THE UNIVERSITY OF UTAH
College Of Science

Exploring Students' Enactment of Data Analysis Practices in Interdisciplinary IPLS Laboratory Courses

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Research Questions

1. What are the components of a theory of the nature and enactment of data analysis, as observed and theorized from three-dimensional (3D) lab settings?
2. In what ways do students enact the process of data analysis in a three-dimensional (3D) lab setting?

Research Impetus

Three-dimensional (3D) learning of the NGSS Framework[1] contains scientific practice *Analyzing and Interpreting Data*:

- Valued as component of scientific process, but not extensively studied through research[2]
- Has connections to literature from Computational Thinking[3,4], Mathematics Education[5,6], K-12 instruction[7], and undergraduate lab[8,9,10] research settings

Reformed IPLS lab courses contain more extensive opportunities of *Analyzing and Interpreting Data* than traditional physics labs:

- There is a need to engage in research to better understand how students engage in these practices in newly-developed and understudied lab courses
- In this research literature there is limited knowledge available related to student thinking and perceptions when engaging in data analysis

Phase One: Observations

Video and audio data from University of Utah reformed IPLS course:

- We found more opportunities for student use of *Analyzing and Interpreting Data* sub-practices than anticipated
- We found that students do not engage in these practices during experimentation as often as necessary; such engagement typically includes incorrect steps or reasoning

Preliminary development of coding method for completed lab course observations, task-based interviews, and student assignments:

- Grounded qualitative analysis to develop code book of ongoing themes of student engagement in data analysis practices[11,12]
- Providing the initial framework of theory of nature and enactment of data analysis

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Preliminary Theory of Data Analysis

Preliminary results of IPLS lab observations suggest that the process of data analysis involves iterations of *data collection*, *cleaning*, *manipulation*, *mathematization*, *utilizing representations*, *interpretation*, *engaging in argumentation*, and *modeling*.

Data Analysis Process	Preliminary Definition	Reformed IPLS Lab Examples
Collection	Designing and conducting an experiment to collect data to be used in answering a question or explaining a phenomenon.	Students take into account biological sample size and expected motility rate to configure microscope and software packages for video data collection
Cleaning	Scrutinizing collected data to detect, diagnose, edit, and/or remove faulty data that could diminish validity or skew results.	Students assess diffusive motion data that is expected to exhibit randomness and determine how to modify/edit patterns and trends resulting from systematic error
Manipulation	Editing data through unit changes, mathematical calculations, etc.	Students transform x-y coordinate positions into directional displacements and mean-squared displacements
Mathematization	Utilizing mathematics to generate meaning, in quantitative terms, of data collected from an initially qualitative system.	Students utilize modified diffusion equation to extract diffusion coefficients from raw data or representations
Utilizing Representations	Utilizing various forms of representations (graphs, tables, equations, etc.) to display and highlight pertinent information to assist in process of argumentation.	Students plot particle velocity vs. time to extract an average terminal velocity for a fluid dynamics system
Interpretation	Make sense of data and processes utilized to develop results.	Students, after extracting effective viscosity of fluid system through experimentation, assess their results based on other group's results and comparison to biological fluids
Engaging in Argumentation	Utilizing evidence and reasoning from scientific experimentation to make claims about scientific questions or phenomena.	Student groups provide arguments to their classmates and instructors for or against their data analysis procedures and results
Modeling	Creation of model (explanatory, simulation, physical, mathematical, etc.) that incorporates experimental data to extrapolate meaning to systems or phenomena more complex than experimentation can simulate.	Students make claims about how studying diffusion in synthetic microspheres in solution can serve as a model for real-world biological systems

Phase Two: Developing Research Instruments

Task-Based Assessment

- Generated biology and physics content-rich tasks designed to capture student engagement with data analysis.
- Conducted pilot talk-aloud interviews with STEM undergraduates, physics graduate students, and math faculty to refine tasks.
- Created pilot solutions rubric.

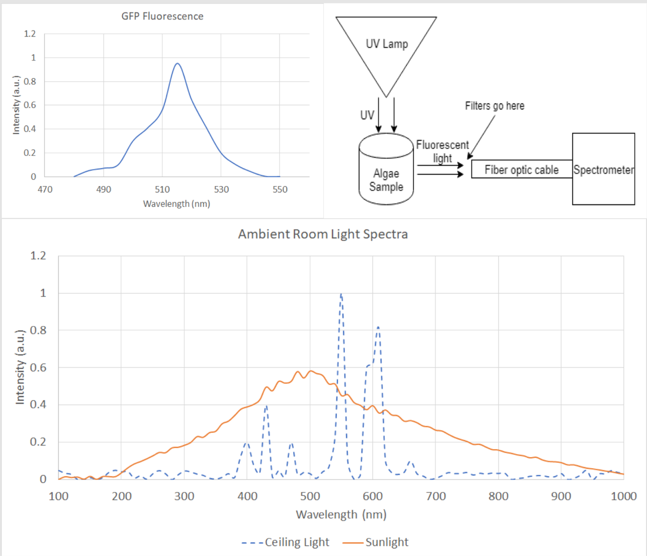

Figure 1: Example data analysis assessment task. Students are asked how they would limit exposure to ambient light using filters and other methods.

Task-Based Interview

- Single task comprised of data-rich authentic research experimentation and analysis derived from a biophysics lab at University of Utah.
- Conducted pilot interviews with undergrad and grad students to iteratively refine tasks.
- Ongoing and future student interviews.

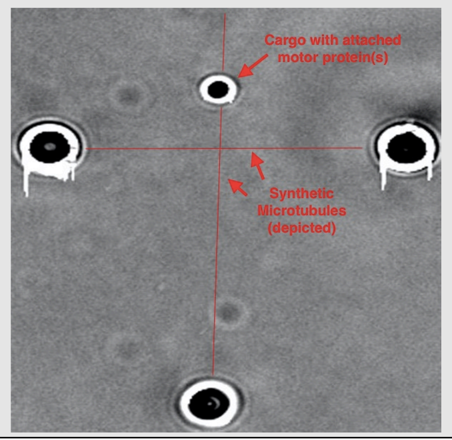

Figure 2: Example imaging from interview task. Students are asked to study kinematics of motor protein while connected to synthetic microtubules.

Attitudes and Perceptions Survey

- Survey to be loosely based on CLASS/E-CLASS surveys.[13,14]
- Intended to elicit student views on engaging in data analysis in interdisciplinary physics /biology settings.
- Intended to proceed through iterative development, piloting, and validation as described by best practices in literature.[13-17]

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