

# Designing an Assessment of Systems Thinking Skills Using the Context of COVID-19

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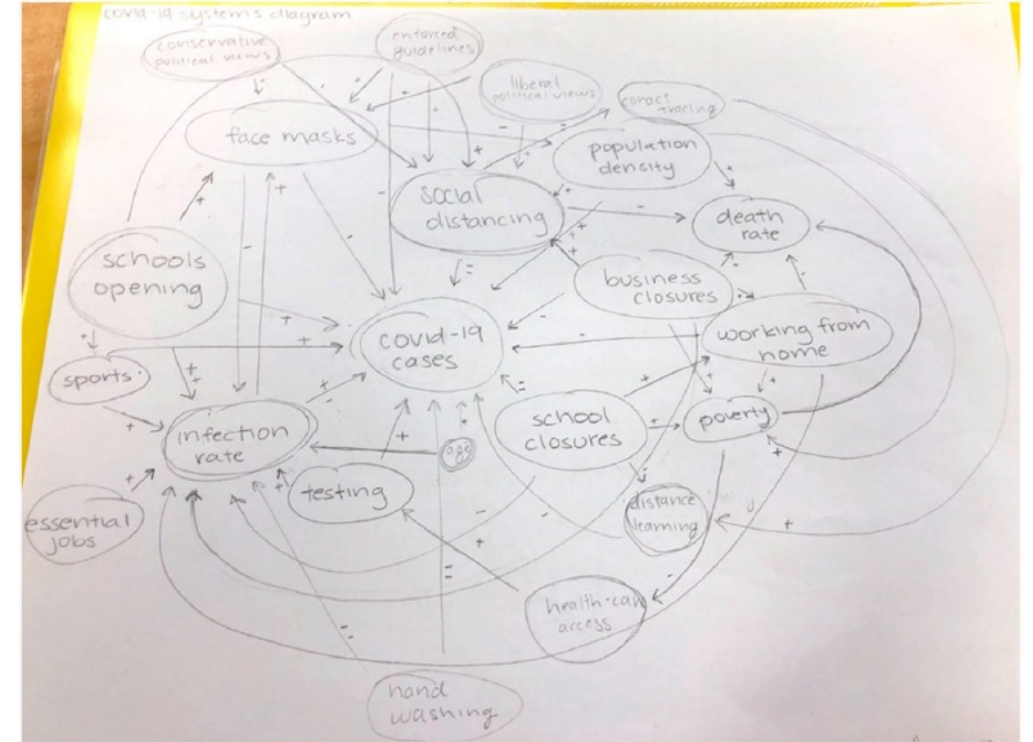
# Introduction: Research Context

- “How do students use multiple models to understand and explain complex socio-scientific issues?”
  - Curriculum and assessment development
  - Professional development
  - Research in multiple schools
- Anchoring phenomenon: Respiratory virus (COVID-19) pandemic

# Introduction: Socio-scientific System Models

Include knowledge from both social and scientific facets of SSI

System models allow students to explore how political, economic, and scientific factors shape the course of the pandemic



# Introduction: Design Motivation

If we want to study the use of socio-scientific system models we need to understand:

- What skills students rely on when representing and interpreting socio-scientific systems
- How skills vary across students and over time
- How this variation manifests in student learning, reasoning, and modeling

We need an assessment that helps us achieve these goals

# Design Considerations

Reveal variation in student abilities

Large scale implementation by teachers

Be adaptable to future pandemic contexts

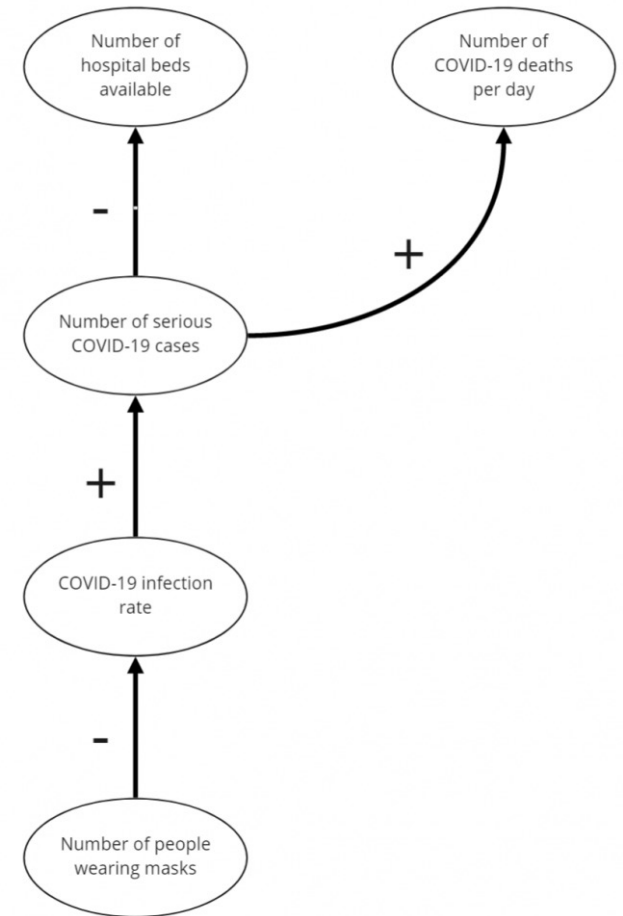
Account for characteristics of socio-scientific systems

Minimize confounding effects of variations in content knowledge

# Sample Item:

Select which of the following options shows a correct cause-effect relationship in this system.

- Number of serious COVID-19 cases (cause) – number of hospital beds available (effect)
- Number of hospital beds available (cause) – number of serious COVID-19 cases (effect)
- Number of COVID-19 deaths per day (cause) – number of serious COVID-19 cases (effect)
- Number of serious COVID-19 cases (cause) – COVID-19 infection rate (effect)



# Challenge: Reveal variation in student abilities

**Design decision:** Assessment Framework (Mehren et al., 2018)

- Emphasizes three skills
  - Identifying system organization (system organization)
  - Identifying behaviors within system (system behavior)
  - Manipulating system to create desired system states (system modeling)
- Three stages of competence



# System Thinking Skills

## System Organization:

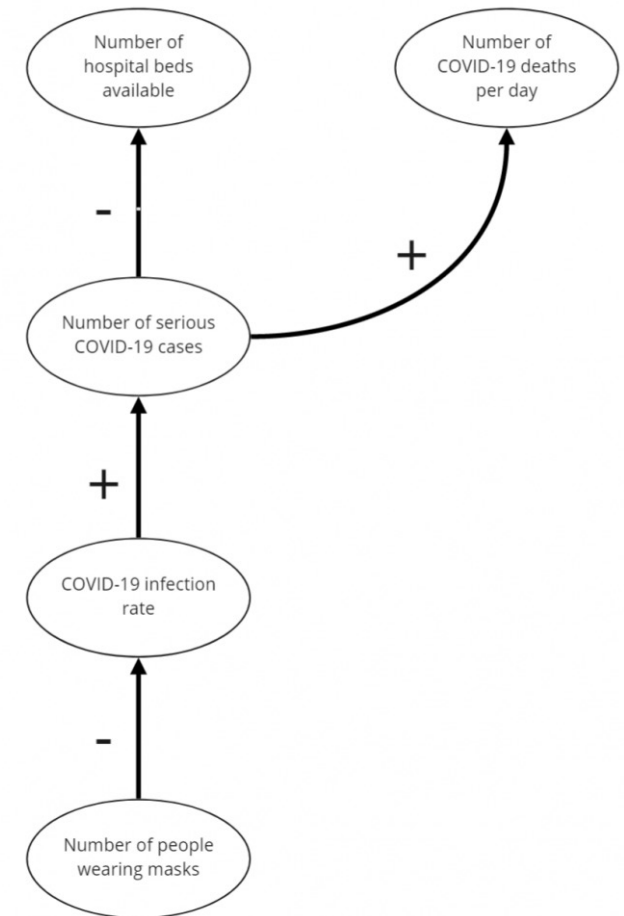
- “Select which of the following options shows a correct cause-effect relationship in this system.”

## System Behavior:

- “Imagine the number of **serious COVID-19 cases** is **increasing**. Select the statement that best describes what will happen to the number of **COVID-19 deaths per day** according to the figure shown.”

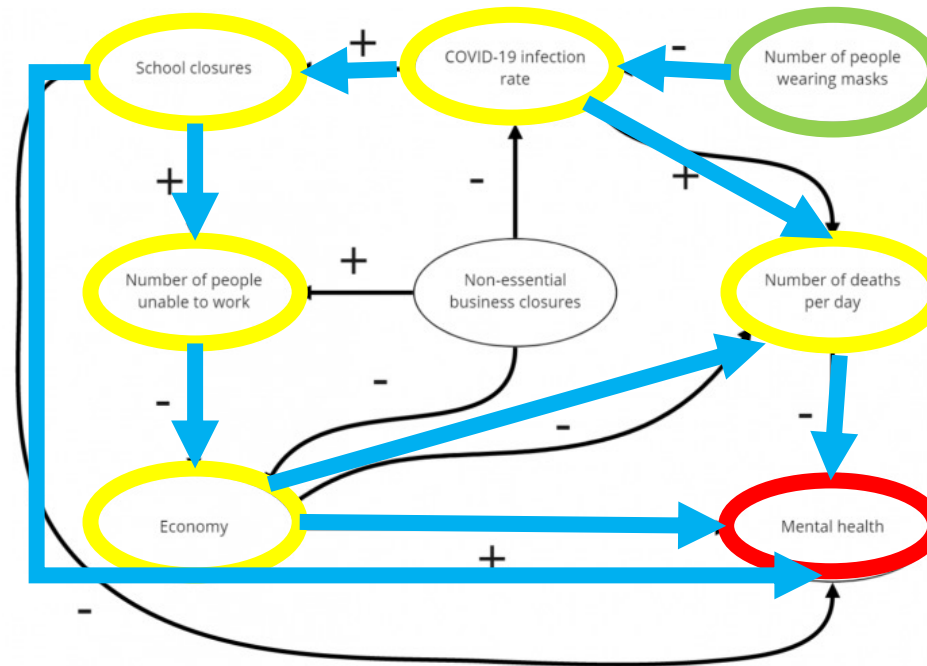
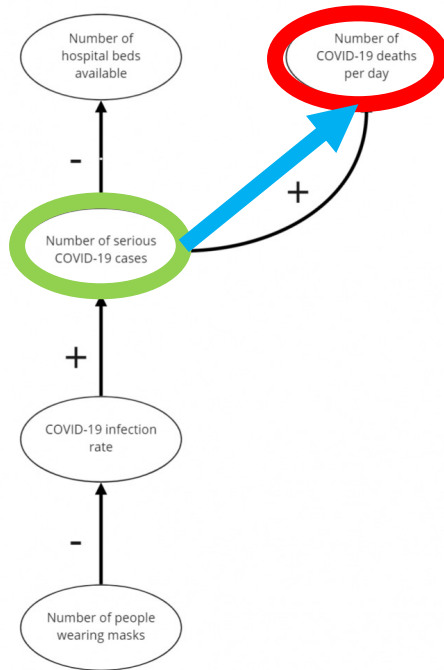
## System Modeling:

- Your goal is to **increase** the **number of hospital beds available**. Using this figure, choose the option that would best accomplish this.



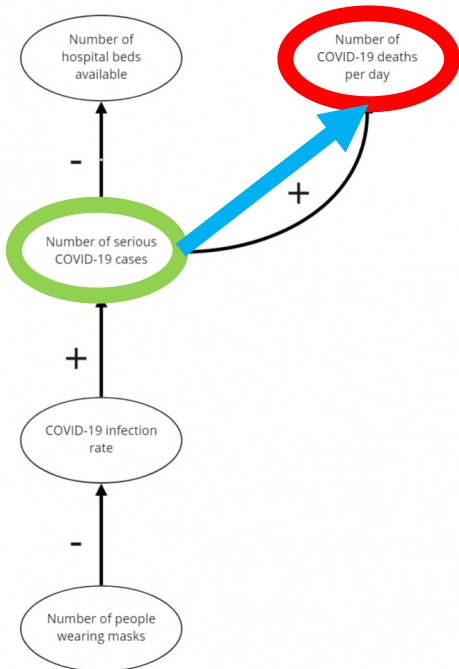
# Challenge: Reveal variation in student abilities

- Students can exhibit three stages of competence in each skill (Mehren et al., 2018)
  - Systems and tasks vary in complexity

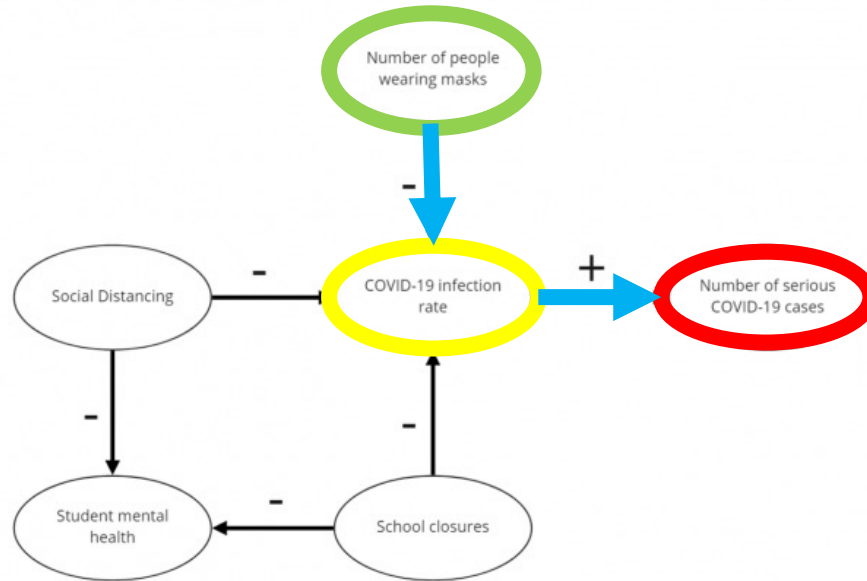


# Stages of Systems Thinking Ability

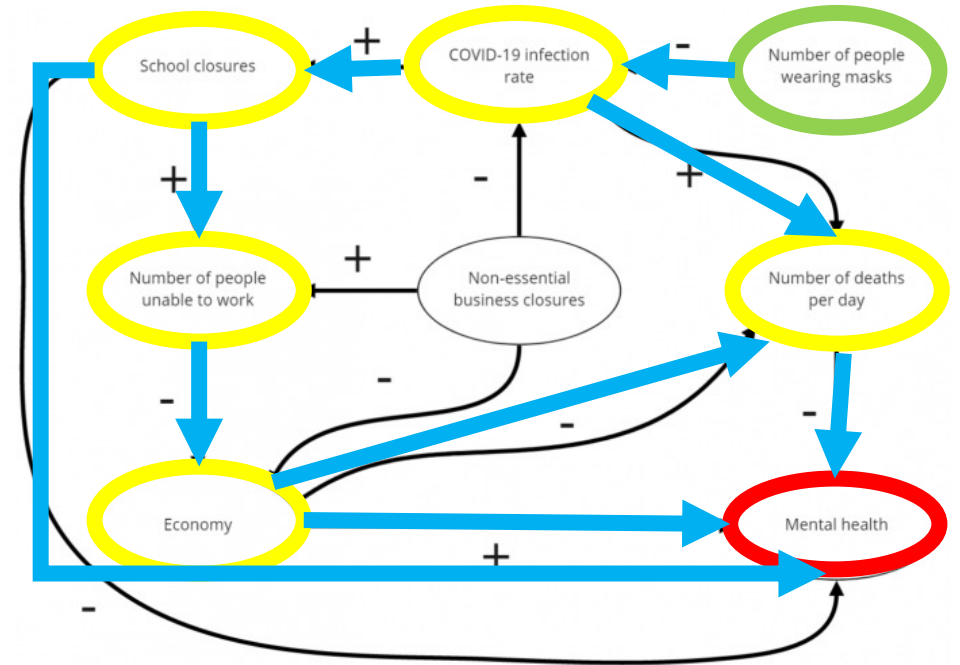
## Stage 1



## Stage 2



## Stage 3



# Challenge: Large scale implementation with partner teachers

## Design decisions:

- Multiple choice assessment
  - Modeled after food web assessment by Mambrey and colleagues (2020)
- <20 multiple choice items
- Delivered through Qualtrics

Protect instructional time

Quick dissemination and collection

Quick analysis

# Challenge: Adaptable to future pandemics

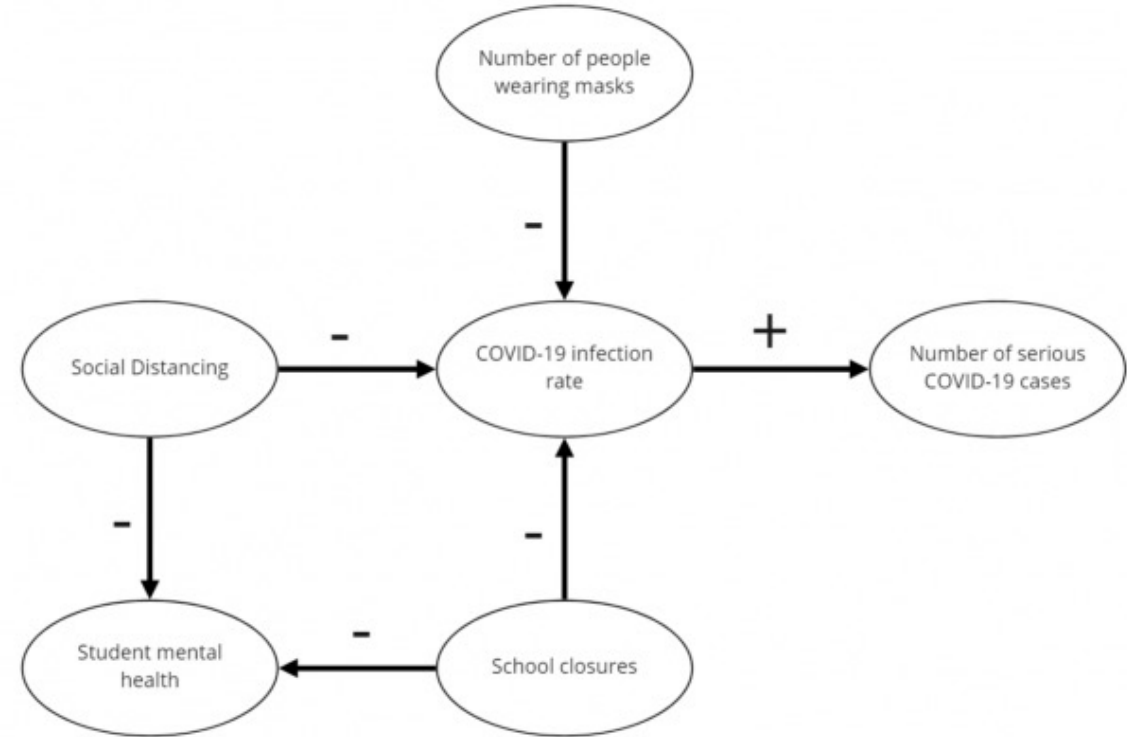
Project aimed at developing materials to teach about respiratory virus pandemics, not COVID-19 specifically

Should be easily adapted to future pandemics so researchers and educators can focus on teaching, not assessment development

# Challenge: Adaptable to future pandemics

Design features:

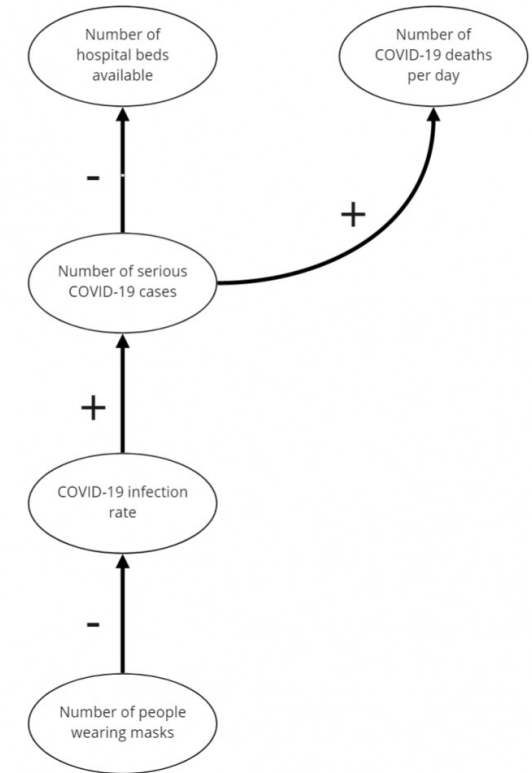
- Domain-general skills
- Focus on factors likely to be present in future pandemic
- Interchangeable surface details



# Challenge: Accounting for complex socio-scientific system relationships

Focusing on causes and effects:

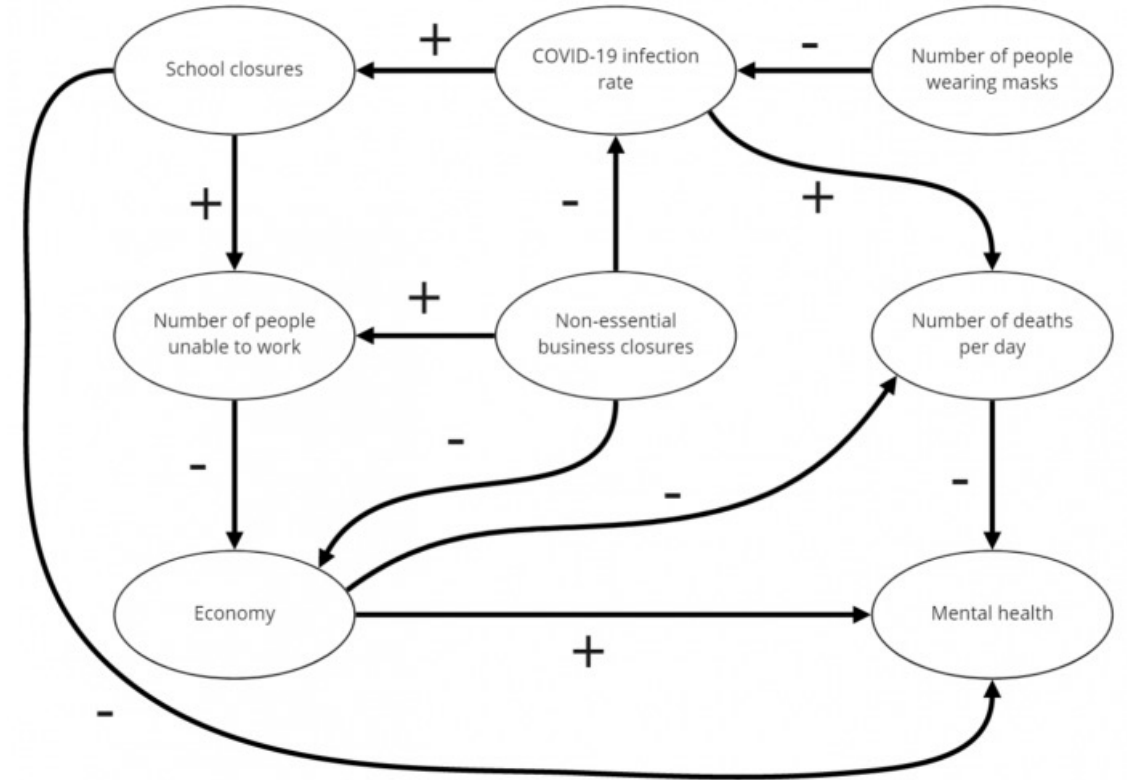
“Select which of the following options shows a correct cause-effect relationship in this system.”



# Challenge: Accounting for complex socio-scientific system relationships

Designing for readability rather than uniform structure

Avoiding overlapping arrows

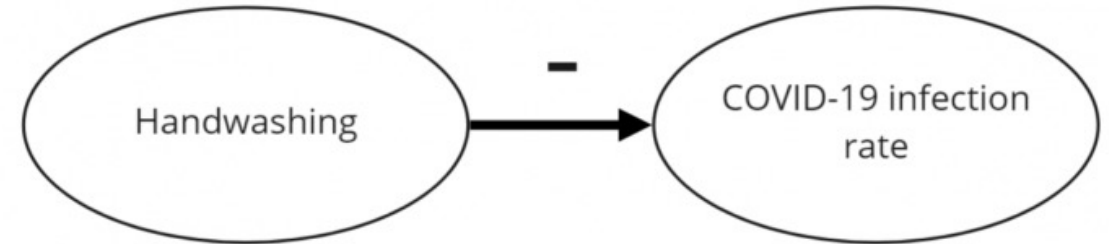




# Challenge: Variations in prior knowledge

Embedded content supports

“A positive relationship means that as one bubble increases or decreases, the second does the same thing. A negative relationship means that as one bubble increases or decreases, the second does the opposite.”



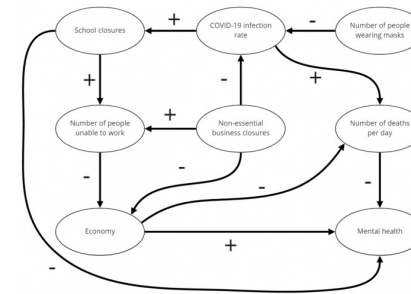
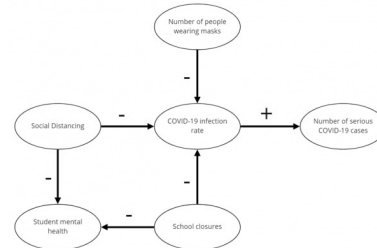
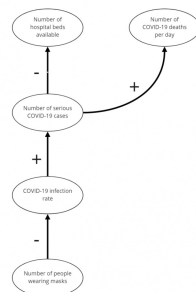
Ask students to rely on information provided, not prior knowledge

“Please answer the following questions based on the maps provided. COVID-19 is a complex issue and there are relationships that are not addressed in every map. Please use **ONLY** the information provided in the map to respond to each question.”

# Final Design

19 multiple-choice, single-select items

Stage 1		Stage 2		Stage 3	
System 1a	System 1b	System 2a	System 2b	System 3a	System 3b
Organization	Organization	Organization	Organization	Organization	Organization
Behavior	Behavior	Behavior	Behavior	Behavior	Behavior
Modeling	Modeling	Modeling	Modeling	Modeling	Modeling (1)
					Modeling (2)



# Pilot Data

Sample: Public high school; Midwest US; N=34

Mean: 13.52

SD: 4.10

Max: 18 (N=4)

Min: 5 (N=4)

Cronbach's  $\alpha$ : 0.85

Item difficulty\*: 0.48-0.91

Average Item Difficulty				
	Organization	Behavior	Modeling	Mean
Stage 1	0.833	0.864	0.848	0.848
Stage 2	0.788	0.727	0.773	0.763
Stage 3	0.712	0.667	0.606	0.662
Mean	0.778	0.753	0.742	

# Pilot Takeaways

Assessment behaved as hoped

- Stages were progressively more difficult
- Variation between scores was satisfactory
- Good internal consistency

One potentially problematic item

No logistical concerns

## Future directions

Collect think-aloud data on potentially problematic item

Large scale rollout

Pairing assessment data with observations and student products

# Limitations

## Multiple-choice assessment

- Supplementing with observations and work samples

Systems don't portray temporal features of systems, probabilistic nature of systems, magnitude of relationships, etc.

- Introduce confounding variables (e.g., math skills)
- Extend duration of test

Unsure of content support efficacy

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Ideas expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.



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