Scientists Answer Their Own Questions!

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This curriculum unit is recommended for:
Third Grade Science

Keywords: observation, inquiry, forces, motion

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This unit is for teachers who are trying to teach observation and inquiry skills to elementary students. Although it is written using third grade objectives, you could adapt the lessons for any elementary class. The students will engage in hands-on activities that scaffold instruction from guided inquiry to open inquiry. The students will explain and elaborate on their ideas, then come up with their own question to answer. Students will be answering their own questions with science experiments in no time.

I plan to teach this unit during the coming year to 85 *students in Third Grade science lab.*

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Introduction

School/Student Demographics

Rama Road Elementary School is a Title 1 School with 82% free and reduced lunch and all children receive free breakfast. We are very diverse both in socioeconomic status and race, with kids from 31 different countries. Although there are many single parent families, we have a good chunk of families coming back to their neighborhood school. Our PTA is fabulous and they provide materials and resources for classroom teachers and students. My school has 2 church partnerships that are outstanding. They provide books, resources, gift cards, and programs like Girl Scouts to our students. We do have some families living in hotels and participating in the McKinney Vinto program, which means they are homeless or living with multiple other families until they can find something permanent. Our reading and math EOG scores are both below 50% and our Fifth Grade Science EOG scores are 67%. We have a lot of excitement and curiosity built around science and our Science Fair and Math Expo in January is the largest attended family night.

I teach a science lab to all grades Kindergarten – Fifth. I've been in my position for 5 years. The lab is a special area class that all classes attend once per week for 45 minutes. I teach 30 classes in a week. There is an average of 20 students per class. This unit will be taught to my third grade classes. There are 4 of them for a total of 85 students. I'll be teaching the unit for a month. Each third grade class will do one lesson a week.

Unit Goals

From my Science Essential Standards, I know that inquiry based teaching and learning is important to make my students 21st century learners. "The process of scientific inquiry, experimentation and technological design should not be taught nor tested in isolation of the core concepts drawn from physical science, earth science and life science." (NCDPI) My unit goals are students will make careful observations of phenomena and accurate measurements. Students will ask questions that are age appropriate and will design experiments to answer their questions. The students will use inquiry and observation skills while addressing these third grade goals as well: Infer changes in speed or direction resulting from forces acting on an object, compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time, and explain the effects of earth's gravity on the motion of any object on or near the earth. The Inquiry and Observational goals can be met through any science objectives. You can apply these skills and lessons to life and earth science as well. The lessons are designed for 3rd – 5th grade but can be modified for younger students as well. See Appendix 1 for the standards.

Rationale

Throughout my 5 years teaching the science lab, I've seen the love of science grow in my students at my school. My students don't often have varied background experiences to pull scientific knowledge from so, by being involved in our science lab, they are creating those experiences. We use tools and hands-on materials to investigate questions we have about the world around us. I have seen growth in my students from Kindergarten to 5th grade. For example, 6 years ago, my 5th graders couldn't read a set of directions and set up an experiment to test a question, but now they can do that with ease. I see that my students are clearing up some of their misconceptions about science and I know they can do prescribed experiments, but I still see areas where they can improve. I want to focus my unit on developing students' observational and inquiry skills so they can design experiments to answer their own questions. My hope is that by attaining deep observational skills they will be able to solve problems in a variety of disciplines, not just in science class. In learning inquiry skills, my students will understand their role as a scientist in their community and know that they can contribute to ongoing research.

I've noticed that my students get to a certain level of scientific knowledge and seem to level off there. My Kindergarteners can learn vocabulary like hypothesis and observation and they will try any experiment I ask them to. As they get older, it seems they stay at this level and do not deepen their level of scientific knowledge to extend beyond memorizing some vocabulary words and having fun in science lab. I am always trying to think of ways to get them to take ownership of their learning and to go deeper. I know the standards well and the vertical alignment between the grades so I'm trying to design a curriculum in which I'm not always introducing "new" concepts. They should remember the experiences they've had in previous grades and build upon that knowledge with new learning. To do this, I have to design the learning to embrace inquiry and observation. Students have to take risks, make mistakes and learn from them. They also have to be able to organize their thoughts, remember the details that are important, and make meaning of new experiences they have.

I also notice that my students are relying heavily on media sources for their scientific knowledge and experiences. They love to watch YouTube videos passively and see what others have done. They want to try the experiments on their own, but often don't understand the deeper meaning behind the experiment and often can't connect the learning to something else they've seen or something we've done in class. They are exposed to a lot of information and have a hard time determining what parts are important and how to connect their experiences to form meaning. They love using the tools and materials but they need to be taught proper ways to use these in order to collect important data. They aren't sure how to use data either. If we make a graph, they aren't likely to connect it to the real world or sense how it's important unless I point it out to them. They love learning science but the second it presents a challenge for them, they want the easy way out. They ask me the answer or Google it instead of trying it again or trying to organize their data.

I love teaching science lab because even my students that aren't engaged in their Reading and/or Math classes get involved in Science. This has really stuck with me, "Because science text is an abstract representation, students are less likely to learn science concepts from reading text if they have not had prior concrete experiences and appropriate concept development. However, when students have had a rich learning cycle sequence, which includes concrete experiences, they will be able to tackle science text with greater success." [1] Knowing that in

middle and high school, science class will be based on reading a textbook and interacting with scientific articles, I want to provide as much exposure to hands-on materials and experiences as possible so that when they are presented later with drawings, charts, formulas, and graphs, my students will be able to interpret their meaning and relate it to something they've experienced. I also want to provide opportunities for my students to work with groups of their peers. I'm learning in my lab visits that scientists function in communities and rely on each other for their research. Therefore, working with others is critical to acquiring the 21st century skills required in the workplace today.

Content Research

Inquiry and Observational Skills

"Instead of just presenting the facts, use questions, problems, and scenarios to help students learn through their own agency and investigation." [2] Inquiry based learning is about getting students excited about what they want to know. It's designed to tap into students' higher level thinking skills and embraces their natural curiosity about the world.

> "The publication Inquiry and the National Science Education Standards (NRC, 2000) identified the following five essential features of classroom inquiry: (1) learners are engaged by scientifically oriented questions; (2) learners give priority to evidence in responding to questions; (3) learners formulate explanations from evidence to address scientifically oriented questions; (4) learners evaluate their explanations in light of alternative explanations, particularly those reflecting scientific understanding; and (5) learners communicate and justify their proposed explanations." [3]

The teacher has to do some behind the scenes work to set up experiences that are authentic to a group of learners and has to let them respond in the way they need to. When you are excited about a topic, the students will embrace that enthusiasm as well and it will lead to questions they have. Sometimes, the learner will need to do research and reading during class to build some background and gain knowledge to answer their questions. This can be done in collaborative groups to increase the effectiveness. In the inquiry-based classroom, once the teacher has introduced a topic or aroused interest, the students think of "big" questions they will attempt to answer. If the students are very young, the teacher will have a bigger role in designing experiences that will help students answer their questions. If the students are older, the teacher will leave more of the designing and questioning to the students. The teacher can provide examples and materials as well as help students control their experiments. In "Making Science Real" authors Olson and Mokhtari indicate that it may be more effective for teachers to present students with concrete representations in science before reading about the topic.[4] In an inquiry-based classroom, a teacher would allow students to roll balls down ramps, work through misconceptions they may have, and try new things with materials before ever reading about the laws and theories behind these phenomena. For students to be able to develop a scientific concept, they need to explore first. This could be through a challenge question, an observation of something unique, or another guided experience. "Students discuss with one another and with the teacher their observations, questions, and possible explanations. The teacher uses students' ideas to pose additional challenges to clarify their thinking, moves students' thinking from the concrete to abstract through discussion and introduction of concepts and provides appropriate terminology for concepts." [5]

Good observational skills are important to a scientist because that is where inquiry starts. “In everyday life observation is simply seen as “looking at things”. However, in science observations are used to generate further explanations and theories about observed phenomena; they require skills associated with collecting and interpreting data and are influenced by the observer’s assumptions and domain knowledge.” [6] Typically, a student will see something happening and ask questions about it. Or, one will watch an event in nature and wonder how it happens. From my research, I understand that an observation also involves your past experiences. Students may look at something and connect other things to it that may or may not be related. Or they may watch something and form new learning. Because of their background, they may pay attention to a different part then someone else. I notice my students barely glance at something and immediately tell me ‘the answer’ or what the item is, instead of describing it in detail or just taking it in quietly. I want to strategically design lessons that will lead them to have better observation skills so they can channel curiosity about the world and practice stronger inquiry. When good observational skills are combined with cooperative group learning, the results can be exciting. Each person in the group can provide a fresh perspective to the situation and therefore lead others to new ideas as well.

To become a better observer, you have to use all the five senses to gather information about your world that may lead you to a new understanding of how it works. Teachers can provide experiences for students to look, touch, listen, taste, and smell things that will help them. Students should learn how to use measurement for size and accuracy. For example, they can use measurement tools or graph paper to copy the size or make a scale drawing. Teachers can also demonstrate how to draw pictures to show the details of something and also to remember it the next time they look. “That said, simply having students closely observe a phenomenon does not mean they will develop complex science ideas. The teacher needs to help them make sense of experience and to introduce concepts and terminology when students are ready for them. In addition, most published laboratory activities are not in a format that makes them well suited for students in an initial exploration phase.” [7]

From my experience in my seminar, Doing Science: Hands-on Learning in the Lab, I learned about how scientists do research. I learned that they collaborate with other researchers in various fields to gain knowledge about their own research. I visited various science labs and found that they are very similar to my elementary science lab. I have always known the importance of the scientific method but I am seeing more and more how to apply it in the real world and how to facilitate learning for my students that will prepare them for collaborating with colleagues and finding answers to their own questions about the world. In visiting labs in all areas including life, physical, and earth science, I’ve been able to see how each scientist could help another in a different discipline. They offer to help each other to save money and to continue research on various projects. For example, a 3D printing lab can be useful to a sports physicist in that they could print prototypes to test that will allow for cheaper and quicker experimenting.

When doing an experiment, the results have to be analyzed. Although this is not the “fun” part, the analysis can take weeks, even years. The observer has to try his/her best to record all of the results, whether or not he/she thinks it’s important. The results will be analyzed later and the importance of each observation can be determined. Also, some will reach conclusions in different ways, choosing different ways to solve the same problem.

In visiting other labs, I've seen very complex equipment and I've also seen some creative use of everyday materials to do experiments. Funding is hard to come by for basic level scientific research, so scientists work together and use materials they already have to answer their questions. You have to be resourceful and reuse materials so that you can meet the needs for your research.

Science is becoming more and more real to me as I observe more scientists, teach more children and read more books. I am learning that science connects many disciplines in the book, A Little History of Science by William Bynum. Bynum says, "Science might be something as simple as observing the sun rise each morning, or as complicated as identifying a new element." [8] It's been around since the beginning of time and even though in modern times, we have more technology, people have always been curious and have always been investigating phenomena in our world. Science connects people to the world and to each other in so many ways. That's why it is so important to teach students to make connections for themselves and to stay curious about how things work. We want them to design processes to improve those we already have and we need new research even when the funding runs out. "We need good scientists, but we also need good citizens who will ensure that our science will make the world a better place for us all to live in." [9]

Force and Motion

Newton's laws of motion are the basis for teaching physics in elementary school. From these, we develop our force and motion lessons that explain how things move and cause change in motion. The first law is that objects at rest will stay at rest and objects in motion will stay in motion until a force acts upon them. This law is also known as the law of inertia. The second law of motion states that something balanced is not going to move (accelerate) and something unbalanced will move (accelerate). For every action, there is an equal and opposite reaction is a cause and effect relationship demonstrating Newton's third law of motion. To understand the laws of motion, you also need to know Newton's law of gravitation, the force of gravity increases when the mass of the object increases and that same force of gravity decreases when the distance between the objects increases.

In the book, Stop Faking It! Force and Motion, Robertson explains the importance of understanding the background of Newton's laws and how they would work if you could always have experiments work. This book and its companion book of classroom activities have been so helpful to me in teaching force and motion. Things you need to know about the first law are that inertia is the way an object keeps doing what is was doing. The law only works when all forces are taken into account, including friction. Friction from air resistance is what I find to be the force that tends to be missed by kids. To understand Newton's second law, Chapter 7 helps students to understand the relationship between unbalanced forces, accelerations, and inertia. Students use the term mass in place of inertia, understanding that mass has a number. Try to get students to see that things will keep moving if that's their tendency and that unbalanced forces cause movement. To understand Newton's third law, try to get students to understand the idea of pushing back. Objects push back on each other even if they aren't alive. This is because they are made of atoms and are constantly in motion. You can do simple demonstrations using rolling chairs, pushing on tables, and coins bumping each other to show the idea of pushing back.

Instructional Implementation

Teaching Strategies

To teach this unit, start with Directed Inquiry and progress to Guided Inquiry when/if your students are ready. In Directed Inquiry, teachers provide students with specified resources one by one, providing challenging questions and clear outcomes.[10] The students will still have choice and decisions about how to interact with the materials but the teacher will have some expected outcomes in mind and help the students to reach these. The teacher will help students to analyze their results. They may not know what their data represents at first. They will need help determining the importance of what they found. Teachers can do this through questioning or by taking data from a larger group and helping students analyze it.

In Guided Inquiry, the students will have more choice. They will choose the order to investigate their resources, often choosing their own resources to understand phenomena. Students will have to analyze their own data and summarize it in a way that will address the question they were trying to answer. They have to determine the importance of their findings and communicate the results. It's important that the teacher gives feedback during these experiences. Without this, students can get hung up in the exploration and lose sight of their goals.

For the force and motion content, Students need to know:

1. When a force acts on an object it will result in a change of speed and / or direction.
2. Speed can vary.
3. Varying the speed of a moving object will affect the time it takes for the object to travel a particular distance.
4. The earth 'pulls' on all objects on or near the earth without touching those objects.

Unpacking this further, the following are statements from my districts' Science Essential Standards Resource Guide:

*Forces are all around us and can change an object's motion.

*A force is a push or a pull.

*Pushes move away from you. Pulls move toward you.

*When forces are equal, or balanced there is no change in motion.

*Unequal forces cause a change in motion.

*The heavier an object, the more force you need to move it.

*Whenever you push or pull on something, it pushes or pulls on you.

*The push or pull that you feel is a force in the opposite direction.

* Many things can create forces (example a magnet).

*Some forces push or pull on objects without even touching them.

These are essential vocabulary needed for the content objectives:

Change in motion occurs when an object starts moving or stops moving, speeds up, slows down or changes direction.

Direction is the line or course along which a person or thing moves. When a batter hits the ball it changes direction.

Position is the location of an object. People often describe a position by comparing it with the positions of other objects. Words like below and above, right and left, behind and ahead give clues about position.

Speed is how fast an object moves over a certain distance. To measure speed, you need to measure time and distance. The distance an object travels in a period of time tells you its speed. An equation we can use is:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Gravity is a force that pulls two objects toward each other. Anything that has mass also has a gravitational pull. The closer you are to an object, the stronger its gravitational pull is. Often when we think of gravity we think of the gravitational pull of the Earth on us and everything around us. When a person throws a ball up towards the sky, gravity pulls it back down.

Weight is how much pull gravity has on an object. Gravity is what gives you weight. I would weigh much less on the moon! This is due to the fact that the moon has much less gravitational pull.

Mass is defined as the measure of the amount of "stuff" in something. The more mass something has, the harder it is to move or, the more sluggish it is. If we were on the moon our mass would be the same, but our weight will have changed.

Friction is the force that occurs when one objects rubs against another. Different materials produce different amounts of friction. Ice produces very little friction while sandpaper creates more friction. Friction slows things down.

Momentum can be defined as "mass in motion." All objects have mass; so if an object is moving, then it has momentum. The amount of momentum that an object has is dependent upon two variables: how much *stuff* is moving and how fast the *stuff* is moving. In terms of an equation, the momentum of an object is equal to the mass of the object times the velocity of the object. A ten pound bowling ball moving at 1 mile an hour has as much momentum, or striking force, as a five pound bowling ball moving at 2 miles an hour. (www.dpi.state.nc.us)

"The 5 E's is an instructional model based on the constructivist approach to learning, which says that learners build or construct new ideas on top of their old ideas. The 5 E's can be used with students of all ages, including adults." [11] Each E stands for a section of learning and they are, Engage, Explore, Explain, Elaborate, and Evaluate.

To **Engage** students, the teacher introduces the topic in a way that activates interest and focuses students on the topic or questions. Students will connect what they already know to a new

learning experience and orient themselves to a new activity. The teacher may ask a question, propose a problem, show a discrepant event, or have the students participate in a role-play.

Exploring involves students interacting with materials that will give them a basic knowledge of what the teacher has introduced. They work together in cooperative groups or teams to begin the process of sharing and communicating. The teacher becomes a facilitator. Exploring puts the students on a common playing field and gives some background to those that may not have it.

The **Explain** phase is where students connect what they have found with the vocabulary or big ideas the teacher wants them to learn. Students will put into words their thoughts and connect the experience with the vocabulary.

The **Elaboration** phase "extends students' conceptual understanding and allows them to practice skills and behaviors." [12] Students will collect more information and deepen their understanding of the activities.

In the **Evaluation** phase, the teacher will assess what the student has learned. Often, the teacher will assess throughout the unit, not just at the end. Students can also assess themselves.

Problem Based Learning (PBL) can be defined as an inquiry process that resolves questions, curiosities, doubts, and uncertainties about complex phenomena in life.[13] A problem is any doubt, difficulty, or uncertainty that invites or needs some kind of resolution. [14] Student inquiry is an integral part of PBL. [15] I've been using PBL in my classroom for 4 years now. My special area team builds PBL lessons to help students dive deeper into a complex, real world problem across the disciplines of Music, Art, Media, Innovations Lab, Science Lab, and P.E. In these PBL projects, students are involved in the search for knowledge about the topic introduced by the teacher. They explore and experiment to find answers to their own questions and it develops their inquiry skills in the classroom community. Research has shown that students are not prepared to solve real-world problems when they leave school, so PBL has been an innovative classroom strategy to help address this issue. In a PBL unit, students use knowledge in multiple forms and across multiple contexts, instead of just sitting and obtaining information. Problem based learning and the 5 E's can be used together to be even more effective. Within a PBL, teachers will allow students to encounter a problem or a scenario, take on specific roles (within cooperative groups), ask questions and understand new situations, search for answers, analyze results and draw conclusions, assess them in various ways, and examine the unit to see what they liked. Problem based learning is like the ultimate class project but instead of focusing on the project (the end result) the students are focused on the process of solving a problem. They may or may not have a project to present at the end, but they will be able to explain the process they used.

Discrepant events are surprises, puzzles, or things a teacher can do to astonish the observer. Often, a discrepant event does not appear to follow the rules of matter or energy. The outcome is unexpected or not what the student would predict. The explanation for what happens is not easily explained and requires further exploration. A teacher can set up these events to introduce a topic to engage students. They help the students wonder about the world and allow for inquiry to happen.

"Cooperative learning is an instructional method in which students work in small groups to accomplish a common learning goal under the guidance of a teacher." [16] Using cooperative

groups in science class is helpful for students to work as a team and depend on one another. They can talk with each other to gain new insights about the question or experiment at hand. Students will still be assessed individually on their work and their contribution to the group, but they are working together toward a common goal. Learners can develop better social and communication skills when they are involved in cooperative groups. They will also appreciate the diversity of their group and be more accepting of each other's opinions if the experience is designed correctly. Students do learn from each other because the teacher can't always reach everyone in every lesson. If the group is functioning properly, everyone will have a part, will be heard, and will contribute to the lesson.

Problem Based Learning, Discrepant Events, and Cooperative Groups are strategies that can help teachers combat the fact that media is such a huge part of our students' lives. Kids have so many distractions throughout the day and are engaged in more screen time than ever before. Instead of passively watching a video or a show, these strategies allow for higher-level critical thinking skills that will allow them to enjoy their learning.

Classroom Lessons/Activities

You may need to show a few videos and introduce some of the vocabulary before you teach these lessons. I am a special area teacher, so when I teach these lessons, the vocabulary has already been taught in their classrooms and they have also done some investigating in our Innovations Lab that will lead them to a better understanding of the vocabulary. I use a word wall to teach/reteach vocabulary and also picture dictionaries but I don't spend too much time worrying about usage while we are investigating.

The following lessons address force and motion standards, but lessons of observation and inquiry can follow this format and you can plug-in any objectives you are currently teaching. I try to get my students to 'play around' with some materials and make observations, then I design a couple experiments to get them using the materials. Then I put out materials they can use to design experiments to answer their own questions and drive their own learning. I stay focused on the big questions I want students to learn and try to steer them back to the question if I find them too off topic.

Lesson 1 Objectives: make careful observations of phenomena, infer changes in speed or direction resulting from forces acting on an object, and compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time. Big Question: How do things move in different ways? This lesson will involve 2 steps of the 5 E's, Engage and Explore.

Teacher Input: Engage - Tell students they will have 30 seconds to look closely at a picture on their table. They will be making notes of their observations after. Students turn over a picture of an amusement park at their table. They will get 30 seconds to look closely. After 30 seconds, tell students to turn back over and record all observations you remember. Students will share these with your tablemates. At this point the teacher will go over today's objectives and say, "We will be learning about how things move – Forces and Motion." Ask students what they remember from first grade – whole group discussion. Teacher will have a bucket of 3-4 various balls for each group ready.

Guided Practice: Explore - Students will look at the bin of materials for their group: 3 different balls, different sizes, made of different materials. The teacher will give students their recording sheet (Appendix 2) and explain the lesson. Go outside (weather permitting) to see how these will move in different areas of the playground. Before going outside, get students to understand that exact measurements aren't always important. Help them to come up with a way to measure time by counting seconds, "one one thousand two one thousand." Practice counting together. Before going outside, students should look at their recording sheet and make a plan for what they want to try. Write down at least one question they have that they'd like to investigate.

Independent Practice/Assessment: Students try out their question once they are outside and fill out the recording sheet. Come inside with about 10 minutes left for some inquiry and discussion. The discussion should follow the guiding questions at the end of the recording sheet. If the students can handle it, let them discuss as a small group. If the class needs some more direction, the teacher will lead a whole group discussion and guide students to filling in the rest of their recording sheets.

Lesson 2 Objectives: Investigate how the speed of an object affects how it travels. Make observations and ask questions about how objects move and how forces affect how they move. Big Question: How does the speed of an object affect how it travels? This lesson will involve the explore and explain steps of the 5 E's.

Teacher Input: The teacher will set up the room ahead of time with areas for a ping pong ball to be thrown and rolled. Tape off sections of the room for each group. Remind students of what they learned in their last lesson – refer to any questions they had about force and motion. Tell students they will roll an object a short distance and record how long it takes. They will then throw the object the same distance and record how long it takes. (Appendix 3) The teacher should remind students about the counting and let them practice again. During the investigation, the teacher will circulate and assist students. I try to use my cell phone or my document camera to record several groups performing their experiment. That way I can show them to the class and we can also pause or put them in slow motion to better analyze results. If you teach multiple classes like I do, you can also show as a demonstration for your next class.

Guided Practice: For the second half of class, students will analyze their data. Have students work in pairs or cooperative table groups. Discuss any similarities or big discrepancies in the data. Once data collection has commenced, the teacher can model how a graph should be completed.

Independent Practice/Assessment: Explain - Each pair/group will construct a graph to represent their data. Compare that graph with another pair/group. (Teacher can compile data to show at the beginning of next class.) Respond to questions in notebooks and add to list of questions about force and motion.

Lesson 3 Objectives: Investigate the force of gravity on things that are dropped. Investigate the use of a ramp on various types of balls. Make observations and accurate measurements. Big Question – How does the force of gravity affect how things move? This lesson will incorporate the engage, explore and explain steps of the 5 E's.

Teacher Input: The teacher will set up the room so students can complete two stations – one with dropping various objects and another with rolling different balls down a ramp. Engage

- Use a discrepant event from one of the websites here to get the kids excited about gravity. http://www.csun.edu/scied/4-discrpeant-event/rolling_uphill/index.html In this example, place a conical object on a ramp of two rails and it will not roll the way you expect it to. It leads to a good discussion about the center of mass and other places on Earth where things appear to defy gravity. https://physicstricks.wikispaces.com/Mechanics In this example, you collect a variety of circular objects and group them by property. You then race them down ramps and find patterns in how the objects perform in their race.

After discussing the event for a few minutes and recording observations/questions, tell students they will be investigating the pull of gravity on various objects.

Guided Practice: Explore - Give out the recording sheet and go over any questions the students have. (Appendix 4) Tell the students that they'll be making observations and asking questions before, during, and after both investigations. Before the lesson, show students several items that will be dropped/rolled. Let them write down what they notice about the items using their observational skills. Model correct use of the ramp and show your expectations. The teacher will need to demonstrate how to hold hands correctly during "Ball Drop" and how to start the balls in the same place on "Ramp it up." Guide students to the understanding that you don't want to push the balls down the ramp – this is measuring a different variable. During the lesson, the teacher can again record several groups dropping/rolling their items to playback later to analyze results. Have students record what they notice along the way as well as leaving time at the end to write questions they still have that they'd like to investigate.

Independent Practice/Assessment: Explain - Students will work in groups dropping/rolling items and recording results. If students are not coming up with the correct conclusions (gravity pulls each item to the ground at the same time), the teacher may have to go back to guided practice and work with the whole class. This would be where the videos of students working could be used. Discuss results and observations and any discrepancies.

Lessons 4 and 5: Students will use inquiry and observational skills to design an experiment to answer a question they have within the force and motion objectives.

Teacher Input: Start by reviewing the previous investigations. Review the dependent and independent variable in each investigation. If students need help with this, try here: http://www.schoolofdragons.com/resources/identifying-variables-view This website has a worksheet that helps with identifying variables. It reviews what the variables are and gives sample scenarios in which they can identify each variable.

Elaborate - Tell students they will be designing their own experiment to test a variable and ultimately answer a question they have about how things move. This lesson will need to have more direct inquiry if the students aren't able to come up with age appropriate questions addressing one variable. If students are comfortable with choosing one variable and designing an experiment, then allow the lesson to follow a guided inquiry format. (Appendix 5) The teacher will facilitate an example to begin with showing a question he/she had while investigating in the earlier lessons. Show what you've chosen to help you answer your question and these materials you'll use to collect data. Remind students of the force and motion objectives they've been working on and what they've learned so far. Keep these up throughout the planning process so the students will have a reference. They also should have a list of questions they have from the experiments they've done so far. You can scaffold this activity by using the pre-

prepared experiments (Appendix 6) and let students find the materials. If the student does the experiment and wants to ask a further question, they may be ready at that point.

In Lesson 6, students will show what they've learned on an assessment. Evaluate (Appendix 7)

Appendix 1: Standards Addressed

North Carolina Essential Standard 3.P.1.1 *Infer changes in speed or direction resulting from forces acting on an object.*

Students need to know that when an object receives a force, it will accelerate or change direction. They've learned push/pull in their first grade force and motion unit. When completing the first activity, students will understand that they can move the balls in different ways to get different results.

North Carolina Essential Standard 3.P.1.2 *Compare the relative speeds (faster or slower) of objects that travel the same distance in different amounts of time.*

Students understand that if an object has varying speed, it will affect the time it takes to travel a particular distance. When forces change, speed changes. Students also will study friction and its effects on moving objects. In the first two activities, students will do this comparing.

North Carolina Essential Standard 3.P.1.3 *Explain the effects of earth's gravity on the motion of any object on or near the earth.*

Students need to understand that everything gets pulled to earth by gravity and it always effects objects in the same way. It pulls all objects with the same force, taking into account some other factors. In a vacuum and without these factors like wind resistance, all things would fall at the same rate. In the third activity, students will see gravity at work. They've also studied the invisible force since Kindergarten and should be very familiar with it.

Appendix 2: Lesson 1 Recording Sheet

Name _____Date _____

Motion Investigation: How do Things Move in Different Ways?

What materials do you have for your experiment? Describe them.

What is one thing you'd like to try with your materials?

What happened? Why do you think it happened this way?

What else did you try? What did you learn?

Back inside: What other questions do you have now?

Appendix 3: Lesson 2 Recording Sheet

Name _____ Date _____

Speed Investigation: How does the speed of an object affect travel?

1. Fill in the chart to record your data.

Person	Rolling – in seconds			Throwing – in seconds		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3

Discuss with your group and answer the questions.

2. Analyze your data. Are there any patterns you see?

3. What are the results? Make a graph of your data on a piece of graph paper.

4. Write your results in a sentence that summarizes what you learned in this investigation. See the teacher if you need a sentence starter.

5. What questions do you have about this investigation? If you were going to do it again, what would you do differently?

Appendix 4: Lesson 3 Recording Sheet

Name _____Date _____

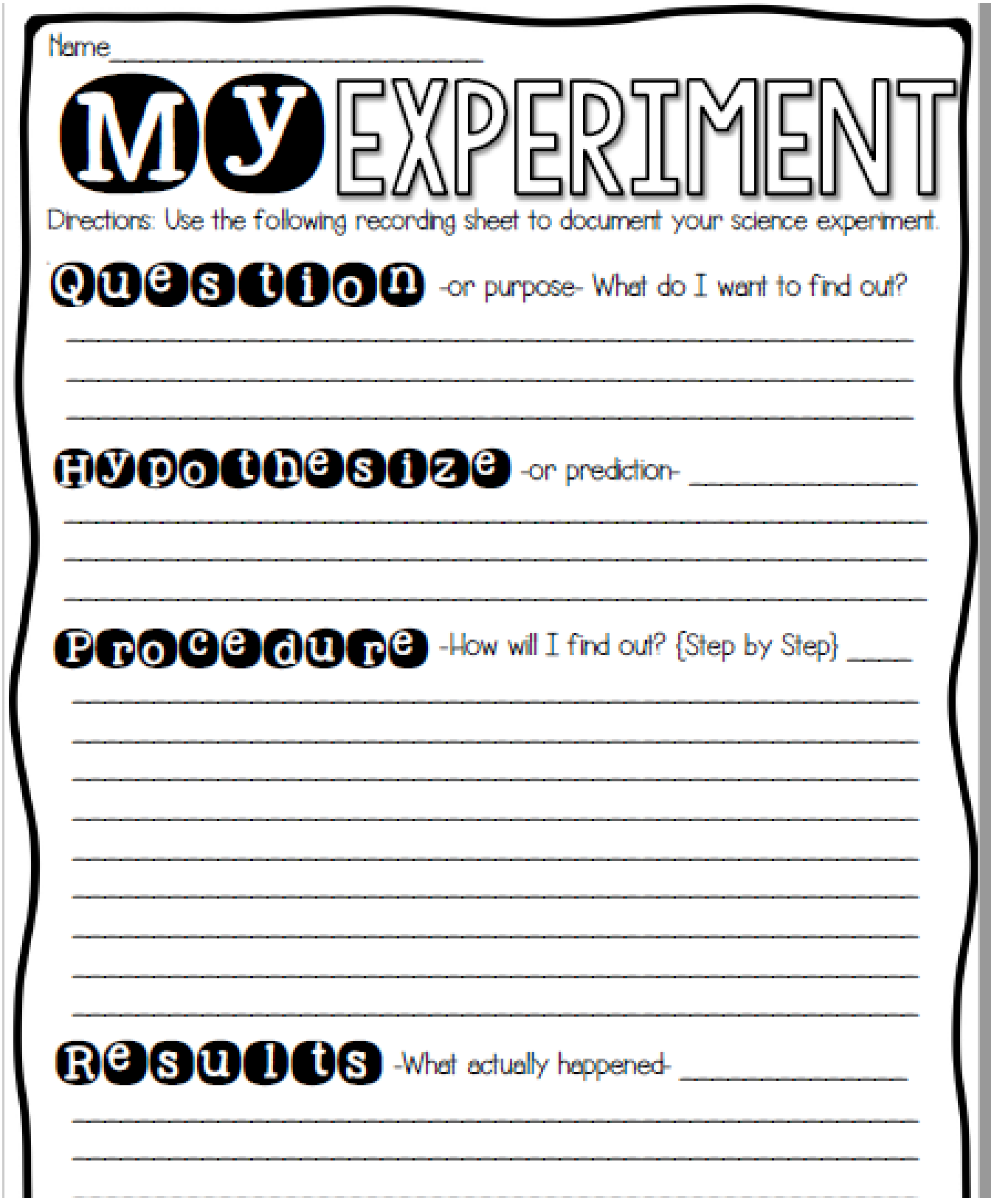
Gravity Investigation: How Does Gravity Affect How Things Move?

Investigation	Ball Drop	Ramp it up!
Describe the objects you'll be using in this investigation.		
What do you want to try?		
What do you think will happen?		
Try it! What happened?		
What else did you try? What were the results?		

1. Make a conclusion: How does gravity affect how things fall to the ground? Use evidence from your investigation.

2. How does gravity affect how balls roll down a ramp? Use evidence from your investigation.

Appendix 5: Lesson 4 and 5 Recording Sheet



Name_____

MY EXPERIMENT

Directions: Use the following recording sheet to document your science experiment.

Question -or purpose- What do I want to find out?

_____

_____

_____

Hypothesize -or prediction- _____

_____

_____

_____

Procedure -How will I find out? {Step by Step} _____

_____

_____

_____

_____

_____

_____

_____

_____

_____

Results -What actually happened- _____

_____

_____

Results Continued...

Data Collected...

Illustration

Conclusions

-What did you learn? _____

-Would the results be the same or different if you would repeat this experiment? How do you know? _____

Appendix 6: Ready-made questions for Lessons 4 and 5

Which ball rolls the farthest distance on the classroom floor, a tennis ball, a ping-pong ball, or a Styrofoam ball?

- Use a ramp to ensure the balls are being dropped at the same speed each time.
- Make a table and perform at least 3 trials of each type of ball.

How does the height of my ramp affect the distance my matchbox car can travel?

- Use 3 differing ramp heights.
- Make a table and perform at least 3 trials of each ramp height.

Will my ball bounce higher on the carpet, the grass, or the tile floor?

- Use only one type of ball
- Make a table and perform at least 3 trials on each surface.

What is the effect of adding mass on a car's distance traveled?

- Test how far the car travels without any added mass.
- Use the washers and tape to add mass to the car.
- Design a way to push the car with the same amount of force each time.
- Make a table and perform at least 3 trials with each mass.

Appendix 7: Unit Assessment

Name _____Date _____

Assessment – Force and Motion

This is an open note assessment. Please use your recording sheets from your investigations and any notes you may have. You may also draw pictures and label them to show your understanding.

1. What are two forces that can act on a ball rolling through the grass on the playground? Describe what the forces do to the ball as it rolls.

2. What happens if you roll a ball on the blacktop part of the playground instead of the grass?

   What causes this to happen?

3. Give an example of how to change an object's speed.

4. How does gravity affect moving objects?

What happens when you drop two items at the same time from your hands?

What happens when you roll two balls down a ramp at the same time?

5. Share what you learned when you designed your own experiment.

6. What questions do you still have about force and motion?

[1] Olson, Kouider, “Making Science Real”

[2] Edutopia, “Inquiry Based Learning”

[3] Liang, Richardson, “Enhancing Prospective”

[4] Olson, Kouider, “Making Science Real”

[5] Olson, Kouider, “Making Science Real”

[6] Haury, “Fundamental Skills”

[7] Olson, Kouider, “Making Science Real”

[8] Bynum, *History of Science,* pg. 3-4

[9] Bynum, *History of Science,* pg. 256

[10] Discovery Education, “Direct Inquiry”

[11] Enhancing Education, “The 5 E’s.”

[12] Enhancing Education, “The 5 E’s.”

[13] Barell, *Problem Based Learning,* p. 3

[14] Barell, *Problem Based Learning,* p. 3

[15] Barell, *Problem Based Learning*

[16] Lin, “Cooperative Learning”

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