Using Problem-Based Learning Analytics to Investigate Individual and Collaborative Mathematics Learning in a Digital Environment Over Time

PIs: Elizabeth Phillips, Alden J. Edson, Kristen Bieda, Chad Dorsey, & Nathan Kimball
Research Team: Taren Going, Ashley Fabry, Sunyoung Park, & Michael A. Quail

Overview of Study

- The project aims to understand how engagement in learning mathematics is enhanced by a digital collaborative platform with an embedded problem-based curriculum and a digital mathematics notebook.
- As technology becomes increasingly common in math classrooms, we need to understand how to support meaningful student learning and engagement in digital modalities.
- Our research questions are:

1. What design characteristics of problem-based learning analytics help students with their developing understandings over time?

2. What influence does student collaborative engagement and the resulting class artifacts that are produced have on the nature of student reflections on their learning of big mathematical ideas?

3. To what extent do problem-based learning analytics impact students' individual and collaborative engagement and the resulting artifacts that are produced?

Participants and Data Sources

- Participants: 7th grade mathematics teachers and students using the digital collaborative platform. For Year 1, this was 5 teachers and ~300 students.
- Data sources include:
  - Electronic surveys on digital platform use
  - Data log files for teacher events in the digital platform
  - Teacher interviews
  - Student focus group interviews

Project Timeline: Design-Based Research

Year 1: Development of full year curriculum with limited pilot testing, design and development of prototype learning analytics for students

Feedback & Modification

Year 2: Pilot testing all units and learning analytics features, development of prototype learning analytics for teachers

Feedback & Modification

Year 3: Field testing all units and learning analytics, continued development and refinement of digital platform

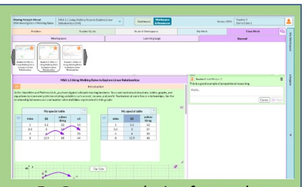
Feedback & Modification

Year 4: Field testing all units and robust learning analytics in a variety of classrooms.

Design for Analytics to Support Student Learning and Engagement

Students have access to their own mathematical work and work published by their peers or the teacher.

Next steps: Develop tools for teachers and students to tag and organize work published by others and in digital mathematics notebooks.



Ex. Prototype design for teacher organization and tagging

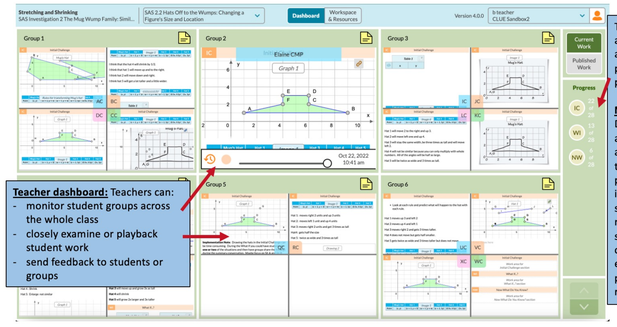
Teachers can monitor digital student work and send feedback to students.

Next steps: Develop machine learning algorithms to enhance engagement and feedback to teachers and students

Students can collaborate in small groups (up to 4), view group work, and easily share or copy content.

Students have access to connected sequences of problem-based curriculum (four 7th grade units complete).
- CMP STEM problem format deepens engagement over time
- Students/teachers can easily copy content (e.g. text, graphs, tables, images) into their own workspace

Next steps: Develop remaining four units of 7th grade content, including an equation tool to represent content in new ways.

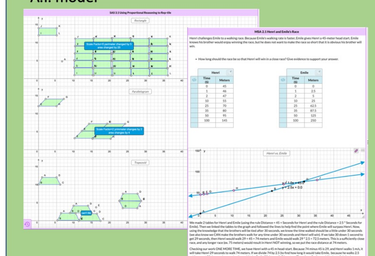


Teacher dashboard: Teachers can:
- monitor student groups across the whole class
- closely examine or playback student work
- send feedback to students or groups

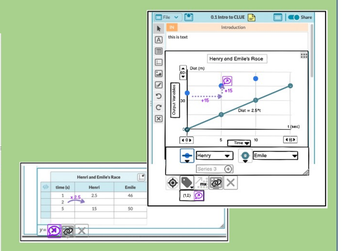
Teachers have access to analytics about student progress through problems.

Next steps: Develop additional analytics for teachers that provide information about students' mathematical strategies and current ways of expressing proportional reasoning

Next steps: Developing a descriptive rubric for how students express key aspects of linear and proportional thinking in their mathematical work (e.g. graphs, explanations).
- Student work "hand-coded" by the research team as a basis for machine-learning algorithms to provide problem-based learning analytics to students.
- Markup features for students and teachers to express proportional reasoning will also improve our A.I. model



Ex: Student work from the digital collaborative platform



Ex: Prototype markup tools for students to express proportional reasoning

Student Insights on Digital Collaborative Mathematics: 4 Emergent Themes

Theme 1: Saving Work and Looking Back

"[For the whole year I'd save] like, the Now You Know."

"Yeah, because they usually summarize what we've learned in every unit… We phrase our answers a different way every time."

"There was the hat situation and the Mug Wump situation, but the two workspaces you can't see them from each other. So we put them in the learning log because we could access both things."

Theme 2: Choosing a Strategy and Being "Right"

"[I would want the platform to tell me] whether it's correct or not, whether it's long enough, whether it's detailed enough, I'm using the bad strategy or not. Our teacher's model would be "show your work" and I'm never sure how much I need to show."

"No, cause I like when you have to think through it and talk with your table to see if it's correct."

"Maybe there could be like click 'check my answer' or something like if you want to see your answer, cause some people might not want to know if they were correct or not."

"Or like it can just tell you if you're getting warmer, like the warm or cold strategy."

Theme 3: Inspiration from Peers

"It's way too easy to press [the share button and 4-up view]. You get a lot of different thoughts and different methods. You can, not 'plagiarize', but get inspiration from each other's work if you agree with it."

"Also if someone has something that you like, you can just be like 'Hey can you share that to the classwork?' And then the other person will be like, most of the time, 'Yeah sure' and then you can just drag it over."

Theme 4: Comparing Tools and Ease of Use

"Making graphs is a lot easier, so that opens up new windows for strategies. So you can make a line with an equation plotting each coordinate, so more methods."

"It's easier to use actual units with paper and pencil rather than sticking a drawing on a graph (tool), which usually doesn't go well because it's hard to move the drawings around it, and your values usually are fractional."

Next Steps and Open Questions

- Year 1 data collection is ongoing.
- Design work for Year 2 focuses on generating an initial algorithm for interpreting student work in the digital platform.
- Since machine-learning algorithms improve over time with feedback, early stages will require feedback from students and teachers on accuracy about their thinking and reasoning.
- What role should teachers play in delivering platform-generated feedback to students?
  - E.g., Platform-generated suggestions for the teacher to choose from

This work was supported by the National Science Foundation grant DRL-2200763. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.