Interactive Ink Inscriptions in K-12

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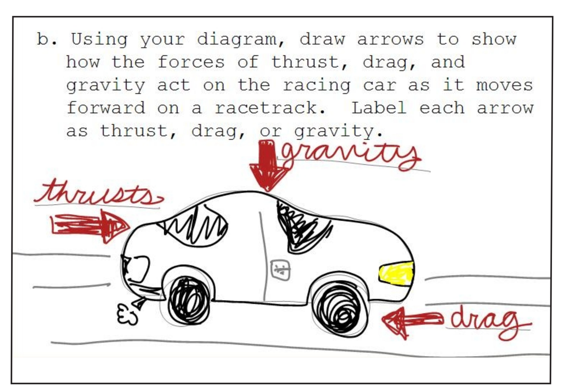
The INK-12 project is investigating how the combination of two technological innovations—***pen-based input*** and ***wireless communication***—can support classroom practices that teach two skills critical to mastering STEM disciplines: 1) ***creation and manipulation of representations for mathematical and scientific objects,*** and 2) ***communication of those representations and associated feedback.*** We are investigating how technology that facilitates these capabilities, via a set of tablet computers, can support teaching and learning key mathematical and scientific concepts in upper elementary school. ***Pen-based interaction*** enables creation of inscriptions—handwritten sketches, graphs, notes, etc, which are critical in STEM fields, where content is often most easily expressed as a mixture of text and drawings. ***Wireless networking*** enables facile communication of inscriptions, and other representations, among teachers and students and supports formative assessment and classroom discussions directly based on student work.

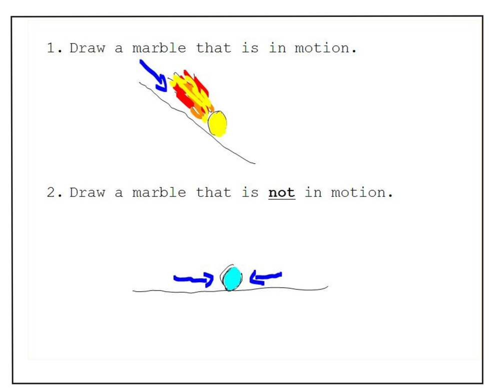
Previous Work

Create

In our previous exploratory grant, we developed and tested technology that supported the ***creation*** and ***communication*** of ink ***inscriptions*** in 4th and 8th grade science and math: Students created inscriptions on a tablet computer and wirelessly sent those inscriptions to the teacher, who then displayed selections of student work anonymously for class discussion, e.g., comparing and contrasting different problem-solving methods.

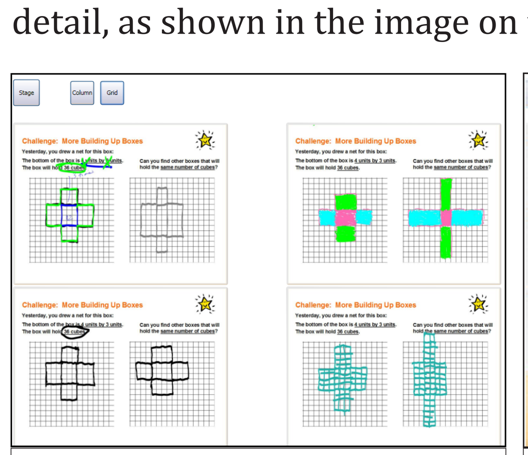
Developing facility with creating and interpreting inscriptions and other representations is a critical part of becoming a scientist or mathematician. Most research on students' inscriptions, however, has examined those created "by hand," with pen and paper, or those created by mouse and keyboard interaction with computer tools. ***Pen-based interaction*** greatly extends students' representational repertoire. We want to know how student learning is affected.



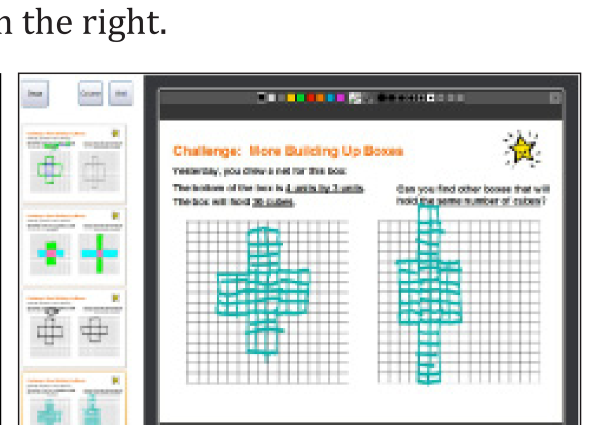


Share

An important part of the value of inscriptions lies in the conversations they support among students and teachers. Recent technological innovations have promoted whole-class interaction by introducing a central shared display and by taking advantage of ***wireless interaction***. The technology we are using enhances classroom communication by making it possible for students to submit their work wirelessly and for the teacher to choose a set of students' "digital ink" inscriptions to display publicly (and anonymously) as a basis for ***class conversation***. We have developed an interface that supports teachers in displaying multiple pieces of student work simultaneously. A teacher can choose the pieces of student work she is interested in presenting to the class and place them on a "stage." She can then choose one of two display styles, as shown below: a grid format or a column format. She can zoom in on any particular piece of student work to comment on it in more detail, as shown in the image on the right.



Grid mode



Column mode with zoom on one piece

The MIT Center for Educational Computing Initiatives (CECI) was created to advance the state-of-the-art in the use of computation and communication technologies in education. Towards this end, CECI undertakes research and development in the application of computing and communication technologies that improve the effectiveness of learning and teaching.

TERC is an independent, non-profit, research-based organization dedicated to engaging and inspiring all students through stimulating STEM curricula and programs designed to develop the knowledge and skills they need to ask questions, solve problems, and expand their opportunities.

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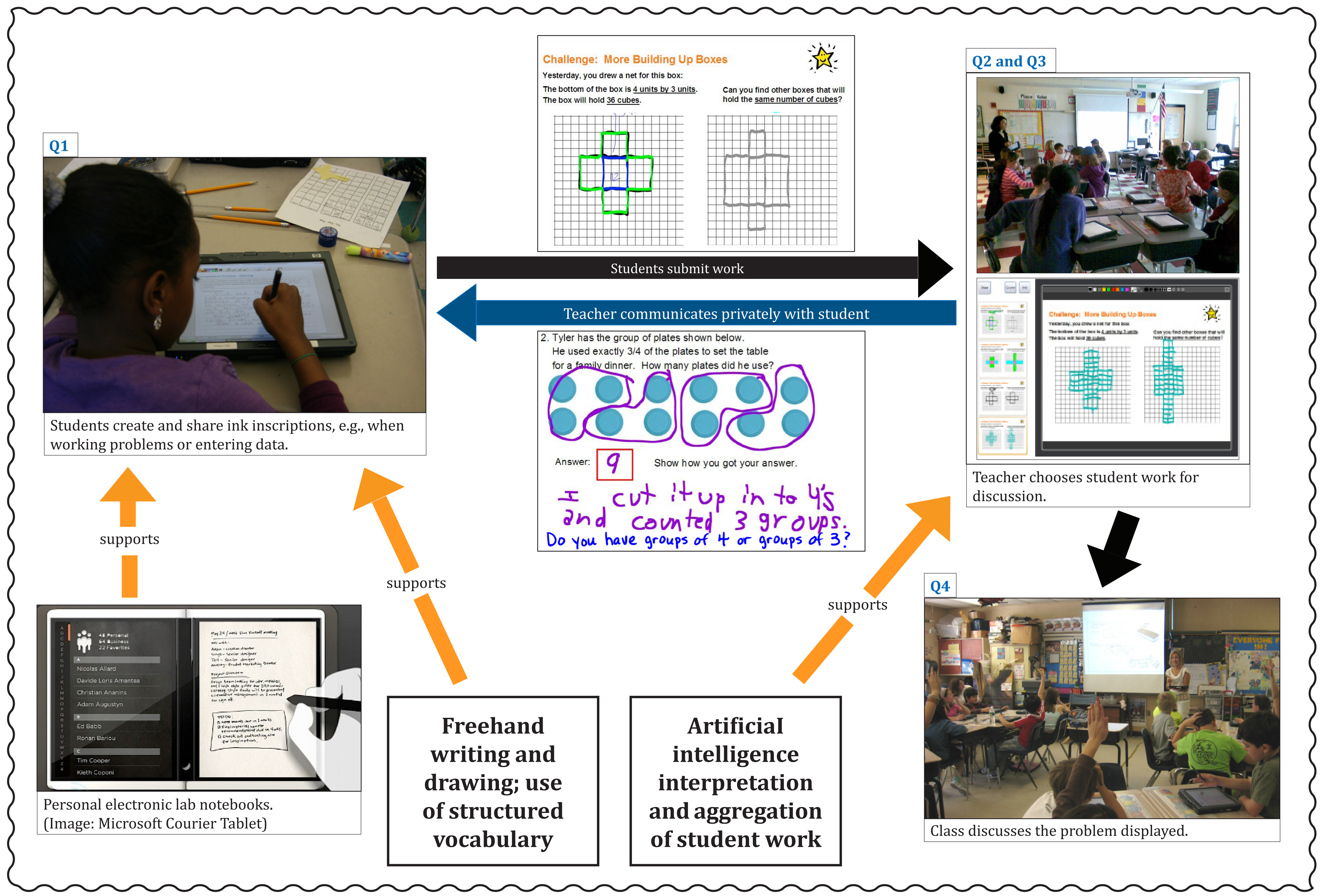
Model of Interaction



This diagram illustrates the process by which we hypothesize that INK-12 technology can affect on students' participation and learning. Students use tablets to write, draw, add graphics, annotate images etc. in an electronic lab notebook; they may use structured vocabularies (palettes) to support their creation. They submit their work to the teacher, who may respond privately to an individual or aggregate student work in order to choose several examples for public display and discussion. Artificial intelligence techniques can help the teacher by interpreting and aggregating student work; the use of structured vocabularies facilitates the interpretation process.

Research Questions

[Q1] How do inscriptions created using pen-based technology differ from those created using pen and paper?

[Q2] How do students' inscriptions differ when using palettes—and the resulting structured vocabulary—vs not using them?

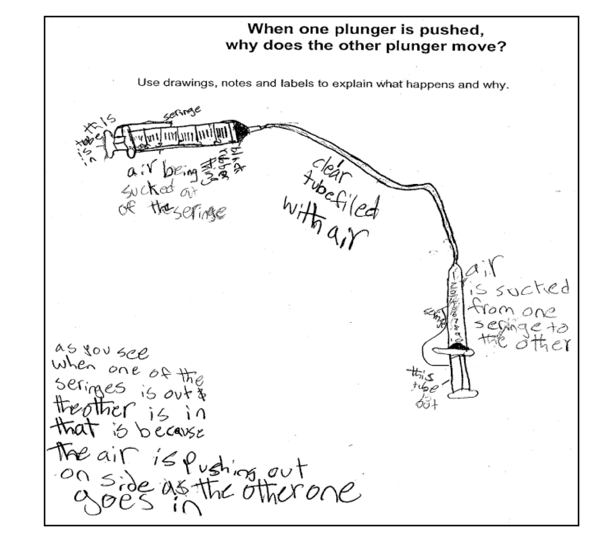
[Q3] What effect does the process of selecting and sharing student work have on student participation and learning?

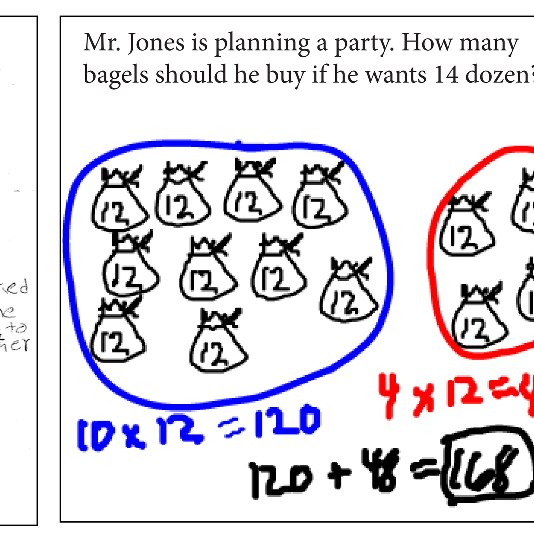
[Q4] What tools, including interpretation and aggregation of student work, can help a teacher choose student work for discussion?

Current Work

Create

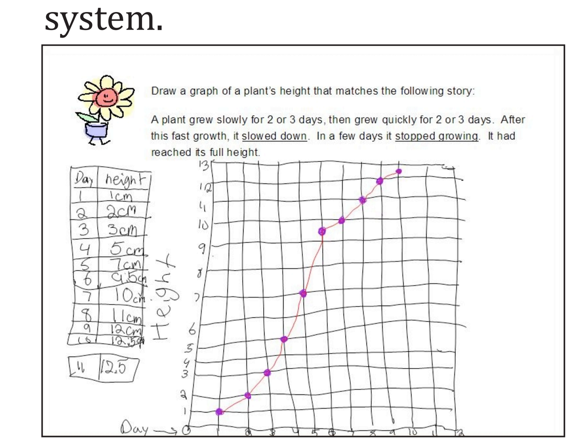
Students will create inscriptions freehand, as in the example below on the left; and also with the aid of what we broadly call ***"palettes"***, sets of graphical icons that can be used as parts of inscriptions. One kind of palette will contain pre-programmed icons such as geometric shapes, grids, or chemical elements. Another kind of palette will contain icons that teachers and/or students design and define in class so that they are using common representational tools. An example is shown below on the right; a bag of 12 bagels has been created and used as a "stamp" to represent multiple bags. Both of these kinds of palettes create a ***"structured vocabulary"*** that can aid interpretation.

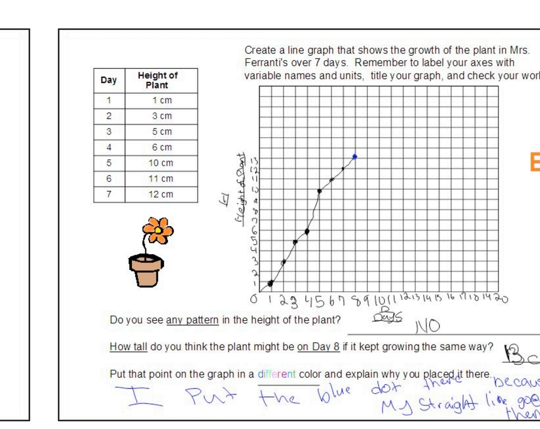




Interpret

The task of sorting and choosing pedagogically interesting student work for class discussion can be overwhelming for teachers. To support teachers in this task, we will develop software, using ***artificial intelligence*** techniques, that will interpret, aggregate into similarity classes, and assess student work when possible. In some cases, it will be possible to use handwriting recognizers to interpret student work. Structured vocabularies, e.g., such as the bag of bagels above, will facilitate this process when recognizers are not sufficient, as the computer will "know" what icon a student has used and what it "represents." A computer, for example, will be able to identify data points in the graph on the right much more easily than on the left since a predefined grid establishes the coordinate system.





Share

Teachers want to be able to ***display multiple examples*** in an organized way and ***annotate*** them as a way to encourage discussion of similarities and differences. Teachers will have a variety of formats in which to show multiple examples of student work and tools to write on the multi-display either before or during class discussion.