InquirySpace 2

Discovery Research PreK-12 PI Meeting

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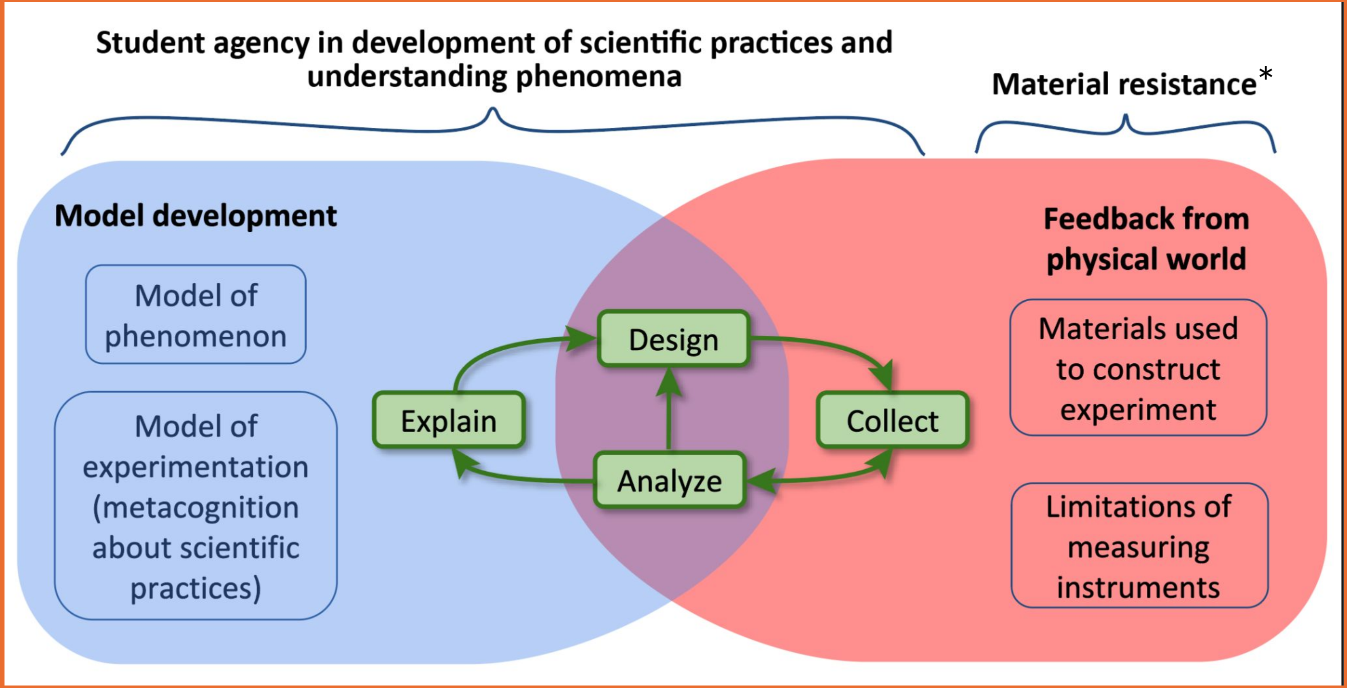
Overview of the InquirySpace project

The **goal** of InquirySpace is to introduce independent experimentation into high school science courses — in other words, to have students ***learn science by doing science***. In a span of four to six weeks across a semester, students are introduced to NGSS science practices, particularly Planning and Carrying Out Investigations, Analyzing and Interpreting Data, and Constructing Explanations and Designing Solutions. They use sensors — including CO_2, pressure, temperature, and motion — to investigate phenomena and CODAP (Common Online Data Analysis Platform) to analyze and visualize data.

InquirySpace Framework

Inquiry arises from an interplay between internal models and feedback students receive from the physical world, as students engage in a non-linear cycle of exploration of phenomena. For instance, when students design their experiments, they are influenced by the materials and by their internal models, of both the phenomenon and of scientific experimentation.



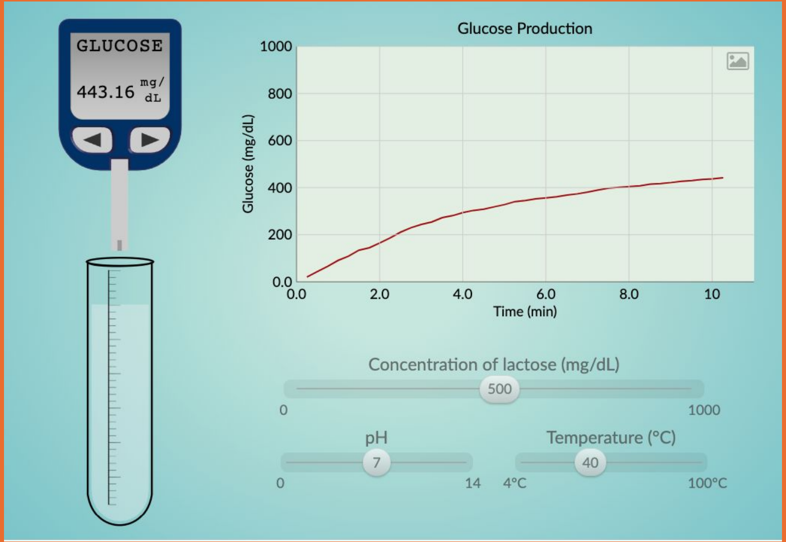
*Pickering, A. (1995). *The mangle of practice: Time, agency, and science.* University of Chicago Press.

Context of the Work

Students should learn science by doing science:

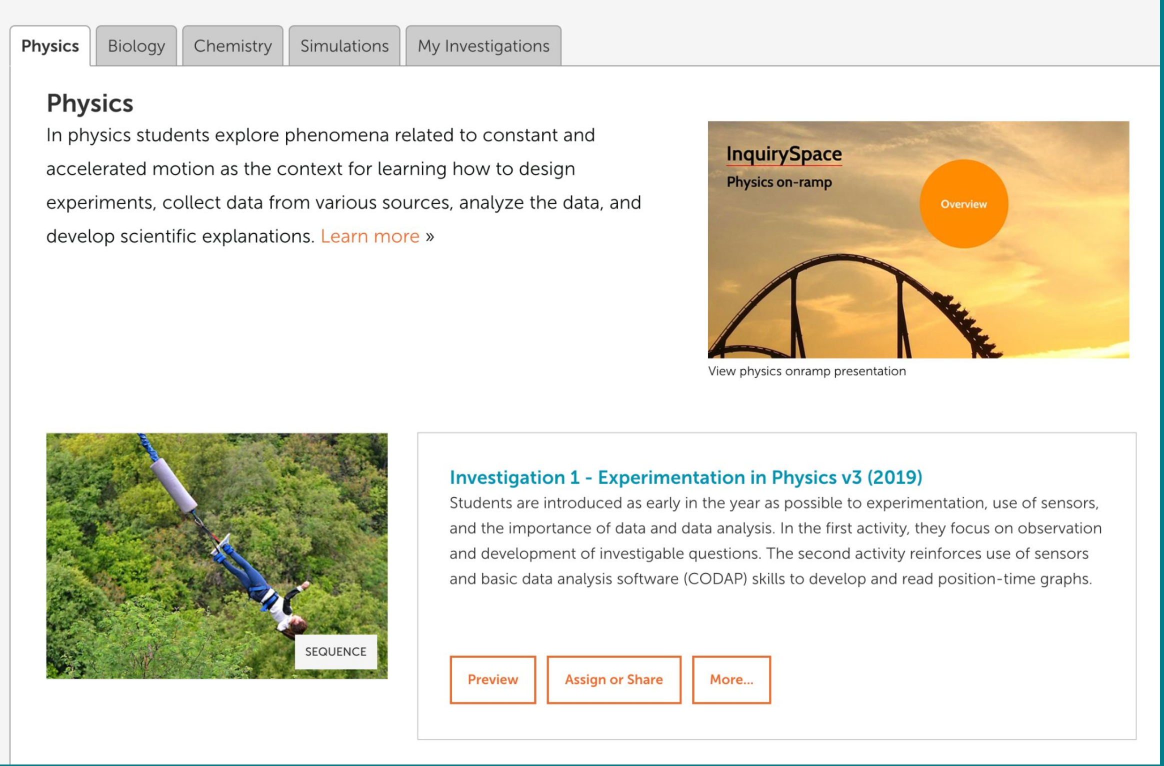
- NGSS-aligned activities
- Real-time data collection
- Sensors and simulations
- Open-ended experiments
- Collaborative inquiry
- Physics, biology & chemistry available

Students use our Common Online Data Analysis Platform (CODAP) to analyze the results of their experiments.



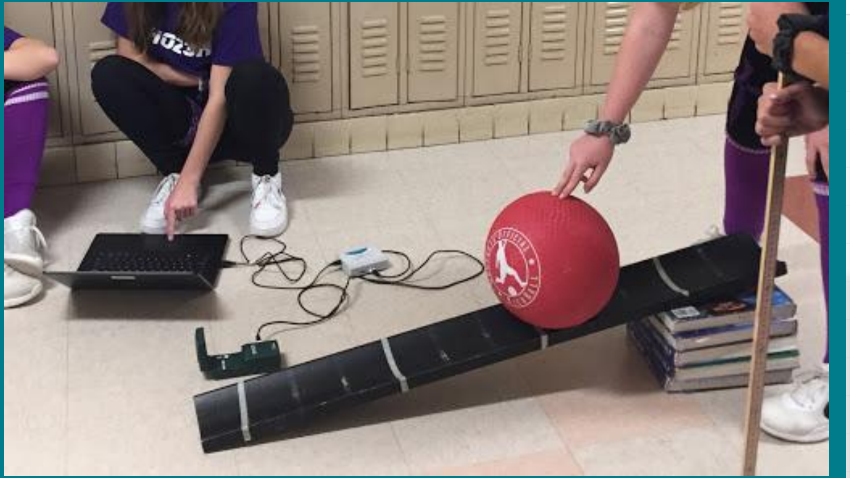
Students explore phenomena via both hands-on lab activities and simulations of those experiments.

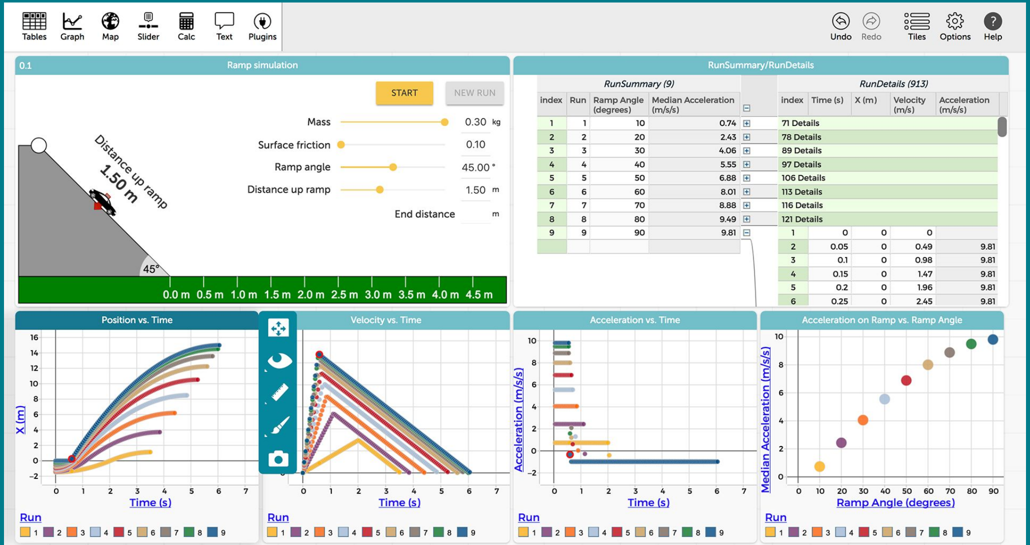
Products: Curriculum



To support these classroom practices, we collaborated with teachers to produce inquiry materials in high school physics, biology, and chemistry. The set of NGSS-aligned investigations for each discipline is designed to introduce and scaffold engagement in science practices and build an understanding of the interplay between experimental design, data collection, analysis, and explanation.

Products: Sensors and Simulations





Here students quickly generate large amounts of data using a simulation, helping to develop analytical techniques that can then be applied to a related challenge they were given to predict time and position of a moving object given a range of possible conditions.

Products: Teacher Support

The curriculum design team incorporates suggestions and feedback from practicing teachers who use the InquirySpace approach. Thirteen teachers from four states spent four days in an in-person workshop in 2019.

During the COVID year, we took our professional learning community online. We held an online workshop and monthly meetups, as well as individual support sessions for each cohort member.

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Research Questions

Student Learning

- What does independent inquiry entail?
- How does the development of independent inquiry differ by teacher support, subject area, and task complexity?

Teacher Support

- What teacher facilitation can support student learning of independent inquiry?

IS2 Impact

- Does the IS2 approach help students learn knowledge needed to carry out inquiry?
- To what extent, for whom, and under what contexts is the IS2 approach useful?

Teaching Barriers

- What are the barriers to implementing the IS2 approach?
- How and to what extent do teachers implement the IS2 materials?

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Researching inquiry at multiple levels

1. Using curriculum-supported student inquiry to accommodate student-initiated engagements with micro-inquiries
2. Redefining “data analysis" to produce evidence for the curriculum-supported inquiry as well as to inspect the quality of data through technical troubleshooting for micro-inquiries
3. Understanding how physical vs. virtual materials enhance, limit, or complement inquiries at micro, curriculum, and class levels
4. Understanding how the nature of inquiry gradually changes from troubleshooting inquiry at the micro-level to investigation inquiry at the curriculum-level to class consensus inquiry at the macro level

Teacher framing of simulation-based experiments

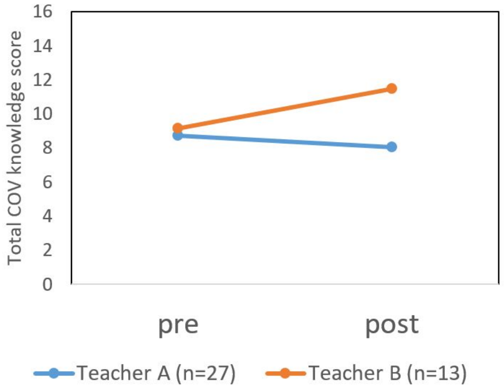
Teacher A

- Content centric
- Classwide inquiry centric
  - Each student group focuses on one independent variable only
  - Collect results and discuss

Teacher B

- Experimentation centric
- Small group inquiry centric
  - Play with it first
  - Determine what to investigate
  - And then take really good data

	Teacher A	Teacher B
No. of experimentation sequences	44	24
Single variable Control of Variables (COV)	25%	13%
Single variable COV + exploration	23%	29%
Multiple single variable COVs + exploration	7%	42%
Exploration only (no COV)	45%	17%



Teacher B's students ended up more productively employing COV with simulations and gained significantly more experimentation design knowledge, $p < 0.05$.

Making the scientific experimentation construct *inclusive across*, rather than *exclusive within*:

Experimental design using independent, dependent, and controlled variables.

Data collection related to measurements, error sources, outlier treatments, and examining data quality and comparability based on means and variations.

Data analysis involving time-series graphs, tables, independent-dependent variables graphs to identify and explain the patterns.

Rasch Partial Credit Model (PCM) analysis of 312 high school physics students' response sets to a 25-item instrument confirmed the presence of **a single underlying construct across experiment design, data collection, and data analysis with a Cronbach alpha value of 0.86**

Broadening access to inquiry

One IS2 physics class with 20 students, 11 of whom were on individualized plans, has a Special Education co-teacher who designed accommodations to the curriculum that broadens access. Her approach is described in this NSTA *Science Teacher* article.


Accessible Physics for All

Providing equity of access for high school physics with extended experimentation and data analysis

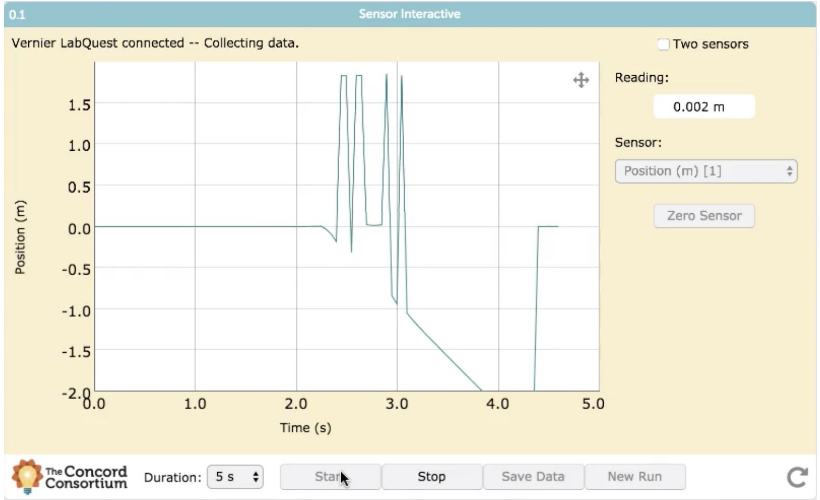
SARAH HAAVIND AND MICHELLE MURTHA

54 | The Science Teacher | JULY/AUGUST 2020

Qualitative video analysis

5 small groups engaged in physics and biology investigations

- Analyzed one small group per class.
- Active scientific reasoning about data occurred in all the groups.
- This reasoning did not necessarily take place after "good data" was collected.
- Often took place when data was anomalous:
    - No change when change was expected,
    - Change when no change was expected.
- Often happened when troubleshooting setups. This triggered some of the most sophisticated and creative reasoning — students trying to decide what was "good" vs "bad" data and what was causing unexpected patterns in the sensor data.



Students decided the jagged lines were "bad data"

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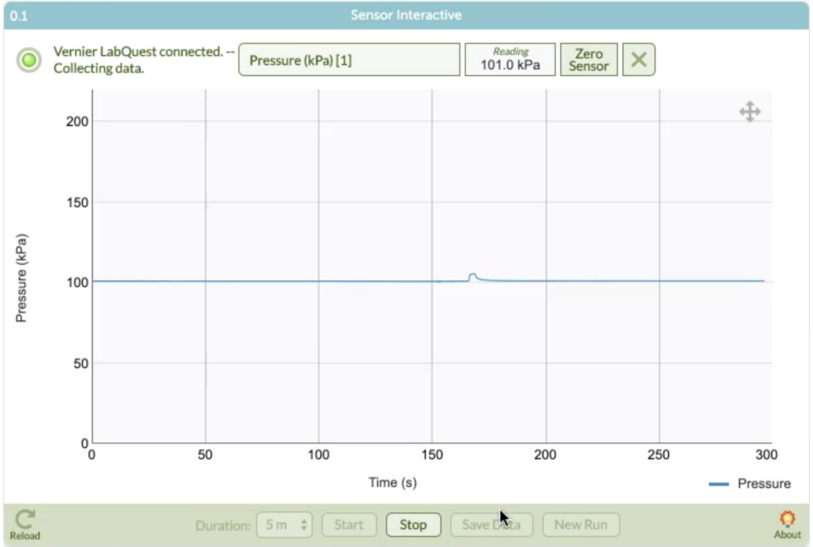
Implications and suggestions for future research

- Teachers need ways to scaffold students to deal with "no change."
  - What are meanings of horizontal line in sensor data? (Sensor not working? No relationship? Graph needs re-scaling?)
- Teachers and students did not recognize the importance of sense-making discussions students engaged in when troubleshooting setups.
  - How do we help teachers reframe this process as a productive engagement in scientific practices?
  - How do we help students make this learning (developing strategies to determine what data to accept) more concrete and transferable?



Students understood the bump--someone bumped the sensor--but not the straight line. (Graph needed rescaling.)

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To learn more:

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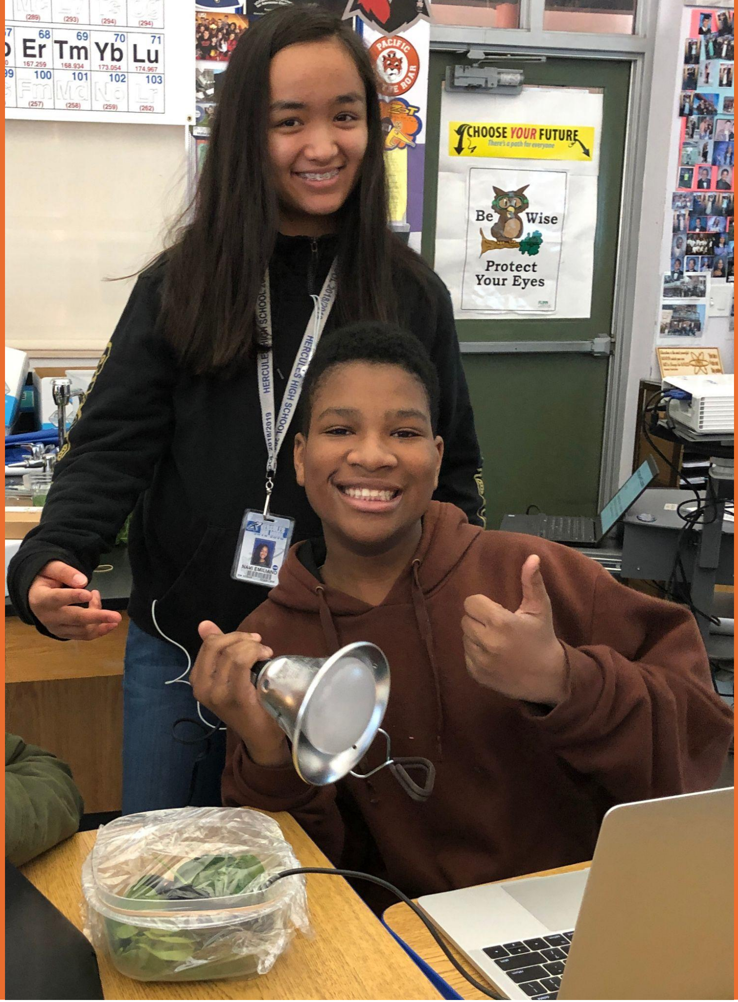

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