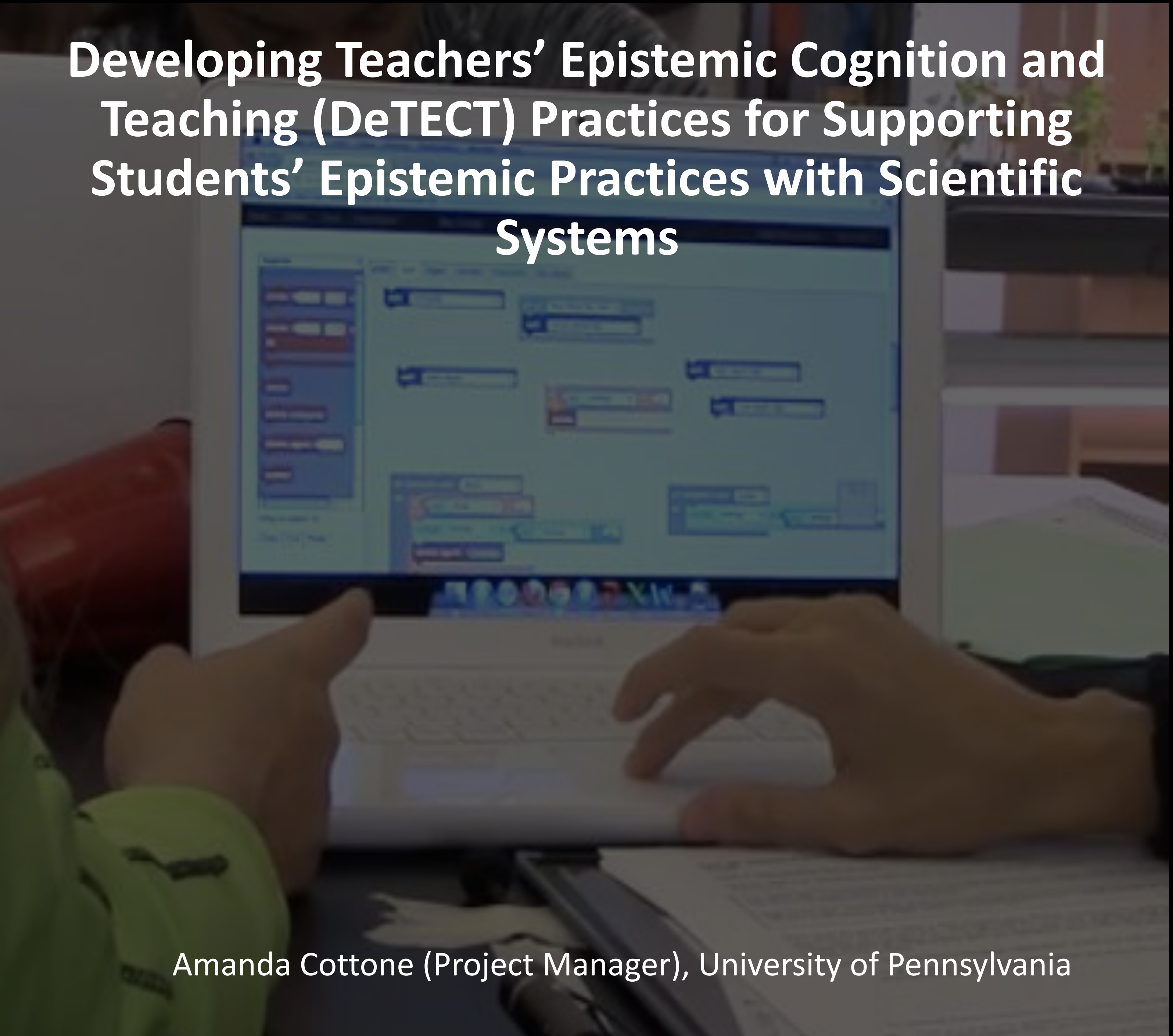
Developing Teachers' Epistemic Cognition and Teaching (DeTECT) Practices for Supporting Students' Epistemic Practices with Scientific Systems



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Overview: DeTECT builds on another current DRK-12 project entitled *BioGraph* 2.0. We focus on investigating the needs and challenges in developing an informed public able to evaluate empirical evidence generated from scientific activities. This includes understanding teachers' and students' epistemic practices and how to provide professional development (PD) to improve instruction. The resulting instruction will offer new affordances to advance teaching and learning of complex scientific models.

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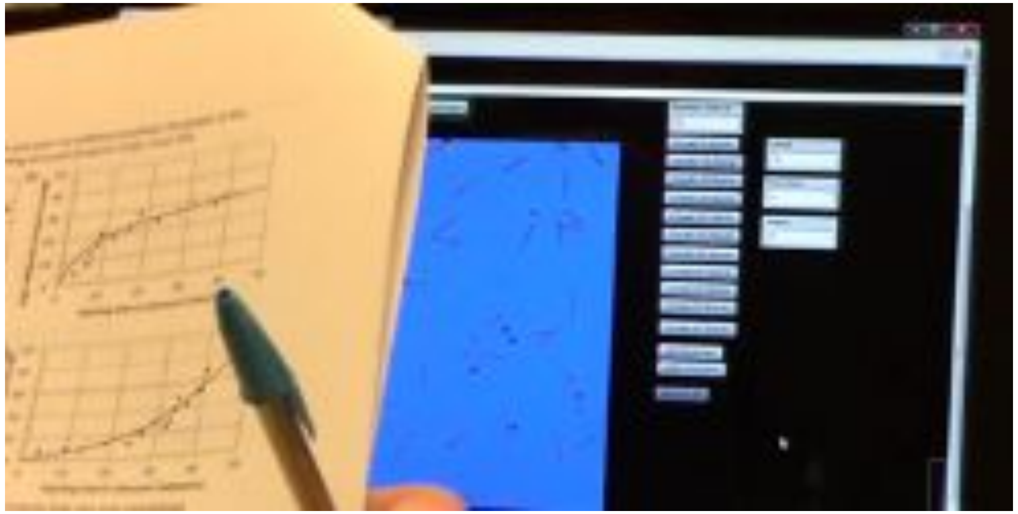
What Are Epistemic Practices?

- Epistemic practices (EPs) are what people do as they are developing knowledge within a particular domain
- General examples of EPs from Barzilai & Chinn, 2018 include:
    - Routinely checking the accuracy of information
    - Checking whether conclusions fit the evidence and not just one's prior expectations
    - Corroborating reports using multiple sources, on the basis of knowing that news can reflect reporters' biases



Above a student working with a BioGraph model compares the graphs on their worksheet to data from running the simulation

How We Can Study and Promote Epistemic Practices: Apt-AIR Framework

***AIR Model + 5 Aspects of Engagement* = Apt-AIR framework**

AIR Model

(from Chinn et al., 2014)

- **Aims** are the specific goals related to an inquiry process
- **Ideals** comprise the criteria that people use to evaluate whether their aims have been successful
- **Reliable processes** denote the strategies that people use to achieve their aims and enact ideals

Multifaceted Framework

(building on Barzilai & Zohar, 2014)

- **Cognitive engagement in epistemic performance**
- **Adapting epistemic performance**
- **Regulating and understanding epistemic performance**
- **Caring about and enjoying epistemic performance**
- **Participating in epistemic performance together with others**

Hypotheses and Research Goals

HYPOTHESES:

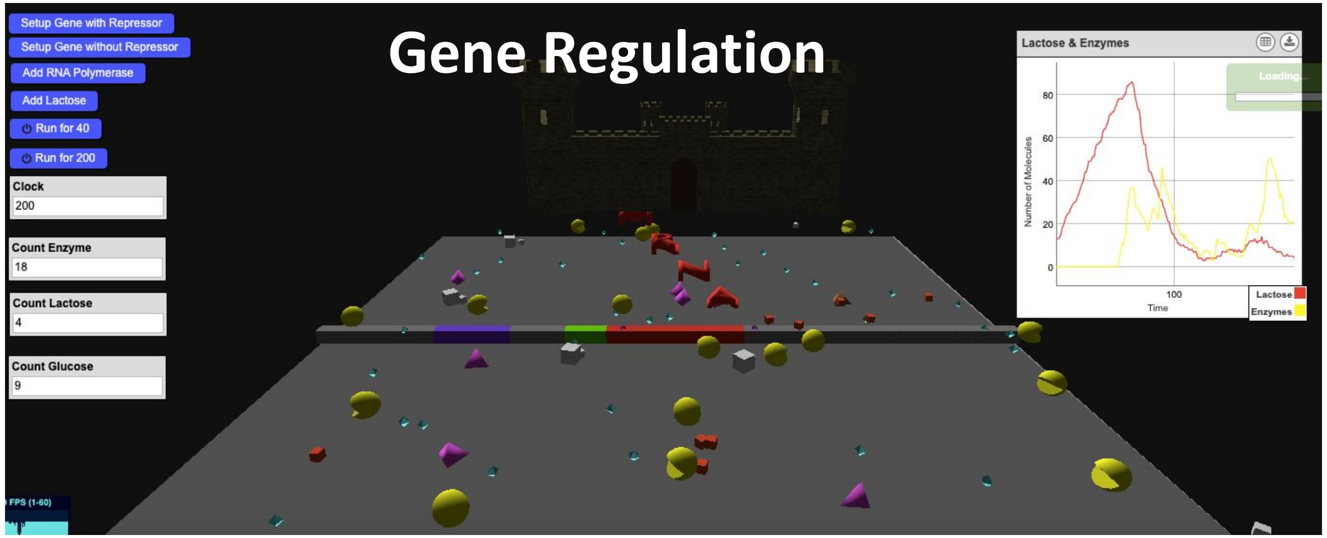
- We postulate that Apt-AIR framework will provide teachers with a conceptual frame that enables them to grasp critical aspects of epistemic practices in model. This understanding will, in turn, support both their own epistemic performance and their understanding of how to structure and orchestrate instruction in ways that effectively support their students' epistemic growth. The ultimate outcome will be improvement in students' own epistemic performance, mediated by the improvements in instruction.

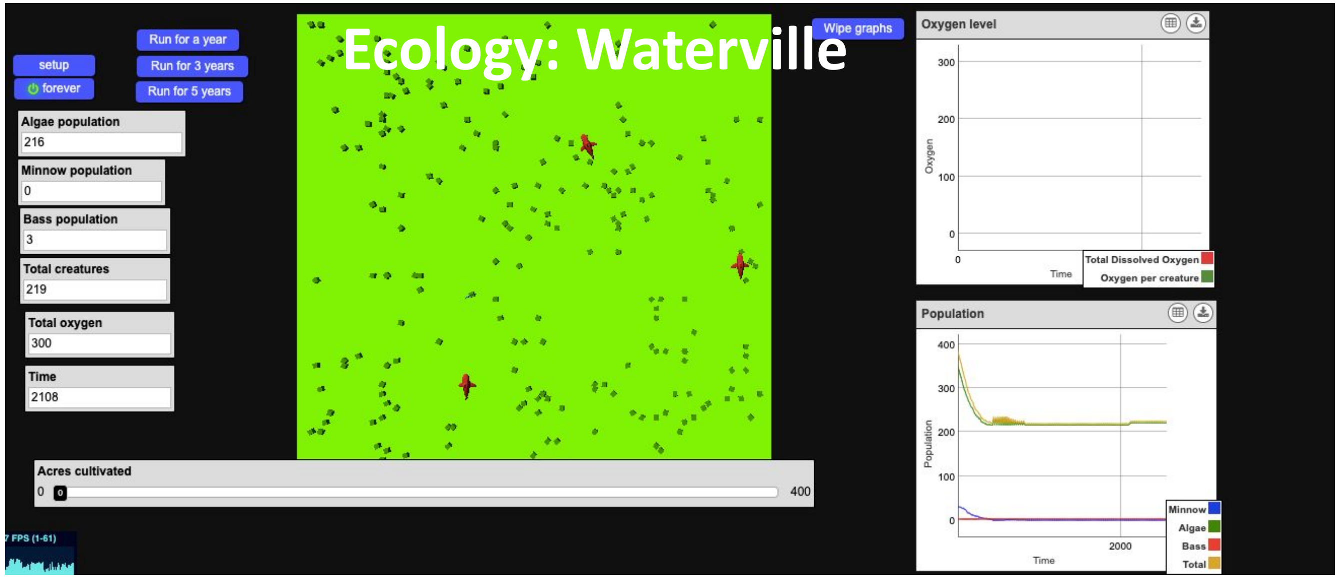
RESEARCH GOALS:

- Understanding how and in what ways the PD (built around the Apt-AIR framework) is effective in supporting increased changes in teachers' epistemic practices and instruction within the BioGraph curricula.

- Identifying contextual variables that afford or constrain instruction toward the research goals.

How Do We Apply Apt-AIR? BioGraph: StarLogo Nova Modeling of Complex Systems





Above are two examples of the BioGraph modeling interfaces

- BioGraph is a curriculum that models complex systems in genetics, ecology, sugar transport, evolution, and enzyme kinetics
- The curricular units include multiple data representations
- Students work through this curriculum to learn about the science content and the complex systems processes involved
- For more information on BioGraph see [Yoon et al. 2017]

Context

- DeTECT began September 2020
- Target population: High school biology teachers and students
  - Cohort 1: n=8 teachers from 8 different schools along the east coast (PA, NJ, MA and SC)
  - All teachers previously completed the BioGraph MOOC
  - Currently collecting data with their students (n = ~40) in order to evaluate the "baseline" level of epistemic performance during BioGraph lessons
- Early-stage/exploratory research bridging theory and practice (IES & NSF, 2013)
- In process of developing 1st iteration of the virtual PD workshop (to occur over two weeks beginning in Aug 2021 with Cohort 1)

Context: Virtual PD Workshop Activity Examples

1. What are epistemic practices? → Read current articles and discuss how teachers use EPs in their classrooms

2. Why are epistemic practices important? → Connect to post-truth world issues

3. Analyzing epistemic practices of previous BioGraph classroom footage to determine what students are and are not already doing from regular BioGraph instruction →

Conduct Interactional Analysis with teachers

4. Modifying BioGraph curricular units to reflect better epistemic practice instruction → Embed epistemic callouts in the teacher guides help promote students' epistemic practices

Research and Intervention Timeline

Sept 2020- Jul 2021

Video-taping in BioGraph classrooms to examine how teachers support the development of epistemic performance with high school students in science through modeling and argumentation

Assessment of this support using the Apt-AIR model; determination of strengths, gaps and apparent challenges in teachers' ability to support epistemic performance

Aug 2021

Inservice with BioGraph teachers on developing epistemic performance

Co-design between BioGraph teachers and DeTECT researchers to construct activities and modules for PD on developing epistemic performance

Sept 2021- Jun 2022

Classroom implementation of epistemic performance activities and modules

Documentation of implementation issues by teachers and researchers that examines classroom practices in relation to PD content and supports needed

Revision of PD and reimplementation with another cohort of teachers

Aug 2022 --->

Using a Design-based Implementation Research approach, repeat and revise the PD/implementation cycle as necessary moving forward

Construction of online module for addition to the BioGraph MOOC for broader dissemination

Preliminary Results and Products: Coding and Identification of OEPs

- Interactional analysis (IA) conducted on previously video-taped BioGraph lessons from 2013 (COVID pivot)
  - IRR obtained with two external raters (Cronbach's alpha = 0.90) on 11 codes related to epistemic ideals and reliable processes

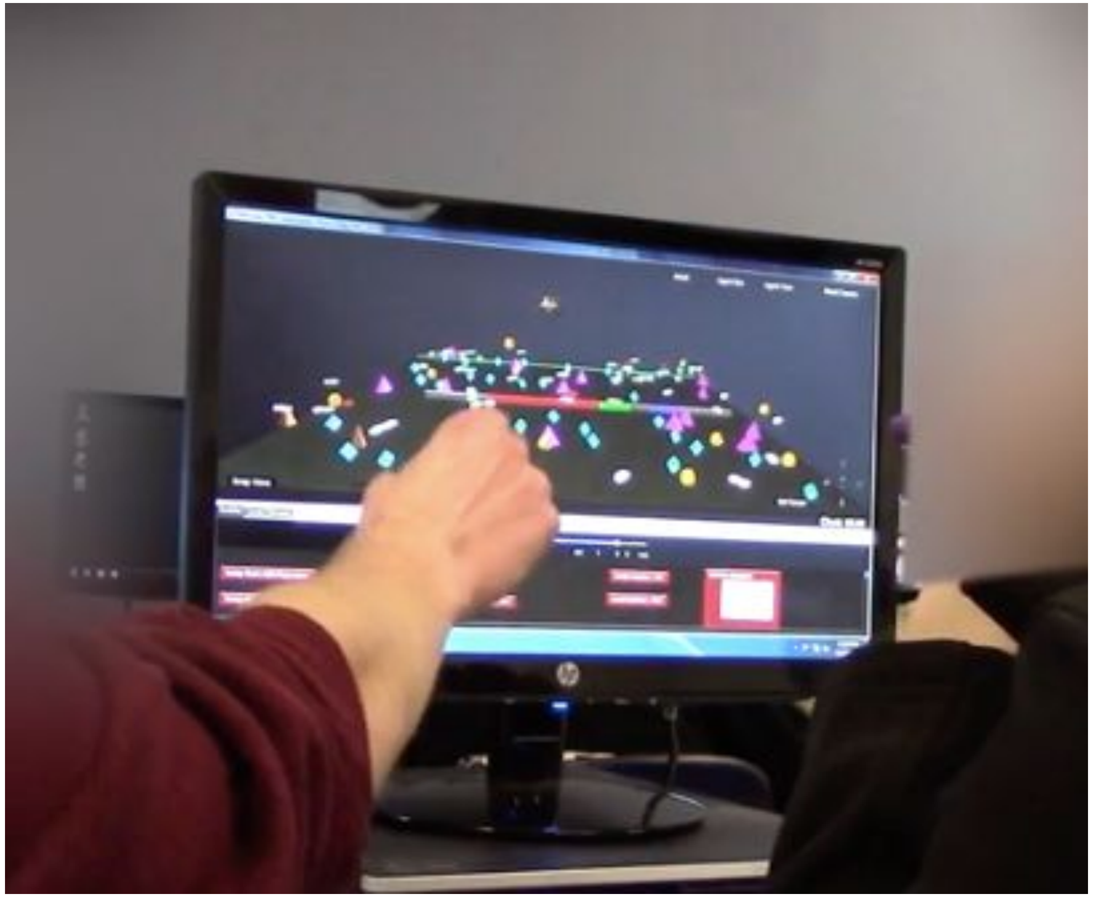
- Optimal Epistemic Practices (OEPs) for students identified from IA (examples on right)
  - These will be presented, further evaluated and revised with teachers in PD this summer
  - Will also be used to frame BioGraph lesson modifications for promoting apt epistemic performance (e.g., in the form of apt epistemic callout prompts within the teacher guides)

Ideal 1: Fit with averaged evidence from contrasts.	
Reliable processes to promote	Less reliable processes that may appear
PREDICTION	
Make predictions about contrastive patterns produced by simulations	Make predictions about single simulation outcomes.
RUNNING EXPERIMENTS TO ESTABLISH PATTERN, RECORD PATTERNS	
Plan series of experiments	Run single simulation trial.
Describe trends on average	Describe trends of single runs only.
Run multiple simulations to establish average phenomena under the same starting conditions.	Run single simulations with any set of starting conditions.
Run simulations contrasting different starting conditions to establish contrastive phenomena	Run single simulations. Run incomplete sets of experiments.
EVALUATION/MODEL REVISION	
Evaluate phenomena against predictions.	Evaluate outcomes of single runs against predictions.
Revise explanatory models when there are small or large discrepancies.	Revise explanatory models when there are large discrepancies.

Above represents a sample of the optimal epistemic practices that emerged from IA of pairs of students engaging in various BioGraph curricula.

Preliminary Results and Products: Research Protocols and Student Learning Outcomes

- Developing all the research protocols that will assess shifts in student learning, teacher learning, and instructional practices related to epistemic performance
- Conducting reflective focus groups with students to understand the epistemic practices they use when using the BioGraph models (i.e., evaluate students' baseline, or pre-intervention, epistemic performance)
  - For example, we ask students:
    - *What do you think are characteristics of good scientific models?*
    - *Think about when you are working through a scientific argument with another person, what are ways in which you interact in the discussion that can help you both develop good scientific explanations?*



Above two students are running the Gene Regulation BioGraph model.

Preliminary Results and Products: Student Learning

- Current BioGraph students already exhibit many of the more sophisticated epistemic practices we had identified:

  "One very important thing in science is going to be building off of other scientific research that's already been done. By doing these [claim, evidence, reasoning] questions, we're able to do this research ourselves and learn about how to use other people's studies that they've conducted to create our own." –Nigel, 9th grade, 12 May 2021

  "*Sharing and comparing evidence, because sometimes you can look at the same data and come across two completely different points and say,* 'Hey, I got this,' *and someone else can say,* 'Yeah, I got that too, but I interpreted it as this instead.' *When you collaborate like that, it can open your perspective to different possible arguments*." –Emma, 9th grade, 12 May 2021

Implications

- In a post-truth world need to closely examine and emphasize apt epistemic performance in education, current instruction has not focused sufficiently on this (Chinn et al., 2020)
- In addition, links between specific instructional designs and how they can lead to successful epistemic performance when learning science is not well understood (Metz, 2011; Sandoval, 2014)
- We aim for our work in DeTECT to provide a model for how to approach designing curricula that can promote the goals of an epistemic education

Above a student points to the number of sugar molecules produced after running an experiment in the Enzyme Kinetics BioGraph model.

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