WHITEBOARDING IN CONCEPTUAL PHYSICS

EVIDENCE FROM A FIRST YEAR EXPERIENCE

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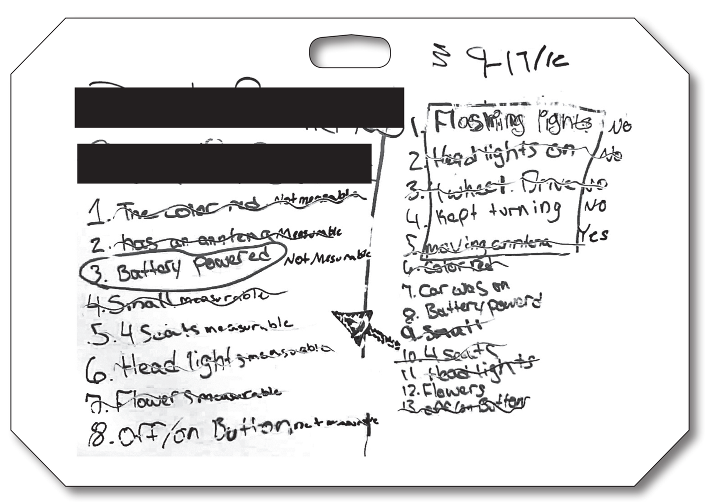
During the 2012-2013 school year, Riverside High School, a persistently low achieving school in the Buffalo Public School District (Buffalo, NY), launched their first offering of Conceptual Physics to support a new Health Science Academy within the school. Two teachers integrated whiteboarding into three sections of Conceptual Physics. Despite chronic absenteeism, high levels of initial student apathy, a preponderance of ESL students, and extraordinarily diverse student demographics, whiteboards demonstrated profound levels of student thinking and highly varied interpretations of shared evidence not typically associated with students in low performing urban schools. Evidence gathered from student whiteboards demonstrated cognitive interaction beyond that typically reflected on high stakes standardized testing for this student population.

This project was supported by Buffalo State College, and the National Science Foundation (NSF) funded Interdisciplinary Science and Engineering Partnership (ISEP) MSP project.*

WHAT WE WHITEBOARDED

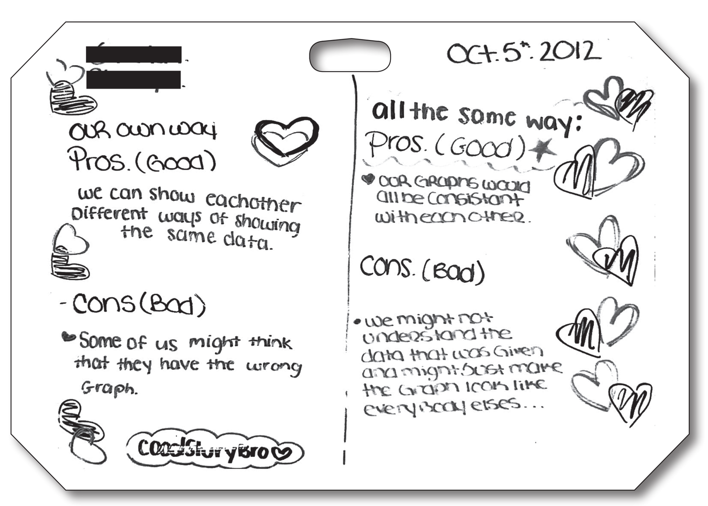
Brainstorming

Creates a profoundly diverse pool of student thinking that is then accessible to everyone in the class.



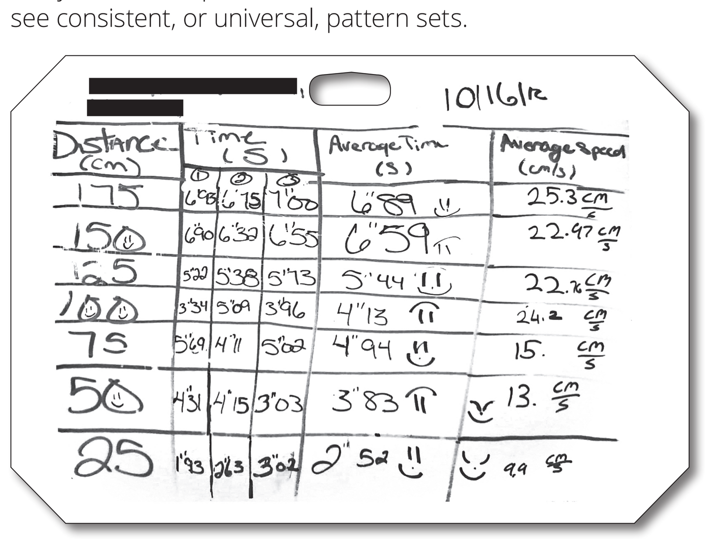
Evaluations

Investigate various aspects of a given idea or topic (Pros/Cons, Cost/Benefit, Similarities/Differences, Observation/Inference, etc).



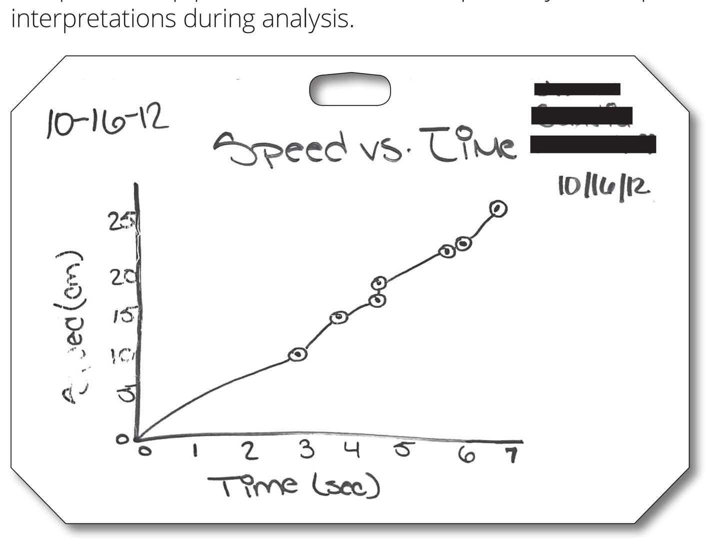
Data Tables

Present data for discussion and allows the entire class to analyze and interpret the results. This enables students to see consistent, or universal, pattern sets.



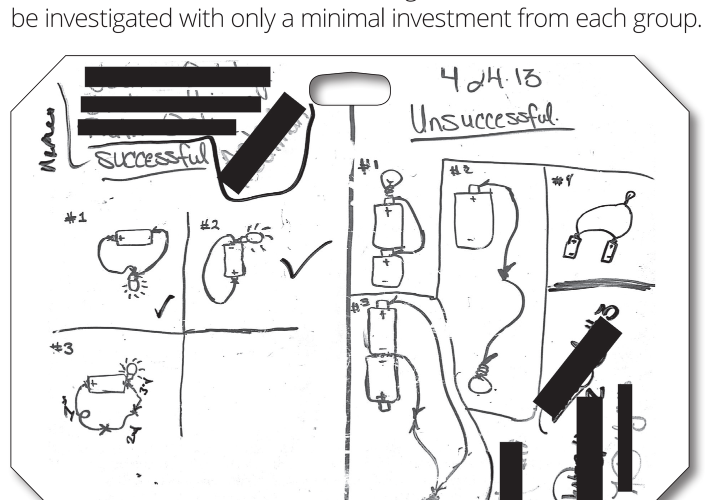
Graphs

Visually represent data collected and the associated best-fit line used in the group's analysis. Carefully chosen setups can help provide evidence for slope and y-intercept interpretations during analysis.



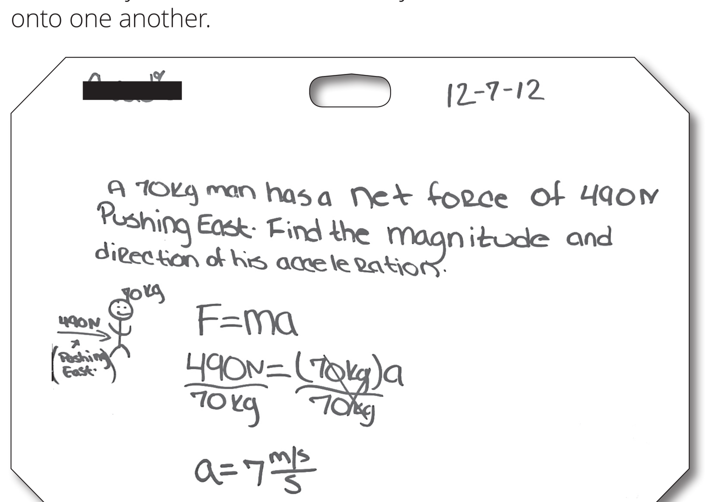
Diagrams

Visualize each group's unique setups, attempts, and their observed outcome. This allows a large number of situations to be investigated with only a minimal investment from each group.



Homework Problems

Students learn from one another and create a learning community that shifts reliance away from the teacher and onto one another.



This poster can be found at
http://physicsed.buffalostate.edu/pubs/AAPTmtgs/AAPT2014Jan/

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A WINDOW INTO STUDENT THINKING

Shared experience, often times, is not sufficient to build a cohesive conceptual framework in the minds of our students. Despite students working through the same activities, the scientific models our students construct can vary dramatically.

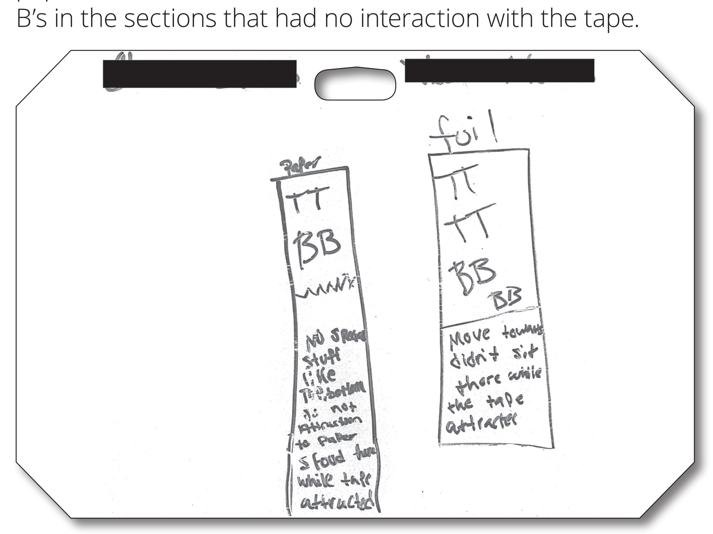
The following whiteboards provide examples of models created by students regarding "action at a distance" using sticky tape, paper and aluminum foil. Each group obtained the same data based on the activity:

	Top	Bottom	Paper	Foil
Top	Repel	Attract	Attract	Attract
Bottom	Attract	Repel	Attract	Attract
Paper	Attract	Attract	None	None
Foil	Attract	Attract	None	None

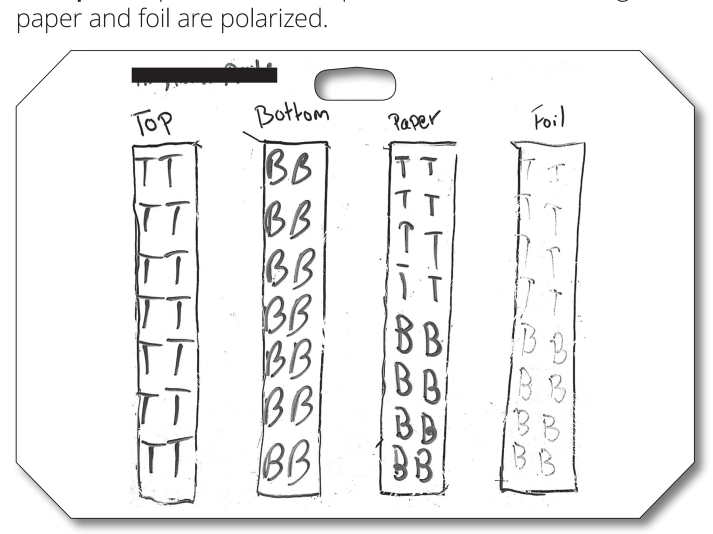
Typically, this provides sufficient evidence for a teacher to assume students have a good understanding of the concepts represented. However, when students are asked to draw, and more importantly, discuss, a model to explain their results, the way in which each group internalizes the results shows diverse variations in their understanding. Through whiteboarding, and classroom discourse, students can work together in a scientific community coming to a standardized model. In doing this, our students are able to develop a consistent model and we, as the teacher, have a clearer picture of their conceptual framework.

We told students that both top tape and bottom tape contained "something unique" that made them behave like a top tape or bottom tape. This "stuff" was appropriately designated T-stuff and B-stuff. The class participated in a whiteboard session that dispelled the possibility of paper and foil each having their own type of "stuff" (no P-stuff or F-stuff). Students were asked to draw appropriate models for all four strips that could explain the 16 interactions observed.

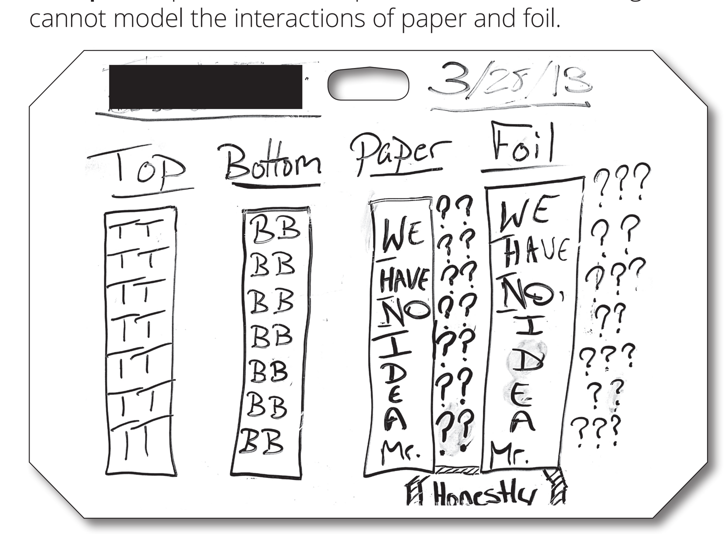
Group 1: Polarized model, but only for top section of the paper and foil. Students indicated that there were no T's or B's in the sections that had no interaction with the tape.



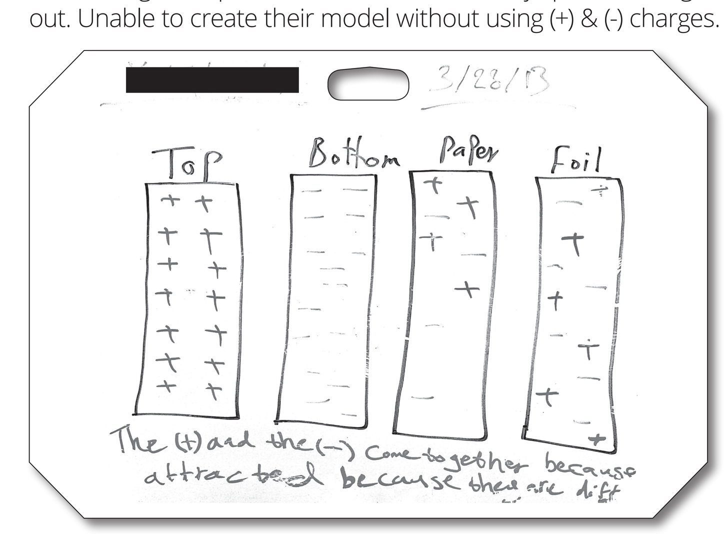
Group 2: Top and Bottom tapes have their own "charge", and paper and foil are polarized.



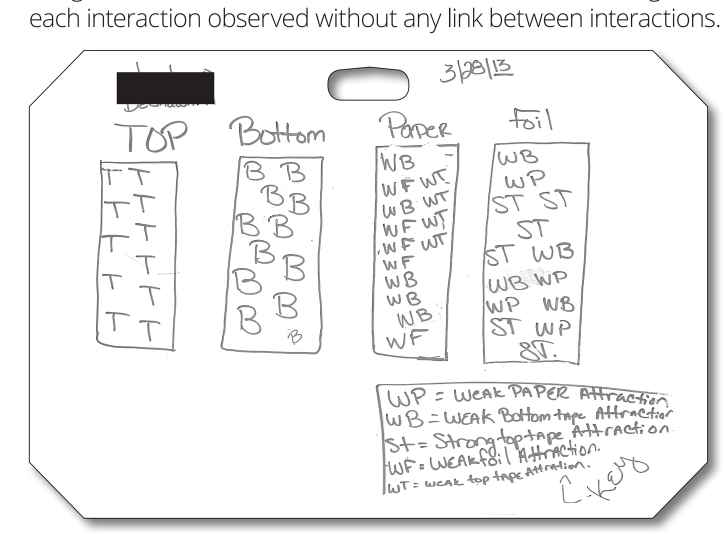
Group 3: Top and Bottom tapes have their own "charge", but cannot model the interactions of paper and foil.



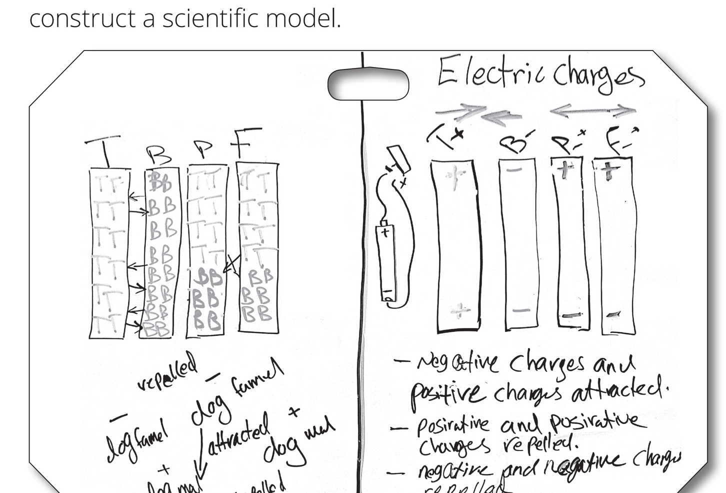
Group 4: Related the behavior to previously learned material (+ & - charges). Paper and foil have these evenly spread throughout. Unable to create their model without using (+) & (-) charges.



Group 5: Top and Bottom tapes have their own "charge", but assign individual characteristics, based on relative strength, to each interaction observed without any link between interactions.



Group 6: Top and Bottom tapes have their own "charge", but paper and foil are polarized without charges between. Students drew a model using + and – charges first and then replaced + with a T and - with a B. Student discourse revealed that they were relying on previously learned material and were unable to use their data and observations alone to construct a scientific model.



Conclusion: Students expressed the greatest comfort explaining the attraction and repulsion between corresponding objects, but struggled greatly to explain the lack of interaction between two objects. The whiteboards showed that most students believed that T-stuff and B-stuff was only present when an attraction or repulsion was observed. Even groups that placed charges throughout the paper and foil indicated that they only did so because they had been previously told that is what is happening by another teacher.

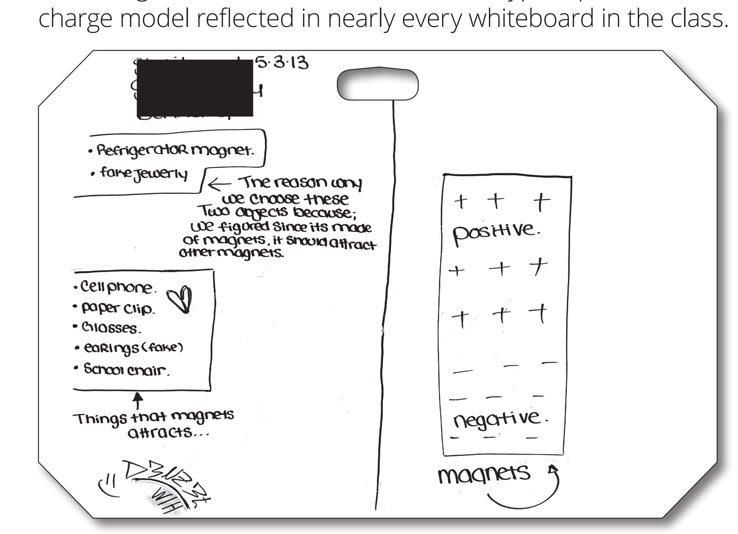
This is a common phenomenon with students where they fail to see the need to provide an explanation to account for seemingly "uninteresting" outcomes (ie: the superposition of balanced forces on a book at rest on a table). Despite this, the students demonstrated levels of cognitive interaction far above that to be expected from students in a persistently low achieving school.

EVOLUTION OF A MODEL

Over the course of a month, students were asked to develop, and revise, a model to explain magnetic interactions based on a series of activities from the Physics and Everyday Thinking (PET) curriculum. The whiteboards presented follow the evolution of one group of students as they worked through the activities. Due to profound levels of absenteeism, the exact group members changed with the exception of two key students who were present for each step.

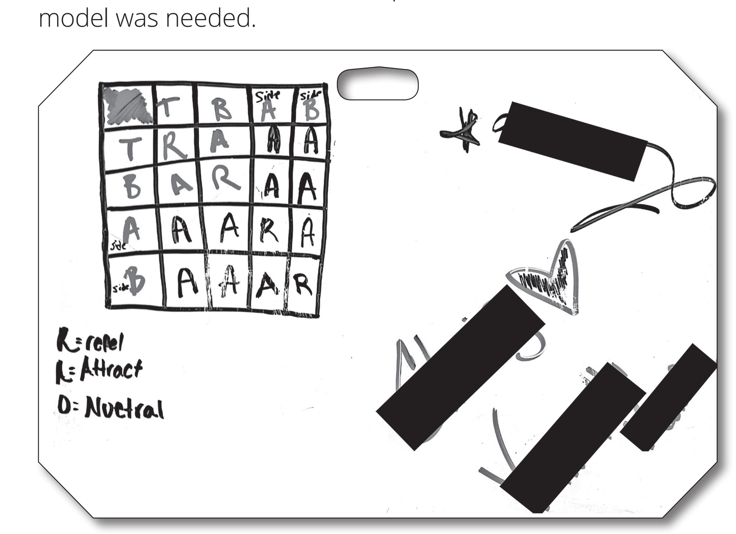
Board 1: Student created a list of objects that would interact with a magnet on the left hand side. Group member indicated that these objects were chosen because they have seen a magnet interact with them.

Students were asked to draw a model of what is taking place inside the magnet, similar to our sticky tape activity (performed before this activity), that makes a magnet behave like a magnet. The model drawn shows a typical polarized charge model reflected in nearly every whiteboard in the class.



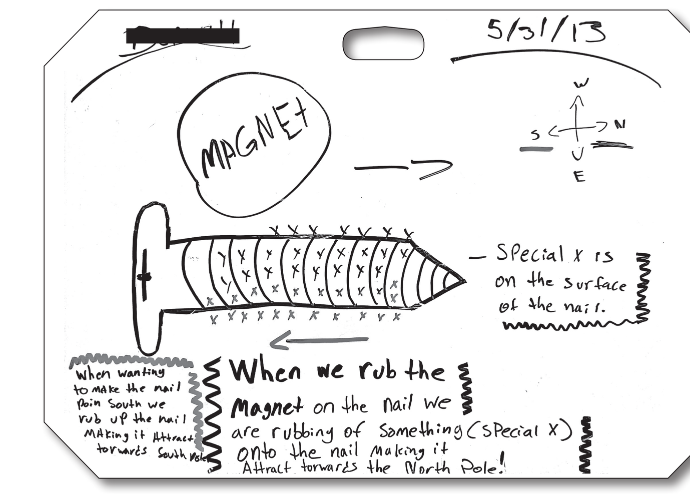
Board 2: Based on the charge model, students were asked to observe the interaction of top & bottom tapes with each side of a magnet (replacing the paper and foil with side A and side B of the magnet).

The group discussion indicated that the magnets behaved similar to the top tape and bottom tape, but magnets must be different since the magnets did not show any repulsion with either tape. Therefore, the polarized charge model could not be accurate and failed to explain the observations. A new model was needed.



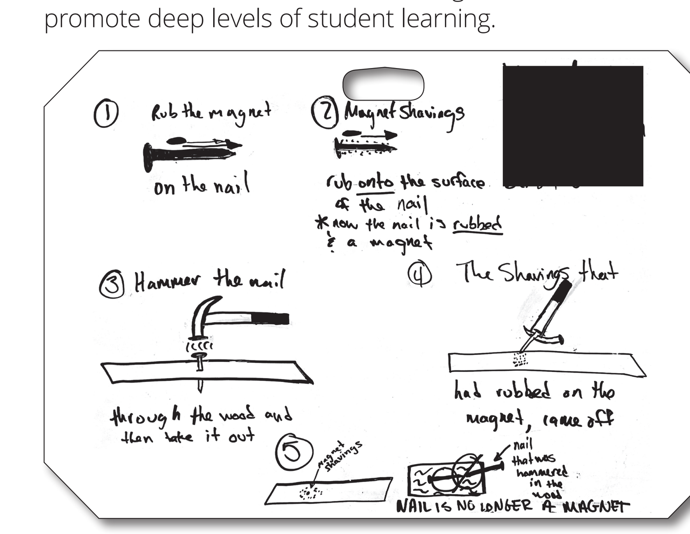
Board 3: After disproving the polarized charge model, the class was unable to develop a new model of magnetism. Based on this, it was clear the students needed additional information before attempting a new model. The class performed an activity where they rubbed iron nails with magnets and discovered that the rubbed nails then behaved like magnets.

After rubbing iron nails with magnets, the class decided to attempt a second model of magnetism. The result took into account that rubbing a nail with a magnet changed how that nail behaved. The new model takes into account that rubbing a nail with a magnet will change its behavior, but failed to attempt to explain why each end of the nail behaved differently.



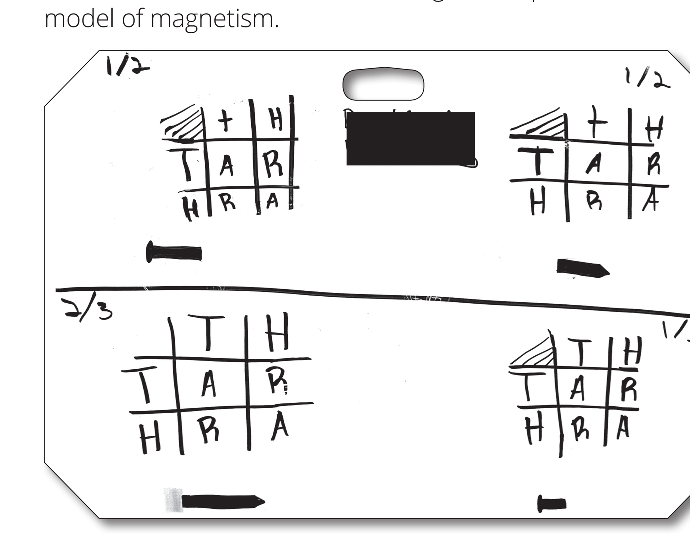
Board 4: Having never seen a "powdered donut" version of magnetism (as the group named it), the group was asked to come up with their own test for their model that could determine whether or not Special X was deposited onto the surface of the nail. They decided to pound the nail into a board and see if Special X was shaken off the nail. The nailed failed to demonstrate any magnetic properties after being nailed into, and removed from, the board. This provided evidence in support of the students' "powdered donut" model.

It is important to note that, as a teacher, it was extremely difficult to allow the confirmation of a model known to be inaccurate. However, it is important that students base their models on evidence, not authority. This was a profound point for teacher reflection, where a "wrong" model was able to promote deep levels of student learning.



Board 5: In an attempt to again address the presence of Special X on the surface of a magnetized nail, the students were asked to cut one magnetized nail in half, and another off center. The pieces were checked for magnetic properties and each piece was shown to have attraction and repulsion observed at each end identical to that of the uncut nail.

Unfortunately, being the last two weeks of school, student attendance was so poor that a third model of magnetism was not possible. Therefore, we have no way of determining how this new evidence would change their "powdered donut" model of magnetism.



Conclusion: Though the evolution of this particular scientific model demonstrates profound thought on the part of these students, this thinking is rarely reflected in their final exam scores. A final model was unable to be constructed due to end of year apathy and absenteeism, not because the students were unable to create the model. It is our hope that work like this can serve as the basis for the exploration of alternative assessment strategies when determining the degree to which learning has taken place, rather than relying on final exam scores from high-stakes state testing. With school wide graduation rates around 25-30%, and passing rates in Conceptual Physics between 50-60%, we believe there is clear evidence that these numbers are inconsistent with the levels of thinking evidenced in student whiteboards and student discourse. Final exam scores, rather than formative assessments like the whiteboards presented here, could inaccurately report on the quality of teaching and learning taking place within these classrooms, and could dramatically under represent the accomplishments of these students.