Supporting Science Learning and Teaching in Middle School Classrooms through Automated Analysis of Students' Writing

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Goals and Objectives

- Develop **NLP** technology (PyrEval) to provide **students and teachers** with **real-time feedback** about students' written explanations to:
- Help **students reflect on quality** of their scientific explanations and **foster** ability to **use evidence**; and
- Provide **teachers** with **aggregated and individual** information about students' **explanation writing** so they can **better scaffold** students' science learning

Research Questions

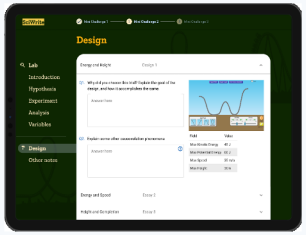
1. How does **feedback** from PyrEval **affect the quality** of **students' written** scientific explanations?
2. How do **teachers use** the **automated assessments** and summaries of students' explanations during instruction?
3. In what ways does scaffolding from the auto-coder and teacher feedback support students' explanations writing and learning?

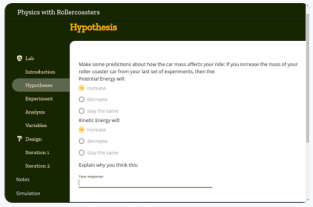
Context: Forces and Motion Unit

- Addresses NGSS core ideas, science practices, and crosscutting concepts for middle school physics
- Immerses student in an **authentic engineering design** challenge to construct a fun, but safe roller coaster

Digital Science Notebook

1. **Support for Student Writing**
   - Scaffolding for design and scientific writing
   - Automated integration of experiment data from the roller coaster simulation
   - NLP feedback on student writing
2. **Support for Teacher Scaffolding**
   - Monitor students' progress through design and writing
   - Track iterative design history of student experiments
   - Use NLP summaries to show a map of common and/or persistent (mis)understandings and explanations
3. **Support for Management**
   - Deliver notifications to class, groups, or individual students
   - Export data needed to answer research questions
   - Provide support for classroom management



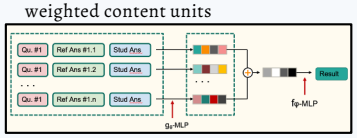


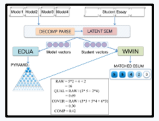
NoteBook Architecture Infrastructure

- Industry standard stack of React, Express, Node.js, and MongoDB
- Focused on user-friendly and accessible aesthetics and appearance
- Web-based application usable by various devices

Automated Analysis of Student Writing

1. **Short Answers - SFRN:** Semantic Feature-wise Relation Network
   - BERT encodes **Q**(uestion)-**R**(eference)-**A**(nswer) into 3 vectors
   - RNs learn vector abstractions over tuples of vectors, e.g. **QRA** triples
   - Up to 11% performance gain over SOTA on benchmarks
2. **Essays - PyrEval:** Wise crowd content evaluation
   - **WTMF:** phrase vectors for reference essays and student essays
   - **EDUA:** set partition algorithm finds optimal sets of vectors in reference essays, producing **weighted** content units
   - **WMIN:** independent set algorithm matches student text to weighted content units





Plans for Year 2

- Revise digital notebook and wise-crowd model based on feedback from advisory board and middle school science teachers
- Test iteration 1 with two science teachers (200 students) to examine (a) how the automated assessment and feedback (b) how teachers use the automated aggregate summaries

Project Team Members

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