Physics: What's the Angle?

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INTRODUCTION

My students are a group of fifty, intellectually-gifted fifth graders who attend T. H. Rogers, an urban school uniquely designated for special needs students in the Houston Independent School District (HISD). Our student population consists of vanguard or gifted students, attending kindergarten through eighth grade. Also included are deaf students in either the oral deaf or signing deaf programs, (pre-k through eighth grade) and students with multiple disabilities, ages three through twenty-something who often stay with us long enough to "graduate" from high school. Our school is not a designated neighborhood school; all of our students are transported by bus or private car.

I teach fifth grade students Mathematics and Science in the vanguard program and my partner teaches English Language Arts (ELA) and Social Science. We have 26 girls and 24 boys divided into two classes. The reported ethnic makeup of our fifth grade students includes 3 African-American, 3 Hispanic, 16 white, and 28 "other" students who represent many different Asian countries. Most of our students are involved in after- school activities such as sports, music, dance, and/or an after school chess program. This school year one student participated in the World Chess tournament held in Turkey, another took a day off for a piano audition in New York, and a third student attended a swimming meet in another city. Many attend native language classes on the weekend (e.g. Chinese or Hebrew) or learn at home (e.g. Russian, Korean, Tagalog). In school our elementary vanguard students are taught American Sign Language, Spanish and French. Many of our students' parents were not born in the United States; they are professionals with advanced degrees. All of our parents are deeply committed to the education of their children. They are active participants in school activities.

I can best describe my students through an incident that occurred during a lull in a field day activities program. A small group gathered on the adjacent Little League field, and began a scratch game of baseball. Soon the others joined in; they formed two teams and went about a "normal" game of baseball that included home runs, pop fouls, hits, and line drives that were either "caught out" or successful. There were no arguments, as the two teams rotated positions after three outs were decided. The only thing missing in this "normal" game of baseball, were the gloves, balls, and bats. It was possibly the most exciting game of baseball I have ever seen!

My students deserve an exciting and challenging curriculum, and the Houston Teachers Institute (HTI) seminar, "Everyday Physics: The Way the World Works," seemed like a made to order fit! I hope I am up to the challenge of keeping these remarkable students engaged.

RATIONALE

I chose the University of Houston/HTI seminar, "Everyday Physics: The Way the World Works," to refresh and enrich my own understanding of physics, and thereby enhance the learning experiences for my students through my curriculum unit. My goal is to foster critical thinking and problem solving skills throughout my lessons. In order to meet the curriculum requirements for my students, I have four key concepts in mind for this unit:

1. To help my students understand physics from an historical view, learning to match scientists to their discoveries, as well as recognize how these contributions impact our lives today. For example, which scientists and discoveries made iPods and downloading music possible in today's world?
2. To have my students design investigations that will explore and hopefully support the findings of the scientists we study (Archimedes' Principal of Buoyancy or Newton's Laws of Motion come to mind).
3. To help my students develop research skills by learning how to access and cite reliable sources.
4. To have my students build and use scientific and context-related vocabulary.

Because popular culture feeds a lot of information and, perhaps, misinformation, to our students through movies, television programs, video games, and Internet access (e.g. You-Tube, Wikipedia, etc.), it is my intention to construct a curriculum unit that will help displace misconceptions and clarify scientific concepts by having the students learn how to recognize and choose reliable sources of information. Avoidance of plagiarism will be addressed and the students will be taught to correctly identify sources of information. These research and citation skills will continue to be a valuable tool within their academic as well as professional endeavors.

An important element of the unit will be to have the students appreciate and use academic vocabulary. Using nomenclature pertinent to the context within a particular discipline is a component of our vanguard curriculum, *Scholars & Knowledge*, and is addressed in Sandra Kaplan's workshops and literature for teachers of gifted/talented students. Kaplan refers to this as using "the language of the discipline" and encourages teachers to have our students "think like a disciplinarian" (Kaplan).

OBJECTIVES

As a teacher in HISD (Houston Independent School District), our district curriculum, CLEAR (Clarifying Learning to Enhance Achievement Results), is based on state-mandated objectives called TEKS (Texas Essential Knowledge and Skills), which in turn is driven by the federal "No Child Left Behind Act." Students in fifth grade take state exams called TAKS (Texas Assessment of Knowledge and Skills) in Reading, Mathematics, and Science, and are not promoted to sixth grade unless they have mastered the objectives in Reading and Mathematics. At this time, passing the Science TAKS is not a prerequisite for promotion.

Under the heading of "Nature of Science, Critical Thinking" found in the Vertical Alignment Matrix of CLEAR, we are required to connect science concepts with the history of science and contributions of scientists. Because so many of the laws of physics are tied to specific scientists, (e.g. Archimedes, Bernoulli, Einstein, Galileo), a unit that encompasses learning about scientific concepts by researching the scientists and their discoveries or laws will meet the purpose of this particular objective. I intend to incorporate essential mathematics and reading objectives when appropriate. I hope this format will serve as a constructive catalyst to teachers of other grades and subjects. Perhaps an interesting math, science or history fair project for younger and/or older students may result from reading this unit.

I have relied on our district's CLEAR, Vertical Alignment Matrix to select the objectives I want to incorporate into this unit. Our Math Matrix is for grades 5 through 8, and includes Algebra 1. The Science Matrix is for Grades 5 through 8, and includes Integrated Physics and Chemistry. I will note Power Objectives, those that have been identified by our District as having the criteria of endurance, leverage, and readiness. (Ainsworth). I am only including the following objectives for fifth grade; however, some of these objectives change only slightly by grade level which makes the unit adaptable for middle school as well as younger elementary school students:

- Connect Grade 5 science concepts with the history of science and contributions of scientists such as Galileo Galilei, George Washington Carver, and astronaut Ellen Ochoa. (CLEAR SCI.5.3E)
- Use tools such as real objects, manipulatives, and technology to solve problems. (CLEAR, MATH. 5.14)
- Plan, implement and evaluate descriptive and simple experimental investigations that include a well-defined question, a testable hypothesis, one variable and the use of equipment and technology. (Power Obj. SCI.5.2A)
- Communicate and evaluate valid conclusions….(Power Obj. SCI.5.2D)

In our district the needs of our vanguard and gifted students are met through a Gifted and Talented (G/T) Curriculum Framework, called *Scholars & Knowledge*. These Strands (components) include "ascending levels of intellectual demand, universal concepts, scholarly behavior, depth and complexity as well as independent research and study skills" (HISD Advanced Academics Department, Figure 1.2). Our G/T Curriculum Framework overlays the core CLEAR curriculum, it is a parallel curriculum model, incorporating tenets addressed in Tomlinson's *The Parallel Curriculum.* I will note specific G/T strands in the lessons as applicable.

UNIT BACKGROUND

Driven by my own curiosity and the requirement to have my students match up scientists with their inventions or discoveries, I look forward to teaching and learning about physics through a historical perspective. As I drive past or into service stations these days, with an eye on the increasing price of automotive fuel, I wonder how many of my students recognize the contribution of Rudolf Diesel? (Lienhard) When we build or discuss electrical circuits in class and use the terms ohms, amps, and watts, how often do we stop to recognize the scientists who perhaps lent them their names? (I do not remember if these connections were made when I recall my high school general science or physics courses. Certain names such as Faraday and Bessemer have a somewhat familiar ring, but I cannot remember why).

Galileo, Archimedes, and Pythagoras are familiar, as they are discussed repeatedly in divergent disciplines, such as philosophy, history, math, and science classes (even my computer word processor, recognizes them through spell check). During Black History Month, scientists such as Benjamin Banneker and George Washington Carver are highlighted, but not necessarily within the context of science. Unfortunately their contributions are usually not studied with any depth or complexity.

In *How Things Work: the Physics of Everyday Life*, Bloomfield's index cites the names of over seventy scientists, most of whom I did not recognize (555-561). The term "volt" caught my eye and I wondered if like "amp" there was a real person or scientist connected to the word volt. Yes, indeed, a brief Google search for "volt" produced the following information: Alessandro Volta (1746-1827) is the man who invented the first modern battery and that currently General Motors has named a plug-in electric concept car the Chevrolet Volt. Fast, fun, informative and all "facts" can be further verified and properly cited on subsequent searches. My students will enjoy doing this, so I have decided to have the students write an ABC book of Physics for the classroom. Who were the scientists behind the laws and concepts; what did they do; what was going on at their time in history; were their efforts well received at the time; what is their legacy, or what did we inherit; and how are their contributions regarded or used today? I would really like to set up a Web Quest format for the students to use that includes a bank of safe and dependable web sites for them to access, thereby they can, "Evaluate the impact of research on scientific thought, society, and the environment" (Power Obj. SCI. 5.3D).

In order for the students to get an historical view visually of how scientific experiments were conducted prior to the beginning of the Industrial Revolution one can look at the paintings of Joseph Wright of Derby, (1734-1797) Three of Wright's paintings, *Experiment on a Bird in the Air Pump* (1768), *The Orrery* (c.1768-65), and the *Alchemist in Search of the Philosophers Stone (*1771), appear to depict contemporary scientific investigations of the 18th Century: The Age of Enlightenment. Wright is best known for his scenes lit by candlelight or moonlight. The subject of the Orrery is a model of the solar system using a lamp as the sun (Shephard; Vertesi). Wright's scientists look a bit like the wizards of Harry Potter fame, and the students can be reminded that the first Harry Potter book was originally called "The Philosopher's Stone." Perhaps paintings such as these helped create the constructed identity or mythologizing of the scientist, often depicted as a "mad scientist." Therefore, it would be interesting to have the students draw a picture of what they think a scientist looks like. Their preconceived ideas are often quite illuminating. I would like this activity to be the introductory lesson of the unit.

I also plan to have the students replicate or initiate experiments in the classroom that reflect the work of individual scientists. Although our district curriculum instructs us to teach aspects of energy and force and motion in sixth grade, there is no reason not to introduce these topics through the scientists and formulate ways to test the various theories or laws. I would like to explore Aristotle's ideas about force and velocity; Galileo's description of inertia, "A body in motion tends to remain in motion; a body at rest tends to remain at rest", and Newton's First Law of Motion, "An object that is not subject to any outside forces moves at a constant velocity, covering equal distances in equal times" (Bloomfield 4-5).

I see this unit as a dynamic learning and teaching tool, changing as more information is collected by the students. I feel strongly about the students having a role in selecting and developing classroom experiments. According to our state and district guidelines and the science objectives found across most grade levels, "the study of science includes planning and implementing field and laboratory investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using equipment and technology to support such investigations" (TEKS 112, Science).

I like to "test drive" ideas I have for future lessons with my current students. One morning I called out, "Galileo, Newton, who can tell me something?" for Galileo came responses such as "falling balls, Italy, long time ago, he invented the telescope." For Newton, came replies such as, "laws of motion, inertia, force, the laws have numbers," and one student correctly cited Newton's First Law of Motion and said she wasn't sure about the others, but knew there were more than one. I read, "A body in motion tends to remain in motion; a body at rest tends to remain at rest" ("Galileo") and asked if they could tell me what that meant. They were pretty confident with their answers, more or less reiterating the statement as it stood. Then I read Newton's First Law, "An object that is not subject to any outside forces moves at a constant velocity, covering equal distances in equal times along a straight-line path" (Bloomfield 4-5) and I asked what that sentence meant, and what words were they expected to understand. They came up with speed for velocity, and when I asked about "outside forces," they were able to suggest gravity and friction. I then asked what we call such outside forces when writing up a science experiment; they knew they were "variables" that could influence an outcome.

I took a rock that resembled a potato and told them it was my pet rock, and set it on the desk. I said, "If I tell this rock to *stay*, it obeys and does not move. What law have I demonstrated?" "Inertia", was the reply, "a body at rest stays at rest."

"Now how do we demonstrate the motion part?" I asked. I took a battery operated Air Power Soccer Disk (Educational Innovations) that moves on a cushion of air, and did not turn it on, I gave it a shove, and it travelled about 30 centimeters (12 in). I asked why it didn't go further.

They felt gravity and friction stopped it. I told them I wanted the disk to stay on the ground and not fly off into space, using gravity to help me. I also added, that if the air cushion would eliminate some of the friction, did they think we could test the "moves at a constant velocity, covering equal distances in equal times along a straight-line path" part of the law. The students copied the laws into their science logs and predicted what might happen. We borrowed a video camera to record our actions, and took our disk and science logs out into the terrazzo floored hall to test Newton's First Law of Motion.

Rather than this activity reinforcing Newton's law, it turned into a "learn as you go along lesson" on how to set up and conduct an experiment. The students had to go back into the room for meter sticks. Next they forgot the elapsed time element, and had to find watches with second hands or stop watches. I turned on the disk, and pushed it each time, trying for a "uniform" force. It didn't happen. Sometimes it travelled 5 meters and bumped into something or stopped and reversed direction. Out of twelve attempts, it only traveled in a somewhat straight-path once. The students had to think of why this was happening, what variables were at work here. Was it dust, scratches, uneven floor, the way I pushed it, or something else unseen?

In the middle of one trial I noticed a custodian coming down the hall towards us pushing a very wide mop. I asked the students to consider our newest variable and what should we do about it. Was it a beneficial or harmful variable? They decided a freshly mopped floor would be helpful, and we encouraged her to continue and to be a part of our investigation.

There were three students operating the video camera, two taking measurements and three with stop watches. The rest of the students took notes for each of our trials, and voted on which ones would not count. When the students with stop watches came up with different times, they asked if they could just ignore one of the times. The group decided to average the times. We talked about not changing facts; that everything that happened in an experiment needed to be recorded and that we needed to repeat our trials many times to get a valid result. So far the only law we were able to substantiate was "the body at rest" part. The students were animated, active participants in this process; they are determined to get better results.

I played the video of our morning endeavors for the afternoon class and they brainstormed ways to regulate the "force" (my shove) and the problem of the wandering disk. It was definitely not a "straight-line path." The students suggested putting meter sticks along each side to keep the disk from wandering. One or two suggested the batteries might have an effect if they were weak. Several said we needed a launcher to regulate the force. One suggested a ramp; the others thought a catapult-like device would work best. I encouraged them to design and bring their inventions to class.

The next day one boy brought in a Lego built launcher and a girl had a very complex drawing for her device. The boy, who suggested a ramp, was told to go ahead and make it. He did, with books and a dry erase board; it worked beautifully. The next day more ideas and launchers arrived. We tested them. We were finally at a place where we could regulate the force, using the ramp. The disk stayed in a fairly straight-line path, covered the same distance in equal times, and now we are able to check the "constant velocity, covering equal distances in equal times" part of the law.

How fortunate I feel knowing that we have addressed the "student is expected to plan and implement descriptive and simple experimental investigations including asking well-defined questions, formulating testable hypotheses, and selecting and using technology" (TEKS 112.7) and then, taking this concept to a G/T Depth and Complexity level within the Differentiation Strand (Scholars & Knowledge) with so little direction from me! Almost like Newton's First Law paraphrased here to read, "Once you get these students going, it's hard to get them to stop!"

Quite honestly, I did build a track about forty centimeters (16 inches) wide and two and one-half meters (about 2 ½ yards) long at home. I nailed meter sticks and a quarter round furring strip to the sides to keep the disk from falling off the track. And by using a level, I was able to test the air disk on a level as well as an inclined surface. At the end of the track I placed a clock with a second hand visible to me from the starting edge of the track. At this point I realized that this experiment needed several helpers: one to clock the time at both the mid and end points of the track, in addition to the person(s) launching, and stopping the disk. The inclined track had more consistent results than the level track and I am embarrassed to state that I did not think of using a ramp to launch the disk on the level track (as did my ten year old student). If time is limited, I could use this track at school, with the students measuring times at 50 cm intervals. This would become an investigation that only tested Newton's law, and would deprive students of participating in the trial and error process of designing and implementing the experiment; I much prefer the student-driven type of investigation.

In retrospect we used math skills of measuring time and distance, used the "language of the discipline" by using and understanding terms like "velocity" and discussed and questioned variables of "outside forces" such as gravity, friction and air. We wrote, recorded and questioned results, and used problem-solving and critical thinking skills (Santa) to get the job done. It has been a very successful lesson.

This lesson, or investigation, is based on Bloomfield's first chapter "The Laws of Motion." I intend to use this textbook designed for first year physics students for many of my lessons. This is the textbook we have been using in our Houston Teacher Institute seminar, and most of my ideas have come from our professor, and the lessons we have been taught in our weekly meetings. My students are always thrilled to find out they are "doing university level" work, and enjoy hearing about my classes and homework assignments. I hope to instill a yearning to learn, as well as a learning to learn desire in my students. I especially like to model being a life long learner: to have them see a teacher in the role of a student as I share my university lessons with them.

There are four components of my unit: 1) An Introductory Activity, *What Does a Scientist Look Like?* (REMSEL); 2) The Classroom ABC Book of Physics; 3) The Experiment Lessons and 4) and Fostering Academic Vocabulary.

I have created *concept* lessons (lessons in progress, as in G.M.'s *concept* car, the Volt). Lessons based on our state's mandated objectives for science and mathematics that are developed and completed by the students (often referred to as discovery investigations). I will use the TAKS results to address specific areas. Our testing data show that some of our students missed questions in Strand 1, The Nature of Science, which includes "analyzing, evaluating, and critiquing scientific explanations" (CLEAR). Working with the students through the process of setting up and testing hypotheses and theories will be an important component of this unit. Regarding Mathematics, TAKS results indicate a weakness in the area of Strand 4, Measurement, and the following lessons afford an excellent opportunity to utilize concepts of linear measure in metric units and of lapsed time.

One of our Gifted/Talented objectives is to have our students "think like a disciplinarian and use the language of the discipline" (Kaplan). In this unit it will be to think like a scientist and use the language of science.

In the teacher's manual *Building Academic Vocabulary*, the authors discuss the need for building academic vocabulary, especially for students from academically disadvantaged backgrounds, and offer many strategies to be used in developing discipline specific vocabulary. They state, "…that the more terms a person knows about a given subject, the easier it is to understand—and learn—new information related to the subject" (Marzano and Pickering 3).

They continue, “People’s knowledge of any topic is encapsulated in the terms they know that are relevant to the topic (2).

Their explanations remind me of a sentence I once read in a boating class, “A metal thimble in the eye-splice keeps the rode from chaffing at the shackle.” Although I recognized some of the individual words, I had no idea of what the sentence meant within the context of sailing, and I was about ready to “throw the sheets to the wind” (give up). Fortunately, I was taught about anchor lines (rodes) and the eye-splices and metal thimbles used to secure lines to an anchor or dock, in such a way, as to prevent the lines from wearing away from the constant tugging of waves and tides. I learned to truly enjoy sailing in spite of the strange and unfamiliar (at the time) nomenclature.

In *Building Academic Vocabulary* the authors stress the importance of “systematic instruction in important academic terms” (3) and have included almost eight thousand terms chosen from eleven subject areas in the Word Lists section of their book (Appendix B). They include activities and games as well as templates for graphic organizers. I have not decided on what specific format the language development component will take, however, I know it will be essential to include activities or games that help reinforce specific language, and I think of these vocabulary exercises as “imbedded lessons” within the unit.

Marzano and Pickering ask us to question ourselves about what we choose to teach, “Is this term, or objective, *etc*., critically important to the subject content I will be teaching this year?” (7) So whether we are choosing the most important objective (power objective) or key vocabulary terms, we are reminded to choose wisely and consider consequences of our choices.

Presenting this unit will definitely be a learning experience for me. Basically I want to incorporate what I have learned about physics with research-based strategies for increasing student growth. These strategies were presented at different District seminars this past year.

LESSON PLANS AND ACTIVITIES

Introduction to the Unit

Activity One:

What does a Scientist Look Like? (Individual Activity)

Purpose*:* Brainstorming to access prior knowledge (Santa)

To see a student’s preconceived ideas about science and scientists. I did this activity with my students last year.

Student Practice:

The students are asked this question, “What does a scientist look like?” and are prompted to list attributes and characteristics of what they think a scientist does and what they think a scientist looks like on the back of Activity Sheet #1. When they have completed their lists, they turn the sheet to the front (entitled: “What a Scientist Looks Like”) and draw a picture of what they think a scientist looks like.

Closure:

Collect the papers and display them on a bulletin board. Discuss the drawings. Do their preconceived notions match the reality of their lives? Even with parents or family engaged in medical and scientific research many drew “mad scientist” type illustrations. Most of their “scientists” were male! Some drew very detailed labs and equipment. One or two drew very basic almost stick figures with few features. Several drew futuristic scenes and creative experiments, and it is interesting to note how their background informs their drawings. Think of this activity as a window on their preconceived ideas about science and scientists. This is not an original lesson; it came from the Rice Elementary Model Science Lab (REMSL) 2006 program.

Lesson One: The ABC Book of Physics: *G is for Galileo* (Whole Class Activity)

Objectives

- Connect Grade 5 science concepts with the history of science and contributions of scientists such as astronomer Galileo Galilei. (CLEAR SCI. 5.3E)
- Use computers and information technology to support scientific investigation. (TEKS, 112.7 Science Grade 5 (a) Introduction (1).

Introduction

The first research lesson should be a whole class guided practice. Here is where I will introduce the colorful notebook used during a research project. It is used to record sources and information so that one may find the information a second time, and be able to cite sources correctly in a bibliography.

First discuss search engines. Terban's book, *Ready! Set! Research! Your Fast and Fun Guide to Writing Research Papers that Rock!* contains a list of search engines suitable for young researchers, as well as other helpful information. The students can begin by sharing the search engines they use when looking for information. Together create a list of suitable and reliable search engines. (Check them out). Have the students put this list in the front of their research notebook. They could also include a list of online dictionaries and encyclopedias. Remind the students that the school librarian should be at the top of their list when beginning any research project!

Next discuss web sites. Would your students agree with the following? "If the web site is from a college, museum, historical or scientific society, government agency, or any similar institution, the information is probably accurate" (Terban 48).

For the class ABC of Physics Book, I will use the 5W Method, wherein the students answer the following: Who, What, Where, When, and Why questions. For example: Who is Galileo? What were his contributions to science? Where did he live? When did he live? Why is he remembered? And then ask, "What information is given when you do an internet search for the key words, Galileo, Inertia?" (See "Galileo")

Concept Development

This section works best with an on-line computer and connected projector, or an interactive whiteboard system such as SMART Board (SMART Technologies) wherein the students work interactively with you in the preliminary searches. They are able to see the information that comes up and are able to discuss and ascertain reliable sources with you.

Using Google.com, I was able to access many university sites with biographical information about Galileo, written in rather technical terms; however, using Google for kids, (Terban 96), I was also able to access university sites with short and to the point biographical information written for kids, specifically Rice University's Galileo Project web site. I was not so lucky in using the key words "Galileo, Inertia," on Google for kids, no matches were reported. When using Google.com, and the key words "Galileo, Inertia," I was able to quickly find a site (*Zona Land*) with clear descriptions and moving illustrations of Galileo's concept of inertia.

Being able to use classroom technology to illustrate how an internet research project can produce reliable information in a short period of time is a valuable lesson. This lesson could be also take place in the classroom using portable computer carts with battery run computers for each student, or in a computer lab.

Student Practice

Follow up searches for information about the other scientists will be done at home or in the lab using a guided practice type of Web Quest and Rubric. (Students without computers at home are always given time to use one of our two classroom computers or the library computers.) Additionally, I think it will be important to require that the students use books, magazine articles, and other materials for their information.

I would like to have the students include one fun fact that appeals to them. There are many fascinating fact filled books for students. *Mysteries & Marvels of Science* (Clark) includes Internet links for Usborne websites. One Interesting fact about Galileo is that it took the church 359 years to restore his reputation after the Inquisition condemned Galileo in 1633 because his teachings clashed with the Bible (Pullella).

Assessment

Did the student meet the objectives of the lesson? Is the information correctly cited? (Gibaldi 151; Terban 96) The Rubric (Appendix 2) sets the guidelines for the format the students are to follow, and includes a scoring range for each entry. See O'Connor's *How to Grade for Learning* for assessing grades.

Materials: For each student.

A Research Notebook 5" x 8" (with a colorful cover). This will contain the list of suitable and reliable search engines, online dictionaries and encyclopedias for recording and identifying sites and facts the students may wish to use. Students may make their own note books, the colorful cover makes it easier to see or find!

The List of Scientists and Concepts to Investigate. (Appendix 1) Create your own list appropriate for your grade level. The scientists can be assigned one at a time, throughout the year. I would like to have a "free choice" selection of scientists for at least one assignment. (See Howell 57) Rubric (Appendix 2) and possibly a Web Quest guide for some selections.

Modifications

One may need to adjust the requirements depending on the interest and ability of the students, as well as the consideration of time and availability of technology. Perhaps one scientist and concept per six or nine week period could be assigned.

Experiment or Investigation Lessons

Objectives (for all experiments)

- Plan, implement and evaluate descriptive and simple experimental investigations that include a well-defined question, a testable hypothesis, one variable and the use of equipment and technology. (Power Obj. SCI.5.2A)
- Communicate and evaluate valid conclusions…. (Power Obj. SCI.5.2D)

Lesson Two: Galileo (1564-1642) & Inertia

Introduction

The following lessons are examples of how I will set up investigations designed to support or demonstrate science concepts.

Concept Development

The plan is to have the students generate a science investigation following an acceptable format, and being able to conclude with a viable explanation of what took place. Look for evidence of "strategic and extended thinking" (*Texas Teacher's* 6).

Student Practice

I will challenge the students to think of how they might demonstrate the following statement: "A body in motion tends to remain in motion; a body at rest tends to remain at rest" (Bloomfield 4), using the Air Soccer Disk, a launching ramp, meter sticks, and timers. I would have them plan and write up the investigation up as a group, making sure that they discuss and include variables and modifications necessary for more successful outcomes.

Assessment

Each student will write up the investigation, using illustrations and graphs to show the results. They would be required to share and defend their conclusions.

Closure

Talking through the steps, and discussing what did and did not work, or debriefing is a valuable learning experience.

Materials

Student Lab books, pencils, Air Soccer Disk, a launching ramp, meter sticks, and timers.

Modifications

This would be the opportunity for student input. They can explain what they would do differently if given the opportunity to repeat the experiment. If they have valid reasons for repeating the investigation, I would allow them to do so and incorporate their suggestions in repeat lessons.

A fun follow up investigation to test "the body at rest" concept would be to see if the students can pull a tablecloth out from under a plate, without having the plate fly off the table. This investigation requires cloth squares of different fabrics, and plates, bowls and cups or glasses made of plastic or wood. Practice pulling the cloth out from under the dishes in one quick motion, *before* you demonstrate the technique in front of the students. They can predict results using the different fabrics and dishes, and then experiment with the materials to support the concept that a body at rest tends to stay at rest (Bloomfield 1). As an incentive to try something on their own, I demonstrated this concept with a stapler on a sheet of paper, and then challenged them to try it at home with non- breakable items.

Lesson Three: Sir Isaac Newton (1642-1727) Newton's First Law of Motion

Introduction

Using the previous investigation and materials as a model, I would challenge the students to think of how they could demonstrate or prove the Newton's First Law of Motion: "An object that is not subject to any outside forces moves at a constant velocity, covering equal distances in equal times along a straight-line path" (Bloomfield 5).

Student Practice

As a whole class activity have the students paraphrase the statement, substituting synonyms for "constant velocity," and giving examples of "outside forces" and explaining "equal distances in equal times, along a straight-line path."

Then have the students in groups of four or five, write up a method for testing this concept using the Air Power Soccer Disk, launching ramp, meter sticks, timers and other materials they think they will need (masking tape, chalk?). Ask how they will determine equal distances in equal times, and how they plan to account for the outside forces, or variables. Did they think of gravity, friction, and air pressure? Give them time to test their investigations, and come together to discuss the pros and cons. Allow the students to rewrite their investigations and retest the concept. (See Blosser)

Assessment

Have the students write a summary of their investigation. Use a rubric to evaluate their summaries and conclusions. Have the students create "mini-science fair" boards, using large sheets (12" x 18") of construction paper, that demonstrate how they conducted this experiment. Display the boards.

Closure

The groups will need to share their results and determine if they were able to support Newton's First Law of Motion with their investigations.

Materials

Student Lab books, pencils, Air Soccer Disk, a launching ramp, meter sticks, timers, masking tape, etc. (some way to mark off equal distances).

Modifications

If time or space is limited, use a teacher made prepared track as mentioned above in the background section of this unit. Have the students had experience with air pressure investigations? One of my students lay on the floor blowing on the Air Disk in order to keep it moving. This brought up the notion of a variable we did not see!

Lesson Four: Sir Isaac Newton (1642-1727) Newton's First Law of Motion *continued*.

Introduction

Have the students repeat the above experiment, (final and most acceptable version) on an inclined plane. Use a wheelchair ramp with a smooth surface, or create a track, (as mentioned above) and raise one end, perhaps 10 cm at first and 20 cm next. Have the students determine the angle. Questions for the students to answer are: Do you need a launching ramp with this investigation? How do the different heights affect the progress of the disk? Is the disk travelling in equal distances at equal times? Can you find an explanation for these same or different results? Might there be a different concept at work here? (Present velocity = initial velocity + acceleration x time)

Younger students are not expected to know these laws, but should be able to compare results and note the differences between the investigations.

The rest of the lessons will be the investigations related to specific scientists and concepts in physics, based upon specific objectives for the grade level, or areas of interest expressed by the students.

Imbedded Vocabulary Lesson

This past week as a quick review of science terms, I had boy and girl teams compete for points. Each team member was given a term to define, and team members were not allowed to help. If a member missed then the other team took their turn. I gave one point per correct answer. It was spontaneous, and they enjoyed the challenge. This could be done as a quick review before a quiz, or to check for background knowledge. I could switch the rules, by giving them definitions and having them supply the term. I could raise the stakes by having the teams complete for homework passes or extra reading time.

I have really enjoyed the Houston Teacher Institute (HTI) seminar, "Everyday Physics, How the World Works," and the opportunity of incorporating what I have learned at the University of

Houston into my unit, along with the research-based strategies presented in many of our District's professional development sessions. This past year the emphasis was on student growth, based on the research and writing of Robert J. Marzano and his fellow researchers and co-authors.

APPENDIX 1

A Brief List of Scientists and Concepts or Accomplishments to Investigate

Physicists Name Bank		
Name	**Time in History**	**Field of Interest**
Aristotle	c. 384-322 BC	Developing Scientific theories
Archimedes		
Ampere, Andre Marie	1775-1836	Electricity and magnetism
Banneker, Benjamin		
Barden, John		
Becquerel, Antoine-Henri	1852-1908	Discovered radioactivity
Bell, Jocelyn		
Bernoulli, Daniel		
Boltzmann		
Brache, Tyco,		
Brattain, Walter		
Brewster		
Carlson, Chester F		
Celsius, Anders	1701-1744	Invented temperature scale 0-100 units
Chadwick, James	1891-1974	Discovered the neutron
Coulomb, C. Augustin de		
Count Rumford,		
Curie, Marie & Pierre		
D'Alembert, Jean Le Rond		
Davisson, Clinton Joseph		
De Laval, Carl Gustaf		
Diesel, Rudolf	1853-1913	Invented the diesel engine
Hooke, Robert	1635-1703	Relationship between elasticity & force
Newton, Isaac	1642-1727	Laws of gravity and motion; light spectrum
Pascal, Blaise	1623-1662	Hydraulics and atmospheric pressure
Torricelli, Evangelista	1608-1647	Principle of the barometer
Watt, James	1736-1819	Improved the steam engine,

Most of the dates and brief information on the individual scientists came from Howell, page 57. This chart is an example of how I intend to organize the list of possible scientists and their contributions for inclusion in our ABC Book of Physics… just enough information to get the students started on their own research.

APPENDIX 2

Research Report: The ABC Book of Physics

Teacher Name: Mrs. Garrett
Student Name:____

Category	**4 WOW**	**3 Well Done**	**2 Good Start**	**1 Needs Work**
	16-17 points	13-15 points	10-12 points	0-9 points
Organization	Information is very well-organized with well-constructed paragraphs and subheadings.	Information is organized with well constructed paragraphs.	Information is organized, but paragraphs are not well-constructed.	The information appears to be disorganized.
Amount of Information	All topics are addressed and all questions answered with at least 2 sentences about each.	All topics are addressed and most questions answered with at least 2 sentences about each.	All topics are addressed and most questions answered with at least 1 sentence about each.	One or more topics were not addressed
Mechanics	No spelling, grammatical, or punctuation errors.	Almost no spelling, grammatical, or punctuation errors.	A few spelling, grammatical, or punctuation errors.	Many spelling, grammatical, or punctuation errors.
Internet Use	Successfully uses suggested internet links to find information and navigates within these sites easily without assistance	Usually able to use suggested internet links to find information and navigates within these sites easily without assistance	Occasionally able to use suggested internet links to find information and navigates within these sites easily without assistance	Needs assistance or supervision to use suggested internet links and/or to navigate within these sites.
Sources	All sources (information and graphics) are accurately documented in the desired format.	All sources (information and graphics) are accurately documented, but a few are not in the desired format.	All sources (information and graphics) are accurately documented, but a many are not in the desired format.	Some sources are not accurately documented in the desired format.
Diagrams & Illustrations	Diagrams and illustrations are neat, accurate, and add to the reader's understanding of the topic	Diagrams and illustrations are accurate, and add to the reader's understanding of the topic	Diagrams and illustrations are neat, accurate, and sometimes add to the reader's understanding of the topic	Diagrams and illustrations are not accurate OR do not add to the reader's understanding of the topic

From the RubiStar teacher home page, I chose the heading, “Research Report,” and used the pull down menu options to choose the 6 categories, along with their pre-written descriptors. I chose not to make any changes to illustrate the ready made options available to teachers.

I added the “WOW, Well Done, Good Start and Needs Work” captions and assigned points for each level. The maximum points that can be earned for each of the levels will be 102, 90, 72 and 54 respectively.

ANNOTATED BIBLIOGRAPHY

Works Cited

Ainsworth, Larry. *Power Standards: Identifying the Standards that Matter the Most.* Englewood, CO: Advanced Learning Press, 2003.
This book explains why there is a need to identify the absolutely essential objectives students must learn in order to be successful. “Power objectives” are now being identified in CLEAR.

Bloomfield, Louis A. *How Things Work: The Physics of Everyday Life*. Hoboken, NJ: John Wiley & Sons, Inc., 2006.
This textbook is designed for first year university students. It will serve as my main resource for this unit. There are good diagrams, pictures, and helpful explanations. Many of the lessons can be adapted for younger or advanced students. The author lists over 70 scientists in the glossary; however there is no bibliography.

Blosser, Patricia E. *Ask the Right Questions*. Arlington, VA: National Science Teachers Association, (NSTA), 2000.
A very useful booklet for generating effective responses by using specific questioning strategies in the classroom. Blosser’s topics include, types of questions, the value of silence, factors of questioning, and analyzing questioning behavior. A small, (14 pages) but extremely effective guide.

Clark, Phillip, Laura Howell, and Sarah Khan. *Usborne Internet-Linked Mysteries & Marvels of Science.* London, UK: Usborne, 2004.
The title speaks for the content: A colorful book that includes pertinent information, photographs, and illustrations as well as a recommended internet links for interactive activities. The book discusses internet safety and is designed for youngsters.

CLEAR (Clarifying Learning to Enhance Achievement Results), Houston Independent School District’s (H. I. S. D.) core curriculum < http://www.houstonisd.org/ >. The district’s objectives now match and are in line with the Texas Education Agency’s objectives called TEKS (Texas Essential Knowledge and Skills) found at their web site <http://www.tea.state.tx.us/ >. Teachers in H.I.S.D. have access to both Horizontal and Vertical Alignment Matrices. The former shows grade level objectives across a specific time period, the latter, shows like objectives across several grade levels.

Educational Innovations. Air Power Soccer Disk. 2/12/2008. <www.TeacherSource.com>.
Catalog and internet sales of science related “gadgets” (e.g. Newton’s Cradle, or Kinetic Yo Yo”). The air disk uses four double AA batteries, and runs for about 30 minutes. (Have extra batteries on hand). $19.95, plus shipping and handling.

“Galileo.” <http://Encarta.msn.com/text_761557587__0/Galileo.html>. 3/22/2008.
One of many reliable sites available when looking for basic information about Galileo.

Gibaldi, Joseph. *MLA Handbook for Writers of Research Papers. Sixth Edition.* NY: Modern Language Association of America, 2003.
The MLA publishes this book for high school and undergraduate students and another for graduate students and scholars. Go to www.mla.org for most recent editions and additional information.

Houston Independent School District Advanced Academics Department. *Scholars & Knowledge: A Scholarly Approach to Learning.* HISD Gifted and Talented Curriculum Framework, K-12. Revised 2003.
This is the curriculum for G/T students, found online and available to all district teachers.

Howell, Laura, ed. *The Usborne Internet-Linked Library of Science Energy, Forces & Motion.* NY: Scholastic, 2002.
Illustrations, photos, facts and lists, and web sites, all pertaining to Physics. It also includes an index of scientists and discoveries, as well as an "A-Z of Scientific Terms."

Kaplan, Sandra. "Think Like a Disciplinarian: Theory and Practice: Curriculum and Instruction for Educators." 23 March 2008. < http://www-ref.usc.edu/skaplan/disciline.html>.
Kaplan describes how teachers can have their students "thinking like an "expert" within a particular context: by recognizing terms, resources, trends, and rules specific to a particular discipline, as well as making comparisons across disciplines.

Lienhard, John H. "No.1435 Rudolf Diesel." *Engines of Our Ingenuity*. Episode 1435. < http://www.un.edu/engines/epi1435.htm >. 31 May 2008.
A University of Houston web site, and Public Radio program, KUHF-FM.

Marzano, Robert J. and Debra J. Pickering. *Building Academic Vocabulary; Teacher's Manual*. Alexandria VA: Association for Supervision and Curriculum Development, (ASCD), 2005.
The authors stress the need for systematic instruction of essential terms specific to individual context areas. The book includes activities, games and graphic organizers as well as a list of about 8,000 terms specific to 11 subject areas.

O'Connor, Ken. *How to Grade for Learning: Linking Grades to Standards.* Thousand Oaks, CA: Corwin Press, 2002.
The author argues against zeros in the grade book, and for teachers to adopt a ZAP (Zeros Aren't Permitted) policy. His premise being that zeros don't usually reflect a Student's ability, but rather behavior (late or missing assignments). He suggests that the student should be made to complete the work, before, after, or during school, and a grade be taken on the actual ability exhibited. In other words, a student doesn't have the choice to opt out of an assignment and settle for a zero. An interesting and informative book.

Pullella, Phillip. "Pope Says Church To Seek Pardon For Past Errors." 1 September 1999. April 26, 2008. <http://www.bibletopics.com/biblestudy/71.htm >.
Article about the Vatican's apology about past iniquities.

REMSL**.** Rice Elementary Model Science Lab (REMSL) 2006 program.
A program in conjunction with Rice University and the Houston Independent School District. Teachers spent one day a week at Sanchez Elementary learning how to create exciting lessons based on science TEKS. For information contact the following web site:
< http://centerforeducation.rice.edu/PDF/Centerpiece2007Spring.pdf >.

Rubistar. 2007. Advanced Learning Technologies in Education Consortia ALTEC. 5/30/2008. <http://rubistar.4teachers.org/index.php>.
Excellent source of online rubrics for teachers all subject areas. The sample templates can be altered to suit your needs. Very helpful! Join online, no fee.

Santa, Carol M., Lynn T. Havens, and Bonnie J.Valdes. *Project CRISS: Creating Independence through Student-owned Stategies*. Dubuque, IA: Kendall/Hunt, 2004.
This book is used in a 12 hour professional development course. The plus side is that the teachers get to practice the strategies in their classrooms, and then come back to discuss the results. Teaching students to learn, through student-centered metacognitive exercises and activities, such as setting a purpose for learning, require deeper student involvement and result in more meaningful learning. A very helpful teacher resource.

Shepard, Michael. “Wright, Joseph.” Web Museum. 14 Oct 2002, Nicolas Pioch. BMW Foundation. 21 March 2008. < http://www.ibiblio.org/wm/paint/auth/wright>.
This site contains two of Wright’s paintings, *Experiment on a Bird…* and *The Alchemist…*, as well as a brief biography of Wright taken from the Encyclopaedia Britannica, 1994.

Smart Technologies. < www.education.smarttech.com >.
Makers of an interactive whiteboard that combines the whiteboard with the power of a computer. We are in the process of having these delivered and set up in our classrooms. It makes an excellent teaching and learning tool. I will be able to use mine with this unit!

Terban, Marvin. *Ready! Set! Research! Your Fast and Fun Guide to Writing Research Papers that Rock!* New York: Scholastic, 2007.
This 128-page book is written as a guide for students who are expected to complete a research assignment in school. It addresses multiple sources for information and the correct way to cite the material to avoid plagiarism. I found this a useful book for teachers as well as students.

Texas Teacher’s Desk Reference and Critical Thinking Guide. Lometa, TX: Texas Educational Tools, Inc., 2005.
This booklet is a handy TAKS reference and includes a revised Bloom’s Taxonomy and Webb’s “Levels of Depth and Knowledge.” The format, spiral bound and tab indexed, makes it a very convenient source to consult when writing up or reviewing lesson plans for content as well as depth and complexity. Available for grades K-12, and specific middle and high school content areas.

Tomlinson, C., Kaplan, S. et al. *The Parallel Curriculum.* (a Service Publication National Association for Gifted Children) Thousand Oaks, CA: Corwin, 2002.
This book is at the heart of our Gifted/Talented Curriculum Framework, “Scholars & Knowledge.” Our G/T universal concepts frame or overlay CLEAR (our district curriculum) subject area concepts.

Vertesi, Janet. *Light and Enlightenment in Joseph Wright of Derby’s The Alchemist.* Diss. 21 March 2008 <http://www.geocities.com/jvertesi/wright/>.
This site pulled up Vertesi’s complete thesis (34pp) when I was only looking for photographs of Joseph of Derby’s paintings. By accessing the site without “wright” at the end, one can find a list of her (Janet) essays, many relating to science.

“Volt.” *Wikipedia.* 21 March 2008. <http://en.wikipedia.org/wiki/Volt>.
This site confirmed the existence of the Italian scientist Alessandro Volta who invented the first chemical battery.

Zobel, Edward A. “Galileo and Inertia.” 1997-2006. *Zona Land*. April 27, 2008. <http://id.mind.net/~zona/mstm/physics/mechanics/forces/galileo/galileoInertia.html>.
This site brought up four pages of information related to inertia supported by moving illustrations. Their home page states that “the National Science Teachers Association has selected selections of *Zona Land* for inclusion in their sciLINKS database.”

Search Engines

<www.Google.com >
I use this search engine for a quick overview of possible sites to investigate further. Often there is enough information available within the sites listed to answer questions such as, “Was there a person behind the name diesel, amp, or volt?” Then I am able to choose a reliable source for further information.

< www.google.com/TopKids_and_Teens>
I used this search engine to compare the types of information that was available to children with information available to adults. Sometimes the language was an issue, and other times it was the fact that truly unsuitable sites came up on the non-kid Google page. I will use these comparisons to choose suitable web sites for a web-quest activity.

Supplemental Sources

Bryson, Bill. *A Short History of Nearly Everything.* New York: Broadway/Random House, Inc., 2003.
This is a non-scientist's approach to learning all about science from 1600 to present. Bryson's humorous touch helps make some complicated concepts easier to understand. He includes often ignored anecdotes about some of the well-known scientists. It is a great resource for those little known or "fun facts" that I think my students will enjoy.

Corbeil, Jean-Claude, ed, et al. *The Macmillan Visual Dictionary.* NY: Macmillan, 1992.
This is a beautifully detailed and illustrated source for seeing models of the solar system as well as how the Hubble telescope is constructed. From simple items such as staplers to complicated off-shore oil platforms, aircraft carriers, and optical instruments, it is a fascinating book to simply enjoy looking at.

Gould, Alan. *Hot Water and Warm Homes from Sunlight.* Berkley, CA: LHS GEMS. (Lawrence Hall of Science, Great Explorations in Math and Science), 2005.
This is one of many teacher guides in an ongoing curriculum program in Math and Science produced by GEMS. It includes worksheets and directions to create experiments that explore solar power and heat energy. For information about this and other titles contact: < http://lhsgems.org/gemskits.html >.

Hawking, Stephen W. *A Brief History of Time: From the Big Bang to Black Holes*. NY: Bantum Books, 1988.
One has to think about the accomplishments in science and technology that enable this brilliant man to communicate so effectively. Hawking describes it as a "book for those who prefer words to equations" (fly leaf) Glossary and Index, no Bibliography.

Larsson, Ulf, Ed. *Cultures of Creativity: the Centennial of the Nobel Prize.* Trans. Daniel M. Olson. Canton, MA: Watson Publishing International, 2002.
This book was published in conjunction with the Centennial Exhibition of the Nobel Prize (1901-2001) in an attempt to answer the question, "What is creativity, and how can it best be promoted?" The book contains a fascinating collection of photographs and biographies of scientists, authors, and advocates of peace who won the Nobel Prize.

Marzano, Robert J., Debra J. Pickering, and Jane E. Pollock. *Classroom Instruction that Works: Research Based Strategies for Increasing Student Achievement.* Alexandria, VA: Association for Supervision and Curriculum Development, 2001.
This, and the other Marzano books, directing teachers to use research based strategies in order to increase student achievement have been the focus of many of our District's professional development seminars this past year.

Marzano, Robert J., et al. *A Handbook for Classroom Instruction That Works.* Alexandria, VA: Association for Supervision and Curriculum Development, 2001.
A companion book to *"Classroom Instruction that Works…"* This book contains activities and graphic organizers used for the "nine categories of targeted instructional strategies proven to improve student achievement" (1) Some of the topics include; Homework and Practice, Generating and Testing Hypotheses, Identifying similarities and differences, etc., and can be use across disciplines.