Context for Learning Form

1. What is the name of the course you are documenting? Physics

2. What is the length of the course? One year

3. What is the class schedule? 50 minutes once a week + 100 minutes twice a week

4. How many students are in the class you are documenting? 31

5. How many students in the class are: English learners: 5

   Redesignated English Learners: 4 Proficient English speakers: 5

6. How many students have Individualized Education Plans (IEPs) or section 504 plans?
   Three

7. What is the grade-level composition of the class?

   3 sophomores, 17 juniors, 11 seniors

8. Describe any specialized features of your classroom setting, e.g., bilingual, Sheltered English. N/A

9. If there is a particular textbook or instructional program you primarily use for science instruction, what is it? (If a textbook, please provide the name, publisher, and date of publication.) What other major resources do you use for instruction in this class?

Most curriculum resources are designed by myself, my lead teacher, or other instructors in the science department. We do regularly consult the listed text for the course:
Paul Hewitt *Conceptual Physics* Prentice Hall, 2002

10. What technology is available to support science instruction? NOTE: If this data is difficult to obtain, then provide an estimate, e.g., "a few" or "about 30."

	# of scientific calculators	# of graphing calculators	# of computers	# of computers connected to the Internet
Available in classroom	40+	5	2	2
Available elsewhere in school	X	X	4 sets of 25 laptops	All laptops

11. What other types of technology, e.g., LCD projector, smart boards, are available to support instruction in your classroom?

Projector, smart board, various kinds of probeware (force, movement, sound)

Context Commentary

I teach a Physics course at a large comprehensive high school in the San Francisco Bay Area. Firebird High School is much maligned by the community as the “black sheep” of its district, thanks to comparatively low test scores, high rates of free & reduced lunches, and a history of gang activity and violence. Over the course of many decades, socioeconomic and political factors have shaped the district’s zoning, and in the end Firebird HS is disproportionately disadvantaged and ethnically diverse when compared to the community at large and the other district high schools. Upwards of 60% of students qualify for free/reduced lunches, and Firebird’s test scores have been historically low as compared to other schools. That being the case, school administrators have been pushing to improve the quality of curriculum, boost test scores, and polish the school’s image. Thanks to a conceptual push in physics and a renewed department emphasis on reading strategies, Firebird's physics scores on the STAR test increased an astounding 20% last year.

Diversity in ethnicity and socioeconomic status and the drive to improve student achievement are the two primary factors that have shaped my classroom context. Between the varieties of students themselves and the variety of reasons for which they are in Physics, the class is highly heterogeneous along multiple axes. First I will address the factors at Firebird and in the science department that are influencing what sorts of student take the course. Second, I will address the students’ widely varying personal and developmental characteristics.

The culture of the science department at Firebird places enormous trust and faith in individual teachers. The school-wide “expected student learning results” are obviously in effect, but the department chair encourages creative and innovative curriculum. Besides being held accountable for student performance on state standardized tests (STAR and CAHSEE), science teachers at Firebird have no additional requirements or structures affecting curriculum or practice. My cooperating teacher has passed that freedom along to me, and since autumn I have been allowed to design and implement activities independently.

Classes at Firebird are not strictly-speaking tracked, but teachers and counselors make recommendations about how students should move forward with their schedules. To understand how a student might find herself in my class this year, my Physics course must be contrasted with the other Physics class available – Honors Physics (AP Physics will be available next year). The differentiating factor is math achievement and ability. Counselors encourage students to take three or four years of science courses, in order to meet UC and state college entry requirements. Historically, physics comes third after biology and chemistry and is mostly taken by juniors and seniors. If a student happens to do well in math simultaneously, reaching pre-calculus as a junior, he or she would be encouraged to take Honors Physics. Otherwise, they are encouraged to take Physics. My cooperating teacher has designed the Physics curriculum to include math only where the standards demand. Students are aware of this distinction, though, and a significant number of students who have done well in math opt out of Honors Physics explicitly to avoid it.

Change may be coming to the classic physics-third structure, however. There has been a push in the science department for more students to get a grounding in physical sciences before pursuing biology or chemistry. There is a general consensus that this has cognitive merits and could improve test scores. Some students are now taking environmental science or another general science course as freshmen, and then physics as sophomores.

To generalize, students have ended up in our conceptually-focused Physics course for one of three reasons: First, their achievement has been steady along the classic bio-chem-physics track, but they are weak-to-average in math. Second, their achievement has been excellent in math and science, but they have elected to take the "easy" of the physics classes. Third, their counselors have channeled them into physics as sophomores. Thus, our class of 31 students has a mix of 10^{th} to 12^{th} graders, with some who passed AP Calculus and others who failed Algebra I.

This heterogeneity means the students have very disparate prior knowledge and academic abilities. As I approach the subject matter of this unit – electromagnetic force fields – I have to bear in mind that students vary tremendously in their familiarity with the concepts of electricity, magnetism, and forces. Some students learned about Newton's Laws as eighth graders and now possess strong and accurate intuitions about how objects push and pull on each other. Some students have had their notions of electrical attraction and repulsion shaped by experiences in chemistry, if their instructor then emphasized atomic structure. Other students have no background in electricity or forces.

Socioeconomic status has also influenced students' prior knowledge in somewhat unexpected ways. Some of my students attended science camps as children and learned about magnetism there, and others have had personal experience with electronics through their parents. More disadvantaged students in the class have had much less experience with such phenomena, since their previous schools and/or parents could not provide the specialized resources needed to investigate electromagnetism.

In terms of overall academic skills, students also vary widely. A few of the AP Calculus students could handle mathematics far and beyond what we see. Other students have difficulty solving algebra equations for a single variable. Some students have experience doing complex hands-on activities In other science courses, while others have sadly only been exposed to videos and bookwork. Some write in English eloquently and thoughtfully, while others struggle with anything beyond a sentence or two.

Nevertheless, the students in my class do have certain academic commonalities. They all understand spoken English and converse in it very well, even the English learners. Thanks to the relative ease of communication, students work together effectively and collaboratively so long as the task is group-worthy and well-scaffolded. Of course, depending on the exact demands of the task, certain low-status students might tend towards shyness and certain high-status ones towards domineering. However, I've seen those hesitancies shift and change from task to task, grouping to grouping, and even day to day. In designing tasks and activities, I can generally rely on students to cooperate with another while engaging in groupwork.

Another academic commonality is students' unfamiliarity and uncertainty with scientific graphic representations, even though they are all decent artists and enjoy open-ended drawing. I am immediately reminded of a time I showed what I called a "photograph" to students of a falling ball. To the side of the ball, there was a meterstick. Students reacted strongly: "That's not a picture! That's a diagram! It has numbers!" Adding an analytical or qualitative element to visuals adds a layer of complexity to students' interpreting task, and almost all of my students continue to grapple with that layer. Since interpreting and creating diagrams is so crucial model-rich physics, I have emphasized graphic representations throughout the school year. The newness of the material being represented helped to level the academic playing field, so-to-speak. Regardless of background, no students have been exposed to certain concepts, vectors being one example. In one unit, students were introduced to the abstract construct of vectors; in the next, we applied vectors to describe moving objects; most recently we used vector diagrams to analyze the motivating forces. Throughout, students have been asked to produce diagrams alongside every problem we do, and every task or activity includes some sort of representational element.

Much like the physics-related representations, the physics academic language is entirely new for the wide majority of students. Even in cases where they have seen the concepts, only a handful has any exposure to the phrasings and terms we use. Even after students can express their understanding to me verbally, they can struggle to get their entire point across in science language. Much of the difficulty relates to their lack of practice in arguing from evidence. There are few opportunities for this in Firebird, and virtually none in the science department aside from physics. Even students with strong chemistry and biology backgrounds have only really been asked to follow directions, not explain what they think and why. I have often attempted to address these two issues, academic language and arguing from evidence, in tandem, using thought-provoking scaffolding and verbal examples.

Outside of all the academic areas I have mentioned, I would be hard pressed to make any further generalizations about my students themselves. Their interests and personalities vary in the way one would expect in a highly diverse comprehensive high school. Across the board, though, they have shown themselves to be mature and helpful. They know of my ongoing education and they have fully supported my efforts to try new and exciting activities or approaches, even when it's lead to wasted time or frustration. In any planning I do, I know that these students will be open-minded about giving things a shot. I can plan on getting good constructive feedback from them, regarding both on the content and on their own experience. Even if things go poorly and I see an activity has failed, I never have to fear mutiny or disorder. On a few occasions, students have transitioned calmly and without complaining after technical breakdowns struck in the middle of activities. In designing this unit, I felt immense freedom to design exciting and complex tasks, knowing my students' willingness to "go with the flow."

LESSON 1

May 8 – Friday 100 min

Guiding Question:

As a warm-up students will be shown a nail in a coil of wire that is somehow functioning as a magnet: Picking up bits of metal and sticking to surfaces. Students will watch a video clip of a large electromagnet on a crane picking up heavy loads.

In pairs and as a class, we will discuss the question: *What is the connection between electricity and magnetism?*

To answer this question, we will introduce the idea of "electric field" and the drawing of field lines.

Learning Goals:

CA Physics Science Standard 5e –Students know that charged particles are sources of electric fields and subject to the forces from the fields of other charges.

Students will recall that positive and negatives charges exist as protons and electrons, usually in balance. Alike charges *repel* (push apart) and opposite charges *attract* (pull together).

Students will come to understand that these pushes and pulls are *vector forces*; we can draw them as vectors and they follow vector rules we know. This electric force still looks a bit spooky since nothing ever touches – people once called it "*action-at-a-distance.*" It seems slightly less spooky when we think of a *force field* all around charged particles, so that when particles move through each other's fields they feel forces. Our vector drawings make this easier to visualize:

We represent fields by connecting all the vector forces we can draw around them. We call the resulting drawings "*field lines*." More lines in an area mean more force on a particle plopped down there.

We draw electric field lines according to 4 rules:

1. Lines start on + charges
2. Lines end on – charges
3. Lines never cross
4. Bigger charges put out more lines.

Students will come to understand the resulting drawings of electric fields lines, and that these drawings show how a positive test charges would move. They will be able to look at a set of charges, interpret the interaction going on, and draw the corresponding field lines.

Listening Strategies and Applications (Intermediate ELD Level):
Comprehension: Ask and answer instructional questions by using simple sentences.
Reading Strategies and Applications (Intermediate ELD Level):
-Read simple vocabulary, phrases, and sentences independently.

Students will interact with me while working on their worksheets and learning about electric field lines. They will need to read the rules for drawing field lines independently and then apply them.

Activities:

Students will watch a demonstration of drawing electric forces, given by me. I will use large construction paper cutouts to represent positive and negative charges; students will see the charges stuck up on the board with magnets and I will draw the forces on the board as the charges move around. Students will predict the correct drawings in response to my verbal prompts, using physical gestures (pointing), or some recently-ordered small whiteboards (if they arrive by post in time).

Students will complete a worksheet where they draw electric forces as vectors. The visuals from the board will be re-created on paper, showing a large fixed charge and smaller charges around it. Students will draw in the forces on the small charges.

Students will watch a second demonstration with the cutouts on the board, but now with forces represented by field lines.

Students will complete another worksheet where they describe electric fields and the rules for drawing them. They will write brief descriptive sentences in doing so. On the same worksheet, they will draw the electric field lines for sets of charges.

Assessment:

I will know students understand the electric force as a vector when they respond to my verbal prompts during direct instruction, by physically pointing in the direction they think the force will go. I will know they can draw the electric force as a vector when they successfully complete the first worksheet.

I will know students understand electric fields and drawing field lines when they successfully complete the second worksheet.

Resources:

- Primary content source is Hewitt's *Conceptual Physics*.
- Manipulatives on board made with construction paper.
- Class set of whiteboards (if possible)
- Handout with rules of drawing field lines, as summarized by me.
- Worksheets created by me.

LESSON 2

May 11 – Monday 50 min

Learning Goals:

CA Physics Science Standards
5f – Students know… electric current is the source of magnetic fields.
5g – Students know how to determine direction of the magnetic field produced by a current.

Students will come to understand that Einstein's Theory of Relativity explains how times, distances, and forces depend on reference frame. This happens because the speed of light is the same in all frames. The light from a flashlight moves the same no matter how fast it moves compared to an observer. Students will come to understand that if one basketball player passes the ball to another while on the court, an observer from the side agrees with the players about the time, distance, and force of the pass. If the players are standing on a train and an observer watches from the side, then they (the players and observer) disagree about the time, distance, and force. When things have relative motion, observers in the different frames measure different values of distance, time, and force. The faster the relative motion, the more they disagree. When Special Relativity is applied to electric fields, observers experience fields they don't expect would be there. We call these "magnetic fields."

Students will come to understand that a steady flow of charge creates a circular magnetic field. A magnetic compass brought near the wire orients itself with the magnetic field that comes from those fast-moving charges. The "Right-Hand-Rule" describes the direction of the field that gets made by a current.

CA Investigation and Experimentation Standard
1d – Students will formulate arguments by using logic and evidence
1k – Students will recognize the cumulative nature of scientific evidence

Students will create arguments for what they think the shape of the magnetic field is, based on the evidence of compass readings. Since different students' groups will have the chance to try different arrangements of wire, the class' final conclusion will depend on the accumulated evidence from the many groups.

In groups, students will be expected to communicate and cooperate readily in arranging wire, taking measurements, and recording/drawing results. They will need to draw magnetic fields, and interpret line drawings of wire. Using sentence scaffolds if desired, students will give arguments of the sort "I think the magnetic field around a wire is shaped like a ring, because the compasses all pointed perpendicular to the wire."

Listening Strategies and Applications (Intermediate ELD Level):
Comprehension: Listen attentively to stories and identify important details and concepts by using both verbal and non verbal responses.
Comprehension and Organization and Delivery of Oral Communication: Identify the main idea and some supporting details of oral presentations, familiar literature, and key concepts of subject-matter content.

Students will respond to my presentation verbally and by writing short answers. The writing demands will not be complicated, since the main content idea is novel for students.

Reading Strategies and Applications (Intermediate ELD Level):
Vocabulary and Concept Development: Use more complex vocabulary and sentences to communicate needs and express ideas in a wider variety of social and academic settings.
Vocabulary and Concept Development: Understand and follow simple written directions for classroom-related activities.

In groups, students will need to follow directions and express their ideas to their peers in order to move forward with the activity.

Activities:

Students will watch a presentation, by me, about relativity. Volunteers will pass a basketball at the front of the class, and I will draw the path of the ball on the board behind them. Students will predict how things change if the players are in motion, and the volunteers will try and recreate that situation. Students will answer a reflection question about how the rules of physics change when things have fast relative motion.

In groups, students will measure the direction of magnetic field around a current-carrying wire. Students will have to use team work to maintain a flat plane for the compass measurement, while still trying the wire at different angles and orientations. Students will make 4 measurements for 3 orientations for a straight wire, and then 4 measurements for 3 orientations for a shape of their choosing. They will hand in numerical results as a group, then complete individual questions about the shape of the field.

Students will practice the "Right-Hand-Rule" gesture as an entire class.

Assessment:

I will know students understand that Special Relativity motivates magnetism when students respond to reflection questions after my presentation: "Normal laws of physics work for everyday speeds. What happens at high speeds, when things have very fast relative motion? What happens to electric fields?"

I will know students are arguing from evidence when they complete the sentence scaffold: "The magnetic field from a wire points__________. I know this because if I bring a compass near a wire, the compass ________."

I will know students can determine the direction of the magnetic field created by a current when the whole class can use the Right-Hand-Rule gesture correctly.

Resources:

- Primary content source is Hewitt's *Conceptual Physics*.
- Relativity Powerpoint made by me.
- Flashlight
- Basketball
- Investigation Materials
    - Experiment Procedure & Data Table
    - Wire
    - Battery
    - Compasses
    - Construction Paper

LESSON 3

May 13 – Wednesday 100 min

Learning Goals:

CA Physics Science Standard 5f – Students know magnetic materials and electric currents are the sources of magnetic fields, and subject to forces from other sources of magnetic fields.

Students will come to understand that magnetic material, with which we are all familiar, creates magnetic fields through Relativistic effects. The individual atoms of magnetic material have electric charge spinning and circulating within them, like tiny loops of wire. The moving charges (electrons) create a magnetic field just like electrons flowing in a wire. Each atom has its own magnetic strength and direction depending on how its loop is pointed – this is a vector called Magnetic Moment". We call one end "North" and the other "South." When many atoms align their ends in the same direction, we call them a "Magnetic Domain." The magnetic domains of materials can themselves be aligned or not.

Students will come to understand that in a compass, the domains in the material all line up and create a magnetic field across the whole piece of metal. This magnetic field likes to align with the magnetic field of the earth. We can represent this process more easily if we use our idea of "field lines" to draw magnetic fields, too.

We draw magnetic field lines according to 4 rules:

1. Lines start on North end
2. Lines end on South end
3. Lines never cross
4. Stronger magnets put out more lines.

Reading Strategies and Applications Vocabulary Development:
Vocabulary and Concept Development: Apply knowledge of academic and social vocabulary while reading independently.
Organization and Focus, Penmanship: Write legible, simple sentences that respond to topics in language arts and other content areas (e.g., math, science, history–social science)

Students will need to read and take notes from a conceptual physics textbook. They will draw out the most important information by predicting from titles and drawings, reading with help from group members, and identifying & summarizing important ideas.

Activities

Students will use magnets to re-orient compasses. Students will watch an explanation of magnetic moment, given by me. I will use elbow pads and wrist guards to have each of my arms represent an atom and its magnetic orientation.

Students will read from the textbook in groups, following a protocol they use often, called "Active Reading." In groups of four, one student begins as "leader," and moves the group through a series of prompts on index cards – Predicting, Reading, Clarifying, Identifying, Summarizing, Swapping Leader.

Students will complete a worksheet where they draw in the magnetic field for a set of magnets.

Assessment:

I will know students understand magnetic materials as field sources when they answer a reflection question and create magnetism notes from the reading.

I will know students can draw magnetic field lines when they complete the worksheet for homework.

Resources:

- Hewitt's *Conceptual Physics*, Chapter 36 pp. 563-567
- Props designed by me
- Reading cards – created by Kip Scott, Firebird HS
- Worksheet created by me.

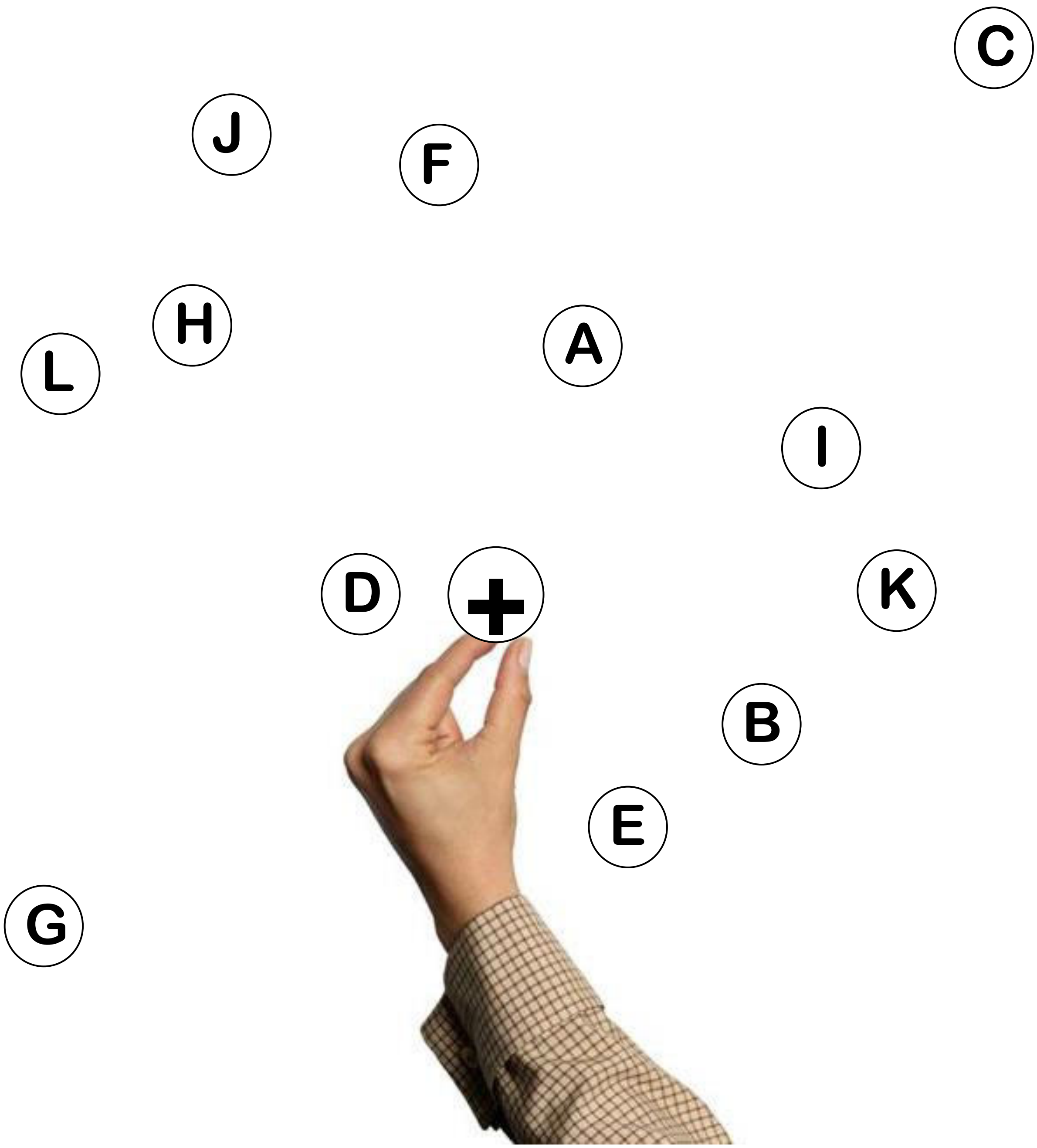
Summative Assessment

Following the learning segment outlined here, students will demonstrate their cumulated knowledge through a performance assessment. Students will construct their own speaker using a paper plate, magnet, and wire. They will complete a report describing how their speaker demonstrates electromagnetic induction, which will require them to use the skills and knowledge they have acquired through this segment and the rest of the unit:

- How fields are represented
- How current creates a magnetic field
- How magnetic materials create magnetic field
- How changing currents create changing currents and vice versa

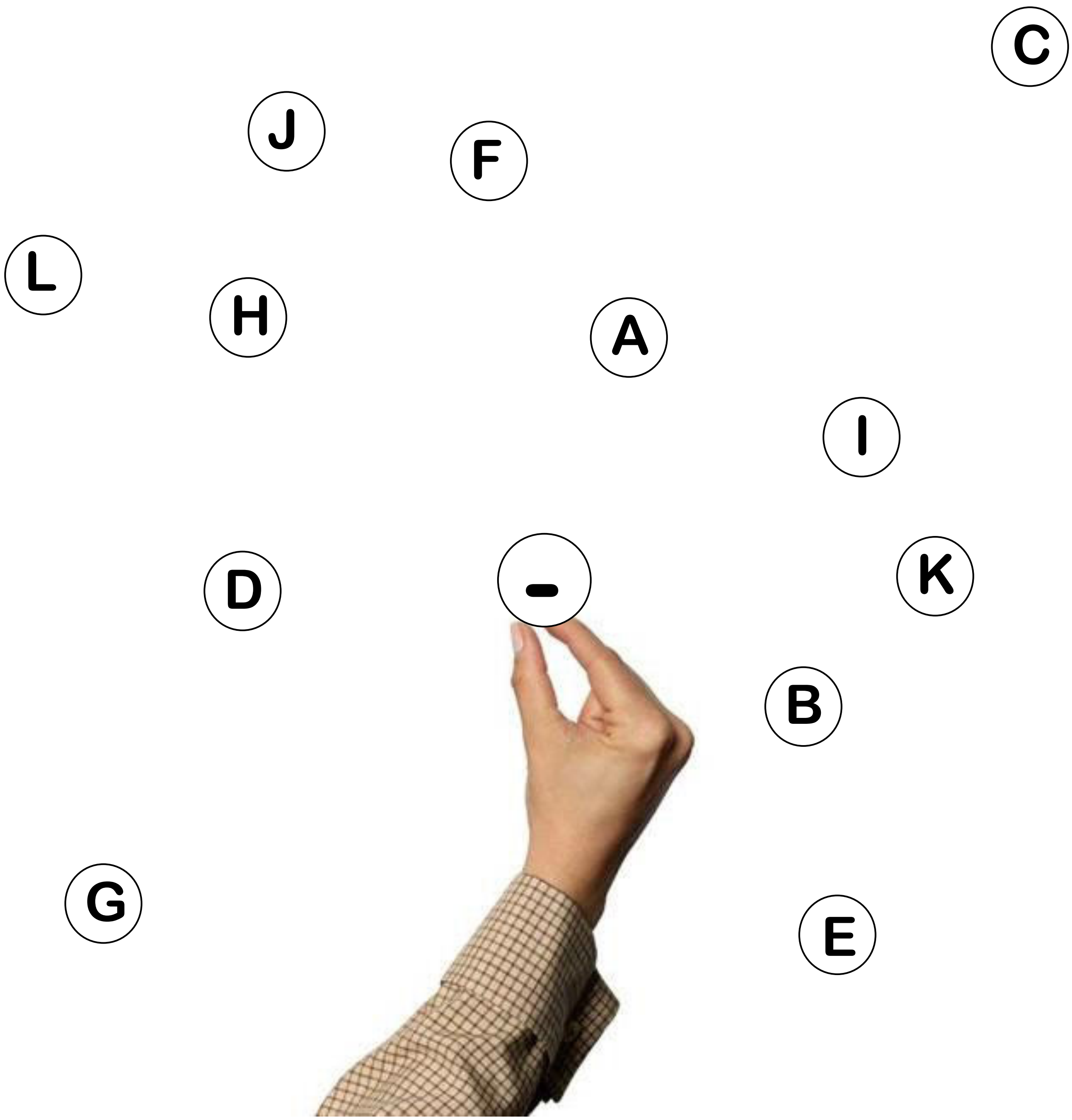
LESSON 1 MATERIALS

DRAWING THE ELECTRIC FORCE



Draw the force on each *positive* charge (A-L) exerted by the *big positive* charge. Use the rules you know for electric charges.

DRAWING THE ELECTRIC FORCE



Draw the force on each *positive* charge (A-L) exerted by the *big negative* charge. Use the rules you know for electric charges.

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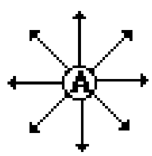
HOW TO DRAW ELECTRIC FIELD LINES

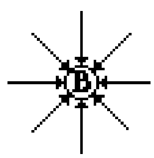
1. Lines start on + charge
2. Lines end on – charge
3. Lines never cross
4. Bigger amounts of charge put out more lines

Field lines point in the direction a *positive* test charge would move. More lines in an area mean there would be more force on a test charge there.

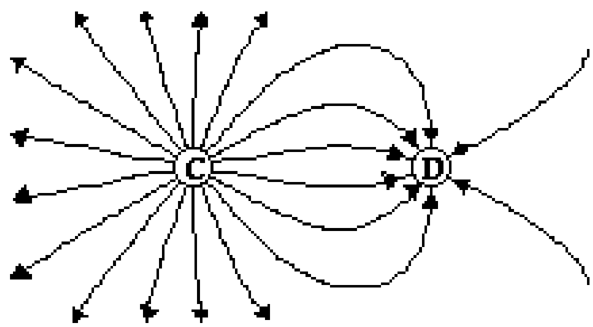
Are these charges positive or negative? Circle which one.



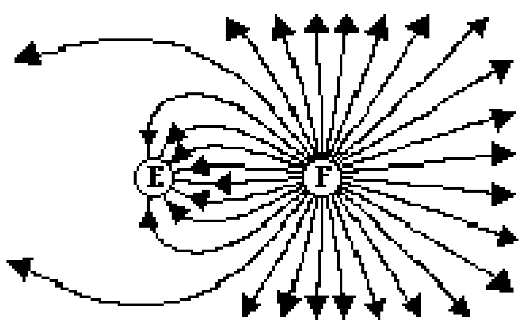
A: + or -



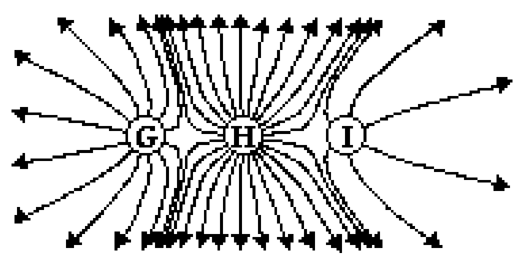
B: + or -



C: + or - D: + or -



E: + or - F: + or -



G: + or - H: + or - I: + or -

NAME______________________ DATE___________ BLOCK____

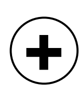
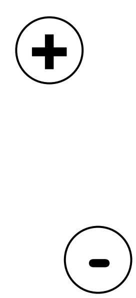
ELECTRIC FIELD LINES

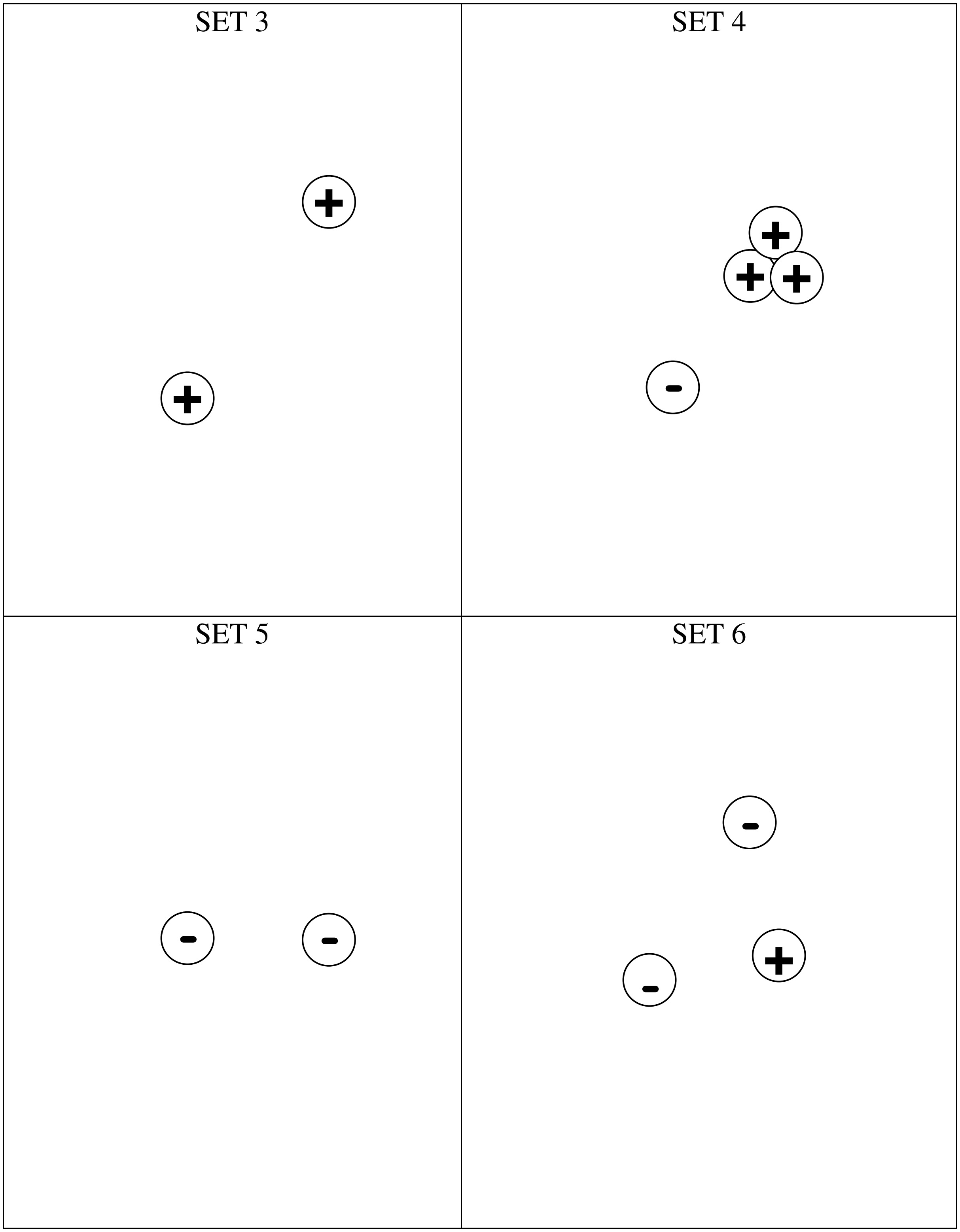
Answer these reflection questions:

1) What creates electric fields?

2) How do we represent electric fields? What are the rules?

Draw the electric field lines for each set of charges, 1-6.

SET 1	SET 2
	


SET 3
SET 4
SET 5
SET 6

<u>LESSON 2 MATERIALS</u>

The Effects of Special Relativity

Moving Frame “Pilot”	Stationary Frame “Observer”
Experiences the normal passage of time. “My clock has ticked one second.”	From this view, it looks like the pilot is experiencing slow time. “No you’re wrong! *My* clock has ticked one second; yours has only clicked 0.99 seconds!”
Experiences normal distances. “My meter stick measures one meter.”	From this view, it looks like the aircraft is shorter than when it stands still. “No you’re wrong! *My* meter stick measures one meter; yours is only 0.99 meters long!”

The disagreement between clocks is called **“Time Dilation.”**
This disagreement between meter sticks is called **“Length Contraction”**
The really puzzling thing is that all motion is relative:
From the observer’s point of view, the pilot is moving fast.

BUT
From the pilot's view, the observer is moving fast.

The Lorentz Transformations

←X→

In their own frames, the Pilot and the Observer both measure normal time and normal distance:	When they look at the other person's frame, moving in the x direction, it looks to have different time and different distance
Time t Length x Width y Height z	Time t' Length x' Width y' Height z'

Time and length in the two reference frames are related by these equations:

$$\begin{cases} t' &= \gamma\left(t - vx/c^2\right) \\ x' &= \gamma\left(x - vt\right) \\ y' &= y \\ z' &= z \end{cases}$$	Where $$\gamma = \frac{1}{\sqrt{1-\frac{v^2}{c^2}}}$$ v = the relative velocity of the frames

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	c = the speed of light

NAME________________________________ DATE__________ BLOCK_____

The Magnetic Field

According to the rules of Special Relativity, when electric charges move, their fields behave strangely. You already know an example of charges moving: electric current in a wire.

It turns out that when we observe electric charges from outside a current-carrying wire, we experience a strange new field we wouldn't expect:

We call it the magnetic field.

For this task, you will answer this question:

What is the shape of the magnetic field around a current-carrying wire?

Does it point straight away from the wire?

Does it run along the side? Does it wrap around like a donut?

To find out, you'll make a circuit and chart the magnetic field with a compass.

Materials

D-cell battery, wire, tape, compass

Procedure

1. Construct a circuit using the wire, tape, and battery.
2. Stretch out a section of the wire
   Note: Try and keep the rest of the circuit as far away as you can from the long straight section – that way their magnetic fields won't interfere.
3. Bring the compass near the wire. Make sure it stays level!
4. Observe the direction the compass points. It will line itself up with the magnetic field from the charges in the wire, because the field from the wire is stronger than the earth's magnetic field.
5. Complete Set-Ups #1-3 in the data table. Get at least FOUR compass readings for each set-up.

6. Re-arrange the wire into some shape – YOUR GROUP CHOOSES
7. Complete Set-Up #4 in the data table.
8. Answer the conclusion question.

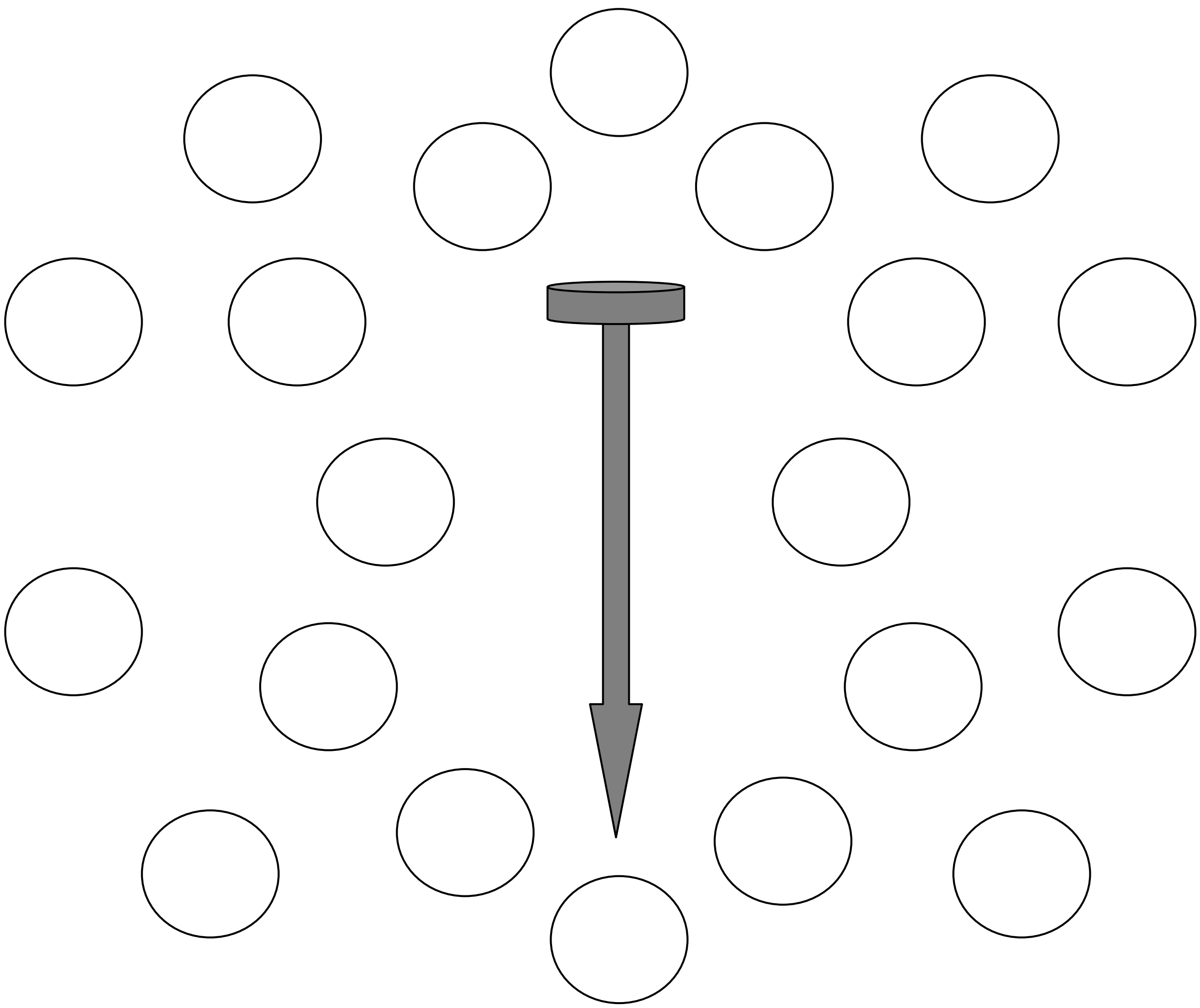
DATE TABLE Set-Up	Draw your best rough idea of the magnetic field's shape, from what you observe in this set-up.	Write a description of the shape based on what you see in this set-up.
1. The wire goes horizontally; the compass is nearby on either side.		
2. The wire goes horizontally, the compass is nearby above or below.		
3. The wire goes horizontally, the compass is nearby around the sides.		
4. Group Choice:		

CONCLUSION: What is the shape of the magnetic field near a current-carrying wire? What evidence do you have for this? How can you tell?

LESSON 3 MATERIALS

CHARTING MAGNETIC FIELD - SOLENOID

Find your electromagnetic nail from before or build a new one. Lay it down on a flat surface. The diagram below represents your electromagnet, looking down from above. The circles represent spots to take compass readings. In ALL 20 CIRCLES, draw the compass needle the way you saw it point.



When you are done, draw in curving magnetic field lines that follow the directions of the compass readings.

Magnetism Notes

Magnetic Poles

Magnetic poles create magnetic forces

A magnet always has a north and south pole, located at the ends of the magnetic material

Like poles repel; opposite poles attract

It is impossible to get just a north or south pole of a magnet, even if you divide it to the atomic level

A magnet is made up of the magnetic fields of individual atoms

Magnetic Fields

The space around a magnet is charged with the magnet's field

The shape of the field is shown by magnetic field lines

The lines spread out from one pole, curve around the magnet, and return to the opposing pole

The magnetic field is stronger closer to the poles, and weaker farther away

The Nature of a Magnetic Field

Magnetic fields are created due to the effects of special relativity on the orbital and spinning motions of electrons

Every atom is a tiny magnet because of this, and they combine to form a magnet

Magnetic Domains

Magnetic domains are clusters of atoms that align there charges in like directions

This alignment is what keeps an atom's charge from canceling out another, and the reason that magnets can exist

A magnet is a metal that has its atoms permanently aligned

Magnets can be created by aligning the atoms with strong forces

Magnets can be ruined by heating or jostling them

Planning Commentary

1. What is the central focus of the learning segment? Apart from being present in the school curriculum, student academic content standards, or ELD standards, why is the content of the learning segment important for your particular students to learn?

The central focus of this learning segment is the connection between electricity and magnetism, with a decided emphasis on the ways to represent electric and magnetic fields with field line drawings. This focus ties together several important factors that I value as a physicist and science instructor.

First, this learning segment is designed to bolster students' abilities to interpret and produce scientific diagrams, specifically field-line drawings. Gathering qualitative and quantitative data from diagrams is a key component of scientific literacy, and representing physical systems with models is a key component of physics. The *inability* to interpret graphic representations is paralyzing in our modern world, and I believe my students are well-served by any learning segment that encourages them to grapple with visuals. This segment presents a particularly good opportunity for developing expertise with science diagrams because field-line drawings represent very tangible interactions and follow very clear rules. There is less room for stylistic interpretation than with, say, a free-body diagram. This clarity will make it easier for me to assess their performance and understanding – and easier for students to self-assess.

Second, this learning segment uses those field-line drawings to help bring students to a fundamental understanding of magnetism. I value this approach because many high school physics curricula do not fully explain how electricity motivates magnetism. Our conceptual physics text says the author "…will not go into the details, except to acknowledge that magnetic field is a relativistic by-product of electric field" (Hewitt 565). Relativistic effects are discussed elsewhere in the text, with no mention of electric fields. I find this insufficient. There are already too many situations where my curious students are told that the explanation of something is beyond their bracket – issues of quantum mechanics, cosmology, and the like. Students have also explicitly stated they appreciate more detailed explanations of things. One student told me she recommended my physics course to a friend because I "actually take time to explain things." It is valuable for these students to see a physical phenomenon (in this case, electricity causing magnetism) and investigate it to the furthest level their backgrounds allow. It enables deep understanding, empowers students as learners, and takes science down from a dogmatic pedestal.

Third, this learning segment is steeped in tangible real-life applications. We will explicitly focus on magnets' use in sound systems, but will also mention magnetism's application in electronics, such as magnetic tape, hard-drives, TV monitors, and more. In the end, a relativistic understanding of magnetism and field lines will even enable students to think about how the earth even creates its own magnetic field.

2. Briefly describe the theoretical framework and/or research that inform your instructional design for developing your students' knowledge and abilities in both science and academic language during the learning segment.

My general theoretical framework has four main pillars, motivated by different writers and researchers in educations. First, I believe that the teacher-student relationship should follow a trajectory similar to what Paolo Freire recommends; teachers should pose thought-provoking problems out in the world and then endeavor to solve them side-by-side with students[1]. Second, I believe that students build their own understanding gradually over time. Students should not be expected to master things just be seeing or hearing them. Rather, teachers should allow for students to develop their own expertise over time. In this domain I have been particularly influenced by Collins and co.'s "cognitive apprenticeship" theory, which states that learners acquire expertise by seeing good models, receiving good guidance, and trying on their own[2]. Third, I believe that science in and of itself is an area in which individuals can be "literate" or "illiterate." Science has cognitive and discursive patterns that are unique to the discipline. As much as students must gain new content understanding (a theorem of physics, for instance), they must learn the language of science in order to express their understandings to high proficiency (stating what that theorem means for physics). Finally, I believe that all teachers should "backwards plan"[3]. An instructor must design learning experiences with end goals specifically in mind. Only by identifying desired outcomes can a teacher work effectively with students towards those outcomes.

3. How do key learning tasks in your plans build on each other to support student learning of science concepts, inquiry skills, and the development of related academic language? How will students use the science concepts and inquiry skills to make sense of one or more real world phenomena? Describe specific strategies that you will use to build student learning across the learning segment. Reference the instructional materials you have included, as needed. (TPEs 1, 4, 9)

The key learning tasks of this segment are structured first and foremost to meet students at their current level of understanding. Students have demonstrated accurate and confident understanding of electrostatics, and they are proficient at drawing force vectors (in the form of Newtonian Free-body diagrams). This learning segment will begin by building on these strengths by asking students to represent electrostatic attraction and repulsion as vector forces, which students have not been asked to do. I have chosen to model the drawing of forces with manipulative electric charges on the board, with students physically gesturing their predictions for the forces vectors' directions and lengths. This should provide a

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[1] Freire, P. (1970). *Pedagogy of the Oppressed.* Continuum Publishing Company

[2] Collins, A., Brown, J. S., & Holum, A. (1991). *Cognitive apprenticeship: Making thinking visible.* American Educator, 6-46.

[3] McTighe, J. & Wiggins, G. (1999). *Understanding by Design*. Prentice Hall.

concrete example for students to return to in their thinking and in my questioning as we move on to the more abstract worksheet – drawing force vectors on a sheet of paper. I will coach students through creating their own drawings, and we will return to the manipulative charges on the board once students have completed their own drawings, and I will physically connect the lines of force to demonstrate how electric field is represented.

Approaching electric fields through force drawings should make these invisible entities more approachable while also pushing students' abilities to work with graphic representations. It will build on students' understanding of the tangible pushes/pulls of electrostatics, instead of asking them to consider a new and mysterious entity that permeates all space.

The next task, a worksheet, will serve as the assessment for the day's learning goals. Students will be asked to state what creates electric fields and what the rules are for drawing field lines. Students will then draw the field lines of different sets of particles. I have created a resource handout to help students complete the assessment, since I do not expect them to have memorized and mastered electric fields in a single block. The handout lists the rules for drawing field lines and shows a few examples of field line drawings.

The next learning task in the segment, a presentation and brief reflection on Special Relativity, is admittedly disjointed from the drawing of field lines, but it serves a crucial conceptual purpose in explaining the step between electricity and magnetism. It's divergence from field-line drawings as such will also serve as a break for students who *do not* enjoy drawing.

The inquiry portion of the segment will ask students to investigate what happens when electric fields (as seen in the drawing tasks) experience relativistic effects (as seen in the presentation). Through direct investigation, students will try and answer the question, "How do these unexpected new fields behave?" Rather than having students gather qualitative numerical data, such as magnetic field readings, I have chosen to focus students' investigation on the *shape* of the magnetic field, as part of this segment's emphasis on graphic representations. I have included sentence scaffolds to help students express their findings in scientifically appropriate language: They will write statements drawing conclusions about the shapes of fields and do so by providing evidence from compass readings.

I have expectations that the inquiry segment may spill over into the next class session's instruction, but I think that this could be advantageous because the wrap-up of the inquiry and the next task are so intimately related. As a whole class, students will discuss the findings of their investigations, and I will lead the class to a negotiated understanding of magnetic fields forming rings around straight wires. Students will see that their findings are in keeping with a physics principle called the "Right Hand Rule." I will model the Right-Hand-Rule and students will practice the corresponding gesture and use it to draw a magnetic field diagram.

Once students understand that moving charges creates magnetic fields according to the right-hand-rule, their prior knowledge of atomic structure will help in establishing that even normal atoms have moving charges inside of them, creating magnetic field. I will use manipulative representations of atoms to show how atoms in a material might have aligned or mis-aligned bits of magnetic field. With this tangible demonstration in mind, students will read about magnetism in materials, including magnetic domains. Students will organize the general information they learn by creating notes, and as a class we will add to these notes with the clear rules for drawing magnetic field lines. Students will apply the rules we discuss by drawing the magnetic field lines of various magnetic objects.

When this learning segment is complete, students will be prepared to look at the real-life phenomenon of electromagnetic induction as occurs in loudspeakers. Students will build and explain a homemade speaker with a permanent magnet, and in explaining how it works will be required to utilize magnetic field line drawings and describe the Right-Hand-Rule.

4. How do your choices of instructional strategies, materials, and the sequence of learning tasks reflect your students' backgrounds, interests, and needs? Be specific about how your knowledge of your students informed the lesson plans, such as the choice of text or materials used in lessons, how groups were formed or structured, using student learning or experiences (in or out of school) as a resource, or structuring new or deeper learning to take advantage of specific student strengths. (TPEs 4,6,7,8,9)

Most generally, these students have weak math backgrounds. Our course is officially labeled as "physics" but our text is "Conceptual Physics" and we approach most topics using as little math as is necessary. We utilize math to describe physical situations, but the math always comes secondary to the intuitive (or sometimes counter-intuitive) explanation. In keeping with this, I have designed this learning segment to focus on qualitative understandings first and foremost, and have excluded most of the equations that govern magnetic fields from the tasks.

These particular students almost all enjoy drawing, but are extremely hesitant to draw or work with explicitly scientific diagrams. To overcome their squeamishness towards graphic representations, I have structured the learning segment to build on something students have confidence in: drawing force vectors. Furthermore, by providing clear rules for drawing and interpreting field lines, I hope to tap into these students' penchant for puzzle-solving. This was effective in the past at getting these students to engage with circuit diagrams.

This group of students has also shown a tendency to latch onto physical demonstrations, which can be a great asset to work with. In the past, mentions of particularly striking skits and demos have popped up again and again as students work through their thinking. I have designed this learning segment to provide those sorts of central events at key times. As students work on drawing electric fields, for instance, the demonstrations on the board will be fresh in their minds and available for us to discuss together moving forward. As they read about magnetic material later, they will have just seen me act out the magnetic moment of atoms and will be able to center their thinking on that event.

These students have also shown a measure of inquisitiveness whenever "weird" physics things get mentioned – cosmic events and quantum mysteries, for instance. Once this group of students knows that strange fields are appearing thanks to Special Relativity, they will be inclined to want to see the physical effects of such unexpected fields. I hope that the learning task on relativity will actually motivate students' curiosity to engage in the inquiry task.

Lastly, these students have proven themselves comfortable and sociable when it comes to working in groups. I have confidence that the students of this class could be shuffled into any group permutations possible and still work well together. There are only two students who shy away from participating or sharing while working in groups. To assist these two, and indeed all my students, the group tasks embedded in this learning segment will all have explicit guidelines for what individuals must do to help the group along.

5. For this learning segment, identify students' possible common sense understandings or misconceptions that contrast with accepted scientific understandings. How will you detect and attempt to change these common sense understandings or misconceptions?

My pre-assessments reveal that most students believe electricity and magnetism are only connected by their similar rules. That is, students seem to believe that the notion "opposites attract and likes repel" is the overarching phenomena, and that electricity and magnetism both follow this rule of the universe. I have already detected this misconception in specific students through my pre-assessment (I have included some student responses with my materials), and will attempt to change it through the tasks on relativity and investigating magnetic fields. Students will be explicitly shown how the rules of electric interactions give rise to the rules of magnetic interactions. I will be able to detect lingering misconceptions through informal assessment and questioning, students' creating notes on magnetism, and primarily through the summative assessment that follows the learning segment: students' designing, building, and explaining a home-made speaker.

A secondary misconception some students possess is that electricity and magnetism both happen thanks to the same charges – "protons" and "electrons." I have designed this learning segment so that students will see first that magnetic fields occur when relativistic effects happen to electric charges, as opposed to looking at magnetic material first, because the existence of magnetic material lends itself well to justifying (falsely) the existence of magnetic charges. I will explicitly state, and students will read again, that there are no magnetic charges and that magnetic stuff still creates magnetic fields with moving electric charges.

6. What language demands of the learning and assessment tasks are likely to be challenging for your students at different levels of language development? Explain how specific features of the learning and assessment tasks in your plan support students in meeting these language demands, building on what your students are currently able to do with language. Be sure to set these support plans in the context of your long term goals for your students' development of academic language. (TPE 7)

I expect students to have the most difficulty with the inquiry task, since it requires the interpretation and execution of written directions. Furthermore, the conclusions students are to draw at the end of that task could be challenging to write out for students who lack ability with general academic language and scientific language. To help students meet these language demands, I will review the instructions extensively with the whole class and include pictures with the instructions. I will provide sentence scaffolds for students to fill in if they are having a difficult time verbalizing their findings from the compass readings.

My most general long term goal for my students' academic language is that they will be able to state with confidence what they think and why. In science, more often than not, this amounts to giving an interpretation and then justifying that interpretation. This is the exact language students will use to complete the inquiry task: "The magnetic field from a wire points__________. I know this because if I bring a compass near a wire, the compass ________."

In terms of output, the rest of the learning tasks will only require sentence-level responses that I have complete confidence all students can answer. In terms of input, the written and verbal content is well within the realm of students' abilities. Hewitt's "Conceptual Physics" text sometimes uses wordy academic language, but students reading in groups have always been able to overcome the language and gather the important information.

7. Explain how the collection of assessments from your plan allows you to evaluate your students' learning of specific student standards/objectives. (TPEs 2, 3)
My assessments will offer a chance for students to directly demonstrate they have met my desired learning goals.

I will assess students' understanding of electric fields and the rules of field lines by reading their answers to the questions "What creates electric fields" and "How do we represent them? What are the rules?" I will assess students' ability to draw electric field lines by looking at their attempted drawings on a worksheet. I will assess students' understanding of Special Relativity by reading their responses to the prompt "Normal laws of physics work for everyday speeds. What happens at high speeds, when things have very fast relative motion? What happens to electric fields?"

I will assess students' ability to argue from evidence by reading the arguments they base upon their compass data. I will assess their understanding of magnetic materials by having students share the notes they create about magnetic materials. I will assess their ability to draw magnetic field lines by asking them to perform the right-hand –rule and by looking at their attempted magnetic field drawings.

8. Describe any teaching strategies you have planned for your students who have identified educational needs (e.g., English learners, GATE students, students with IEPs). Explain how these features of your learning and assessment tasks will provide students access to the curriculum and allow them to demonstrate their learning. (TPEs 9. 12)

My classroom has five designated English learners, all of whom speak and interact very well in English. Since most of their difficulties concern the written word, I have designed this learning segment to rely on manipulative and group reading strategies to overcome ideas that are complex in writing. To help the English learners in their writing, I will provide verbal scaffolds to more simple questions ("Electric fields are created by_____," for instance) and more detailed scaffolds for the inquiry activity, as I described.

Three of my students have IEPs for what amount to behavioral/study habit issues, but they have never been problematic in my classroom. I have never altered my lesson plan to address management needs simply because my students have been overwhelmingly respectful and well-disciplined. The students with IEPs have required no special treatment to engage and access the content. If anything, they seem to be put at ease by my lack of focus on their behavioral track records.

Video Label Form

Candidate ID # 05274998

Clip # 1

Lesson from which clip came: Lesson #3

Clip # 2

Lesson from which clip came: Lesson #3

If Electronic, Video Format of Clips: *(check one)*

☐ Quicktime

☐ Real One

☐ Windows Media Player

☐ Other *(please specify)* ___________________________________

Instruction Commentary

1. Other than what is stated in the lesson plan(s), what occurred immediately prior to and after each video clip that is important to know in order to understand and interpret the interactions between and among you and your students? Please

provide any other information needed to interpret the events and interactions in the video clips.

The two clips are pulled from the same class period, during Lesson 2 of my segment. Before the first clip, I had framed the activity as an investigation into the shape of the magnetic field surrounding a current-carrying wire. I drew a representation of a wire on the board and then drew in electric charges with field lines being warped by Special Relativity. Outside the wire, I drew some possible ways the magnetic field could point, such as straight away, at an angle, or in a coil. I told students it would be "up to [them] to find out." Students were allowed to select their own group of three for the task, and could begin gathering supplies for the inquiry once they gave me their list group members. Just before the clip begins, the last group had checked in with me to have their group recorded, and I have begun circulating the classroom to assist students in setting up the circuit and gathering initial data.

Just following the first clip, several students approached me about the material they missed while absent. I addressed their questions just enough to alleviate any pressing concerns and then get them back on pace with the investigation task. Afterwards, I circled around the classroom to focus any groups that seemed slow to start or disengaged. One group was caught up by typo on the worksheet I created, so I immediately stopped the class to make an announcement about the typo. Luckily, that group was the first to reach the typo, so that no students had completed the assignment based on faulty directions.

The second clip begins very shortly after this announcement, as I circulate the class once again, but now primarily to assist with analysis, since many groups had acquired usable data at this point. Just seconds after this clip ends, the bell rang. In my enthusiasm to help students I fell into some poor time management. My students are used to receiving time warnings from me, so the end of the period struck us all as a bit of a shock. Nonetheless, students quickly and neatly returned supplies, and waited respectfully while I announced they should hold on to their lab handouts until next time, when we would finish our investigations.

2. Describe any routines or working structures of the class (e.g., group work roles, class discussion norms) that were operating in the learning tasks seen on the video clips. If specific routines or working structures are new to the students, how did you prepare students for them? (TPE 10)

Students in this class are accustomed to working in groups, managing their own supplies, and generally conducting their own focused activities. Involving all group members was established as a norm early on, though in those early cases groups were assigned by me. In fact this activity was a major shift in that regard; this was only the second occasion when students could choose their own groups. That being said, most open-work time in our class leads to students working with their friends, and students had shown good collaborative tendencies even when choosing their own work partners. I have observed that several students actually deeply engage material when working with friends, but remain quiet and copy others' work when placed in a group without any friends. This is particularly true of my three English-learning Latina students, who are close friends. As a trio, they take ownership of tasks and push each others' thinking, but when placed individually into heterogeneous groups, they fade into the background. After officially trying self-selecting groups, the example of these three ELs proved indicative of many small friend clusters in the class. I felt confident that letting students pick the groups for this learning task would facilitate meaningful collaboration.

3. In the instruction seen in the clips, how did you further the students' knowledge and skills and engage them intellectually while collecting, analyzing, and interpreting data from a scientific inquiry? Provide examples of both general strategies to address the needs of all of your students and strategies to address specific individual needs. (TPEs 1, 2, 4, 5, 7, 11)

First and foremost, I have furthered students' intellectual engagement and confidence through the classroom environment I have established. Over the course of the year, I have consistently encouraged students to go with their own findings and have faith in their own thinking. Given students' lack of experience in gathering and arguing from evidence, students often ask me if their findings are "Ok" or if they are "doing things right." This happens numerous times in the clips, and I maintain an encouraging tone throughout.

Another way in which I furthered students' knowledge and skills was through my planning of this task. I designed the activity as a question – "What is the shape of the magnetic field?" – and gave students familiar tools – battery, wire, a compass – to try and answer the question. I anticipated certain procedural difficulties and then included them in the handouts to further students' self-efficacy. When and if those issues arose, students could find the information they needed in the resources given, without consulting me. If they did consult me, I could just point them to the resources instead of walking them through procedures. This happens at several points in the video footage, such as 50 seconds into the first clip, when I direct the group to consult their instructions about holding one section of wire nice and straight.

Originally, I anticipated helping students through the language of arguing from evidence by using sentence scaffolding. However, as students moved into the interpretation stage of their investigations, rather complicated three-dimensional visualizations became necessary to even think of a conclusion. I ended up helping students to actually assemble their picture of the magnetic field's shape piece-by-piece. Some students responded well to my pantomiming of compass readings. Around 1:45 and 7:40 into the second clip, I gesture compass readings with students who have finished gathering data, in order to help them visualize the three dimensional shape and decide on a final conclusion.

4. Describe any language supports used in the clips to help your students (including English learners as well as other students struggling with language) understand the content and/or academic language central to the lesson. If possible, give one or two examples from the video clip(s) of how you implemented these supports. (TPEs 4, 7)

In order to help students who struggle with language, I designed this activity to begin with everyday language and then move into academic language, with a sentence scaffold available for students to use in completing their argument from evidence.   As they gathered data, when students struggled to describe the behaviors of the compass, I helped them write their qualitative observations as written findings or evidence, often times using more advanced scientific or academic language. For instance, around 3:45 into the second clip, I help a group of three EL students summarize and restate their observations. I began to use the word "oscillate," but realized that was outside their knowledge and instead began to say "wiggle" and pantomime the motion with my hand. Just as I am about to leave the group, one student indicates to the response box and begins to stutter, "Wait, so, uh… what do we…" I simply told her to write down what she had been saying aloud ("it wiggles back and forth…"), so that she and her group would not become hung up on academic language at the data-gathering stage.

5. Describe the strategies you used to monitor student learning during the learning task shown on the video clips. Cite one or two examples of what students said and/or did in the video clips or in assessments related to the lesson(s) that indicated their progress toward accomplishing the lessons' learning objectives. (TPEs 2, 3)

Throughout this activity I monitored student learning by observing their behaviors and statements. By watching students' physical actions and activities I was able to monitor their current place in the task, such as what step in the procedure their group was on or whether their wiring was correct and could even yield a good result. In those cases I guided student learning as I mentioned, by directing students towards the instructions and tips on handout.

Monitoring student learning through their statements actually gave far more insight into their understanding vis-à-vis the learning objectives, as I prompted students to talk out their findings. At 4:40 of clip one, for example, I heard the student on the left say that a reading was "the same as before." I asked him to show me what he meant, and he recreated a prior set-up that was shifted 90 degrees from the current one. This demonstrated to me that he had honed in on a consistent and accurate result, successfully applying his finding even when the set-up transformed by rotating around. From his statements about the reading being the same and the set-up being turned, I could tell that he was progressing towards a three-dimensional picture of the magnetic field.

In an interesting turn, I monitored some specific students' learning at the very beginning of clip two, as they encountered a difficulty that I *did not* anticipate. These two very high-achieving students have some familiarity with magnetic behaviors (though not field lines) and were being very methodical in gathering data. I had known that the Earth's magnetic field would affect students' readings, so I calculated the current necessary for it to be negligible compared to the field of the wire. However, I had not taken account of the large slate lab tables. As it turns out, the tables have been magnetized from the earth's magnetic field from sitting in place so long, enhancing any effect on students' compasses. This interference from the earth's magnetic field and the tables was sufficient to skew readings by several degrees. I noticed this as groups began, but the effect was weak enough that I decided not to announce it, in order to avoid confusion. The casual and qualitative investigation by most groups didn't detect the issue, but the two students at the beginning of clip two detected it consistently. When I realized how thorough they were being, I informed them of the discrepancy in order to push their thinking forward towards a conclusion. As things stood, their careful work had uncovered an unexplainable anomaly that might have derailed their conclusion.

6. Reflect on the learning that resulted from the experiences featured in the video clips. Explain how, in your subsequent planning and teaching, successes were built upon and missed opportunities were addressed.

Student learning during Monday's part of the activity was mixed, and many groups finished in different places. Overall, though, students seemed very interested in the subject and behavior of magnets. Structural weaknesses in my planning kept students from engaging more fully.

When we returned to the activity on Wednesday, I attempted to address what I considered the greatest weakness I saw Monday – lack of clarity. Upon starting the activity, only very engaged or interested students with some background in step-by-step experimentation were able to dive right into the task. Other groups, even passionate ones, seemed unsure of how to move forward. They might have made a sound circuit, and might even have brought a compass nearby and watched it move, but there was not enough description of what exactly belonged in the data table. Students ended up doodling inconsistent pictures and single-word bullet descriptions. My effort to leave the language of data-collection open-ended, and to save the academic language for later, left the activity vague.

In an effort to clarify the entire task, I introduced the Right-Hand-Rule immediately on Wednesday. I created a new worksheet to help with charting magnetic field when students returned to the task on Wednesday. Instead of recording data as they see fit, students completed a chart of compass readings laid out to scale around center point representing a magnet.

STUDENT WORK SAMPLES

1

DATE 5/8/09 BLOCK 4th

ELECTRIC FIELD LINES

Answer these reflection questions:

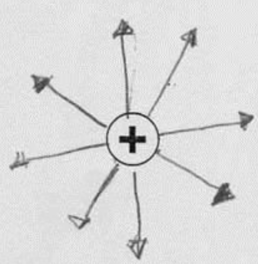
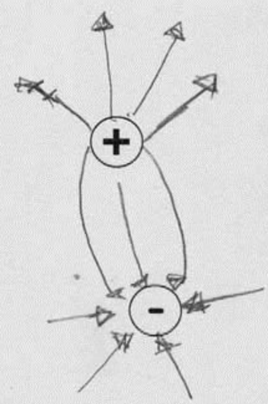
1) What creates electric fields?

The positive and negative charges.

2) How do we represent electric fields? What are the rules?

by + or -

Draw the electric field lines for each set of charges, 1-6.

SET 1	SET 2
	

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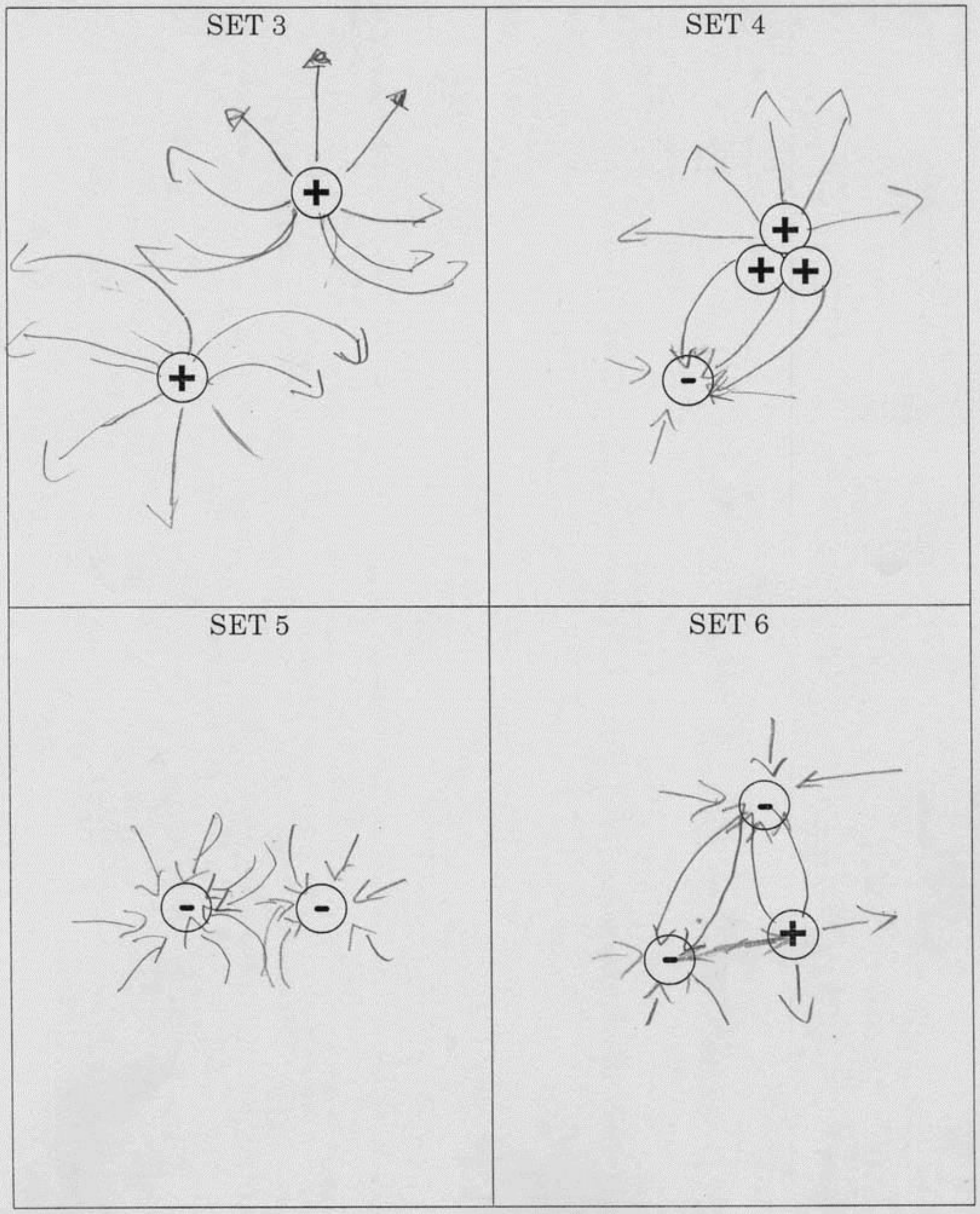

SET 3
SET 4
SET 5
SET 6

2

DATE May 8 BLOCK 4

ELECTRIC FIELD LINES

Answer these reflection questions:

1) What creates electric fields?

The negative [electrons] and positive [proton] charges

2) How do we represent electric fields? What are the rules?

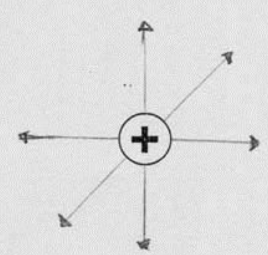
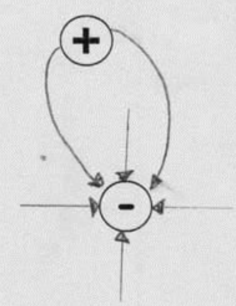
) Lines start on + charge

2) Lines end on - charge

3). Lines never cross

4) bigger amounts of charge put out more lines

Draw the electric field lines for each set of charges, 1-6.

SET 1	SET 2
	

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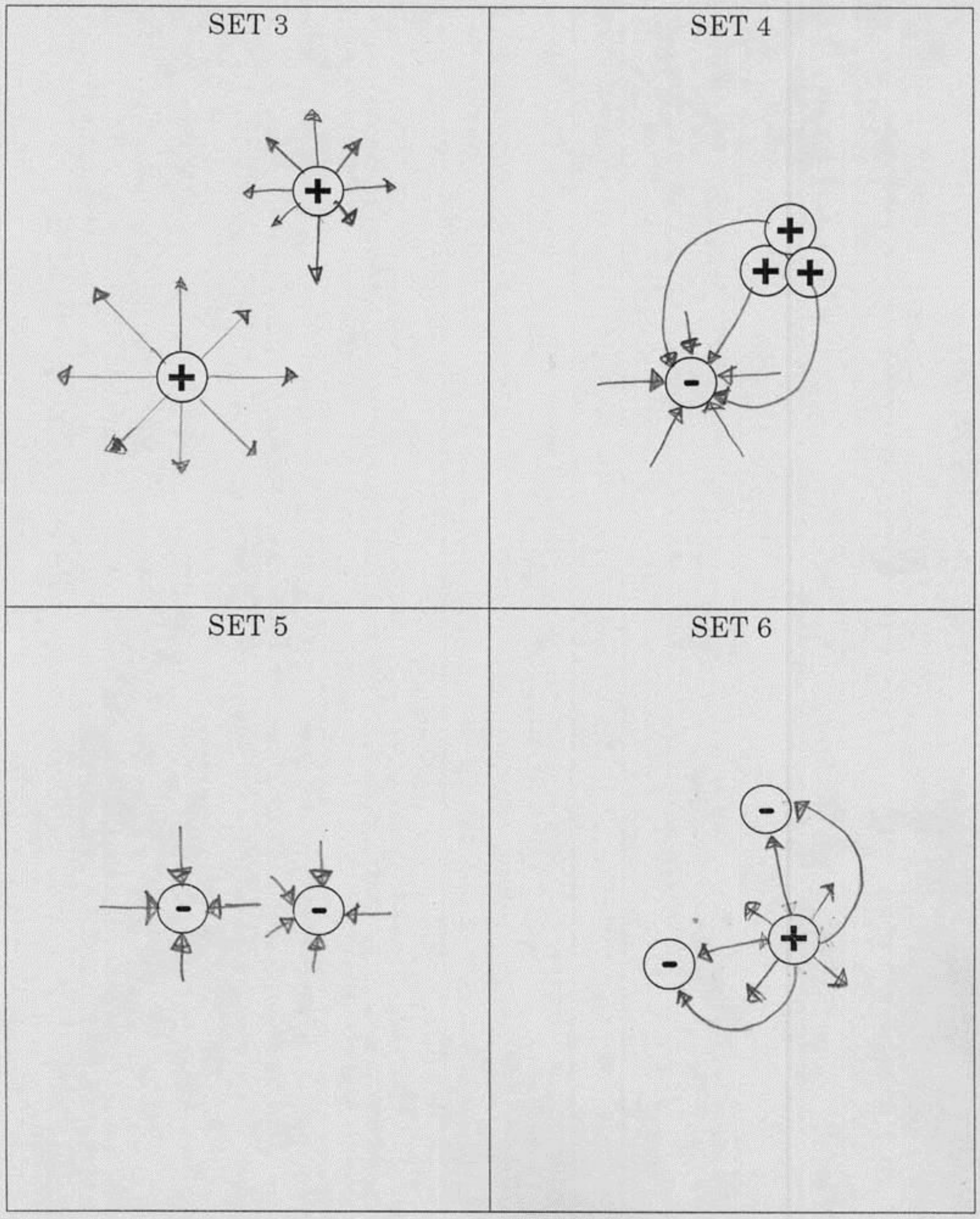

SET 3
SET 4
SET 5
SET 6

3

DATE 5/8/09 BLOCK 4

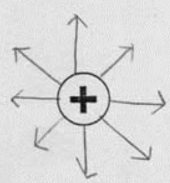
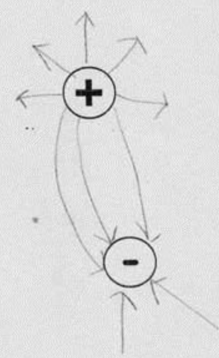
ELECTRIC FIELD LINES

Answer these reflection questions:

1) What creates electric fields?
   positive & negative charges

2) How do we represent electric fields? What are the rules?
   by + or - lines start on + charge, lines end - charge, lines never cross, the bigger amounts of charge put out more lines

Draw the electric field lines for each set of charges, 1-6.

SET 1	SET 2
	

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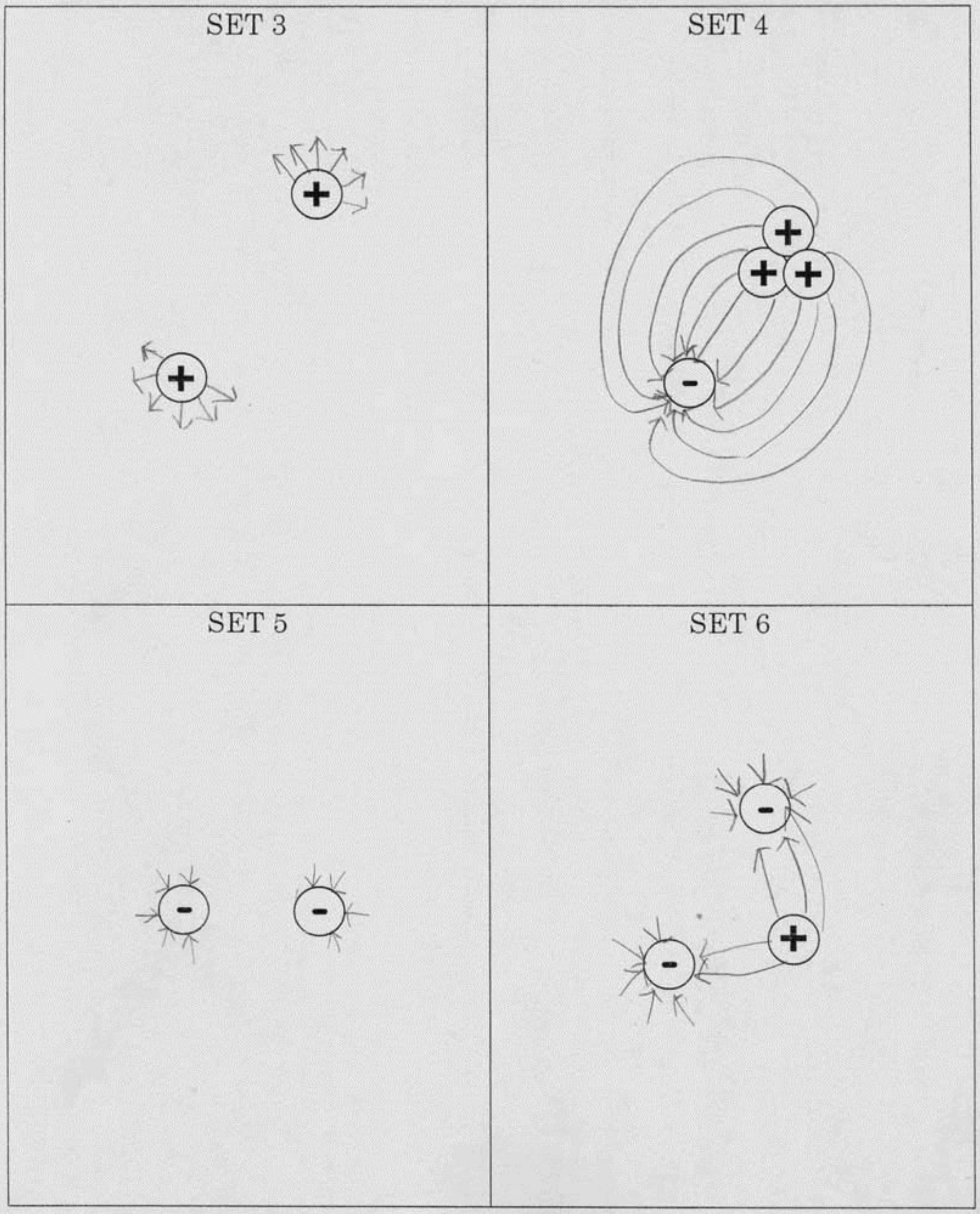

05274998

EVALUATION RUBRIC

Evaluative Criteria Category	Characteristics of Student Work		
	Below Standards	**Meets Standards**	**Exceeds Standards**
Identify electric charges as the sources of electric fields.	Identified something other than electric charges	Correctly identified electric charges as source	**N/A**
Identify the rules for representing electric field with field lines.	Did not identify any of the rules.	Listed some of the rules for drawing field lines.	Listed all four rules for drawing field lines.
Apply the four rules correctly in drawing field lines	Misused one or more rules for drawing field lines	Drew field lines mostly correctly	Drew all field lines totally correctly.

Assessment Commentary

1. **Identify the specific standards/objectives measured by the assessment chosen for analysis. You may just cite the appropriate lesson(s) if you are assessing all of the standards/objectives listed.**

I am including my analysis of the electric field lines worksheet at the end of lesson one. This assessment serves an important role in the overall unit, as students must build understanding of electric fields quickly in order to understand magnetic fields soon after.

The worksheet is designed to assess whether "Students know that charged particles are sources of electric fields…" or CA Science Standard 5e. Beyond this, I am aiming to assess students' knowledge of the shapes of electric fields, based on their ability to draw them according to certain rules provided earlier. Students' general ability to draw according to rules will be utilized again when students are introduced to magnetic field lines. Had students encountered significant difficulty with the nature of this first assessment, I could have modified future magnetism activities with more scaffolding (for example, introducing the four rules one at a time, with examples in between).

2. How do the evaluative criteria (or rubric) measure student proficiency for these standards/objectives? Evaluative criteria are performance indicators that you use to assess student learning. Categories of evaluative criteria include understanding of a particular science concept, the relationship between two concepts, or the fit between evidence and conclusions. (TPE 3)

The first evaluative criterion for this assignment is rather cut-and-dry: whether or not students successfully identify electric charges as the sources of electric fields. The question is phrased as "What creates electric fields?" and correct answers include "charge, "electric charges," and "protons & electrons." The exact phrasing of the question should allow any students with language difficulties (ELs specifically) to key in on verbiage I repeated throughout the lesson – "Charges create fields in the space all around them."

The second evaluative criterion is identification of drawing lines as a representation of electric field, and identification of the four rules for drawing these field lines. This criterion measures students' understanding of field lines as a representative tool; i.e. that electric field lines are something we draw according to rules, separate rules from those that govern electric charges.

The third evaluative criterion for this assessment is the application of the four drawing rules. Students draw the field lines around sets of charges according to the rules and examples they have been given. This criterion measures students' ability to apply rules while diagramming as well as their understanding of the behavior of electric charges and fields. While at first glance these two aspects might seem like unique criteria, understanding of electric field and electric field *lines* are too intimately connected to be assessed separately. In some sense, the rules for drawing the lines establish the shape of the field, but obviously the drawings themselves are based on the shapes of the actual invisible fields around charges. In this case the drawing ability (the rules for field lines) and the content understanding (knowing the shape of the electric field around charges) overlap completely.

3. Create a summary of student learning across the whole class relative to your evaluative criteria (or rubric). Summarize the results in narrative and/or graphic form (e.g., table or chart). (You may use the optional chart provided following the Assessment Commentary prompts to provide the evaluative criteria, including descriptions of student performance at different levels.) (TPEs 3, 5)

Summary of Student Learning Chart

Evaluative Criteria Category	Characteristics of Student Work		
	Below Standards	**Meets Standards**	**Exceeds Standards**
Identify electric charges as the sources of electric fields.	Left blank **8% of class**	Named "electric charges" or "protons and neutrons" **92% of class**	N/A
Identify the rules for representing electric field with field lines.	Left blank or wrote only about electric charges **8% of class**	Wrote about field lines and listed some of the rules for drawing them. **27% of class**	Listed all four rules for drawing field lines. **65% of class**
Apply the four rules correctly in drawing field lines	Misused one or more rules for drawing field lines **15% of class**	Drew field lines correctly except for certain symmetries **50% of class**	Drew all field lines totally correctly. **35% of class**

4. **Discuss what most students appear to understand well, and, if relevant, any misconceptions, confusions, or needs (including a need for greater challenge) that were apparent for some or most students. Cite evidence to support your analysis from the three student work samples you selected. (TPE 3)**

The vast majority of students successfully identified electric charges as the source of electric fields. The three student work samples I have selected are all from English Learners, and all three correctly answered "positive and negative charges," with one of the three even adding "protons" and "electrons" in brackets. Two students in the class left the question blank.

A slimmer majority of students successfully identified the rules for representing electric fields using field lines, as summarized by me and listed on the Resource Handout – "How to Draw Electric Fields." Two student responses fell far below the standard here, including the response shown in Work Sample 1. This student, an EL female, seemed only to respond to the first half of the prompt, and did not connect her answer to field lines. I will discuss her response later on. Seven students simply missed a rule or two, but the remaining 17 students correctly listed all four rules. Some included additional information, which in some cases was correct and in others slightly off-base. In Work Sample 3, for example, the student at first seems to have the same misunderstanding as seen in Work Sample 1, but then lists all four rules correctly.

Drawing offered the most diversity in terms of student response, but several trends were apparent. A few students, as seen in Work Sample 2, drew stunted field lines, so that some lines ended abruptly for no reason, and the interactions between like charges were not shown (i.e. no evidence of understanding "field lines never cross" on sets 3 and 5). Work Sample 3 is indicative of the most common sorts of student drawings – mostly correct, but not entirely in accordance with what we've called rule #4: "Bigger amounts of charge put out more field lines." Many students did not pay attention to the balancing the numbers of field lines coming from any given charge. Student Work Sample 3, set 4, for instance, shows a single negative charge absorbing the field lines of three positive charges. Aside from this counting issue, the shapes and behaviors of the lines that students drew were correct. In fact, some students applied the rules entirely correctly, as seen in Work Sample 1. Though this student did not list the rules, she used them effectively. While not exactly flawless in her representation, the numbers of lines leaving bigger and smaller amounts of charge are just about appropriately balanced, as seen in sets 2 and 3 especially. This student clearly made an effort to adhere to rule #4.

5. **From the three students whose work samples were selected, choose two students, at least one of which is an English Learner. For these two students, describe their prior knowledge of the content and their individual learning strengths and challenges (e.g., academic development, language proficiency, special needs). What did you conclude about their learning during the learning segment? Cite specific evidence from the work samples and from other classroom assessments relevant to the same evaluative criteria (or rubric). (TPE 3)**

All three student work samples that I have included are from English Learners. I found the variance in their answers striking, especially given the general tendency to lump ELs together for pedagogical purposes. Of the three, I will focus my analysis on the students who completed Work Samples 1 and 2.

Student 1 has a strong affinity for drawing but has shown little prior content mastery. Student 1 showed some strong understanding of electrostatics through analogy in a prior unit, but has struggled with content in more recent motion and force units. She understands conversational English almost flawlessly, but is nonetheless often quiet during group work. Academic language is a continuing issue for Student 1. During this learning segment, Student 1 seemed apprehensive at first. When I checked in with her a few minutes later, she was on the back of the worksheet, drawing in field lines. I noted the correctness of her drawing for set 3 and then moved on. Only when I collected and assessed students' work did I realize that Student 1 had not made any apparent effort to list the rules for drawing field lines. Based on her terse answers to the written questions, I would surmise that Student 1 skipped by them and then completed her drawings using visual cues. There were many example field line drawings on the Resource Handout, and they were likely all it took for a strong artist like Student 1 to recreate their patterns. I am pleased that Student 1 can draw electric field lines so proficiently, and I do have sufficient evidence from question one that she "knows that charged particles are sources of electric fields…" which meets the CA

Standard. This being the case, I am not concerned about Student 1's performance on this assessment vis-à-vis the segment's learning objectives, even if she failed to meet one criterion.

Student 2 is a strong reader and confident speaker considering her EL status. She struggles with academic language but is relatively more comfortable than Student 1 at writing. She's well organized and keeps track of old notes and handouts very well. Since Student 2 keeps these resources handy, she is often a gatekeeper of information for her friends and group mates, including Student 1. During this learning segment, Student 2 was quick to consult her notes to answer question one and appeared very excited to see that the four rules were listed on the resource handout. The discrepancies between Student 2's drawings and the examples from that same handout lead me to believe that she did not consult those visuals in the same way as Student 1. Student 2 seemed to apply the rules in a patchwork fashion, undermining one rule in using another and applying the same rule inconsistently. As I mentioned previously, she has drawn many stunted field lines that end abruptly in space and don't interact with other lines. In assessing these drawings strictly against the four rules I listed, however, I see that I hadn't been absolutely clear about how field lines should radiate outwards. I told students out loud, while drawing on the board, that field lines extend to infinity (until they begin or end on a charge), but this was not encapsulated in the four rules. Had I included it, many of Student 2's inconsistencies might have been sorted out. Overall, Student 2 showed understanding of electric fields arising from electric charges, and is definitely developing expertise at drawing field lines.

6. What oral and/or written feedback was provided to individual students and/or the group as a whole (refer the reviewer to any feedback written directly on submitted student work samples)? How and why do your approaches to feedback support students' further learning? In what ways does your feedback address individual students' needs and learning goals? Cite specific examples and reference the three student work samples as evidence to support your explanation.

I collected and sorted the worksheets for my own assessment purposes, but then returned them unmarked so that students could self-assess. As feedback, I went over the first two written questions verbally, since those had been very strong areas in terms of students meeting standards. I reminded students of the Resource Handout listing the rules and showing examples. Next, I addressed the misconceptions that I observed in students' drawings. To address Student 2 and the handful of others who drew too-short lines, I specifically reinforced that lines should extend to infinity, bending around other lines until beginning or ending on a charge. I addressed students' disproportionate field lines by drawing the field lines for the sets of charges 4 and 6 on the board. I emphasized that students must be consistent about the number of field lines emanating from a charge, but also reminded them of their artistic license to choose the exact number.

This feedback method supported further learning in multiple ways. First, students were not penalized for mistakes at this early stage of building understanding about electric fields. Unscored assignments such as this encourage learning and development for its own sake.

Furthermore, the unmarked worksheets invite more thoughtful self-correction than a sheet that has been marked up and scored.

I decided to review the first two questions solely verbally in order to encourage students to be self-sufficient and consult their own notes and resources, particularly since they would do so again while drawing magnetic fields. A visual was clearly needed for going over the drawings for sets 4 and 6, in order to clarify what rule #4 looks like when applied. Students had the opportunity to compare their drawing to mine with regard to that rule and identify where they strayed.

7. **Based on the student performance on this assessment, describe the next steps for instruction for your students. If different, describe any individualized next steps for the two students whose individual learning you analyzed. These next steps may include a specific instructional activity or other forms of re-teaching to support or extend continued learning of objectives, standards and/or central focus/big idea for the learning segment. In your description, be sure to explain how these next steps follow from your analysis of the student performances. (TPEs 2, 3, 4, 13)**

Based on students meeting the standards for all the assessment criteria for *electric* field lines, I feel confident moving forward with *magnetic* field lines. Aside from the non-responses I mentioned, such as Student 1's failure to list the rules for drawing field lines, students' ignoring the proportion of field lines was the only consistent problem I encountered. Students succeeded in drawing the general shapes of electric fields, which shows the base level understanding needed to move onto magnetic fields. After students demonstrate understanding of the basics of magnetic fields, I plan to return to electric field lines to compare and contrast their behaviors. That time will be ideal for re-addressing the few faults I gave feedback on.

Daily Reflection –
Friday May 08, 2009

1. **What is working? What is not? For whom? Why? (Consider teaching and student learning with respect to both content and academic language development.)**

Drawing the electric force as a vector seems to be working well for all students. They had all previously demonstrated proficiency at drawing vector forces and interpreting force diagrams, and have all demonstrated sufficient knowledge of the electric force.

Combining the two seemed like a natural fit for every student I checked in with. I had anticipated the first drawing activity to take 10-15 minutes, but even the slowest workers were wrapping up within 7-8 minutes.

Taking the next step and drawing in electric field lines was definitely more difficult for students initially. When I modeled drawing field lines on the board, many students had emphatic questions. Some students with deep understanding of electric interactions could not see the motivation for using these lines, and students with a weaker understanding seemed overwhelmed and confused by the complexity of the diagrams.

What worked in the end was pointing towards the resource handout with the rules for drawing electric field lines. I actually gave students the handout earlier in the class than I anticipated because of all their questions. Once students saw the rules written out and the examples shown their, many of their questions were answered. They seemed comfortable with learning a new type of diagram, likely because they have been introduced to new diagrams in almost every new unit. Setting electric fields apart as a special drawing tool with clear rules really seemed to clarify things. Students could self-assess their drawings against the rules, and I could let them know which rules their drawings seemed to be violating.

Overall, the entire class completed the electric field line drawings quickly and accurately. So quickly, in fact, that I began the Special Relativity segment in the closing 15 minutes of class.

2. **How does this reflection inform what you plan to do in the next lesson?**

Students picked up electric field line drawings so quickly that I feel more confident about using them in the future. For Monday's lesson, I had not actually planned to draw out the way field lines transform under Special Relativity, but now it's likely that I will. Also, I feel compelled now to revisit electric field lines in the near future, instead of moving on to magnetic fields and neglecting the electric ones from there onwards. The timing of this lesson will actually help for Monday's Lesson – starting the Special Relativity component now has left more time for investigation on Monday and Wednesday.

Daily Reflection –
Monday May 11, 2009

1. **What is working? What is not? For whom? Why? (Consider teaching and student learning with respect to both content and academic language development.)**

The initial return to Special Relativity seemed to work well in terms of engagement – students were curious about the things they had first glimpsed Friday and were very interested in the constancy of the speed of light. The extensive resources I included with my presentation were not helpful, and the way I titled things only seemed to confuse students as to whether "Special Relativity," "Lorentz Transformations," or "Time Dilation/ Length Contraction" was the name of the actual effect we were looking at.

The inquiry segment had clear strengths and weaknesses. The activity itself yielded some good interactions between students and some careful investigation on the part of more engaged students. The students who engaged most readily with the task were the students with strong science achievement/background and those with a keen interest in electric circuits. Many students were not very engaged though, seeming confused by the nature of the task. The disengaged students actually went right to the task at first; they set-up their circuits and then didn't know how to proceed. I think that the conceptual jump between Special Relativity's changing electric fields and our experiment's wire and compass was simply too far.

Eventually all groups began gathering data of some kind, and the evidence gathering aspect of the activity worked for most, if not all, students. A few groups needed assistance in writing or recording their observations, for one of three reasons. Some students simply struggled to describe the physical things they saw, and asked me how to put it into words ("It wiggled a bunch, what do we say?"). Other students lacked the academic language to frame their description ("So it went back and forth between 0 and 90 degrees, how do we write that?"). Finally, some groups had technical difficulties that I hadn't anticipated: Our slate lab tables have been magnetized by the Earth's magnet field, and their strong fields can interfere with the magnetic field from a nearby wire. I consulted with those groups to move their compasses.

In the end, though, the lack of scaffolding around the activity simply didn't work. Even with good or great data, students struggled to assemble a clear overall picture of the field's shape based on their compass readings. Students' drawing abilities did not port over to 3-dimensional visualization abilities as strongly as I had for some reason assumed. One group recorded flawless data but didn't have the additional information needed to piece a spatial argument together from the evidence. I had planned to help students through the academic language of their arguments, but they really needed assistance in drawing conclusions in the first place.

In the end I became so immersed helping groups that I was surprised when the bell rang.

2. How does this reflection inform what you plan to do in the next lesson?

I plan to do three things next lesson to build on the strengths from today and address the weaknesses. First, I'm going to introduce the Right-Hand-Rule in order to help guide further inquiry towards the correct conclusion. Second, I'm going to make electromagnetic coils and stronger magnets available to try and overcome our magnetic tables. Third, I'm going to create a better-scaffolded worksheet that should help students piece together a shape for magnetic field. Rather than have students complete another data table but for the field of a permanent magnet, I will set up a visual chart for students to place compass readings and assemble the final shape.

Daily Reflection –
Wednesday May 13, 2009

1. **What is working? What is not? For whom? Why? (Consider teaching and student learning with respect to both content and academic language development.)**

Drawing with my redesigned worksheet and the electromagnetic coil worked well for students, though it seemed to bring investigation away from our original inquiry – "What is the shape of the magnetic field of a wire?" Regardless, introducing the Right-Hand-Rule before moving forward worked very well. Students who had been struggling to conclude something from their evidence now saw how the pieces fit.

The group reading ("Active Reading") and joint note-taking worked well for most students, for a variety of reasons and thanks to a key change. Compared to previous occasions, I was much less strict about holding students to the step-by-step active reading cards, and this freedom seemed to boost the effectiveness of the task because students were in self-selected groups. One group, full of very proficient readers and solitary workers, quite nearly ignored the reading prompts and took notes independently on each paragraph and then compared key points. Another group read through everything out loud and then created notes together item by item. Three EL Latinas clustered together; one would read aloud each paragraph and then all three would try and figure out what was important for their notes. The self selected groups seemed to have already been roughly differentiated by learning affinities, and so were all able to tackle the information in their own ways. As I circulated the class, I saw that students' notes were thoughtful and well-organized. Since students have not taken notes from a text in several months (I have been presenting notes on the board), I am certain that a handful of note-taking activities from the fall had a lasting impact. In those activities and in active reading, students have grown strong at sorting out the main idea and supporting idea(s) of science texts.

Thanks to overlap from Monday's inquiry, I judged that students would not be able to complete the magnetism worksheet during the block. Still wanting to assess student understanding of magnetic fields post-lesson, I gave a quick exit quiz and had students complete a drawing of a bar magnet's field lines. Clearly, the reading worked at helping students learn about magnetic field lines, because 85% of students completed the drawing correctly.

2. **How does this reflection inform what you plan to do in the next lesson?**

Students have shown me that at this stage in the year they can work proficiently and collaboratively in self-selected groups. Moving forward towards the summative assessment for this unit, the speaker build project, I plan on allowing students to continue selecting their groups. The active reading and note taking were very effective, so I plan on repeating it for any reading we do about induction.

Reflection Commentary

1. When you consider the content learning of your students and the development of their academic language, what do you think explains the learning or differences in learning that you observed during the learning segment? Cite relevant research or theory that explains what you observed. (TPEs 7, 8, 13)

In terms of content, there is strong evidence of all students learning with regard to drawing electric field lines. While no students had significant prior knowledge of drawing field lines, 85% of students met or exceeded the standard for drawing them according to the four rules I outlined. It is likely that such a significant number achieved this understanding thanks to the focus that has been placed on graphic representations in our class. Students may have reservations or apprehensions about dealing with graphic representations, but the sheer amount of practice they've had at drawing diagrams has given them the opportunity to develop expertise at it. Even in this entirely new context, students had the intellectual tools to interpret and apply drawing rules.

Within Lesson One, I encouraged further development of drawing expertise and content mastery through a "cognitive apprenticeship" framework of modeling, coaching, and then fading into the background. To begin, I directly modeled how to connect electric force vectors into field lines and provided some examples of field lines drawings. Next, I coached students through drawing their own diagrams, helping and questioning as needed, then gradually backing off and allowing students to work independently. This sort of sequencing mirrors the natural patterns by which people acquire new knowledge and skills, and strengthened students' developments.

Upon reflection (I did not make draw this conclusion at the time), it's apparent that the learning differences that occurred during Lesson Two, the heart of the inquiry activity, came about thanks to differences in scientific literacy and possibly developmental stage among my very heterogeneous students. In reviewing my video footage and assessing students' work, it appears that the most engaged and successful groups tended to be older students with more documented science achievement and/or strong math students. At first these groups seemed unrelated to me, but really both groups have mastered a specific sort of specialized thinking. All these students guided themselves step-by-step towards understanding by following a structured process of elimination – they systematically isolated and dealt with the many variables at work in the task. According to Piaget's developmental model[4], that sort of thinking falls under the umbrella of "Formal Operational Thinking," and is the most advanced sort of cognitive activity. Many students remained in a mode of "Concrete Operational Thinking," and their understanding remained firmly in the realm of the circuit and compasses in hand. The formal operational thinkers were better able to abstract away from their observations and draw conclusions about the shape of invisible field lines in three dimensions.

The more consistent learning of Lesson Three, particularly students' successful creation of notes based from independent group reading, was made possible through practice and the development of expertise. As with graphic representations, reading has been practiced in every unit. Determining the main idea of science writing was a major point of emphasis early in the year, and group "active reading" has been a mainstay of the class.

2. Based on your experience teaching this learning segment, what did you learn about your students as science learners (e.g., easy/difficult concepts and skills, easy/difficult learning tasks, easy/difficult features of academic language, common misconceptions)? Please cite specific evidence from previous Teaching Event tasks as well as specific research and theories that inform your analysis. (TPE 13)

I have discovered that my students' varying backgrounds and developmental stages influence their learning in ways my pre-assessments sometimes fail to reveal.

I was truly surprised by how proficiently students created their own magnetism notes by reading from the textbook. In general, the heavy academic and science language of textbooks leads me to use them as a supplement to direct instruction only. In prior units, I always had students take notes on my direct instruction and then consult the book to enhance their understanding. I see know that my students are proficient science readers when given the chance to collaborate. Even though individual students have clear reading difficulties, and many struggle with using academic language in writing, the active reading and notes were not difficult for them at all.

3. If you could go back and teach this learning segment again to the same group of students, what would you do differently in relation to planning, instruction, and assessment? How would the changes improve the learning of students with different needs and characteristics? (TPE 13)

If I could re-teach this segment to these particular students, I would make many key changes: First, I would virtually eliminate the Special Relativity component from this segment of instruction. Students seemed keenly interested in the material, but it was poorly sequenced as presented here. I still value students knowing the deep relation between magnetism and electricity, but a learning segment of several days, dedicated just to relativity, would have better served their needs for the field lines segment. Special Relativity motivates magnetism, but is conceptually unique from it (and quite bizarre in its

[4] Piaget, J. (1983). "Piaget's theory". In P. Mussen (ed). Handbook of Child Psychology. 4th edition. Vol. 1. New York: Wiley.

own motivations). With prior knowledge of relativistic phenomena, all students would have been in a better position to focus on force fields, both electric and magnetic.

Given how strongly students performed at drawing electric field lines, I would also change my planning and instruction to emphasize them. I would ask students to complete some applications using electric field on its own, before moving so quickly into magnetic field. Drawing electric field lines was a major student strength that my segment did not really build upon, because we moved immediately into magnetic field lines. The disconnect meant that some students' growing skills went undeveloped

Also, I would change the nature of the inquiry lesson to more directly indicate the shape of the magnet field. As I mentioned, the sheer visualization skills needed for the activity were beyond some students. Assembling a 3D shape from some fragmented compass readings takes abstract thinking of a sort that not all my students were ready for. Better scaffolding around the same physical activity would help all students construct knowledge of the magnetic field's shape. I would include more diagrams by me, criteria for moving the compass around the wire, and more example readings, in order to help students with many learning preferences (graphic, auditory, etc.) gain understanding, so that expert-level visualization skills would no longer be required.