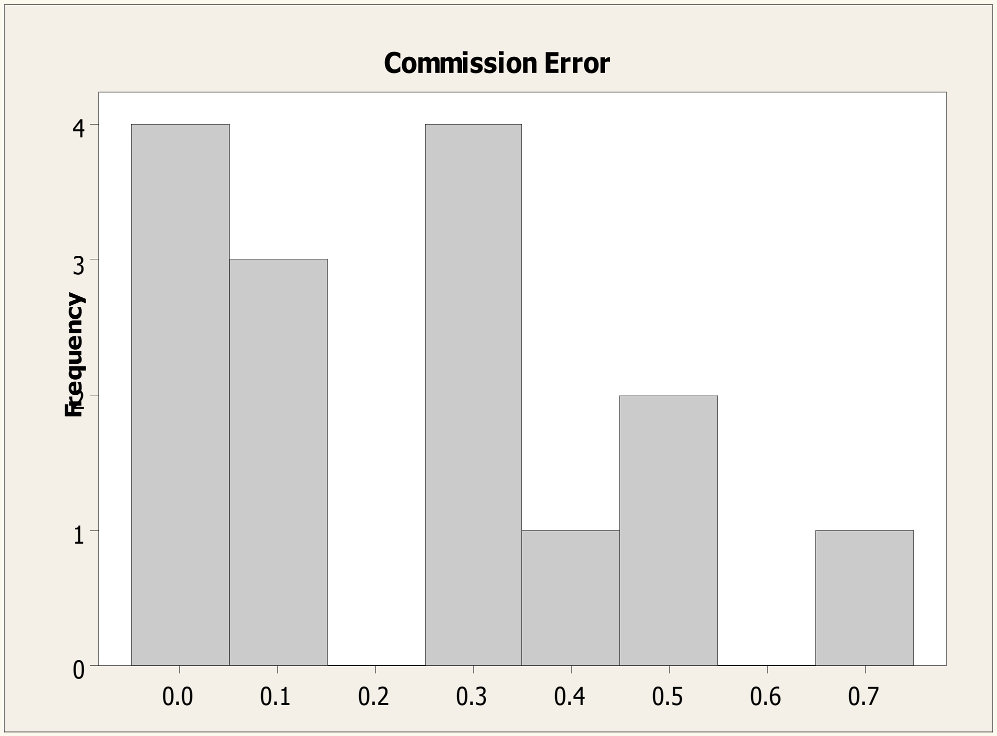
Experiment 3: Commission and Omission

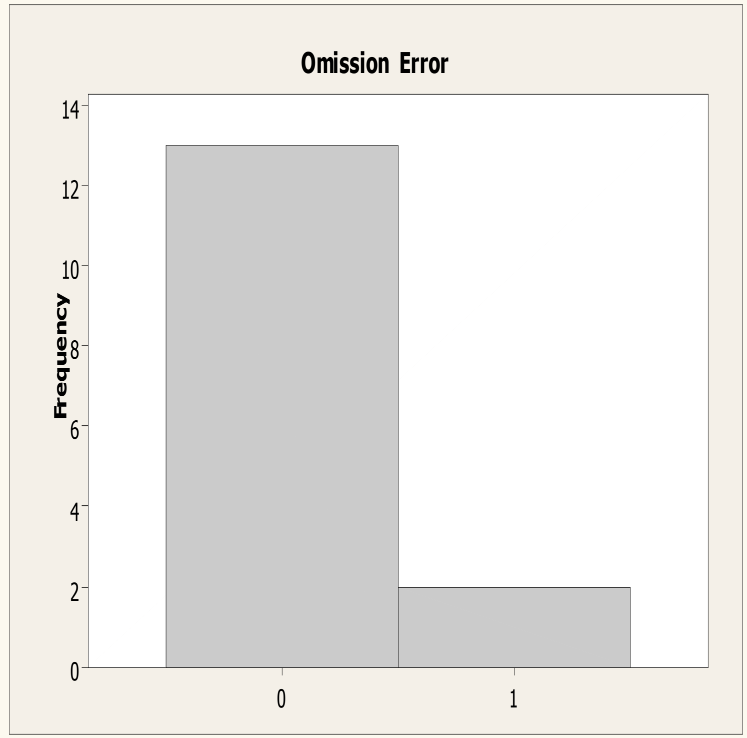


$$\textit{Commission Error} = \frac{\text{\# of graphs retained by student, but not in correct MEC}}{\text{\# of graphs not in correct MEC}}$$

$$\textit{Omission Error} = \frac{\text{\# of graphs in the correct MEC omitted by the student}}{\text{\# of graphs in the correct MEC}}$$

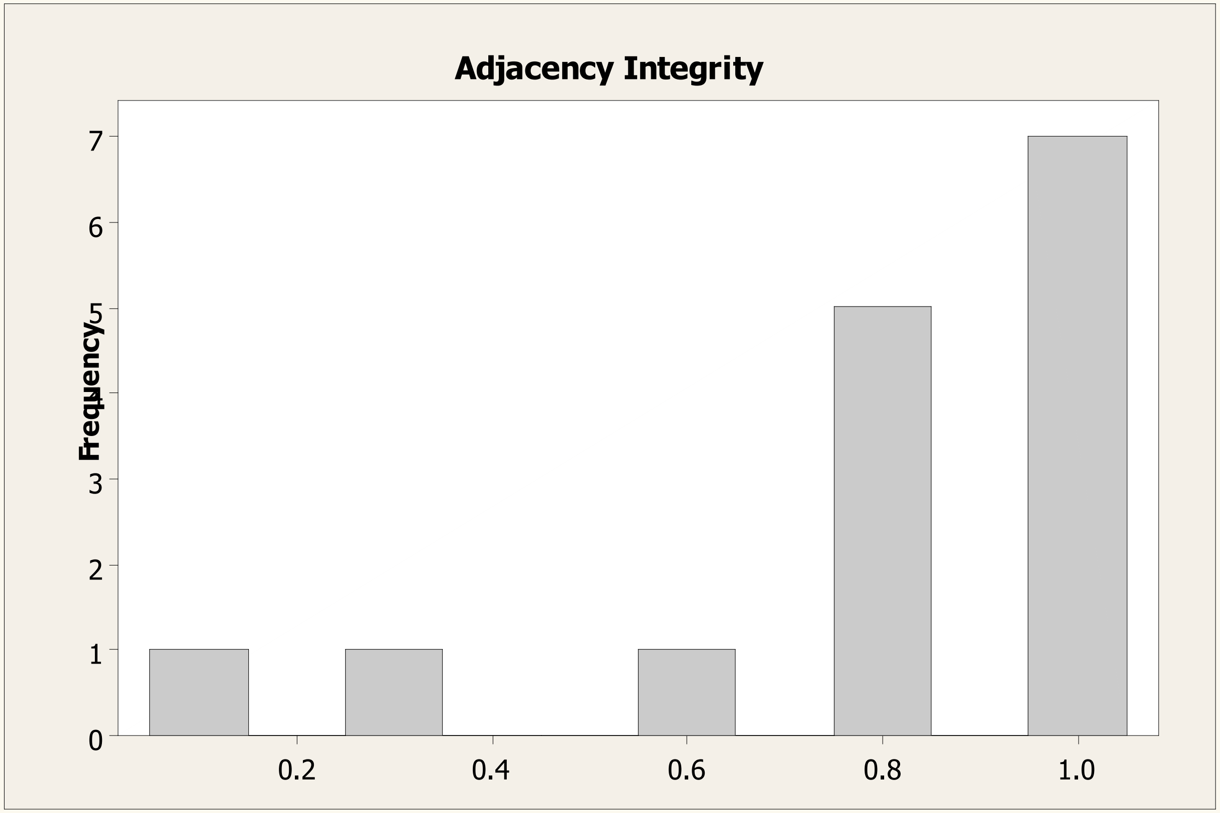
Experiment 3: Equivalence Class Integrity Results





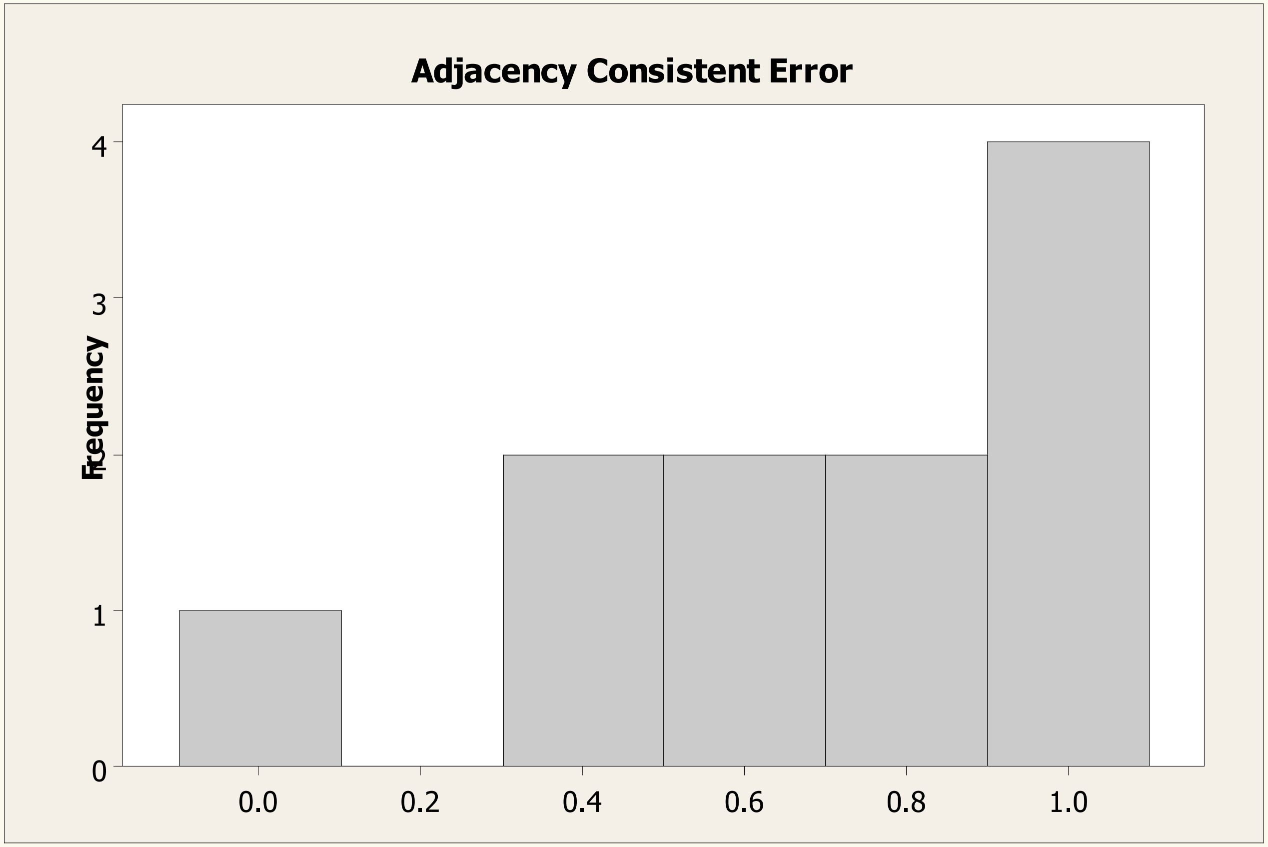
Experiment 3: Adjacency Integrity

$$Adjacency\text{-}Integrity = \frac{\displaystyle\sum_{adj \in \{A,B,C,\ D+G,E+H,F+I\}} \begin{cases} |\mathbf{adj}| : \text{if all models in } adj \text{ were included or all excluded:} \\ \mathbf{0} \quad : \text{otherwise} \end{cases}}{18}$$



Experiment 3: Adjacency Integrity

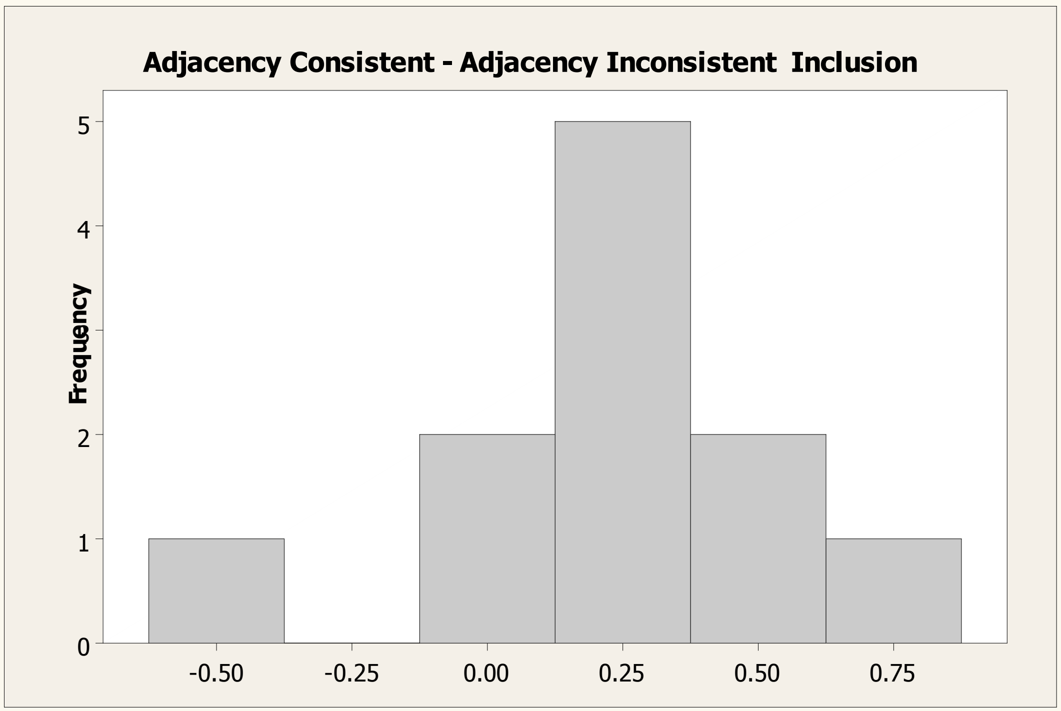
$$\textit{Adjacency Consistent Error} = \frac{\text{\# of graphs committed that are adjacency consistent}}{\text{\# of graphs committed}}$$



Experiment 3: Adjacency Integrity

$$\text{Adjacency Consistent Inclusion} = \frac{\text{\# of committed graphs that are adjacency consistent}}{\text{\# of committable graphs that are adjacency consistent}}$$

$$\text{Adjacency Inconsistent Inclusion} = \frac{\text{\# of committed graphs that are adjacency inconsistent}}{\text{\# of committable graphs that are adjacency inconsistent}}$$



Tentative Hypotheses from Pilot Study

- Students can distinguish direct from indirect causation
- Students prefer passive observation
- Students often choose optimal experiments to orient a chain
- Students act as if they understand adjacency, but not orientation within an adjacency class reliably