

# Utilizing Contrasting Cases to Target Science Reasoning and Content in a Design-for-Science Unit

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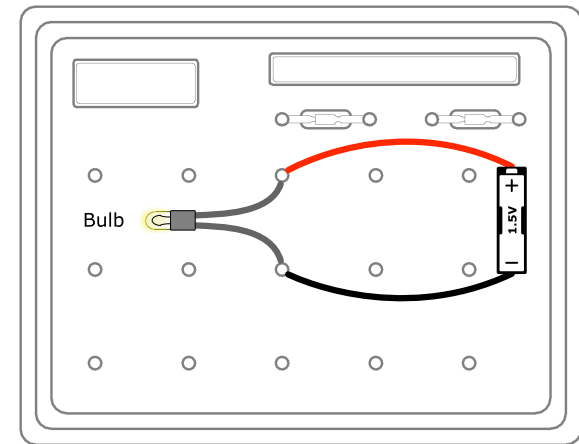


# A “Simple” Suggestion Gone Awry

- Setting
  - 8<sup>th</sup> graders
  - Building electrical alarm systems
  - Learning about electricity concepts

1<sup>st</sup> Try

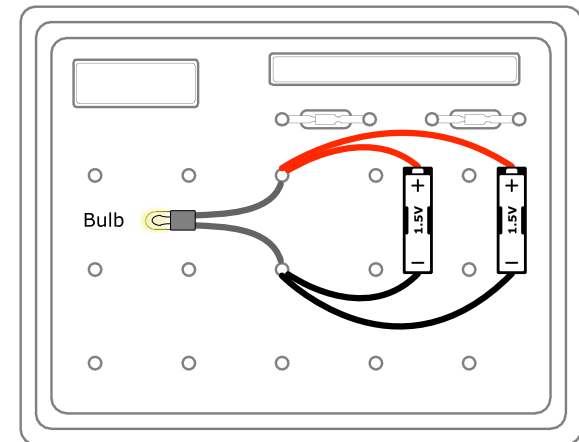
Bulb Dim



- Goal
  - Make your light brighter
- Suggestion
  - “Add more batteries”

2<sup>nd</sup> Try

Bulb Still Dim

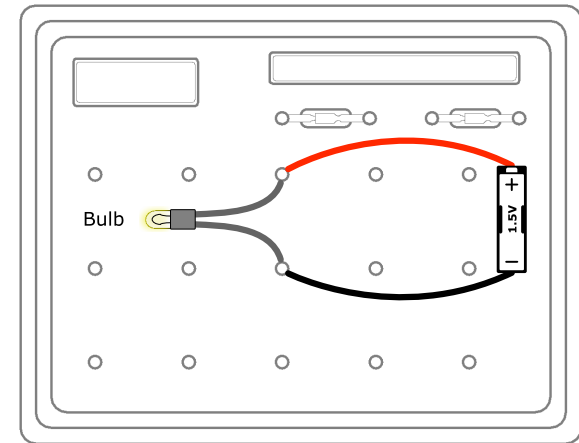


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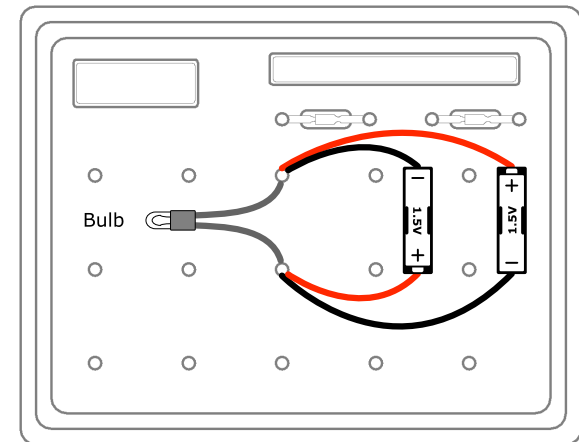
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3<sup>rd</sup> Try

Bulb Off &  
Hot!

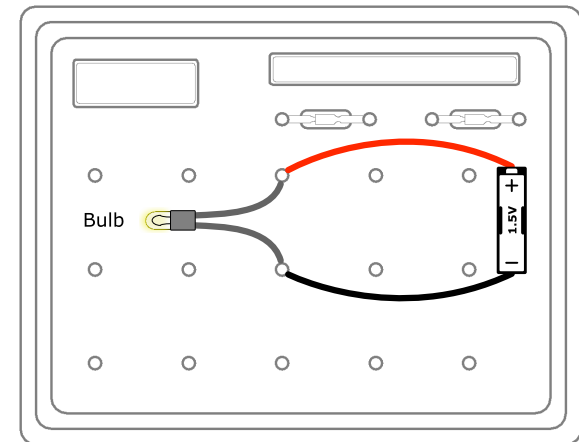


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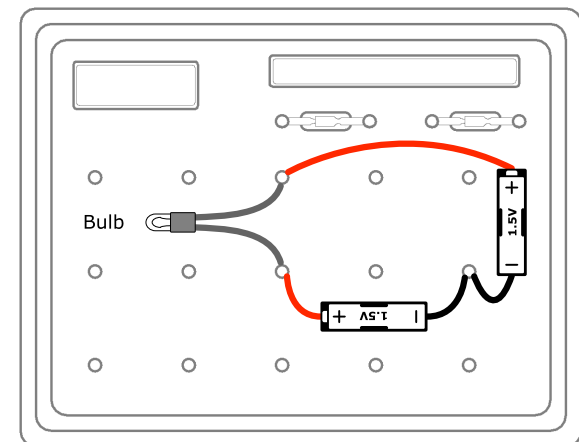
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4<sup>th</sup> Try

Bulb Off!

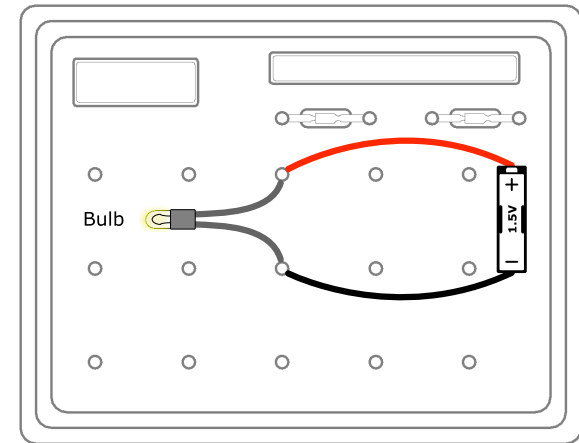


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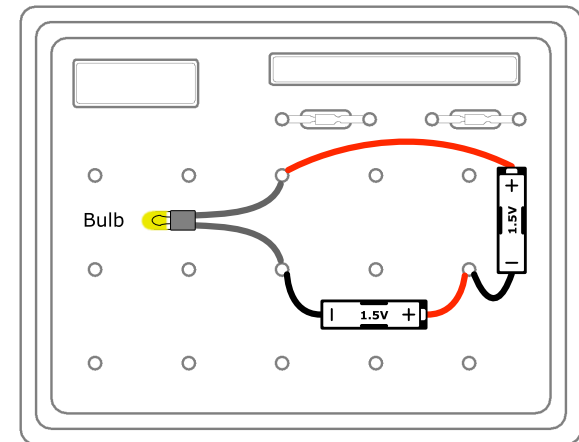
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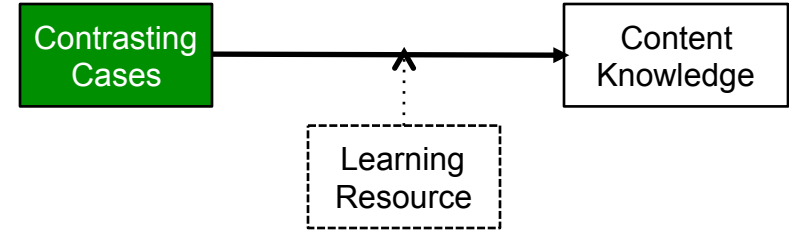
5<sup>th</sup> Try

Bulb  
Brighter!!

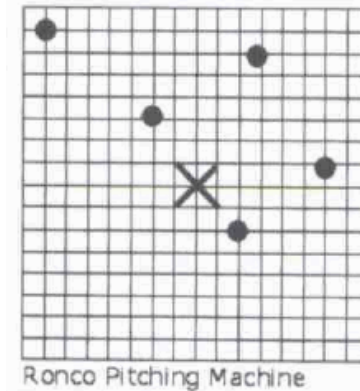


# Contrasting Cases

- Instructional tool for **attending** to important dimensions/features/variables
  - Provokes need to explain them
- A Time for Telling - Psychology (Schwartz & Bransford, 1998)
  - Jasper Series (Barron et al., 1998)
  - Negotiation strategies (Gentner et al., 2003)
  - Complex video cases (Beitzel, 2004)
  - Mathematics (Schwartz & Martin, 2004; Chang, 2006)
- Could we design contrasting cases to target electricity content knowledge?
  - Won't test the **Learning Resource** in this study

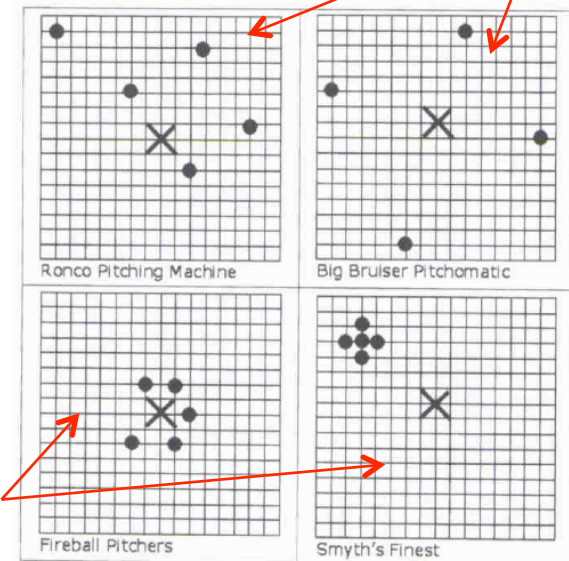


Single Case



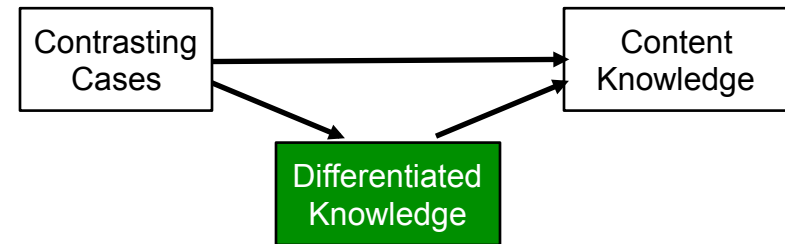
Sample Size

Contrasting Cases



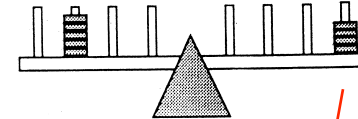
Variability vs Accuracy

# Differentiated Knowledge

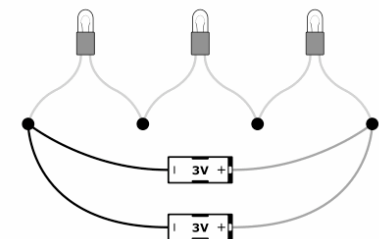
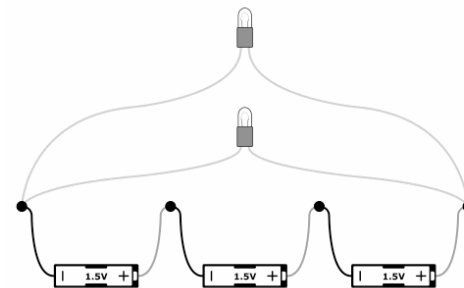
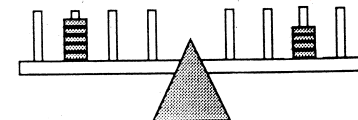


- Attend to and encode key features of a problem
  - Distributions
    - Variability vs accuracy
    - Sample size
    - Outliers
  - Balance Scale (Siegler, 1976)
    - Weight vs Distance
- What is different between the circuits in terms of how they are built?
  - What features of circuits are students attending to and encoding?

Reproduce the Configuration

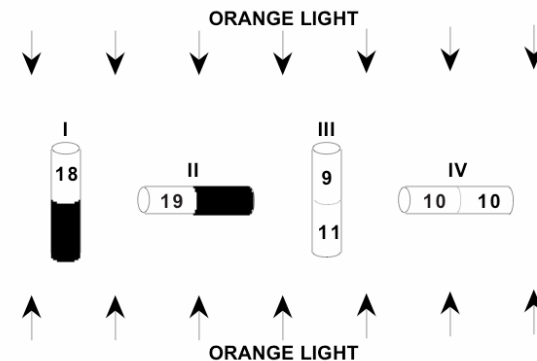
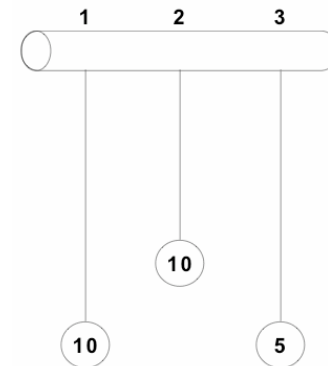
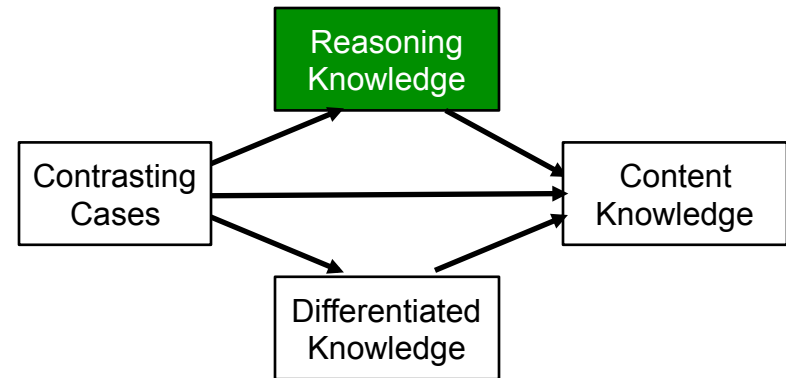


Children Don't Encode Distance



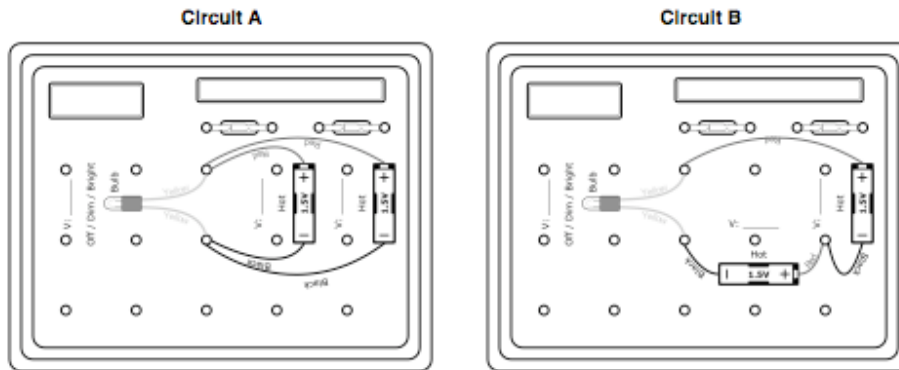
# Reasoning Knowledge

- Science may be different than previous domains using Contrasting Cases
  - Depends on inquiry, want students to **do** science not just learn **about** science
  - Coordination between theory and evidence is hard
  - Requires domain-general reasoning in **design** and **interpretation** of experiments
- Force Concept Inventory (Coletta & Phillips, 2005)
  - Pre-scores associated with Gain (some exceptions)
  - Classroom Test of Scientific Reasoning (Lawson, 1978)
- Focused on 2 relevant constructs
  - CVS** - Isolation and control of variables
    - Which strings should be used to determine whether length of string has an effect on time to swing back and forth?
  - Correlational reasoning** - Weighing of confirming and disconfirming cases
    - Flies respond to gravity, orange light, or both?

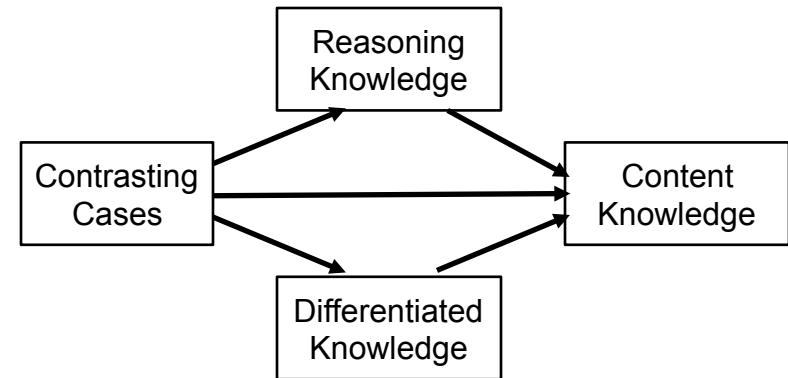




# Our Contrasting Cases Tool



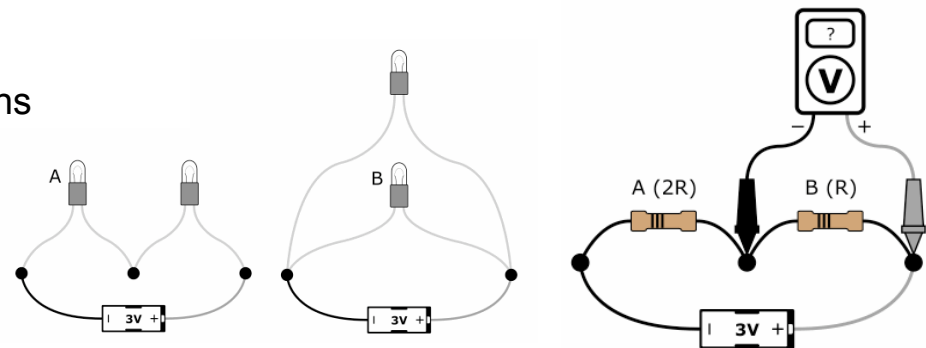
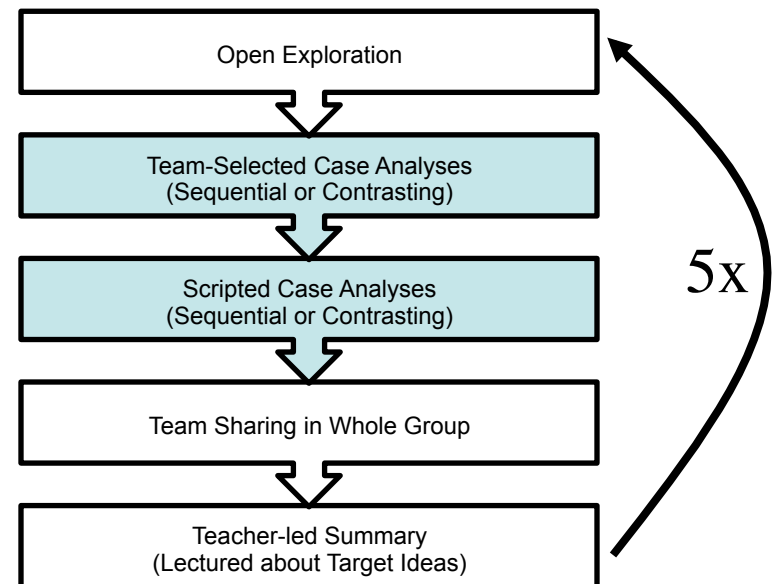
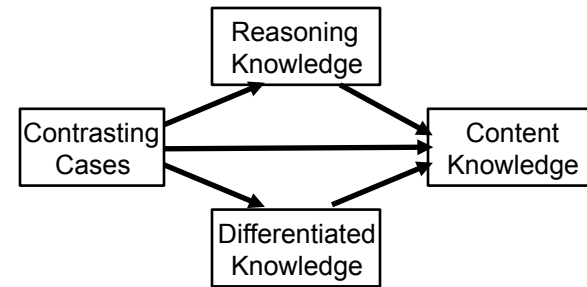
- Compare **designs**, what is different?
- Build them and compare **behavior**, what is different?
- Create rule to explain relating design to behavior



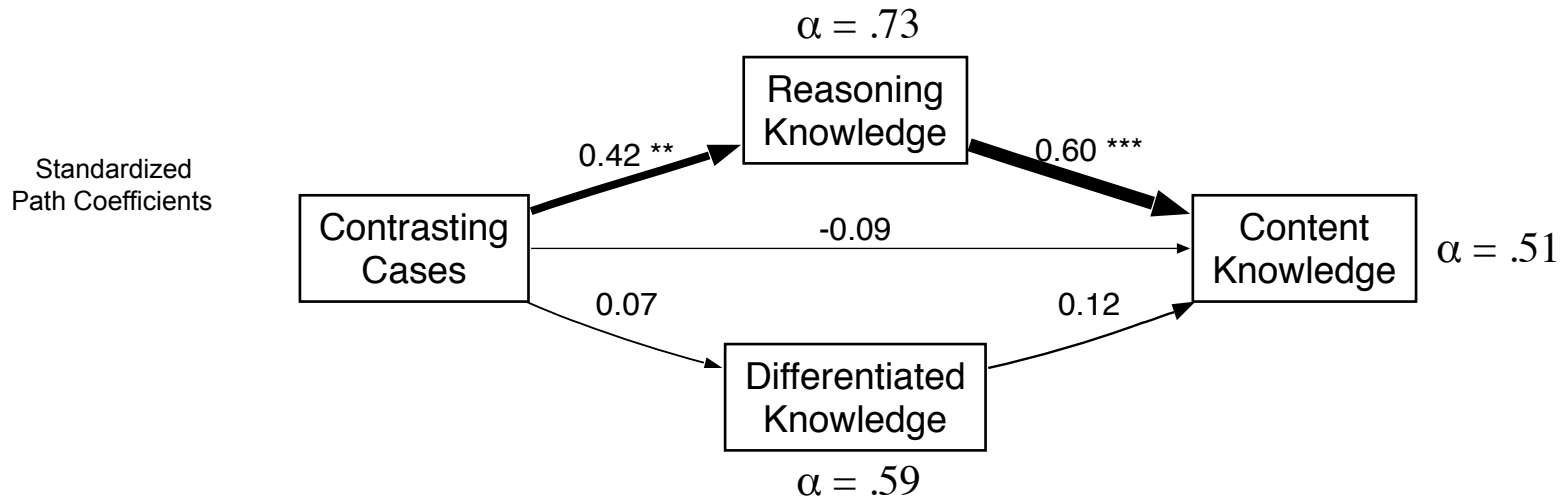
- Target Reasoning Knowledge by modeling CVS and drawing conclusions from results
- Target Differentiated Knowledge by attending to differences

# Study Design

- *Question* – What is the effect of Contrasting Cases on the relationship between these knowledge components in a science context?
- *Instructional Context* - The Electrical Alarm System, 8 week electronics unit
  - Cases given 5 times for the different subsystems
  - Students saw different cases then presented their findings
- *Measures* - Pre/Post of 3 Science Knowledge Constructs
  - **Reasoning Knowledge** (12 items)
  - **Differentiated Knowledge** (9 items)
  - **Content Knowledge** (41 items)
- *Participants* - 1 teacher, 5 eighth grade sections assigned to 1 of 2 conditions
  - **Contrasting Cases** (3 sections, N=54)
  - **Sequential Cases** (2 sections, N=30)



# Results – Path Analysis



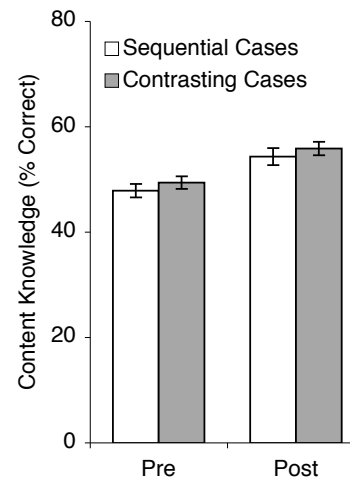
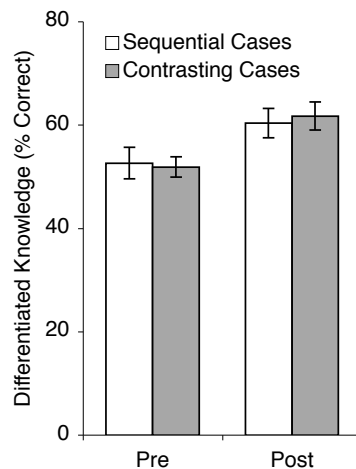
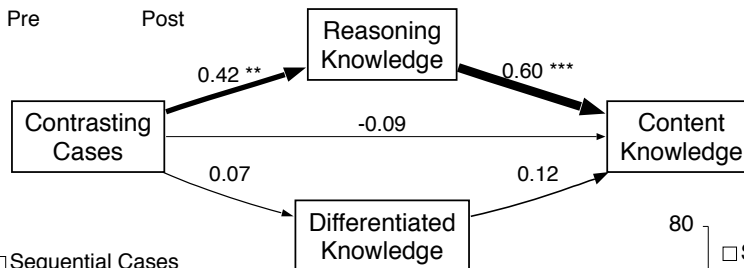
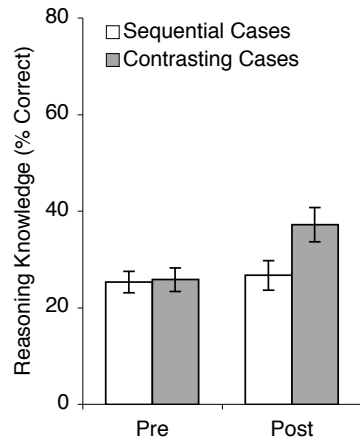
## Not so Surprising

- There was a relationship between Contrasting Cases and Reasoning Knowledge
- There was also a relationship between Reasoning Knowledge and Content Knowledge
- There was no direct relationship between Contrasting Cases and Content Knowledge

## Surprising

- No relationship between Contrasting Cases and Differentiated Knowledge
- No relationship between Differentiated Knowledge and Content Knowledge

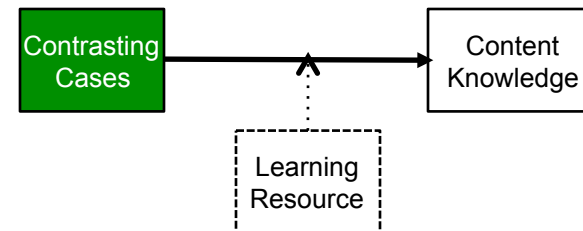
# Results – Condition Effects



- Only a Condition Effect for Reasoning Knowledge
  - Suggested by the Path Analysis
- Gains in each were statistically reliable, but relatively low
  - As a result, it might be hard to observe some relationships

# Possible Explanations

- Is the **Integration** of Differentiation Knowledge and Reasoning Knowledge what is most effective?
  - Interaction term is not significant when added to the model
- Is it a **Time Lag** issue? Students may not benefit from Reasoning Knowledge gains in time to understand significance of Differentiated Knowledge or make strong connections to Content Knowledge
  - Still no effect of Contrasting Cases on Content Knowledge when only considering students with high Reasoning Knowledge at pre-test
- The **Number of Opportunities** to any particular domain-specific idea (Differentiated Knowledge or Content Knowledge) was limited compared to general reasoning ideas
  - May need to build in ways for students to see the same content multiple times
- Need to add the **Learning Resource** back into the model
  - How productive was the sharing of ideas and the lecturing by the teacher?



# Conclusions

- Domain-general Reasoning Knowledge is an important part of the story in a science context
  - Understanding that a feature is important is not sufficient by itself and may be less important than being able to reason through an experiment
- There may still be a role for Differentiated Knowledge, but we need to design instructional tools that do it better
  - Target the deep-level differentiated knowledge ideas that are associated with content knowledge (Chi, Feltovich, Glaser, 1981)
- The Learning Resource that integrates differentiated knowledge and reasoning knowledge in order to connect to content is crucial
  - Should look more closely at ways in which students explain problem features with experiment data and through synthesizing across cases

# Thank You

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## Questions & Comments

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