Student Learning Reflection - Nicholas Merrill

I think a large share of physics teachers would agree that electrostatics is one of the more, if not the most, difficult subjects in an introductory physics course to cover as a teacher and to understand as a student. However, its importance in technology and further pursuits in science is undeniable. Part of the difficulty lies in the fact that many classes and textbooks approach the subject with a mathematical sophistication that reflects more of the interests of physicists than of students. Both my high school and undergraduate dealings with electrostatics showed the subject as a highly abstract mathematical theory, with minimal discussion of the phenomena or its relation to the mathematics. I tried best to construct my unit so that the mathematics would aid the understanding of discrepant events the students would be asked to think about. Therefore the mathematics did not extend past 1D problems involving Coulomb's Law and Electric Field. The idea was that these two pieces were the minimum to sufficiently understand polarization, and other electrostatic phenomena.

My unit which spanned over ten 50 minute class periods consisted of multiple forms of assessment which were intended to guide my instruction and appeal to different types of learners. This included multiple lab assignments, collected classwork and homework, informal formative assessments, exit slips, a small outside project, and a summative assessment. At the same time I attempted to organize my lesson in a way that would be in line with my cooperating teacher's practices. The labs, homework assignments, and summative assessment were formatted and facilitated in a way that was familiar to the students.

I opened the unit on the first day by administering a pretest. My goal was to model the Force Concept Inventory that was designed by physics education researchers and is widely used to assess student understanding of Newtonian Concepts of Force (FCI). Like the FCI, my pretest was purely multiple choice. Each question presented five choices, required no mathematics to answer, and attempted to avoid questions which required definitional prior knowledge. The distractors in the test were meant to probe the students' most common responses based on misconceptions. As references I used two book on teaching the subject. *Five Easy Lesson* by Randall D. Knight and *a Guide to Introductory Physics Teaching* by Arnold B. to expect what these misconceptions about electrostatic might be.

4) Suppose a smaller conducting sphere has a negative -10 nC charge. It is brought in contact with a second larger conducting sphere that is initially uncharged. After the contact, what is the charge on the *larger* conducting sphere?

A) 0 nC
B) Between 0 and -5 nC
C) -5 nC
D) Between -5 and -10 nC
E) -10 nC

.

Because of my self-imposed restriction that excluded quantitative questions, many questions focused on the descriptions of moving charge or the interpretation of diagrams. For this particular question only 32% of students correctly answered D. Post instruction 78% answered correctly.

Not all gains were as significant. The first and second period classes averaged a 26.7% and 26% respectively. This is in line with FCI scores which show percentages minimally above those expected by guessing. The post test scores were 52% and 56% respectively. prior to the Unit I had a personal goal of obtaining percentages above 60, The conventional way to interpret the results of such a test is to look at the normalized gain (G). Defined as the change in score divided by the maximum possible increase.

$$G = (\text{postest\%} - \text{pretest\%})/(100 - \text{prescore\%})$$

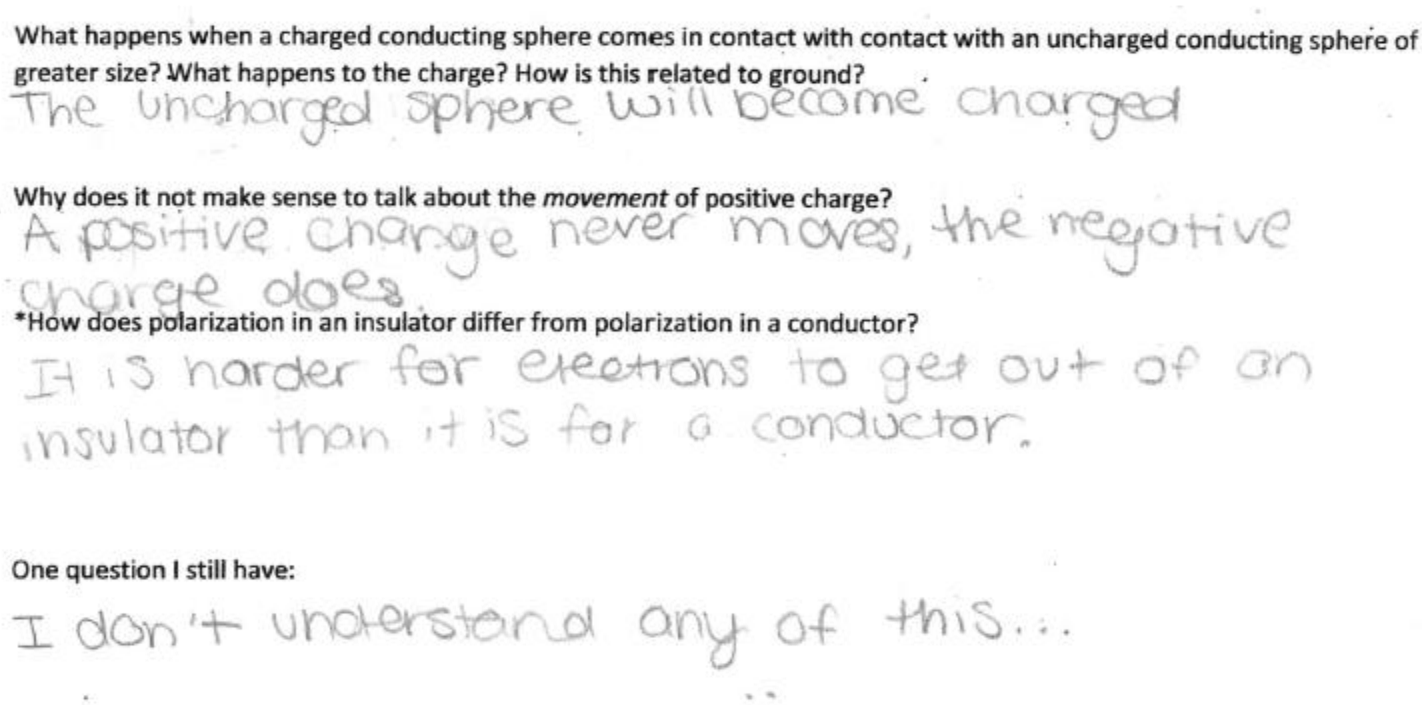
The average gain by this definition was 0.325. In a traditional lecture based class a typical FCI gain after a semester of Newtonian mechanics is around 0.2. Most of the difficulties came from the problems that involved electric forces and fields. Students who were absent and did not complete both the pretest and posttest are excluded from these results.

In addition to the first days pretest the students performed a lab involving the testing of charged and uncharged pieces of tape against each other. They were asked to develop a method of testing if an object was charged, and to compare this new phenomena to the gravitational force. Most recognized that like charged objects repelled that unlike attracted. More had difficulty recognizing that any charged object attracts any uncharged object. Some were able to abstract these ideas to conclude that repulsion was the “definitive test” to conclude something was charged. Most students also recognized that this “force” had to be much stronger than gravity, and that both electrostatic and gravitational forces between the objects decreased in strength with increased object separation. I addressed these difficulties by review the lab toward the beginning of the next day's class and demonstrating the principles with materials other than tape. The humid environment caused some problems as it was difficult to charge items for demonstrations, adding to the confusion of some students.

The second day after the review of the lab involved several typical electrostatic demonstrations involving the Van de Graaff generator. The focus was define the terms conductor, insulator, and ground, before explaining them in the context of a scientific model. During these demonstrations I asked open ended questions and called on different students to gauge understanding. Most of the responses indicated that student had some idea of what an insulator and conductor were capable of doing, but had no explanation of how. Almost all students believed that grounding an object “destroyed” the charge on the object.

The following day was one of the most difficult for instruction. The jump from a qualitative description of the phenomena to a scientific model which proposes a fundamental, atomic, nature of charge confused many students. Though most had already taken a course in chemistry, through a series of questioning, few were able to connect the positive and negative charges associated with protons and electrons to the macroscopic phenomena that they had been observing.

After reflecting on the students responses to the exit slips provided that day I strongly believe that I compounded their difficulties by trying to explain polarization in the same introductory setting as this quantum model of charge. It would have been more beneficial to approach the concept in the following day and focus my efforts the movement of charge between objects first. The exit slip also asked students to talk about grounding, now in the context of moving electrons.



What happens when a charged conducting sphere comes in contact with contact with an uncharged conducting sphere of greater size? What happens to the charge? How is this related to ground?

The uncharged sphere will become charged

Why does it not make sense to talk about the *movement* of positive charge?

A positive charge never moves, the negative charge does.

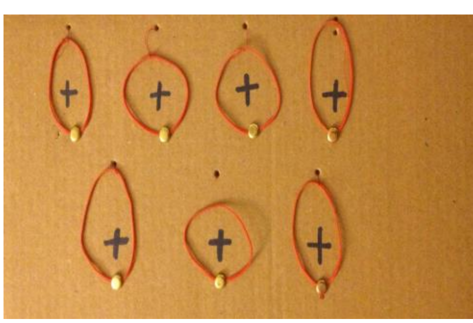
*How does polarization in an insulator differ from polarization in a conductor?

It is harder for electrons to get out of an insulator than it is for a conductor.

One question I still have:

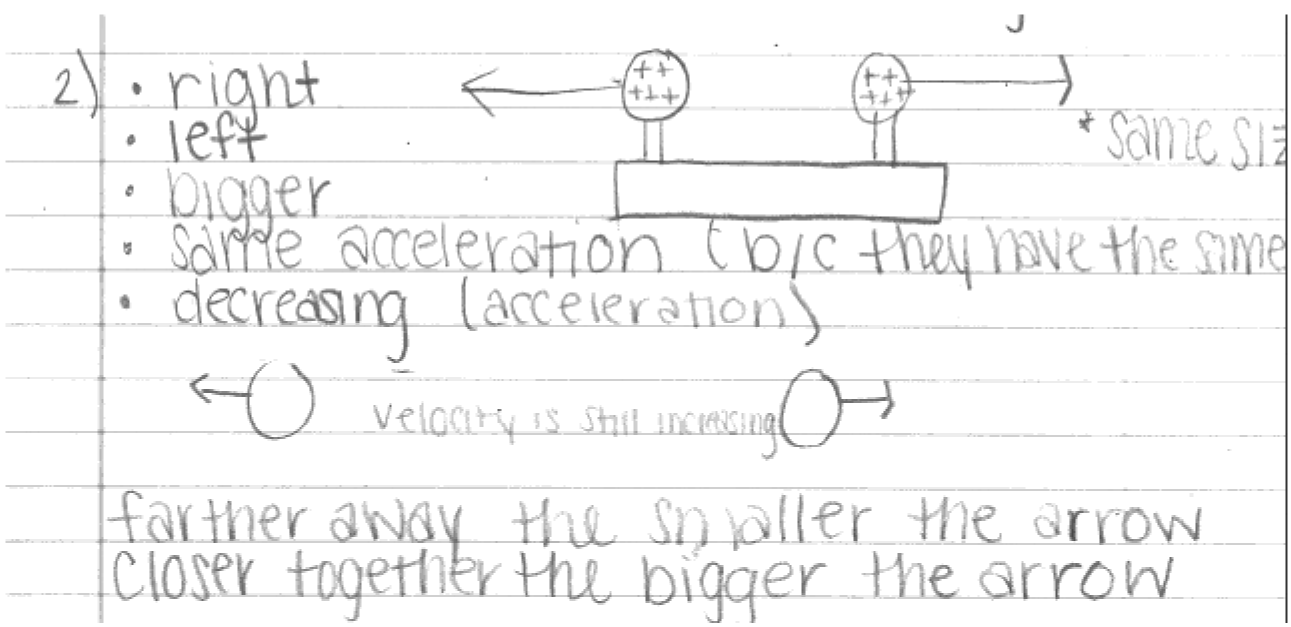
I don't understand any of this...

In a following day I returned to the same topics and was much more careful as to how I introduced them. The students were provided with guided notes, and I produced several visual aids for the class to tackle the different underlying mechanisms behind polarization.

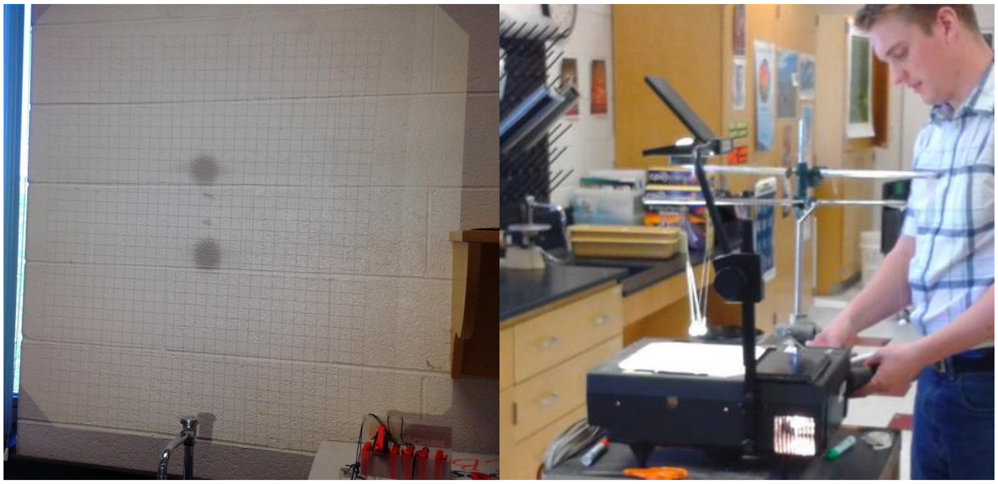


From questioning the class alone I could measure an increase in understanding. I re-administered the same exit slips following this extra day of instruction. Almost all the responses improved and many went into great detail. After the markedly improved responses, the extra period of instruction was totally justified in my mind, although not all confusion was erased.

Prior to the official introduction to Coulomb's Law, I had the class work on a conceptual problem involving two charged conducting spheres on insulating stands free to move on a frictionless air hockey table. This exercise brought about prior difficulties with Newton's Laws. Half the problem was undertaken as class and the second half was undertaken in pairs. There were underlying problems that I saw: Students believed drawn vectors should not overlap (thinking they extended in space), Students did not "believe" that the force on two differently charged objects was equal and opposite. Students had difficulty differentiating between acceleration in velocity. Almost all the class had some doubts about Newton's Third Law of equal and opposite forces.



In the following class, where Coulomb's Law was tackled formulaically, I walked through a demonstration of Newton's Third Law involving electrostatics. Differently charged, but otherwise identical objects were shown to have the same deflection, to most students this was sufficient evidence that there was the same force acting on each object.



This was also the second day that I assigned a problem set for homework over the weekend. Though the problem set only consisted of four question and was graded on completion, only a handful of students completed the assignment. In conjunction with an equal poor response the first homework assignment, I was deterred from assigning future homework assignments, one student commented that this was a mistake, because she needed the opportunity for practice. I regret not coming to a compromise where I could have provided the extra practice, without collecting it for a grade.

At the beginning of the following day I assigned a small project. Students were asked to write three sample test question. One true false, one multiple choice, and one which required a quantitative calculation. I tried to motivate the students choosing particularly good questions to be featured on the test. This assignment was also an opportunity for extra credit if the students went beyond a level dictated by a provided rubric. Overall the test questions were very informative. Many in an attempt to write questions that went beyond the lecture made mistakes that revealed misconceptions that also went beyond the lecture. It was clear that many students felt uncomfortable with the task of creating quantitative problems. Many students took examples from class and only changed the numbers in the problems, showing little extension of their knowledge. However, despite these concerns, many of the student submitted multiple choice and true false questions, which addressed their previous misconceptions, showing reflection on the content.

The summative assessment at the end of the unit was meant to evaluate the students comprehension of all of the material covered in the unit. The Test consisted of 11 true or false question, 7 multiple choice questions, 19 quantitative, 1 five part fill in the blank, and 1 short essay. All the questions together totaled to a possible 50 points. The score was adjusted and reported to students as a percentage out of 100.

There was also a free response extra credit question that involved induction, a topic not covered during the unit directly. My hope with providing the extra credit was that some students would be able to extend their knowledge of electrostatics to interpret a new phenomenon. A review packet was offered to the students two periods before the class. I did not collect the packet because I did not want to force students to study for the test in a particular way.

On the last page of the test was a survey which asked students to evaluate the difficulty of the test and the fairness of the test. Students were also asked to reflect on the amount of time spent preparing for the test and to self-assess their understanding of electrostatics. All responses were given on a scale of one to ten.

Survey: Rate on a scale of 1-10. Answering will have NO EFFECT on your grade or my feelings. YOU DO NOT HAVE TO ANSWER. I'm just curious. Answering honestly will just help me write better future tests. Circle the number on the scale that best applies to your opinion.

I found this test to be
(Very Easy) 1 2 3 4 5 6 7 8 9 10 (Very Difficult)

I found this test to be
(Very Unfair) 1 2 3 4 5 6 7 8 9 10 (Very Fair)

I would describe the amount of time I spent studying for this test as
(Very Little Time) 1 2 3 4 5 6 7 8 9 10 (A Huge Amount of Time)

I would describe my understanding of Electrostatics after this unit as
(Very Little Understanding) 1 2 3 4 5 6 7 8 9 10 (Very Strong Understanding)

The average percentile scores for 2nd and 3rd period were 85.7% and 84.8% respectively. On the six point grading scale these averages sit at a high C's. There were two perfect scores among the thirty-two students. The survey results provided interesting feedback. The average reported difficult out of ten was a 7.5. The fairness a 6.7. The self-reported amount of time preparation a 6.1. The self-reported understanding a 5. A statistical analysis showed a strong correlation between self-reported understanding and raw score, however there was very little correlation between preparation and raw score. The results can be interpreted several ways, but from a formative standpoint as an instructor it seemed that the students who were engaged during class, performed well, and the students who only worked to learn the material for the test struggled.

I am thankful for the opportunity to teach a difficult subject during my student teaching experience. After completing the unit I know I would make several changes in my instruction next year. I think most importantly, gravity must be covered in greater detail, and from a similar perspective of electrostatics, involving a detailed discussion of forces, work, fields, and it's fundamental nature. Electrostatics is highly abstract in nature, therefore it was critical to call upon analogies in gravity. I will also make an extended effort to make students comfortable with vectors, and vectors addition, before advancing into deeper content. A large chunk of class time had to be dedicated to cover that was introduced in the the first few units in physics. I think a separate class focusing on just the mathematical underpinnings of vectors as a half to full period refresher, completely separate from the new content would be beneficial. I was encouraged by the test question project, and am likely to adjust the rubric and assign the same thing in the future.

I had the opportunity to teach a diverse group of students that had a range of abilities and a willingness to provide useful feedback. My cooperating teacher was supportive and the class structure and environment he had in place allowed me to easily take over as a student teacher and command the respect and attention of the students. 5-E lesson planning was largely a success, and provided an easy format to build my unit around. This unit plan has been a very positive experience, and has greatly shaped my ideas about physics education, and what students can connect to, understand, and retain.