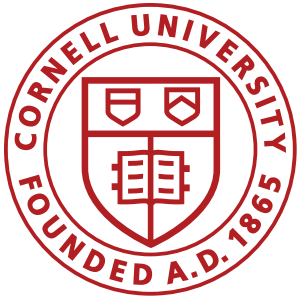

Balancing agency and deliberate practice in lab materials

Emily M. Smith and N. G. Holmes
Laboratory of Atomic and Solid State Physics, Cornell University
Department of Physics, Colorado School of Mines
Partially funded by Cornell University's College of Arts and Sciences Active Learning Initiative

Goal: Teach critical thinking in the context of experimentation

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- Using theory to evaluate instructional materials
  - Comparing E&M lab instructions

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- Also (but not in this talk):
  - Using theory to improve instructional materials
  - Evaluating students' work

Critical thinking: the evidence-based ways through which we make decisions about what to do and what to trust

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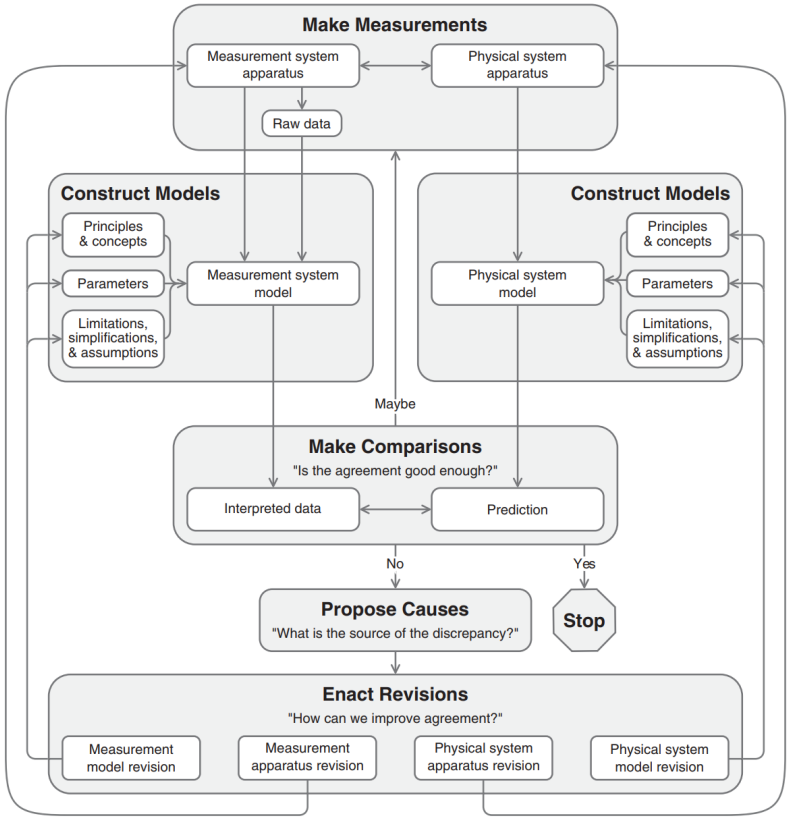
Assumptions about teaching critical thinking:

1. Requires practice of critical thinking skills
2. Is context dependent

Goal: Teach critical thinking in the context of experimentation



Dounas-Frazer et al., Phys. Rev. Phys. Educ. Res. 14, 020118 (2018)

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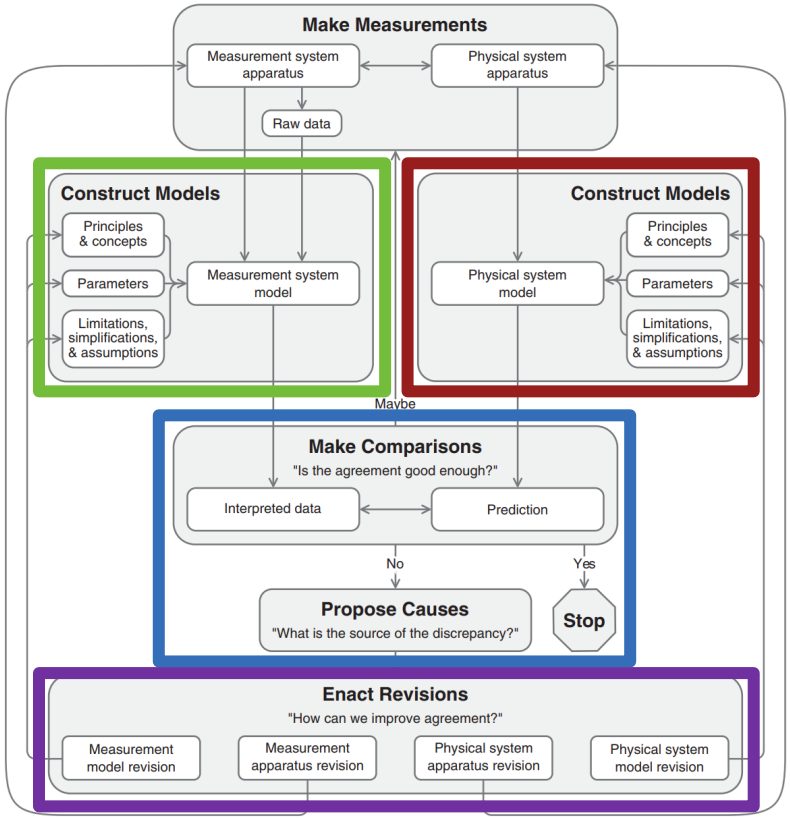

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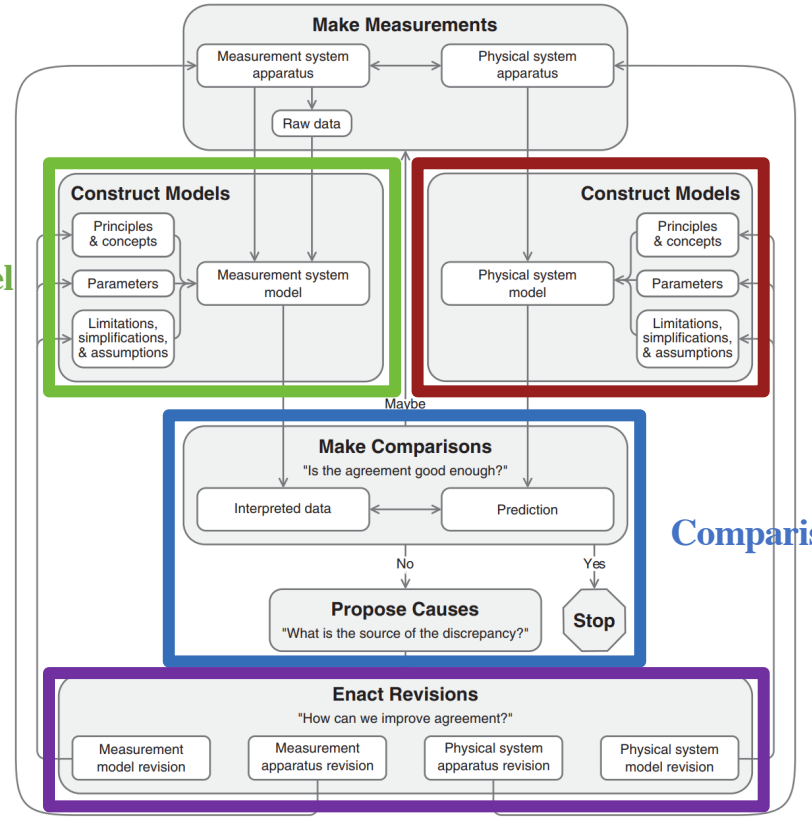

Measurement model

Physical model

Comparisons

Refine

Dounas-Frazer et al., Phys. Rev. Phys. Educ. Res. 14, 020118 (2018)

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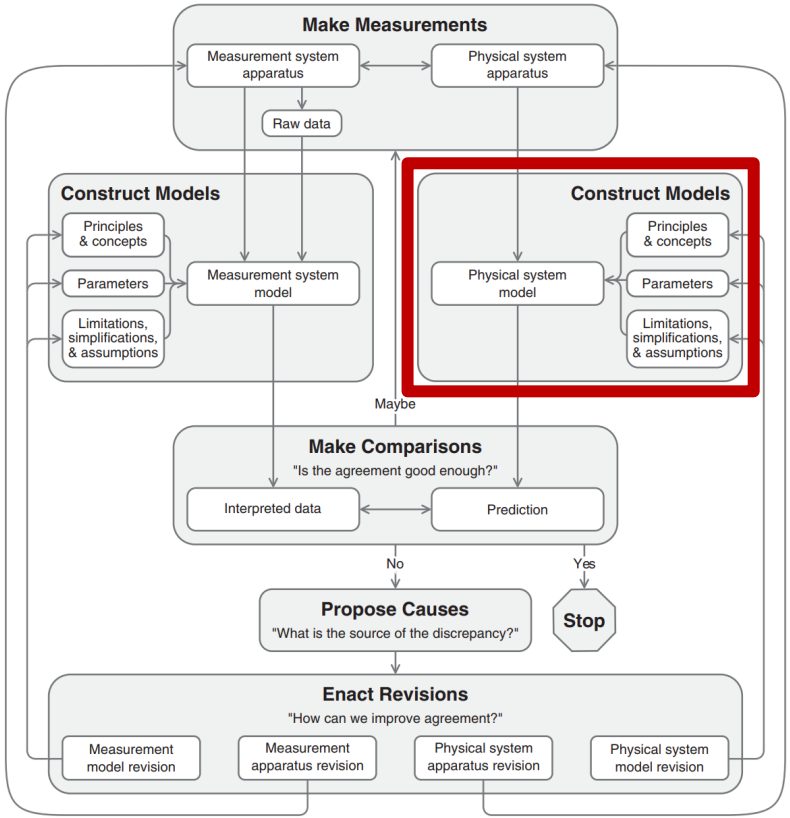


Physical model

- **Design/build physical model**
- **Justify design/build**
- **Predictions**

Dounas-Frazer et al., Phys. Rev. Phys. Educ. Res. 14, 020118 (2018)

Considerations in curricular design

Deliberate practice

Ericsson et al., Psych. Rev. 100, 363 (1993); Ericsson, Cambridge handbook of expertise p. 683 (2006)

Considerations in curricular design

Deliberate practice

Provide practice opportunities: Space for students to make their own decisions to practice critical thinking skills

Considerations in curricular design

Deliberate practice

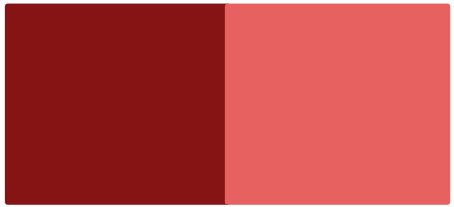
Provide practice opportunities: Space for students to make their own decisions to practice critical thinking skills

Provide feedback: Feedback from multiple sources (e.g., peers, results, instructors)

What could this look like?

Activity 1: Few decisions available for a skill

What could this look like?

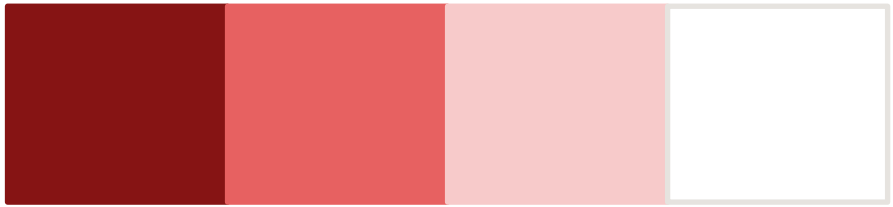


Activity 2: More decisions available but structure remains

What could this look like?

Activity 3: Only hints
for practicing the skill

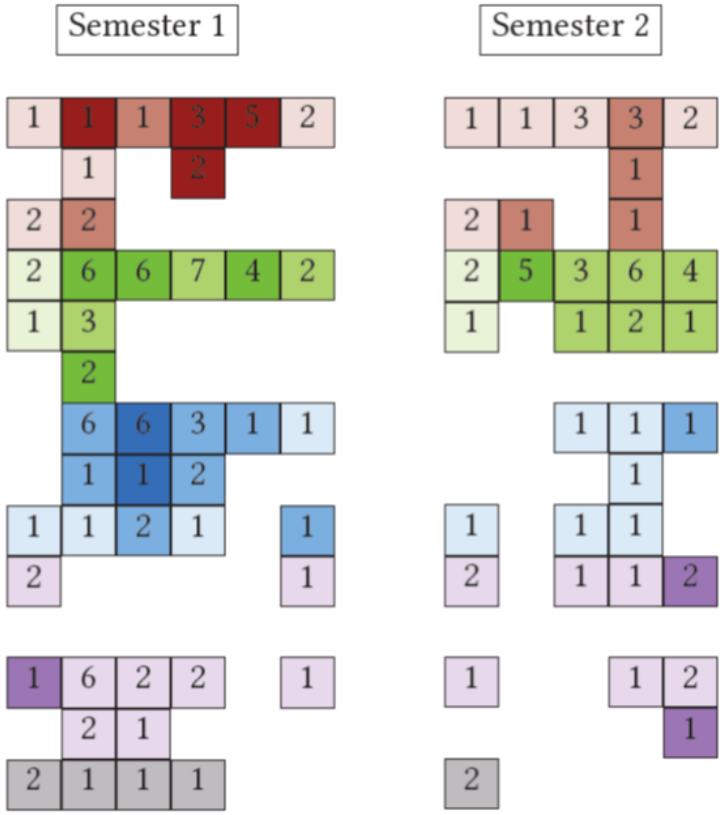
What could this look like?



Activity 4: No cues/hints

Applied to two semesters of E&M labs

Category	Critical thinking skill
Physical	Design/build
	Justify design/build
	Predictions
Measurement	Design/build
	Justify design/build
	Evaluate data
Comparison	Make comparison
	Justify comparison
	Evaluate comparison
Refine	Design refined physical model
	Justify refined physical model
	Design refined measurement
	Justify refined measurement
Cycle	Cycle



Applied to two semesters of E&M labs

Category	Critical thinking skill	Semester 1	Semester 2
Physical	Design/build	1 1 1 3 5 2	1 1 3 3 2
	Justify design/build	1 2	1
	Predictions	2 2	2 1 1
Measurement	Design/build	2 6 6 7 4 2	2 5 5 6 4
	Justify design/build	1 3	1 1 2 1
	Evaluate data	2	
Comparison	Make comparison	6 6 3 1 1	1 1 1
	Justify comparison	1 1 2	1
	Evaluate comparison	1 1 2 1 1	1 1 1
Refine	Design refined physical model	2 1	2 1 1 2
	Justify refined physical model		
	Design refined measurement	1 6 2 2 1	1 1 2
	Justify refined measurement	2 1	1
Cycle	Cycle	2 1 1 1	2

Applied to two semesters of E&M labs

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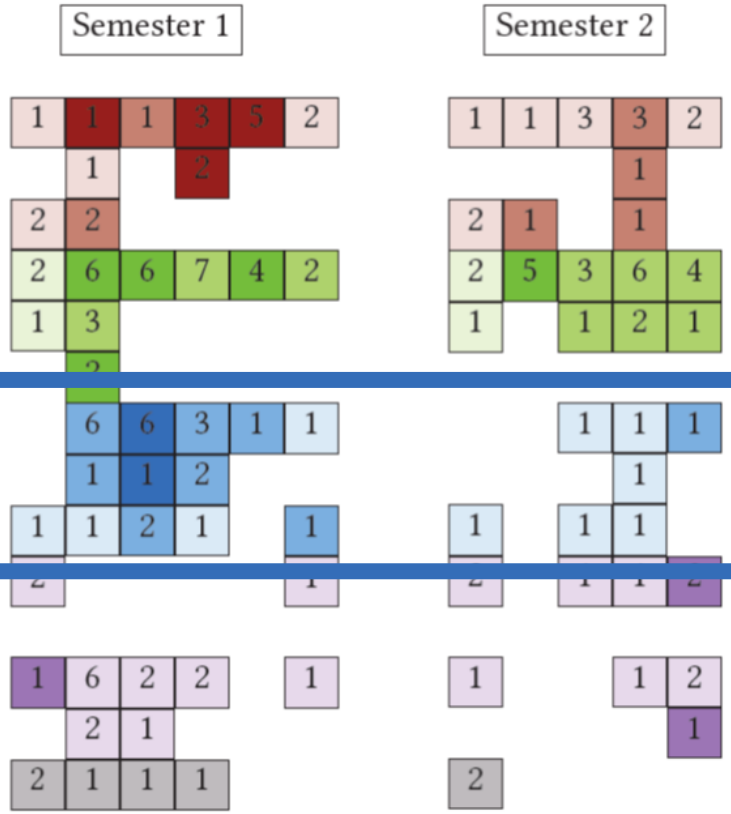

Implications for lab design

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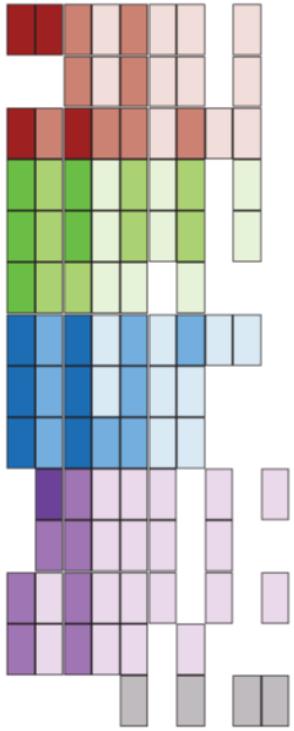

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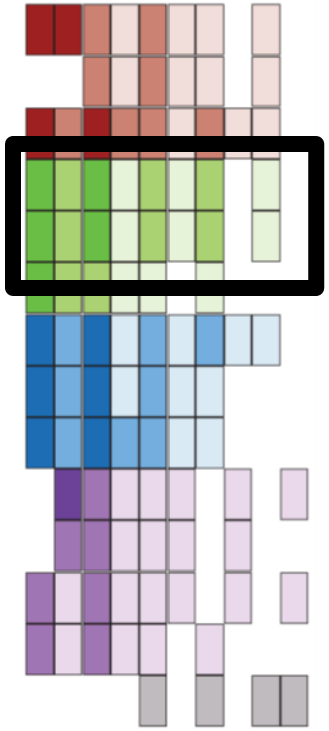

Cycles of agency for each skill

Implications for lab design

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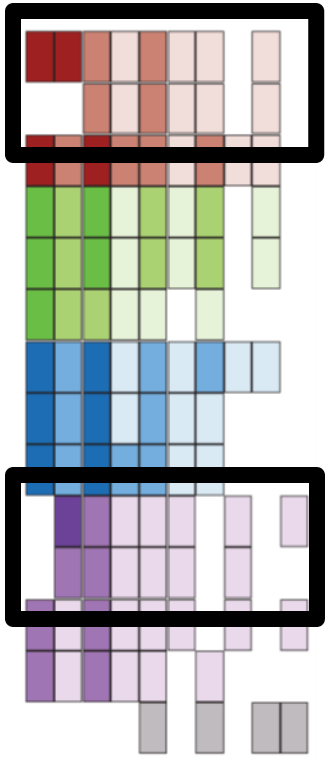
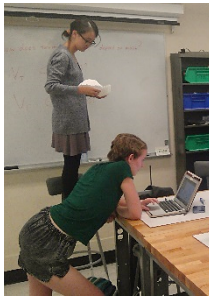


Consideration for cues that build on each other

Additional information

Lab materials available through PhysPort: www.physport.org/curricula/ThinkingCritically/



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