# Professional Development Supports for Teaching Bioinformatics through Mobile Learning

2021 DRK-12 PI Meeting Poster

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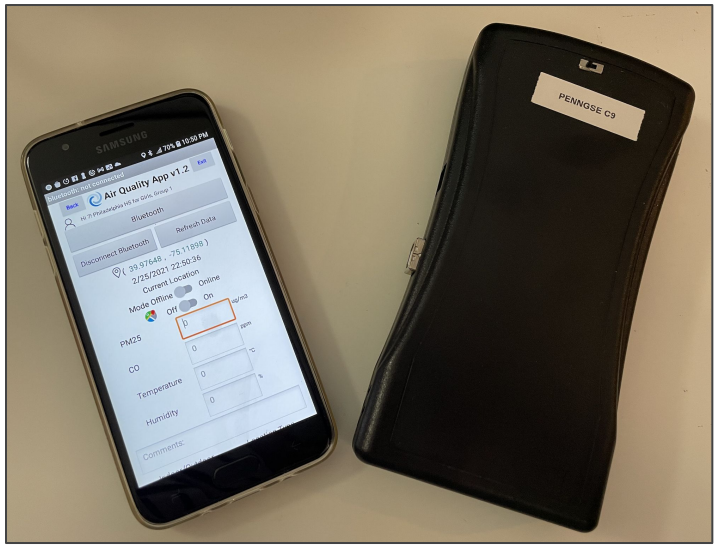
## Overview

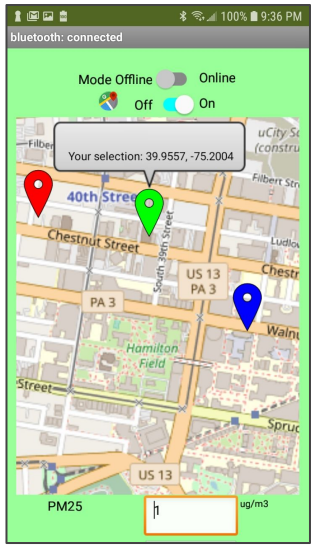
In this an Early Stage Design and Development study where we are co-constructing and field testing multidisciplinary high school units organized around bioinformatics concepts, data literacy, and mobile learning. The overarching goal of the project is to help create an engaged population of informatics-informed students who are capable of critically analyzing information and able to solve local problems related to their health and well-being.

https://youtu.be/AEwLVtvV-CQ

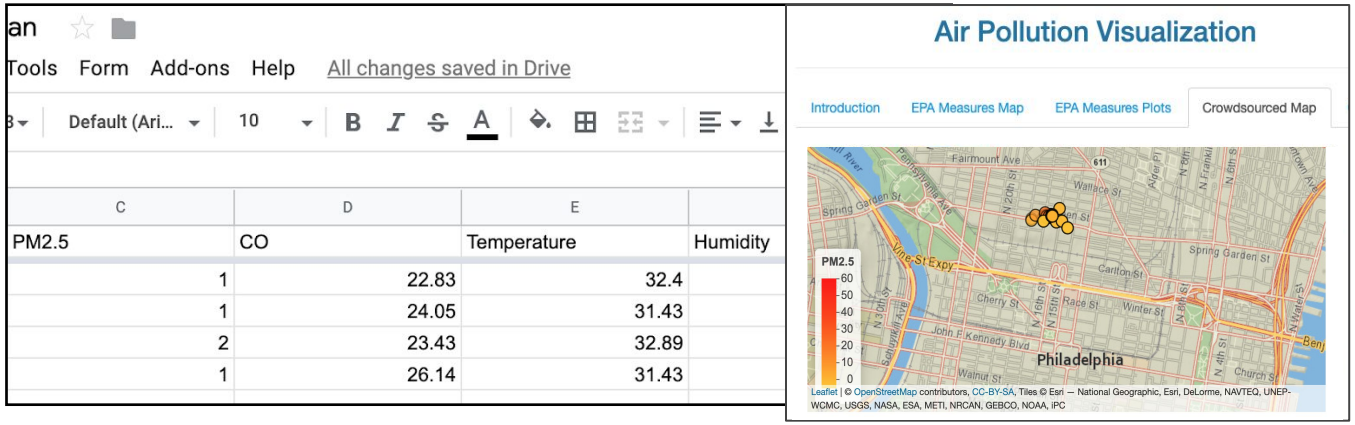
Teacher Interview (1’ 37)

# Central Curricula Activities

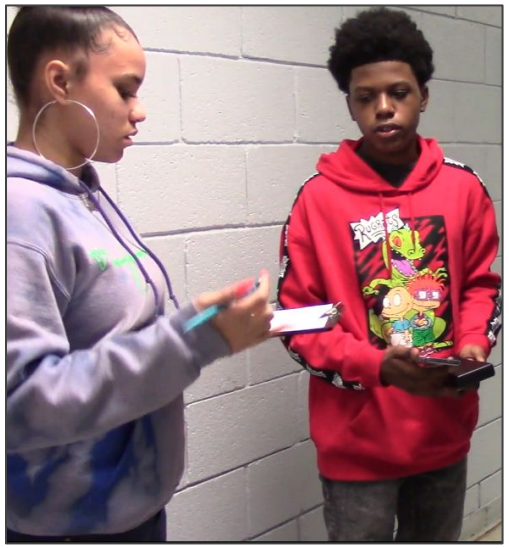


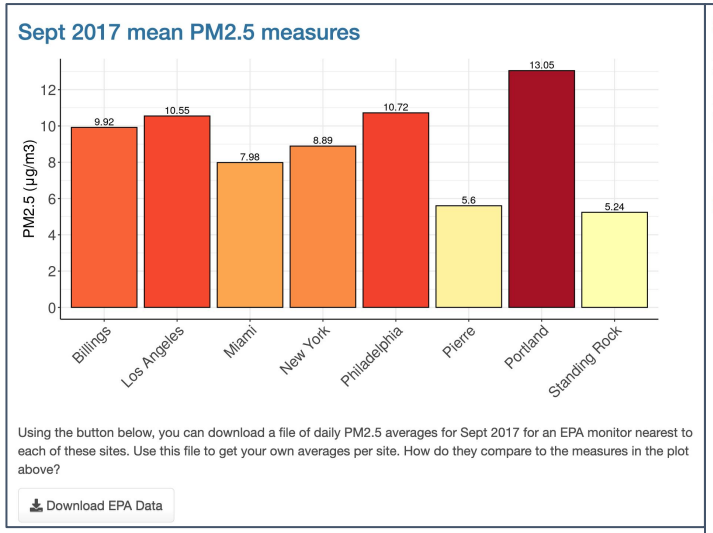

Air quality data collection sensor and mobile phone app interface

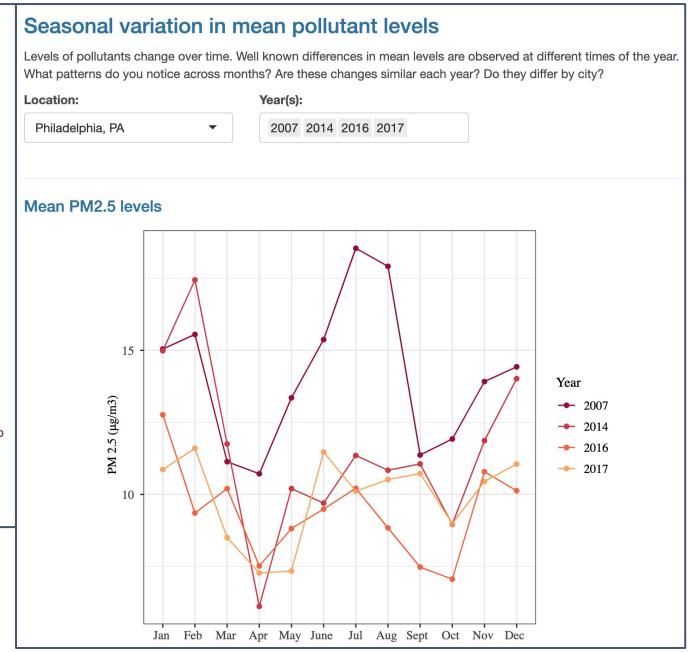



Screenshots of collected air quality data and crowdsourced data visualization tools on project website (k12bioinformatics.org)



Students collecting indoor and outdoor air quality data




Screenshots of sample data visualization tools used for comparison with EPA data

# Goals and Research Objectives

**Needs**

- High quality science teacher professional development and science education
- More integration of bioinformatics units in high school courses
- More inclusive STEM programs for underrepresented populations

**Bioinformatics**

- An interdisciplinary field that combines aspects of computer science, mathematics, and statistics to collect, store, manage, analyze, and interpret biological data

**Data Literacy**

- Ability to understand, use, manage, and communicate data for multiple purposes (Gebre, 2018)

**Research Objectives (Slide 3)**

***#1:*** PD to develop teachers' instruction in:
a) core bioinformatics competencies
b) data literacy
c) mobile learning

***#2:*** Work with teachers to co-construct a bioinformatics unit for high school students

***#3:*** Collect data on classroom instructional challenges and the influencing factors including teachers' content knowledge and skills, and population and school level variables

***#4:*** Collect data on student learning and participation outcomes in a) core bioinformatics competencies; b) data literacy; and c) mobile learning

Gebre, E. H. (2018). Young adults' understanding and use of data: Insights for fostering secondary school students' data literacy. *Canadian Journal of Science, Mathematics and Technology Education*, *18*(4), 330–341.

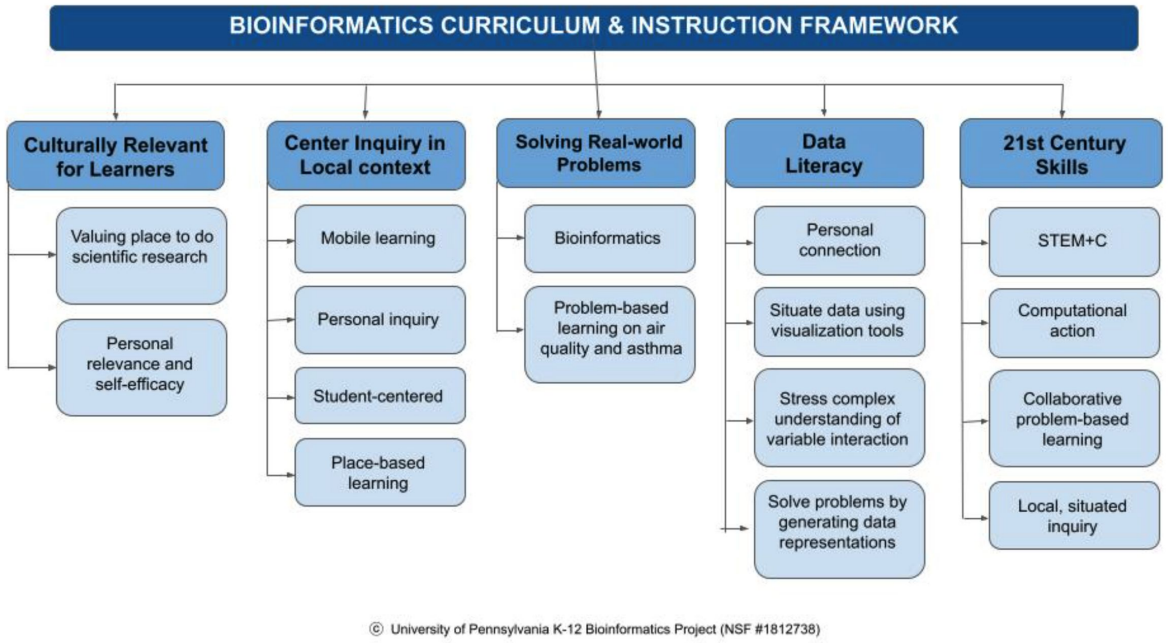
# Theoretical Frameworks

## Best practices in teacher professional development

1) Focus on **disciplinary content**, both the concepts and pedagogies;
2) Addressing how teachers learn through **active learning** and sense-making;
3) Enabling **collaboration** among teachers;
4) Using **models** of effective instruction;
5) Offering coaching and **expert support**;
6) Dedicated time for **feedback** and **reflection** on practice; and
7) **Sustained duration** of PD participation.

***Darling-Hammond, L., Hyler, M. E. & Gardner, M. (2017), *Effective Teacher Professional Development*. Learning Policy Institute.

## Theoretical foundations of the curriculum and instruction framework



# Professional Development Implementation: Year 1

**Year 1 (2019-2020)**

- 3 week **in-person** summer PD workshop
- 3 Biology and 3 Environmental Science Teachers
- School Demographics
  - Science proficiency: Range = 2% - 100%; Mean = 38%
  - Ethnicity (% Minority): Range = 61% - 98%; Mean = 82%
  - Income (Free or reduced lunch): Range = 98% - 100%

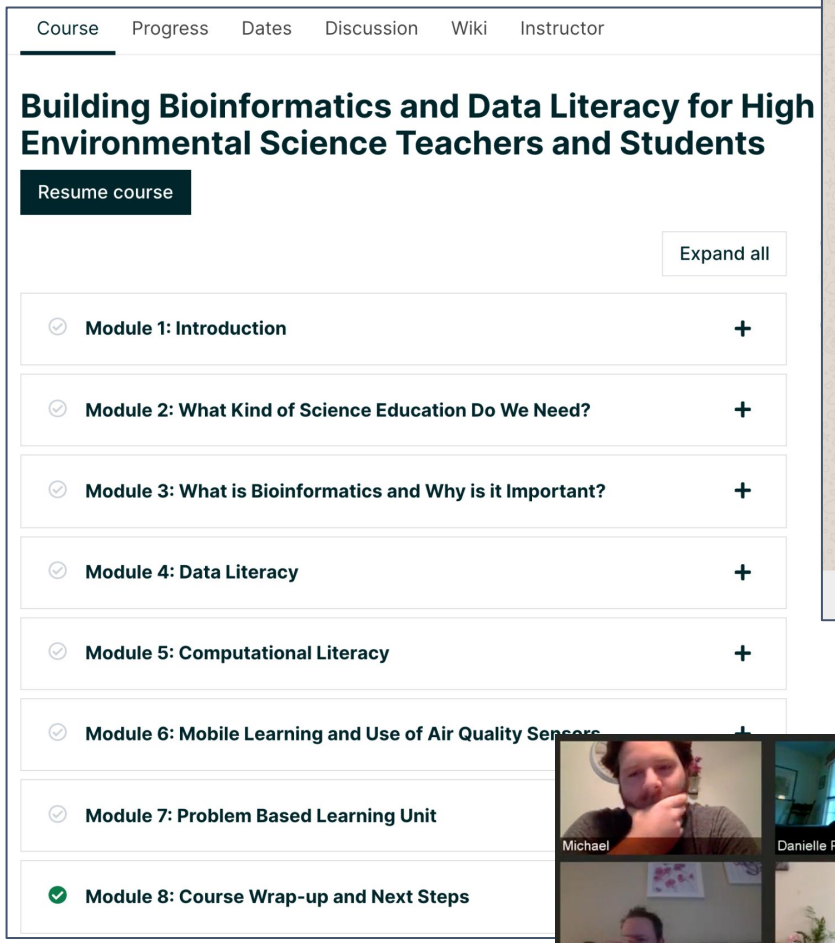

| Week | Details of PD Activities |
|---|---|
| 1 | Comprised instruction in the various components with a majority of time devoted to working with teachers on bioinformatics, data literacy, and mobile learning content and pedagogical content knowledge. |
| 2 | Required teachers to sample portions of the research team constructed PBL unit; to work together in small teams to make detailed lessons plans with adaptations for their local populations; and to plan how to integrate these activities into their standard curriculum. |
| 3 | Asked teachers to pilot core lessons with a small set of high school students. In addition to requiring teachers to collaborate, we included PD designs that met all the requirements for effective PD as outlined by Darling-Hammond et al. (2017). For example, we dedicated time for discussion and reflection on how project activities would be carried out in practice. |

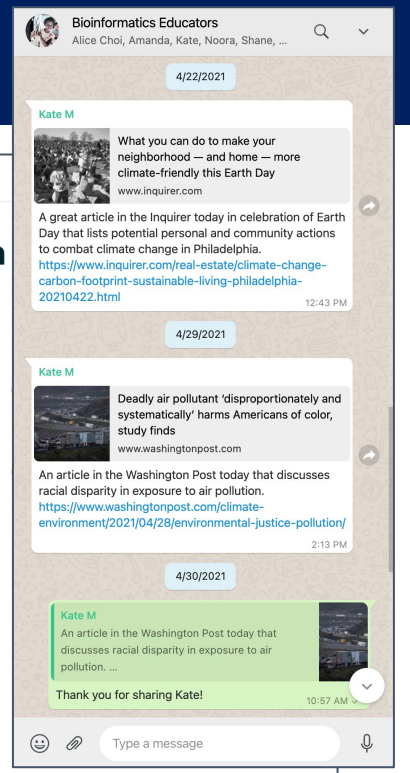
# Professional Development Implementation: Year 2

**Year 2 (2020-2021)**

- 4 week **online** PD workshop (due to COVID)
- 4 Biology and 4 Environmental Science Teachers
- School Demographics
  - Science proficiency: Range = 14% - 96%; Mean = 33%
  - Ethnicity (% Minority): Range = 33% - 97%; Mean = 76%
  - Income (Free or reduced lunch): Range = 98% - 100%

- Design considerations for online PD experiences
  - Utilizing multiple representations of learning content (e.g., pairing audio and video with accompanying text and visualizations)
  - Virtual community building media activities (e.g., whatsapp, monthly synchronous meetups)
  - Social capital building activities (e.g., discussion forums, Google Classroom)
  - Expert peer facilitation (e.g., Cohort 1 teachers facilitating Cohort 2 teachers)




# Problem Based Learning Curriculum

## Scope and Sequence of the Unit

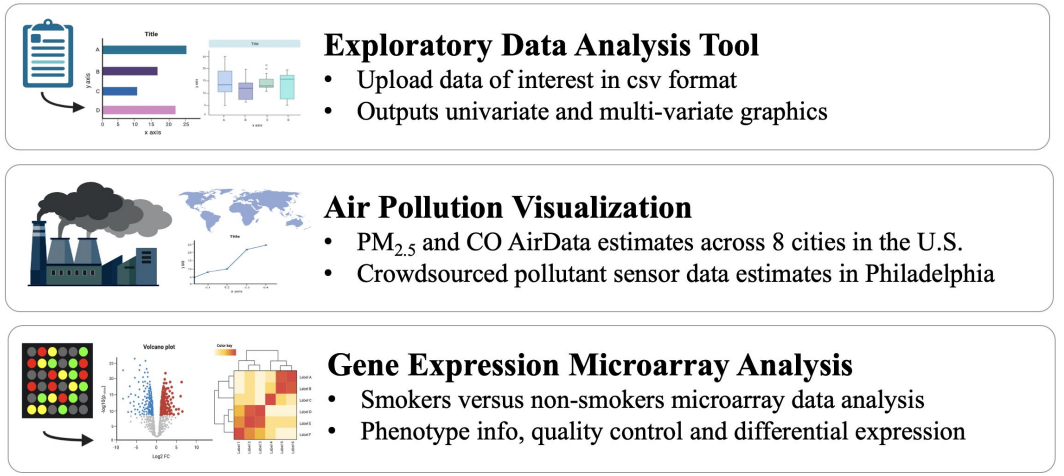
| Lesson | Title |
|---|---|
| 1 | Introduction to Problem-Based Learning |
| 2 | Introduction to Bioinformatics |
| 3 | Introduction to Genotype and Phenotype |
| 4 | Introduction to the Exposome and Air Pollution |
| 5 | Privacy and the Ethics of Data |
| 6 | Reasoning About Data |
| 7 | Introduction to Data Analysis Tools |
| 8 | Analyzing an Air Quality Data Set |
| 9 | Introduction to the Exploratory Data Analysis Tool |
| 10 | Introduction to Measuring Air Quality with Sensors and App |
| 11 | Indoor Data Collection Part 1: Around the School |
| 12 | Indoor Data Collection Part 2: Analysis |
| 13 | Planning Your Investigation Part 1 |
| 14 | Planning Your Investigation Part 2 |
| 15 | Data Collection: Out in the Neighborhood |
| 16 | Outdoor Data Analysis |
| 17 | Using the Exploratory Data Analysis Tool |
| 18 | Citizen Science and Scientific Action |
| 19 | Developing the Project Report |
| 20 | Class Presentations |

## The Scenario

*There is a rising case of asthma in urban areas in the United States. Researchers have hypothesized that air quality contributes to this phenomenon. However, there may be a number of other causes, including a rise in smoking rates, industrial pollutants, and social stress from a lack of access to life resources. The Town Council of Philadelphia has announced a new community program that will fund projects that are likely to support risk reduction of local asthma cases. These projects may include planting more trees to purify the air, an anti-smoking campaign, and building a park to promote activities that can alleviate stress. The Town Council asks you to research the issue and submit a proposal describing a project that your team would like to fund with evidence from public health and environmental data that supports your proposal.*

## Tools


Air quality data collection app and sensor box

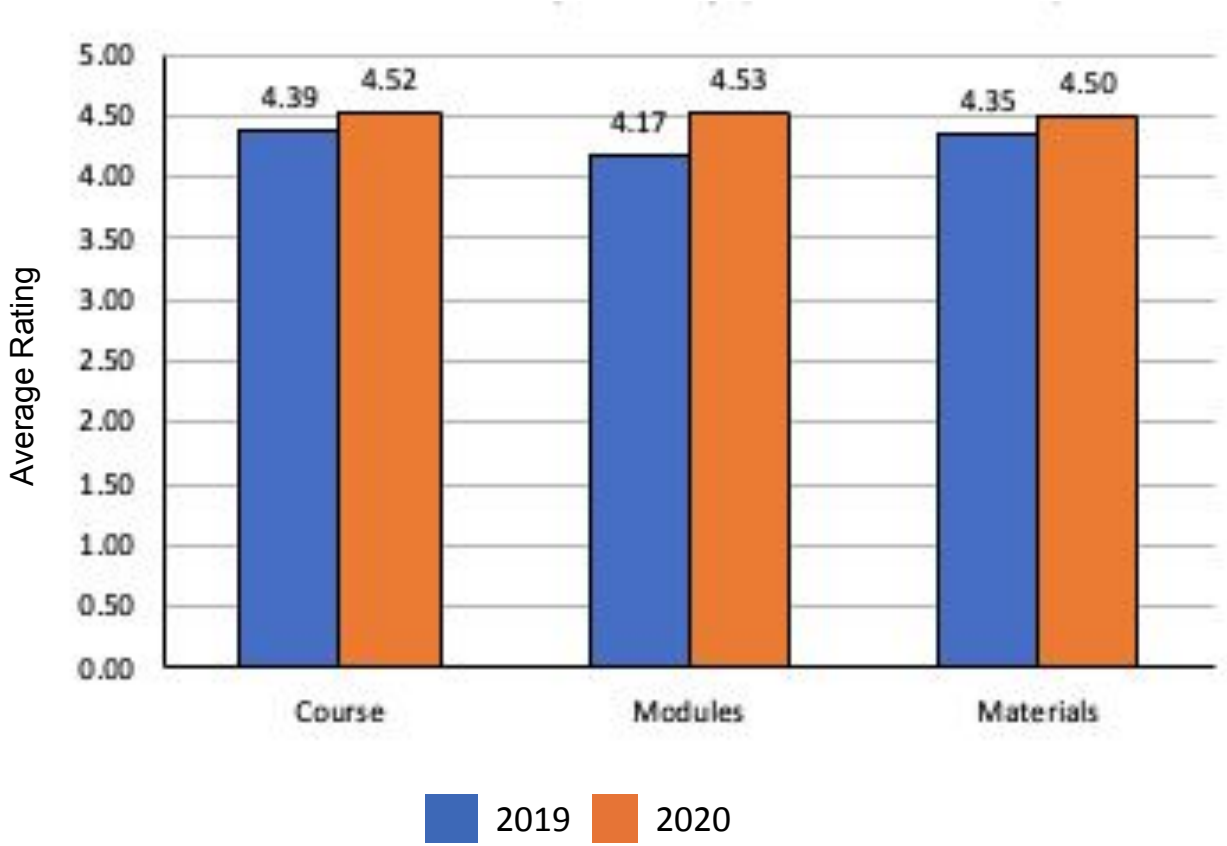



Data visualization web applications

# Sample Findings: Teachers had high satisfaction from PD

## High PD Satisfaction

2019 and 2020 Summer PD Average Teacher Satisfaction




## Improved application of science knowledge

- Student engaging in authenticity and real-world exploration
- Benefit to student science efficacy beliefs and personal relevance

*"...it's a relevant issue that a lot of students will be connected to. It comes with a lot of support from you guys in Penn and it's engaging and the students learn a lot of different kinds of science stuff ...So it's a great project I would totally recommend it."*

*"I think that these kids...they get geeked up about, 'Okay, let's interpret this data set, so that way we can solve this actual, real world problem.'"*

# Sample Findings: Challenges in Implementing PBL activities

**Theme 1: Implementation complexity**

- Teachers said that the project had a lot of complex tasks that required them to divide their instructional attention, that often created implementation and classroom management challenges.

- Example quote: "*And so having gone through it in actuality, there was a couple things that I found tricky. I found tricky the keeping track of all the devices and the technology. [It was like] 'Okay. Here. I'll give you this device. Wait a minute. I didn't…mark who actually had that device*."

**Theme 2: Content preparedness**

- Teachers said they need more training in bioinformatics content, data literacy, and how to integrate into the biology course.

- Example observation: When teaching a lesson on the human genome from slides put together by bioinformatics scientists during the summer PD, one teacher mentioned that he would be skipping through many of them because he himself was not well-versed on the subject.

**Theme 3: Alignment with familiar pedagogical supports**

- Teachers wanted more instructional resources that they were familiar with.

- Example quote: "*I feel like if I just would have planned this out more, you would've had kind of more things to use in our toolbox like handouts, notes, things like that. More substantial things that we can implement*."

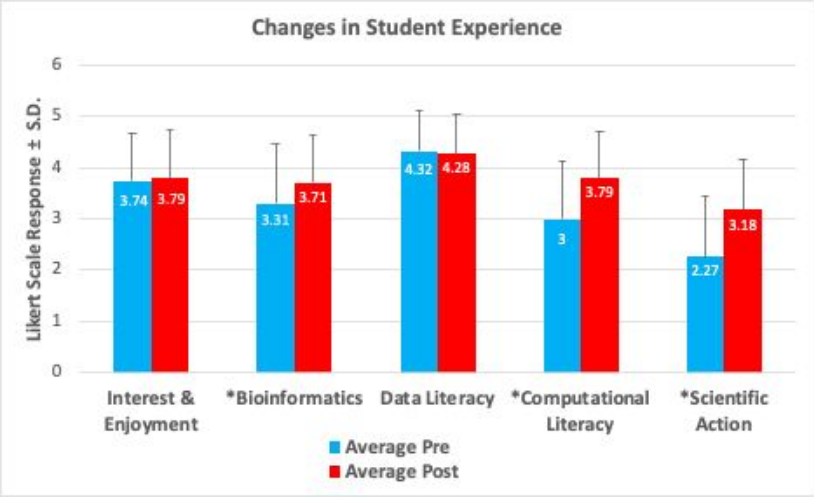
**Theme 4: Resource navigation and access issues for just-in-time instruction**

- Teachers needed easier ways to locate resources such as links to sample datasets at the time of instruction.

- Example quote: "*...but I think by the time that I was teaching that myself, it required some more review. When I was [in the PD workshop], I was kind of getting it, but I think [only] because [the bioinformatics instructor] was right there.*"

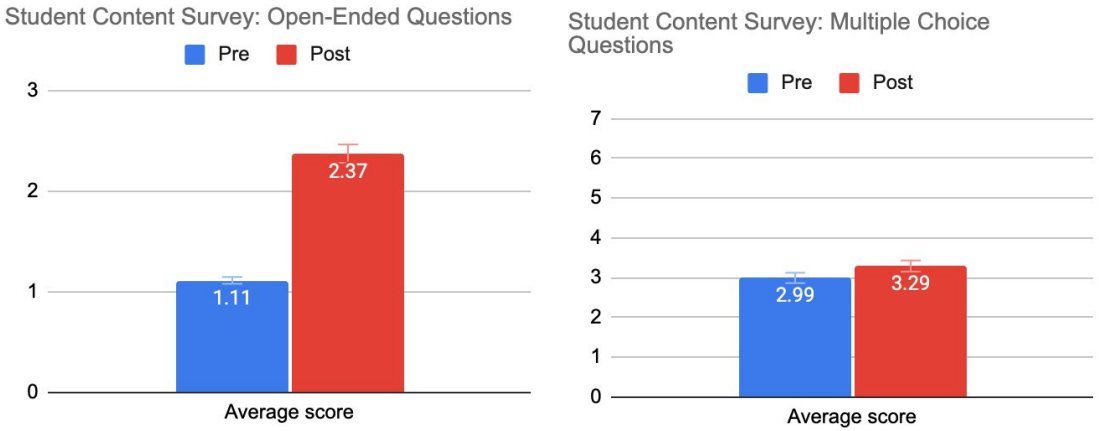
# Sample Findings: Students' learning increased after PBL

## Student Learning: Experience Survey

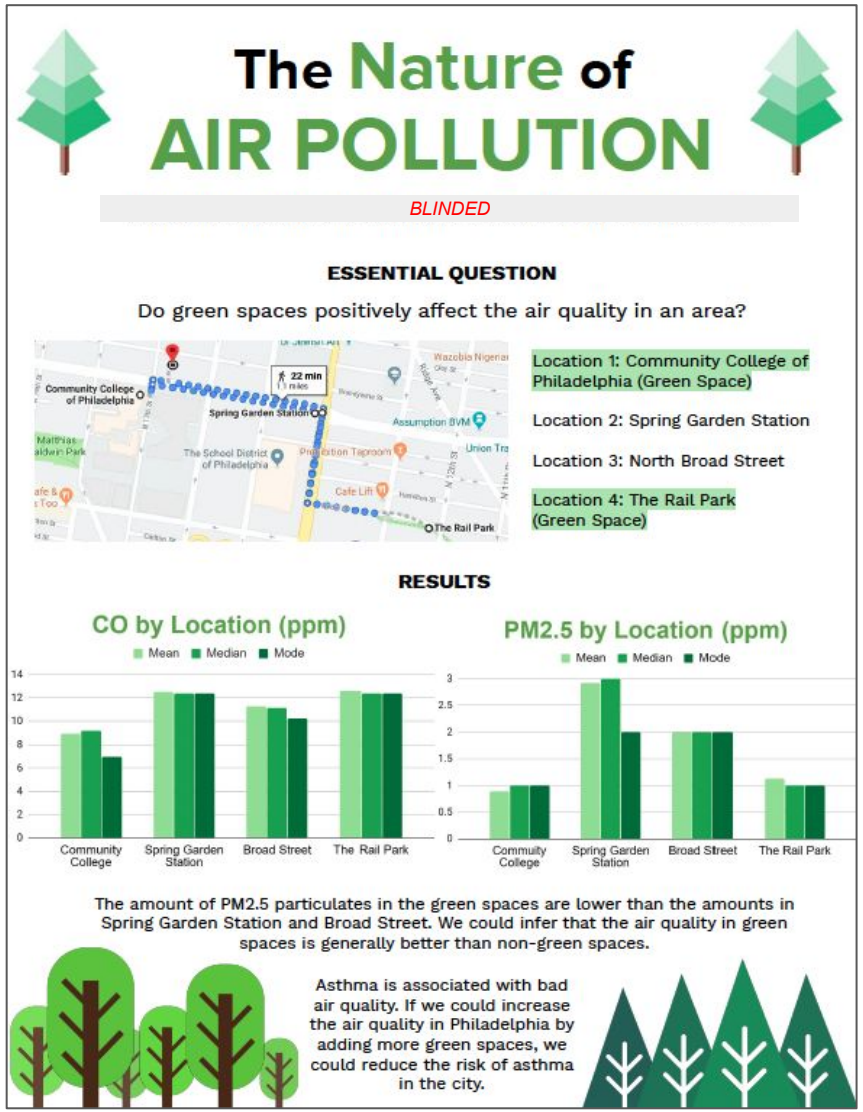



*Cohort 1 students (n=122) demonstrated significant gains in 3 of 5 experience factors measured

## Student Learning: Content Survey



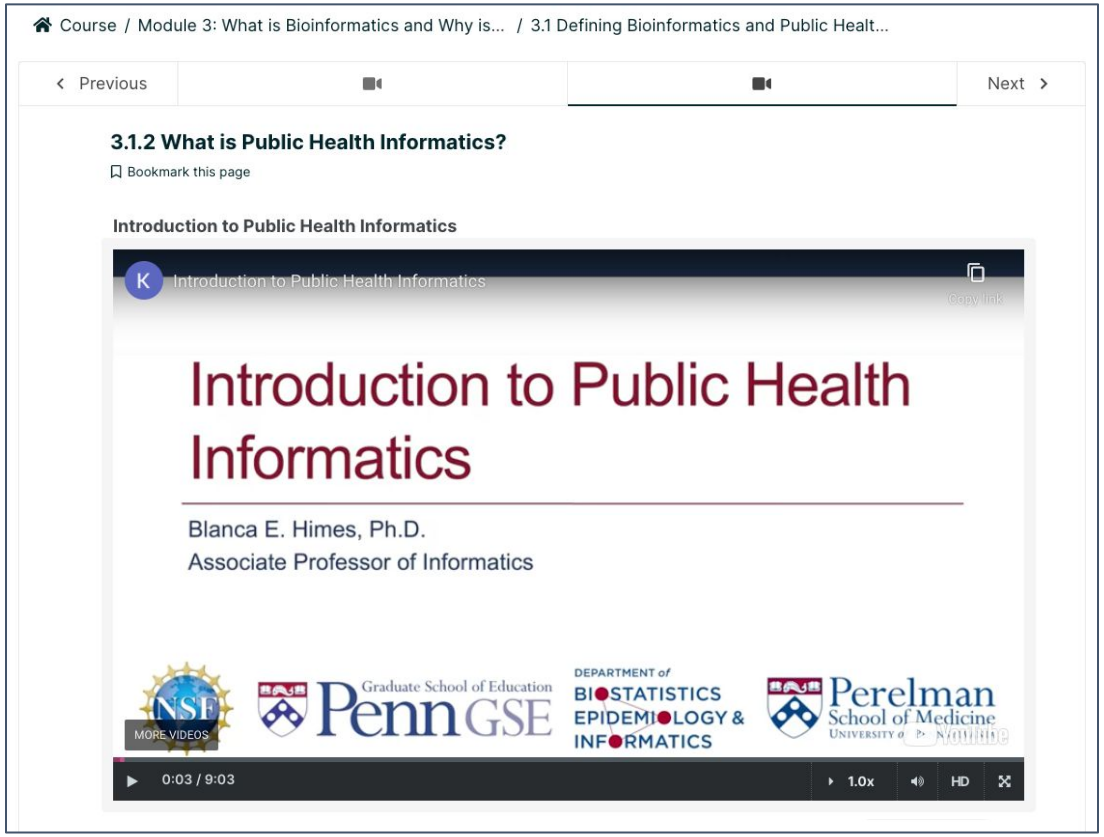

Post survey scores were significantly higher for both open-ended and multiple choice questions. However, the mean scores from the multiple choice questions were relatively low, which indicates that students still had challenges in data literacy.




Sample student artifact

# Research Products: Instructional resources

## Asynchronous PD MOOC offered on Edx Platform

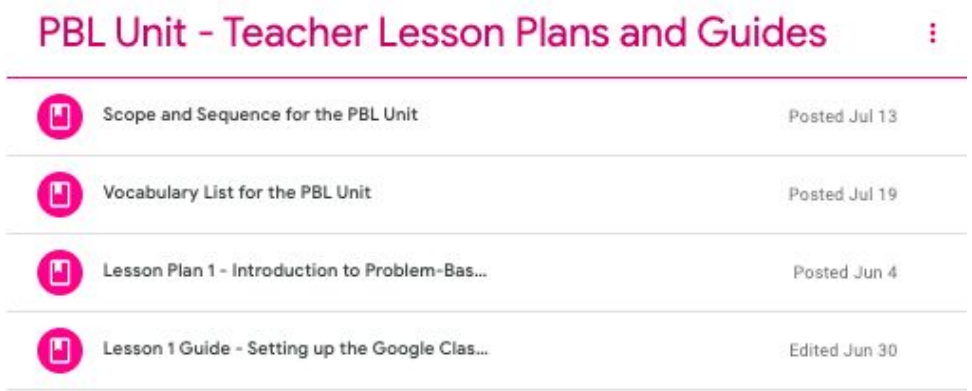



Screenshot of a submodule in Edx Edge online course

## PBL curriculum:

1. 22 lesson plans
2. Multiple annotated PowerPoint Presentations
3. Student worksheets
4. Teacher guides

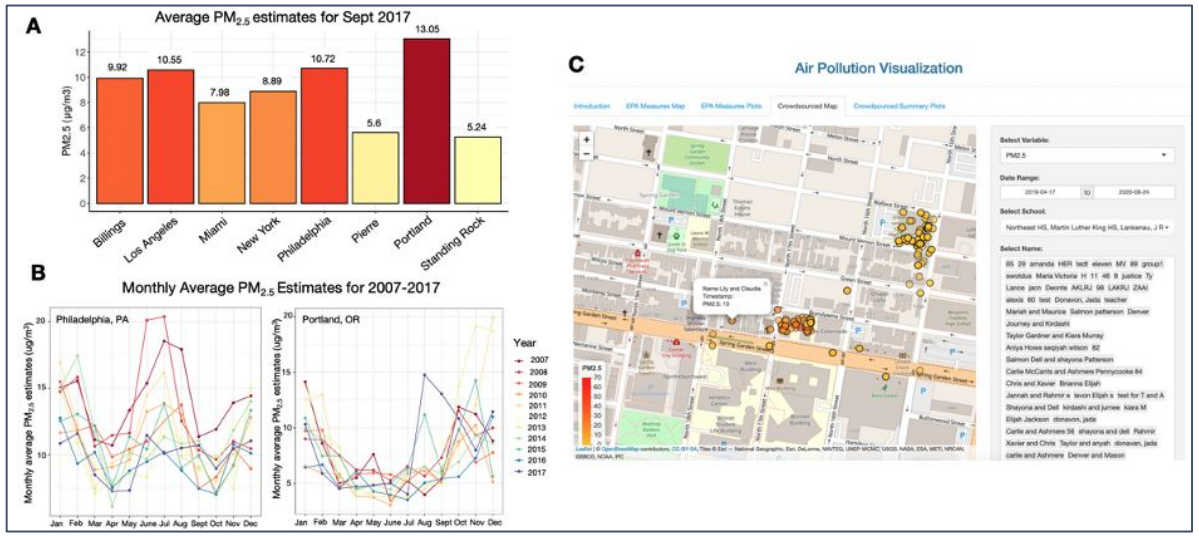
## Google Classroom for archived PD resources




Screenshot of a Google Classroom

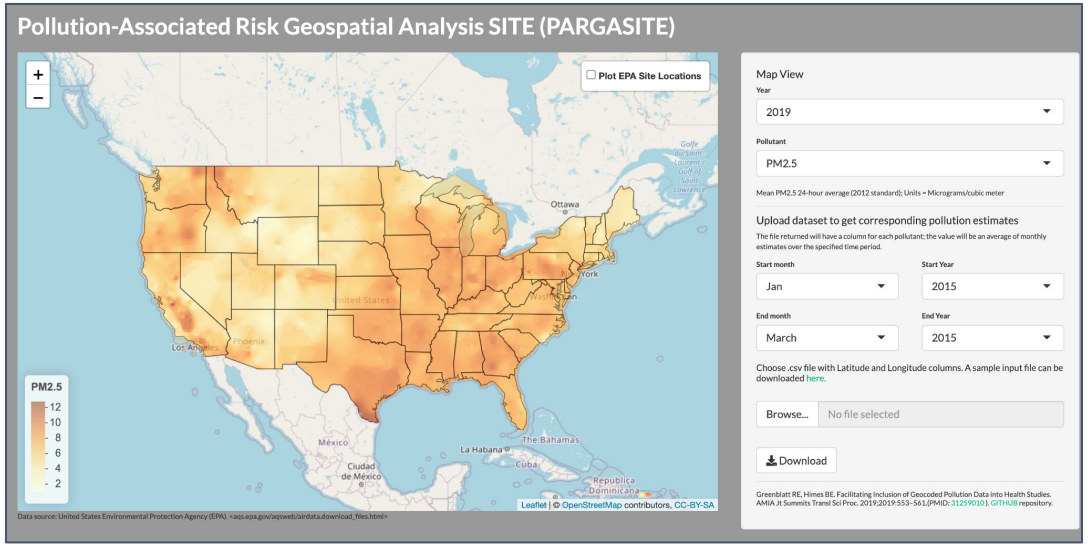
# Research Products: Web applications for data visualization

## k12bioinformatics.org




- Website provides interactive user-interfaces to teach bioinformatics concepts such as asthma and environmental exposures.
- Consists of three apps:
  1) A data analysis tool for basic data visualization
  2) An app to visualize air pollution measures from low-cost sensors and EPA monitors
  3) An app demonstrating gene expression microarray analyses
- A, B, and C are example features of the air pollution visualization app.

## pargasite.org




- Pollution-Associated Risk Geospatial Analysis SITE (PARGASITE) provides visualization of estimate levels of pollutants (e.g., PM 2.5 and CO) in the U.S. for 1997 through 2019 at user-defined geographic locations and time ranges.
- Measures were taken from U.S. Environmental Protection Agency (EPA) regulatory monitor data.

# Implications

- Overall, student interest, engagement and learning increased through project participation.
- While teachers enjoyed the summer PD, when implementing with students during the school year, teachers needed more training in bioinformatics, data literacy, and STEM integration strategies.
- The curriculum is complex with many moving parts. In order for this exploratory work to be scaled, the curriculum needs to be pared down (this is one of our next steps in the coming year working with project teachers).
- During the pivot to online PD, teachers needed more intentional community building structures (we have built this into our next run of the summer PD workshop in July, 2021).

# Impact

- Most teacher research for incorporating bioinformatics in high school curricula has been conducted outside of the U.S. This research represents a rare teacher support and PD study on teaching and learning about bioinformatics in a U.S. context.
- The complexity of novel bioinformatics curricula requires greater attention on what teachers need in terms of content and pedagogical content knowledge supports (this is a focus in the coming year).
- This study aims to specify strategies that can support other PD developers with similar aspirations to update high school science curricula to meet important needs in the rapidly expanding field of bioinformatics.

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# K-12 Bioinformatics Publications


Noushad, N., Shim, J., Yoon, S., & Cottone, A. (2021). Are community relevant PBL supports enough to promote epistemic agency? Exploring variation in epistemic pedagogical practices in science classrooms. Long paper proceedings of *Annual Meeting of* the *International Society of the Learning Sciences.* Bochem, Germany (virtual).

Miller, K., Yoon, S., Cottone, A., & Shim, J. (2021). Integrating data literacy into secondary school science: An exploratory study of a pilot professional development. Short paper in the proceedings of the *International Society of the Learning Sciences*, Bochem, Germany (virtual).

Shim, J., Yoon, S., Cottone, A., & Miller, K. (2021). Two exploratory case studies for teachers' adaptive expertise in teaching Bioinformatics in high school science classroom. Poster in the proceedings of the *International Society of the Learning Sciences.* Bochem, Germany (virtual).

Yoo, J., Shim, J., Noora, N., & Yoon, S. A., Gonzalez, M., Urbanowicz, R., & Himes, B. (2021, April 9-12). *Fostering Data Literacy in High School Science Classrooms: Learning and instructional challenges* [Roundtable presentation]. The annual meeting of the American Educational Research Association (virtual).

Shim, J., Yoon, S. A., Cottone, A., Miller, K., Gonzalez, M., Urbanowicz, R., & Himes, B. (2021, April 9-12). *An exploratory case study of bioinformatics classroom implementation in high school science to support learning of data literacy* [Roundtable presentation]. The annual meeting of the American Educational Research Association (virtual).

Diwadkar, A., Shim, J., Gonzalez, M., Urbanowicz, R., Yoon, S., & Himes, B. (2021, March). *Web-based Tools to Integrate Biomedical Informatics Training into Existing High School Curricula*, 2021 American Medical Informatics Association Virtual Informatics Summit.

Yoon, S., Bressler, D., Shim, J., Miller, K., Himes, B., Urbanowicz, R., & Gonzalez, M. (2020, March). Assessment of professional development supports for teaching bioinformatics in high school biology: Benefits and challenges. Paper presentation at the annual meeting of the *National Association for Research in Science Teaching*. Portland, OR. https://narst.org/sites/default/files/2020-04/NARST%202020%20Conference%20Program%20Book%20with%20URLs.pdf (p. 187) (Conference canceled).