

SCIENCE NOTEBOOKS:  
IMPROVING STUDENTS' CONCEPTUAL UNDERSTANDING  
AND SCIENTIFIC PRACTICES

by

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## ABSTRACT

The objective of this study was to determine if using science notebooks improved students' understandings of science content. Secondary considerations included whether or not science notebooks versus commercial worksheets impacted students' scientific practices and communication skills. This study contained two treatment phases. In the first phase, students used commercial textbooks and worksheets in an Earth Science Unit. During the second phase of the study student science notebooks were introduced and replaced the commercial worksheets during a Physical Science Unit. At the beginning and end of both phases of the study, a student pre and post-test were administered in each content area. Throughout both phases, a variety of formative assessments such as lab reports, concept maps, assessment probes, and other assignments were implemented and evaluated. As a result of this study, it was concluded that student science notebooks did improve students' conceptual understandings. Formative and summative assessments indicated use of science notebooks led to quantifiable growth in conceptual understandings, scientific practices, and communications skills.

## INTRODUCTION AND BACKGROUND

I teach 24 3rd grade students at Florence-Carlton School located in Florence, Montana. Florence is a rural community 20 miles south of Missoula, Montana, in the Bitterroot Valley. It is sometimes referred to as a bedroom community due to many residents commuting to and from Missoula for employment. There are approximately 815 students attending, kindergarten through 12th grade. The majority of students are Caucasian coming from a wide range of upper to lower middle class families (L. Warila, personal communication, November 28, 2011). Most students attend Florence-Carlton School from kindergarten through eighth grade. After eighth grade, many students choose to attend high school in nearby Missoula, where they have a broader range of subject choices. In the elementary grades, there are typically 3 - 4 classes per grade level with approximately 18 - 24 students per class. The class climates are familiar gatherings with students who have known each other since the start of their education and have participated in common community sports activities like baseball or soccer. The students have described the school as safe and a worthy learning environment.

The principal assessment responsibility shared by educators at Florence-Carlton School primarily functions as an accountability measure; teachers are accountable to teach the curriculum and students are accountable to learn the material. These measures include end of unit tests, quizzes, worksheets, projects, and various other assignments scored with percentages which are then translated into letter grades. The averages of these letter grades become the students' report card marks. Students are rewarded for achieving high marks with a variety of awards. Those who don't achieve high marks, even at the elementary level, often see themselves as failures. This sense of failure

creates a lack of confidence in students' ability and willingness to learn. This is especially evident in third grade when grading marks change from E, S, and N (Excellent, Satisfactory, and Needs Improvement) to traditional marks of A, B, C, D, and F. In my current 3rd grade class of 14 boys and 10 girls, I witnessed student disappointment and subsequent lack of effort and enthusiasm for learning. Therefore, the focus of my research based project was to address this issue through the development of alternative assessments, specifically science notebooks. Student science notebooks are more than typical lab reports, which generally consist of a record of facts collected and procedures conducted. Science notebooks become a record of students' reflections, inquiries, speculations, decisions and deductions all focused on the science phenomenon (Thier, 2002).

While different assessments serve different purposes, the overall goal of assessment is not merely to measure achievement, but also to gather evidence of student learning to inspire and encourage students to keep learning. Assessing student achievement correctly and including students in classroom assessment are critical to student success. Educators now understand that assessment can work in encouraging ways to benefit and motivate learning. Although traditional testing and scoring are important, they aren't enough. They don't deliver the everyday information needed in the classroom nor play an important part in student learning (Stiggins, Arter, Chappuis, J., & Chappuis, S., 2004). Science notebooks have proven to be an effective record of what science content is taught and learned and to provide an excellent ongoing assessment and feedback tool for teachers (Ruiz-Primo, 2002).



I envisioned this capstone project capturing the depth of students' understandings through a notebook of student work and artifacts. Students collected, organized, reflected on, and shared their work. The notebook process nurtured a sense of accomplishment that both benefitted the students as learners and me as teacher. The focus question for this project was, Does the use of science notebooks improve students' conceptual understandings of science? Moreover, I investigated the questions, How do science notebooks vs. traditional commercial worksheets improve students' scientific practices? and How do science notebooks promote student learning and communication skills?

### CONCEPTUAL FRAMEWORK

In an era of accountability, it is a common occurrence to hear a news report or read an article concerning the plight of the educational system in the United States. Students' levels of achievement, state assessment testing, Adequate Yearly Progress, along with annual testing for the purpose of accountability are all at the center of attention in education today. Educators and education policy experts acknowledge that traditional and standardized assessments are necessary for evaluating student achievement, but traditional assessment practices are just one piece of the assessment puzzle. The National Science Teachers Association (NSTA, 2011), in its position statement on elementary school science, advocates appropriate science assessment practices that include formative as well as summative assessment practices. Implementing appropriate assessments is a necessary tool for managing and evaluating efforts to ensure all students receive the science education required to prepare them for

understanding science relevant to life in the 21st century (Duschl, Schweingruber, & Shouse, 2007).

According to the National Research Council (NRC, 2012) *Framework* Committee, in order to validate students' achievement of the high-quality science education needed for 21st century learning, assessment practices must go beyond the limited fill-in-the-blank and multiple-choice formats currently used in most science classrooms. These forms of traditional assessments can measure conceptual knowledge to a limited degree and can also provide a glimpse of some science practices. What they fail to measure is other kinds of achievements, such as formulation of scientific explanations or communication of scientific understanding. Such forms of traditional assessments are not adequate in providing a good representation of a student's thinking, nor determining a student's capacity to reason and apply knowledge (Klentschy, 2008; Michaels, Shouse, & Schweingruber, 2008; NRC, 2012).

Traditional assessment approaches such as those described above, have been shown to have limitations for supporting the kind of 21st century learning that is the goal for science education. To succeed in the 21<sup>st</sup> century, students have to learn how to be creative problem solvers who can work cooperatively in groups to explore new ideas. These 21<sup>st</sup> century students must be able to reason logically, communicate effectively, manipulate models successfully, use technology efficiently, and develop positive attitudes toward science (Michaels et al., 2008).

Assessments of student learning must be evident to both students and teachers. In addition, these assessments must measure student achievement related to important competencies. The nature of students' accomplishments and progress must be apparent.

Most traditional assessments used in today's classrooms fail to meet these objectives (NRC, 2011; Pellegrino, Chudowsky, & Glaser, 2001). Therefore, reform-oriented formative assessments may be more appropriate to support student achievement in what's expected of students in 21<sup>st</sup> century science.

Reform-oriented formative assessments have features that differ from traditional assessments. They are more descriptive in the information they provide to the teacher and the learner. These assessments are less concerned with right or wrong answers and more concerned with how well pupils explain their thinking. These assessment strategies provide a clearer picture of what the students understand, what they can do, and how they can apply the knowledge they've gained (Stiggins, Arter, Chappuis, & Chappuis, 2004; Wiggins, 2006). Black (1998) examined the use of formative assessment extensively. His research stressed that "innovations that include strengthening the practice of formative assessments produce significant, and often substantial, learning gains" (Black, 1998, p. 41).

Science educators continue to explore productive ways to use formative assessment in the classroom to support student learning. Science formative assessment examples include, but are not limited to: student-directed experimental designs, authentic performance assessment, student science notebooks, laboratory practicals, real world problem-based learning scenarios, writing challenges, focus groups, and individual student interviews (NSTA, 2011). Many educators and researchers believe that student science notebooks, used as assessments, are more effective than traditional assessments for measuring academic skills and directing instructional decisions (Arellano, Clemmons, Cooper, Dill, & Laase, 1997).

Ruiz-Primo and Shavelson (2002, p. 2) define a science notebook as “a compilation of entries that provide a partial record of a student’s instructional experiences over a certain period of time.” Student science notebooks emulate the journals that real scientists have used for centuries to record their observations and discoveries, and to contemplate about their explorations. The notebooks are a record of students’ observations, ideas, and drawings, along with other illustrations such as charts, tables, models, and graphs. They also include students’ reflections, questions, predictions, and conclusions. Through their use, student science notebooks become a running record of students’ thinking. Student generated products, both written and drawn, become the means by which students conceptualize their understandings in science (Doris, 1991; Hargrove & Nesbit 2003; Thier, 2002).

Science notebooks are one approach to reform-oriented formative assessment. Science notebooks, from a student learning perspective, offer numerous benefits. These include: building conceptual understanding, developing competence with scientific practices, and cultivating communication skills. Student science notebooks become the means for students to relate new information learned to the world around them, in order to develop a deeper understanding of science content (Klentschy, 2008; Rivard, 1994).

Science notebooks are an excellent thinking tool for students to use to construct their own conceptual understandings, which is essential to increasing student achievement in science (Gilbert & Kotelman, 2005; Klentschy, 2008). Numerous research studies have shown that the details included in students’ science notebook entries, both written and graphic explanations, indicate the extent of student understanding of the science concepts and content. These studies also revealed positive

impacts of science notebook use on students' conceptual understandings (Baxter, Bass, & Glaser, 2001; 2000; Rivard & Straw, 2000; Shepardson & Britsch, 1997). Notebook entries can provide a record and act as a guide to students' development of science understandings (Alonzo & Asherbacher, 2004). As students write, draw, and talk about their thinking through the use of notebooks, they interact more deeply with the subject matter (Gilbert & Kotelman, 2005).

Thus, the interacting deepens learning and retention. Competence is developed through active construction of knowledge, which includes explaining core ideas to one's self or others (Chi, 2000). Scientific practices are defined as meaningful when learners are engaged in building, refining, and applying scientific knowledge, to understand the world. Practices include measures for creating and using evidence to develop, improve, and apply scientific explanations to construct accounts of scientific phenomena (Michaels et al., 2008; NRC, 2012). These practices reflect the many ways in which scientists discover and comprehend the world. Science is not only a body of knowledge, but also a way of knowing (Duschl et al., 2007). This knowing or competence is often made more important through communication skills.

Science notebooks also offer frequent occasions for students to communicate their understanding of science concepts through writing, drawing, and speaking (Gilbert & Kotelman, 2005). They are constructing or reconstructing the phenomena through their own lens of experience (Shepardson, 1997). In other words, the student science notebook acts as a central point for students to communicate their ideas. Harlen (2001) proposes that learning science also involves students being able to communicate their thoughts. This form of communication is oral, written and representative in the form of drawings.

Communication is a vibrant aspect of science that involves, developing, expressing, and sharing information.

Student-generated graphical representations in science notebooks are valuable because they allow students to express their ideas and findings while assisting students in making meaning of their thinking (Harlen, 2001). Vygotsky (1978) referred to drawing as a graphic speech and noted that young students' representations often reveal what they know about the object more than what they say or write. The notebook enables students to work as scientists in recording their thoughts and observations about the activities in a unit of study. By creating their own notebook pages, students are able to use words, drawings, and graphs in age-appropriate ways to define their ways of seeing and thinking about science phenomena (Shepardson & Britsch, 2001).

The student science notebook is not only a valuable tool to the students, but to educators as well. Notebook entries give educators access into the complexity of students' conceptual understandings and highlight any misconceptions. They show which skills the students are using and how well they use their words and drawings to transfer information. Student science notebooks also help teachers monitor student progress. For example, educators can use notebook assessments to guide instruction and direct teaching practices. By reviewing students' work, teachers can gain insight into how well students grasped the concept in a lesson and evaluate their own teaching practices to determine whether additional instruction is needed. In this way, science notebooks become a valuable instrument for formative assessment (Gilbert & Kotelman, 2005; Klentschy, 2008).

Being proficient in science is more than just recalling facts (Michaels et al., 2008). The National Science Education Standards created by the National Research Council (1996) state:

Understanding science requires that an individual integrate a complex structure of many types of knowledge, including the ideas of science, relationships between ideas, reasons for these relationships, ways to use the ideas to explain and predict other natural phenomena, and ways to apply them to many events” (p. 23).

These goals set forth for proficiency in science understanding indicate a considerable shift from traditional science education practice. In order for teachers to measure student progress in meeting these goals, assessment practices also need to move beyond discrete snippets of knowledge to include more complex aspects of student achievement (Klentschy, 2008; Pellegrino et al., 2001).

Students are deserving of a more educative and accessible assessment system. Implementing effective assessment techniques and strategies, such as student science notebooks, produce evidence of student learning. This evidence is used to adjust instruction to better meet students’ learning needs. Strategies such as these empower teachers and learners (Leahy, Lyon, Thompson, & Dylan, 2005). Teachers must provide students with accurate and appropriate feedback that encourages improvement and fosters motivation. They must implement corrective practices that aid in developing student understanding and encourage students to take ownership in their learning through shared educational goals and self-assessment. Student science notebooks, used as a means of formative assessment, have the potential to meet these goals for 21<sup>st</sup> century science learning.

## METHODOLOGY

The treatment used with my third grade students involved the implementation of student science notebooks. The purpose was to determine if using science notebooks versus commercial textbook materials improved students' understandings of science content. Secondary considerations included whether or not science notebooks versus commercial worksheets impacted students' scientific practices and communication skills. Science concepts and scientific practices were taught in the context of standards-based Earth and Physical Science curricula for third grade students. The research methodology for this project received an exemption by Montana State University's Institutional Review Board and compliance for working with human subjects was maintained.

The study contained two treatment phases. The first phase occurred through the months of October, November, and December of 2011. The second phase began in mid-January and continued through April 2012. In the first phase, students used commercial textbooks and worksheets in an Earth Science unit. The Earth Science unit included the following topics: water cycle, weather and climate, rocks and minerals, soil, features of the Earth, and weather and erosion. During the second phase of the study, student science notebooks were introduced and replaced the commercial worksheets. The topic for this phase of study was physical science. This unit covered the topics of: matter, energy and its forms, forces and motion, and simple machines. To achieve the objectives of the project and monitor effectiveness of the treatment, I applied various qualitative and quantitative data collection techniques during both phases. Both treatment periods were nine weeks in length.



At the start of both phases of the study, I administered a 16 question Student Pre-Treatment Test in each content area and compared the results to a Student Post-Treatment Test at the end of the unit of the study (Appendices A and B). The tests consisted of 15 multiple choice questions and 1 open ended response question. The questions on the pre and post tests for each unit were the same. The standards-based test questions assessed the expected student achievement goals for each area of study.

Phase one of the treatment continued with students completing commercial worksheets, tables, graphs, diagrams, and charts taken directly from the student edition of the current third grade science textbook, *Interactive Science* (Pearson, 2010). These worksheets include inquiry based activities, content-based questions, predictions, formative assessments, and premade charts, diagrams, and tables for the students to complete. In phase two of the treatment, I implemented the use of science notebooks. Student science notebooks required students to create their own tables, charts, and diagrams along with explanations of their conceptual understandings. These phases allowed for measurement of how science notebooks affected students' understanding of science concepts and impacted scientific practices versus the use of prepared worksheets.

In both phases, a variety of students' work was selected to assess. The work was assessed using a Student Self-Evaluation/Teacher Evaluation Rubric (Appendix C). Both student and teacher completed the rubric using a point value of three to one, three being the highest and one being the lowest, to evaluate student work based on expected achievement goals. These rubrics and self-reflection pieces were compared and analyzed indicating any changes in the two treatment plans.

Treatment continued, throughout both phases, with the implementation of a variety of formative assessments such as lab reports, concept maps, assessment probes, and other artifacts. The assessment probes, Mountain Age (Keeley, 2005) and Apple on a Desk (Keeley, 2008), were administered at the beginning of each unit of study to determine students' misconceptions, naïve thoughts, or incomplete ideas (Appendices D and E). Results from the probes were studied and used for diagnostic and monitoring purposes.

Formal student interviews were also held at the end of each unit of study. Ten students were randomly chosen to answer 5 questions concerning their attitudes towards what was being learned and how learning was taking place in our science classroom (Appendix F). Responses from both sets of interviews were examined and compared.

In addition to documenting students' learning and evaluating their progress in achieving the goals of the class, students shared their progress with peers in student-led conferences at the end of each unit of study. Student presentations were videotaped and shown to students at the conclusion of the class presentations. After reviewing the videotape, students completed a self-reflection piece (Appendix G). Student reflections from both phases of the study were analyzed and compared.

As the treatment progressed through both phases, I continued to reflect as recorded in my teacher observation journal. The focus of my observations concentrated on students' conceptual understanding through ease and/or difficulty of assignment completion and peer involvement and interactions during science class time. My journal also included self-reflection on teaching practices.

In order to track my own growth over time, along with the teacher observation journal, I completed a Pre-Treatment Assessment *for* Learning and Assessment Quality Self-Checklist Survey (Stiggins, Arter, Chappuis, J., Chappuis, S., 2004). This Likert-style survey contained nine questions with a scoring scale of 1 to 5 (Appendix H). The value of 1 indicated *the absence of skill being taught* progressing to 5, which indicated *consistency of skill being taught*. At the end of each unit of study, I completed the identical post-survey to measure my progress in assessing students. I also kept a journal that included self-reflection on teaching practices and observable student involvement in each lesson.

Clear expectations of learning goals through responsible data collection and continuous student and teacher self-reflection contributed to the improvement of students' understandings of science. The data collection techniques addressed above are generalized in a Data Triangulation Matrix in Table 1.

Table 1  
*Triangulation Matrix for Data Collection*

Research Questions	Data Source		
	1	2	3
Does the use of science notebooks improve students' understandings of science?	Teacher observation journal	Formative assessments (concept map, minute paper, exit card, worksheets, and probe)	Student pre- and post-multiple choice test for conceptual understanding  Student notebook entries
How do science notebooks versus commercial worksheets impact students' scientific practices?	Teacher observation journal	Student and teacher evaluation rubric Student-involved self-reflection	Student-generated artifacts (work, projects, assignments, and drawings)
How do science notebooks versus commercial worksheets improve students' communication skills?	Teacher observation journal	Semi-structured student interviews  Student-involved self-reflection	Student-led peer presentation

## DATA AND ANALYSIS

The class average of over-all growth between the Earth Science Pre- Post Test in the first phase of the study using commercial worksheets was 12%, a change from 51% to 63% ( $N=24$ ). During the second phase, after science notebooks had been implemented, growth shown from the Physical Science Pre- Post Test scores was 21%, a change from 58% to 79%. These test scores revealed a 9% additional increase with the use of science notebooks compared with the use of traditional worksheets (Figure 1).

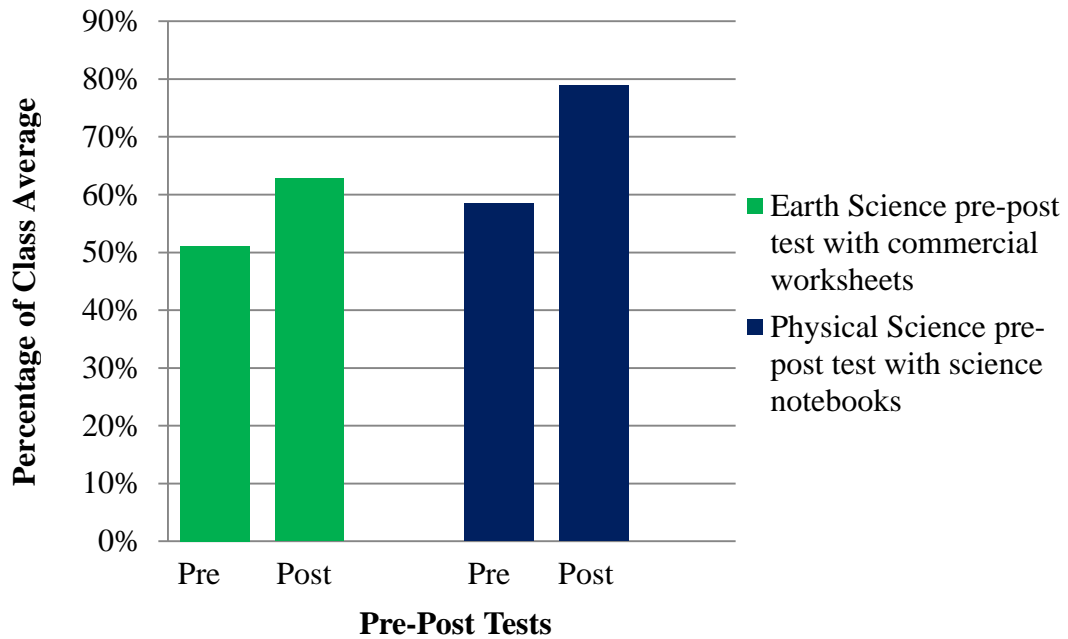


Figure 1. Class average on pre- post science tests, ( $N=24$ ).

Each unit test included an open response question eliciting student understanding of the content focus. Student answers on the open response questions in the post test revealed a greater depth of conceptual understandings after science notebooks were implemented (Table 2). Key words and phrases were used to determine the complexity of information the students had learned. On the Earth Science Post Test (unit with commercial worksheets), none of the students were able to fully answer the question, 70% had partial replies, and 30% had no apparent understanding of the concept. One example of a partial student response to the question was, “The water runs on the land and the weather breaks the rock.” On the Physical Science Post Test (unit with science notebooks), 50% of the students were able to completely answer the question, 49% had partial answers, while only one student was not able to construct any relevant response to the question. One student stated, “When you push open the door you are using force,

when you open the door it changes position which is motion, and when you force open the door you are changing its position...putting it in motion.” Another student responded, “You use force to turn the knob and push the door open. Then the door is in motion and that will change its position.”

Table 2  
*Comparison of Post Test Open Response Questions (N=24)*

Understanding demonstrated from scores from open response questions	Post-Earth Science test	Post-Physical Science test
None apparent	30%	4%
Partial	70%	46%
Complete	0%	50%

In addition to test scores, analysis of student entries in science notebooks showed evidence of improvement regarding conceptual understanding and scientific practices. These entries included expanded explanations, detailed descriptions, drawings, and other representations that exhibited understanding (Figure 2). The page shown on the left displays some students’ diagrams and descriptions of how to make work easier by using simple machines. The student sample on the upper right demonstrates the student’s ability to organize and explain data using a student-created table. From these examples, it is apparent that the students have learned to apply organizational strategies and to construct an explanation of understanding.

4-12-12  
 How can you make work easier?

1. no it would not work on a book

2. By pulling it up.

It makes it easier by it sliding

Best

The second one worked better

used a pulley.

wasent so good.

We used a H rulers, Tape, and cardboard. And string, and notebook.

Both

### Marble Race Track

4/10/12

Sierra, Kinsey

Cardboard tubes, masking tape, scissors, pencil, and science note book

Sierra and I thought that if we make the marble track bigger the marble will go faster. Next time we make one again we want put as much tape. We learned that the longer the tube the faster the marble will go.

Distance the marble traveled	Chaser that were made to the race track after each test.
1st 0m	We made the tube longer.
2nd 0m	We made the tube longer
3rd	we took off tape
4th 18cm 14cm 20cm 7cm	we moved the rug

3-13-12

### What is Gravity

by Eduardo Aparicio

What I know  
 Gravity is a noncontact force. That means it can move something without touching it.

What I want to know  
 If size affects the time two things hit the ground.

What I learned  
 It does not matter what size something is they will hit the ground at the same time.

### Making Work Easier

I will use a first class lever. The tip will go under the leg. The point on the check shape will tip it when I push on the handle.

Figure 2. Student science notebook entries.

The student work from both the Earth and Physical Science Units was evaluated using Student Self-Evaluation/Teacher Evaluation Rubric. Formative assessment data and student generated artifacts indicated growth in conceptual understanding (Table 3). Pre

and Post Formative Assessment Probes were given in each unit of study to diagnose and monitor students' conceptions prior to and throughout instruction. For example, in the first phase of the treatment a probe entitled Mountain Age was administered before and after lessons taught on weathering and erosion. This probe was used to determine if students considered aspects of weathering or if they innately assumed taller mountains were older. Concept maps were used at various times throughout each unit to assess the connections students made between concepts and information as well as to discover preconceptions and/or misconceptions.

Table 3  
*Formative Assessment Data (N=10)*

Class Averages from Rubric-based Scores	Earth Science Unit with Commercial Worksheets (out of 100%)	Physical Science Unit with Science Notebooks (out of 100%)
Student Work	72%	96%
Probes	54%	68%
Stop! Wait! Go! Exit Cards	79%	81%
KLEW Charts	62%	74%
Concept Maps	47%	83%

The results of the analysis of five lessons in each unit of study were compared using standards related to scientific practices. From these comparisons, it was evident the use of science notebooks allowed more opportunities for students to practice these skills (Table 4). Of the 5 lessons analyzed in the use of commercial worksheet activities, 36% included clearly designed instances for students to use scientific practices. Fifty-seven percent of science notebook lessons offered opportunities for practice of these same skills. This represents a difference of 21%. An example of a science notebook lesson



demonstrating students using multiple scientific practices is found in lesson four on Table 4. The objective of this project was to engage students in the scientific practices of designing, constructing, evaluating, and revising a model of a paper tube marble race track, utilizing concepts learned related to forces, motion, position, gravity, and friction. Students recorded data from each revision and then used the data to write and share their conclusions. One team of students shared, “If we could change it again, we would make the top higher and let gravity do it all.” Another team commented, “Our model worked really well except the rug slowed down the marble. If there were not any rugs on the floor our marble would have gone right out the door. I think this is friction at work.”

Table 4  
*Scientific Practices Present in Five Commercial and Notebook Lessons*

Scientific Practices	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Question pertaining to the concept from the material	✓ X	✓ X	✓ X	✓ X	✓ X
Constructed explanations and designed solutions	X		X	X	X
Engaged in argumentation from evidence	X		X	✓ X	X
Constructed drawings and/or diagrams as representations of events or systems	X	X	X	X	X
Developed, used, and revised models	X		X	X	X
Planned and carried out an investigation	✓ X	✓ X	✓ X	✓ X	✓ X

Key: ✓ = Commercial, X = Science Notebook

Observations noted in my Teacher Observation Journal supported other collected data. While using commercial textbook worksheets, I witnessed that students became preoccupied with getting the correct answer. For students it became more of a *copy the right answer* activity rather than processing the actual information studied. A common

student response during these classes was, “Wait, wait, I didn’t get the answer to number 4. What am I supposed to write in the first box?” As students exited the classroom, they had difficulty responding to content questions that were presented during the lesson. Many students had to refer to the text and their worksheets in order to recall what had been taught. In comparison, during the lessons where science notebooks were implemented, the students appeared to take personal ownership of their notebooks. I noticed students made sense of their understandings by creating their own organizational strategies and recordings, while participating in conversations that were personally meaningful.

Responses from the Student Interview Questions reinforced my understanding of students’ frustration to achieve success with commercial worksheets taken from textbook lessons. From the students interviewed, 60% indicated they thought there was too much reading and writing in science ( $N=10$ ). One student commented, “There’s so much reading and writing. I get lost and then I worry I won’t get the right answer or finish in time.” Another student stated, “Science class is too long especially when there’s so much reading, writing, and work.” Three of the students interviewed expressed concern over getting the wrong answer or not finishing their work. After science notebooks replaced commercial worksheets, students’ frustration levels fell to 20%. This was evident from the students’ responses in the post treatment interviews. From these interviews, 40% fewer students believed there was too much reading and writing in science class. No students responded they were worried with getting the wrong answer. An overall theme that was apparent in both phases of the study was students’ desire to participate in investigations.

Five lessons from each unit were analyzed and compared using key words and phrases related to various forms of communication (Table 5). All of the science notebook lessons involved one or more aspects of communication compared to 60% in the commercial lessons. Aspects of communication considered in these five lessons were those that allowed students' opportunities to develop and enhance their communication skills, written, visual, and oral.

Table 5  
*Communication Skills Present in Five Commercial and Notebook Lessons*

Communication skills	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5
Shared ideas with peers in small groups	X	✓ X	✓ X	✓ X	✓ X
Communicate new knowledge via talks and/or papers	X	X	✓ X	✓	X
Collected, organized, and recorded data	X	✓ X	✓ X	✓ X	X
Included scientific drawings: diagrams, tables, and graphs	✓ X	X	✓ X	X	X
Interpreted data and formed conclusions in writing	✓ X	✓ X	✓ X	✓ X	✓ X

Key: ✓ = Commercial, X = Science Notebook

Data from the Teacher Observation Journal showed students were less anxious while using science notebooks. I observed students participating more comfortably and thoroughly in pair-share, peer, and class discussions. Data from Student Presentation Self-Reflections demonstrated student confidence and eagerness in their ability to express their ideas and thoughts about what they had learned. These responses differed from presentation responses in the Earth Science Unit. In the Earth Science Unit, students had not devised their own explanations but were expected to fill in blanks. During those presentations and from student self-reflections, students appeared to be more concerned

with giving an *expected* response then with sharing what they had learned from their experiences.

## INTERPRETATION AND CONCLUSION

Based on the data collected and my observations during the study, I concluded that the implementation of science notebooks improved my students' conceptual understanding, scientific practices, and communication skills in science. Students showed growth in all assessment measures when they used science notebooks as opposed to when they used commercial textbooks and worksheets. Professional observations and students' work indicated the use of this strategy in science instruction was more interesting and personally meaningful to students.

As noted in my Teacher Observation Journal, students excitedly wrote and drew in their notebooks requesting to personalize them by including additional questions, graphs, and charts not required in the lesson expectations. In addition, I observed students became less obsessive and anxious in getting the right answer and more comfortable in processing and sharing their ideas and thoughts, both written and verbal. Furthermore, students who lacked the necessary skills to read and write at the textbook level were able to express their views through small group investigations and graphic representations. It was motivating to me to witness all the unique ways students created various diagrams, graphs, and charts to show their data and/or explain, in writing or through conversation, what they had learned. Science notebooks lessons offered students a greater variety of learning opportunities. This variety allowed all students to interact more deeply with the subject matter and experience success.

## VALUE

The involvement of developing and conducting this Action Research-Based Project has led to important changes in my teaching instruction. These changes included the way in which I assess students' understanding and how I use that information to effectively modify teaching practices in order to meet the needs of all my students. My confidence in searching out and implementing new instructional and assessment practices was significantly impacted as well. This became especially apparent in the pre and post results of my Assessment for Learning and Assessment Quality Self-Checklist Survey. In the nine categories represented in the checklist, my scores consistently showed gains of two to three points out of a possible five points in each category from the beginning of this research project to the end. It makes clear to me the need for continued exploration to discover and implement innovative instructional methods, strategies, and alternative assessments that best meet all students' needs in my classroom.

The students' positive reactions to these instructional strategies affected the quality of my teaching and assessment practices in terms of my students' increased ability to explain their thinking through scientific drawings, written explanations, and verbal dialogue with peers. When using science notebooks, I observed students become confident learners. Students developed unique ways to use their notebooks as tools to create approaches that made scientific understandings more personally meaningful. While participating in notebook activities, students talked to one another and learned from one another rather than looking to the teacher for answers.

The students' overall eagerness to learn, along with their increased active participation in science class, indicated to me that this research process was worthwhile.

Using reliable assessment tools that produced accurate information, involving students in carefully planned investigations where they can use a variety of scientific practices, and giving students ample opportunities to communicate their ideas created an optimal learning environment that promoted student success. Therefore, as I have demonstrated that student science notebooks can improve conceptual understandings and practices, I will continue the practice of using science notebooks in order to teach and assess more effectively.

Through participating in the action research process, I have become a more reflective and actively involved individual. This self-study method has impacted the way I examine and improve my teaching practices, interpersonal relationships, and overall attitude. Action research has given me the tools necessary to be more vested in my own professional growth and to utilize this methodical approach to solve problems when encountering educational choices in my classroom, school, and life. Through the self-reflective process of action research, I have learned about myself, my students, my colleagues, and have come to realize ways I can create positive changes in my world.

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APPENDICES

APPENDIX A

STUDENT PRE AND POST TEST  
EARTH SCIENCE

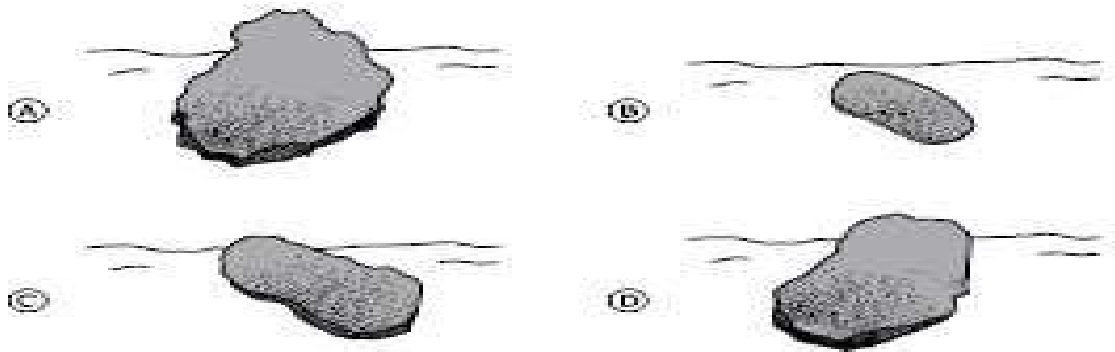
Name \_\_\_\_\_

Date \_\_\_\_\_

### Third Grade Earth Science Test

There are 16 questions on this test. Each question, 1-15, is followed by four choices, labeled A-D. Read each question carefully. Decide which choice is the best answer. Mark your answer by circling one letter for each question. Question 16 requires a written response. Answer all 16 questions on this test. You may not know the answers to some of the questions, but do the best you can on each one.

Lily found four rocks of the same material in a river bed. They had the different shapes and sizes shown in the picture below.



1. Which rock has most likely been carried down the river the farthest??
  1. A
  2. B
  3. C
  4. D
  
2. Large amounts of metals like iron and gold are found in:
  1. Dead trees
  2. Water
  3. Animal bones
  4. Rocks

3. According to scientists, the tall mountains in the western U.S. are younger than the low mountains in the eastern U.S. How can the younger mountains be taller?

1. Volcanoes in the eastern mountains erupted long ago.
2. There are more earthquakes in the western U.S.
3. Eastern mountains have been eroding longer.
4. There are more landslides in the eastern U.S.

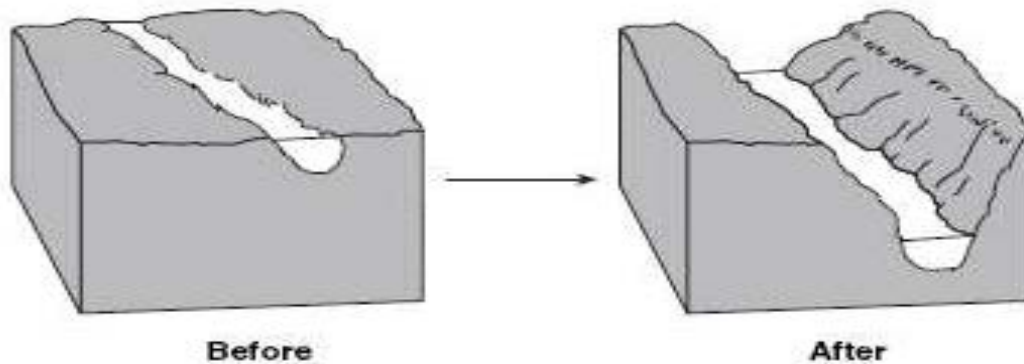
4. What covers most of Earth's surface?

1. Water
2. Bare rock
3. Farm land
4. Cities and towns

5. What is most likely to happen when two of Earth's plates slide past one another?

1. Rain
2. Earthquakes
3. Fossils
4. Climate changes

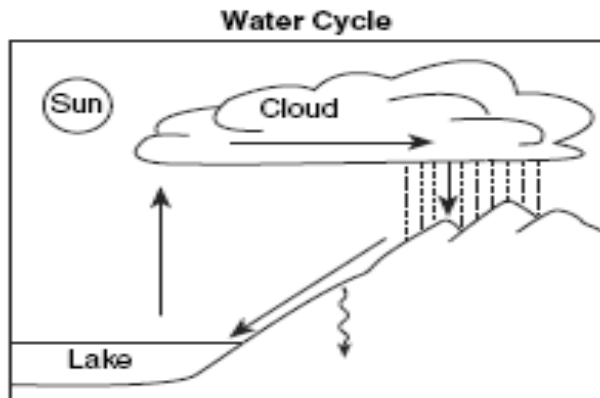
The picture below shows how the surface of land changed when a river flowed through it for many years.



6. What caused the changes in Earth's surface shown in the diagram above?

1. Condensation
2. Erosion
3. Evaporation
4. Rotation

Look at the picture of the water cycle below and then answer questions 7 and 8.



7. What word best describes how rainwater from the top of the mountain gets to the lake?

1. Evaporation
2. Runoff
3. Erosion
4. Precipitation

8. Where does the main energy come from that makes the water cycle work?

1. The lake
2. The sun
3. The cloud
4. The mountain

9. Sleet, rain, snow, and hail are forms of:

1. Erosion
2. Evaporation
3. Groundwater
4. Precipitation

10. The layer of Earth that includes land and the floor of the ocean is called the:

1. Crust
2. Mantle
3. Core
4. Interior

11. Fuel formed from dead plants and animals is called:
1. Fossil fuel
  2. Extinct fuel
  3. Natural fuel
  4. Rare fuel
12. What are the hottest and the coldest layers of Earth?
1. The crust is the hottest and the mantle is the coldest.
  2. The inner core is the coldest and the crust is the hottest.
  3. The mantle is the hottest and the crust is the coldest.
  4. The inner core is the hottest and the crust is the coldest
13. What is likely to happen when air, water, or ice moves across rocks?
1. Earthquakes
  2. Erosion
  3. Fossils
  4. Precipitation
14. Rock that was once melted, but has cooled is called:
1. Igneous rock
  2. Mineral rock
  3. Sedimentary rock
  4. Fossil rock
15. Which of the following is NOT part of the water cycle?
1. Rain falls to Earth's surface from clouds.
  2. Water evaporates from lakes.
  3. Water soaks into the soil.
  4. All of the above are part of the water cycle.
16. Describe how the rocks that make up a mountain can change over time. Use the terms *weathering* and *erosion* in your answer.
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APPENDIX B

STUDENT PRE AND POST TEST  
PHYSICAL SCIENCE

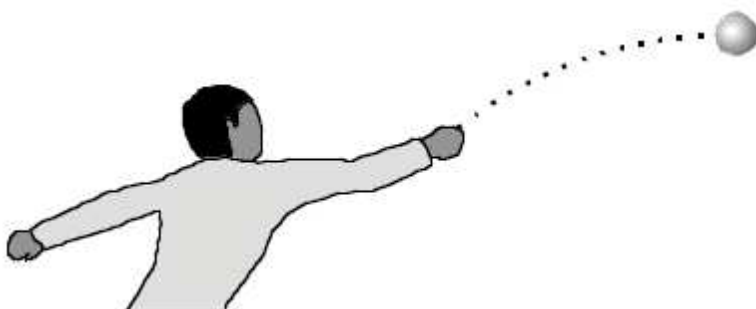
Name \_\_\_\_\_

Date \_\_\_\_\_

### Third Grade Physical Science Test

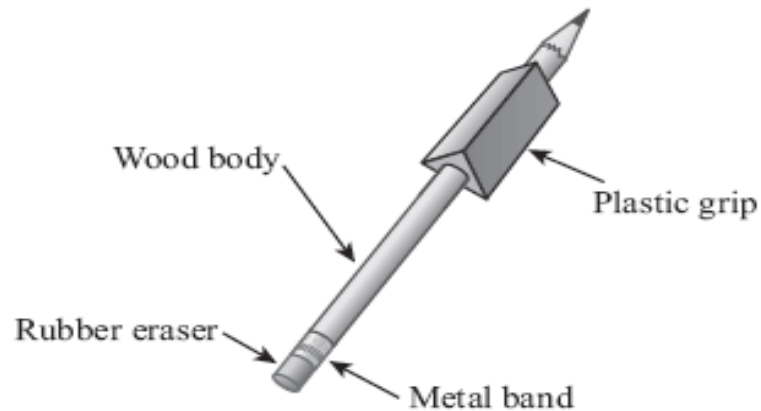
There are 15 questions on this test. Each question, 1-14, is followed by four choices, labeled A-D. Read each question carefully. Decide which choice is the best answer. Mark your answer by circling one letter for each question. Question 15 requires a written response. Answer all 15 questions on this test. You may not know the answers to some of the questions, but do the best you can on each one.

1. There is a thunderstorm close to your house. The windows rattle at the same time that you hear the thunder. What causes the windows to rattle?
  - A. Sound waves from the thunder
  - B. Light from the lightning
  - C. Rain from the clouds
  - D. The high humidity during the storm
2. A student rubs her hands together on a cold winter day. The heat that warms her hands is produced by
  - A. friction
  - B. gravity
  - C. light
  - D. magnetism
3. Scientists say a metal doorknob indoors often feels cold to you because:
  - A. cold from the doorknob goes into your hand
  - B. heat from your hand goes into the doorknob
  - C. heat is pulled from the doorknob by your hand
  - D. metals are always colder than air
4. When a thrown baseball reaches the top of its path (see below), the main force acting on it is:



- A. the force from the person throwing it.
- B. due to Earth's rotation.

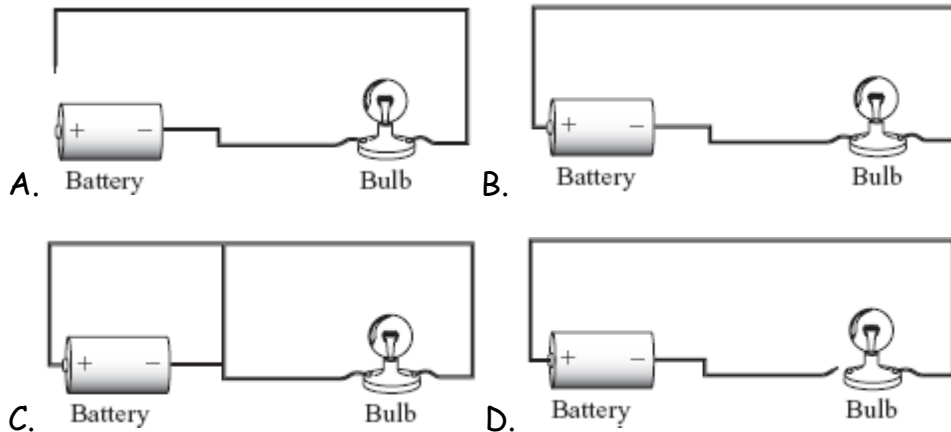
- C. the pull of gravity.  
D. No force is acting on the ball.
5. A car skids along the road and smoke appears to be coming from under the tires. The heat that produces the smoke is caused by
- A. magnetism
  - B. sound
  - C. light
  - D. friction
6. The picture below shows four parts of a wooden pencil.



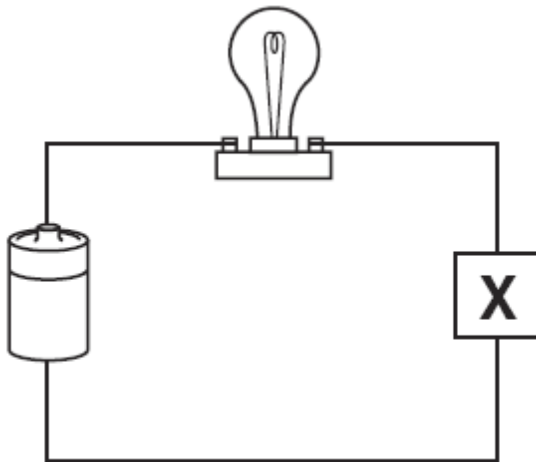
Which part of the pencil is the best conductor of electricity?

- A. metal band
  - B. plastic grip
  - C. rubber eraser
  - D. wood body
7. What force causes objects to fall toward Earth?
- A. friction
  - B. gravity
  - C. light
  - D. electricity
8. A marble is dropped in a glass of water. Which force pulls the marble to the bottom of the glass?
- A. electricity
  - B. friction
  - C. gravity
  - D. magnetism

9. Which diagram below shows a circuit that will cause the bulb to light?



10. An electrical circuit is shown below



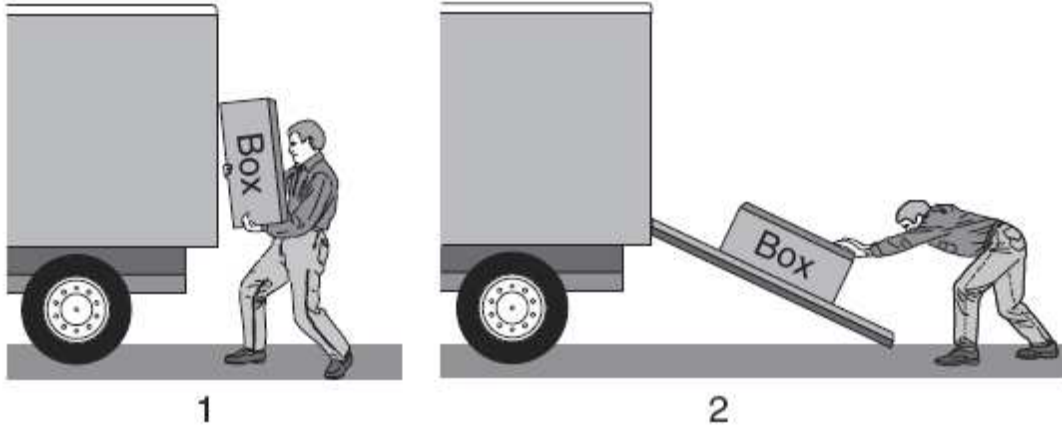
Which object placed at X will complete the circuit?

- A. a metal paper clip
- B. a plastic bottle
- C. a rubber band
- D. a wooden stick

11. When you are riding a bicycle at night, your bicycle's reflectors help people in cars see your bicycle. How do bicycle reflectors work?

- A. They are made of a special material that gives off its own light.
- B. They are hooked up to batteries that allow them to produce light.
- C. They bounce light back from other sources.
- D. They are covered with paint that glows in the dark.

Base your answers to questions 12 through 14 on the information and diagrams below. In diagram 1, a man is lifting a heavy box into a truck. In diagram 2, the same man is using a ramp to move the same box into the same truck.



12. Which type of simple machine is the ramp in diagram 2?
- pulley
  - inclined plane
  - lever
  - wheel
13. Why is it easier for the man to move the same box using the ramp?
- He uses less force.
  - He moves the box a shorter distance.
  - The box is lighter.
  - The truck is lower.
14. It would be easier to move the box if the surface of the ramp was smoother because there would be less
- friction
  - gravity
  - mass
  - volume
15. Describe what happens when you open a door. Use the terms *force*, *motion*, and *position* in your answer.

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APPENDIX C

STUDENT SELF-EVALUATION/TEACHER EVALUATION RUBRIC

3 H Science Rubric		Name:	Date:
Area	3	2	1
Science Content	My written responses demonstrate that I understand ALL of the science concepts and I can accurately use ALL the vocabulary.	My written responses demonstrate that I understand SOME of the science concepts and I can accurately use SOME of the vocabulary.	My written responses demonstrate that I understand a LITTLE of the science concepts and I can accurately use a LITTLE of the vocabulary.
Table of Contents	I am VERY careful to complete and record accurately the required activities.	I am careful MOST OF THE TIME to complete and record accurately the required activities.	I am NOT TOO CAREFUL to complete and record accurately the required activities.
Scientific Tables Graphs Charts Diagrams	Required drawings are MOSTLY completed, accurately labeled and have relevant detail.	Required drawings have incorrect labels, are not carefully drawn or have little detail.	Required drawings are too small, not labeled, or are very messy with little detail.
Legibility And Neatness	My handwriting is USUALLY the best I can do. My work is usually neatly done and	My handwriting is SOMETIMES the best I can do. My work is SOMETIMES neatly done and	I'm NOT TOO CAREFUL. My work is NOT neatly done and legible.



	legible.	legible.	
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Yellow-Student Self-evaluation

Blue-Teacher's Evaluation

Yellow and Blue make *Green* for "You Go!"

APPENDIX D

MOUNTAIN AGE PROBE

Name \_\_\_\_\_

Date \_\_\_\_\_

# Mountain Age



Mountain A



Mountain B

Mountain A is 4,800 feet tall, looks smooth and rounded, and is located in North America. Mountain B is 19,280 feet tall, looks sharp and jagged, and is located in South America. Both mountains were originally formed by the uplifting of the Earth's crust millions of years ago, are composed of similar material, and are found in similar climate conditions.

Put an **X** next to the statement that best describes your thinking about the age of the two different mountains based on their **shape** and **size**.

\_\_\_\_ Mountain A is probably younger than Mountain B.

\_\_\_\_ Mountain A is probably older than Mountain B.

\_\_\_\_ Mountains A and B are the same age.

Describe your thinking. Provide an explanation for your answer.

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APPENDIX E

APPLE ON A DESK PROBE

Name \_\_\_\_\_

Date \_\_\_\_\_

## Apple on a Desk

Mrs. Normal pointed to an apple sitting on her desk. She asked her students to describe any forces acting on the apple. This is what some of her students said.

Archie: "The only force acting on the apple is air pressure.

Melissa: "There are many forces acting on the apple; but, it's the holding force in the apple that keeps it on the desk.

Sam: "There is one force acting on the apple. Gravity is the force that pulls on the apple."

Suzy: "There are two forces: the desk pushes up on the apple and gravity pulls downward on the apple."

Joe: "There are no forces acting on the apple because the desk stops any forces from acting on it."



Which student do you most agree with? \_\_\_\_\_

Explain your thinking. What rule or reasoning did you use to decide if there were any forces acting on the apple?

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APPENDIX F

STUDENT PRESENTATION SELF-REFLECTION



**Science Notebook Presentation Self-Reflection**

Name: \_\_\_\_\_ Date: \_\_\_\_\_

\_\_\_\_\_

Title of My Work in Science:

\_\_\_\_\_

This \_\_\_\_\_ presentation shows that I have  
learned \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

My strengths in this

\_\_\_\_\_ are \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

One area that needs work is

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Next, I would need or like to

learn \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

The thing I liked most about doing

\_\_\_\_\_ is \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

The thing I liked least about doing

\_\_\_\_\_ is \_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

Additional comments:

\_\_\_\_\_

\_\_\_\_\_

\_\_\_\_\_

APPENDIX G

STUDENT INTERVIEW QUESTIONS

## Science Student Interview Questions

Date: \_\_\_\_\_

Student: \_\_\_\_\_

Say to students, "Participation in this research is voluntary and participation or non-participation will not affect your grades or class standing in any way."

1. What is something you like about our science class? Why?
2. What is something you don't like about our science class? Why?
3. If you could name one thing that we do in science class that helps you learn what would it be? What specifically about this helps you learn?
4. If you could name one thing that we do in science class that keeps you from learning what would it be? Why do you think it keeps you from learning?
5. Is there anything else about science that you would like me to know at this time?

APPENDIX H

ASSESSMENT FOR LEARNING AND ASSESSMENT QUALITY  
SELF-CHECKLIST SURVEY

ASSESSMENT FOR LEARNING AND ASSESSMENT QUALITY  
SELF-CHECKLIST SURVEY

1 = I don't do this, or this doesn't happen in my science classroom

2 = I do this occasionally, or this happens occasionally in my science classroom

3 = I do this sometimes, or this sometimes happens in my science classroom

4 = I do this often, or this happens often in my science classroom

5 = I do this always, or this happens always in my science classroom

Survey Statement	Score
1. I understand the relationship between assessment and student motivation and use assessment to build student confidence.	
2. I articulate, in advance of teaching the achievement goals my students are to accomplish.	
3. I inform my students, in terms they can understand, about the achievement goals, how their work will be evaluated, and provide samples of high-quality work.	
4. My students describe what goals they are to accomplish and what comes next in their learning.	
5. I transform these achievement goals into reliable assessments that produce accurate information.	
6. I consistently use classroom assessment information to revise and guide teaching and learning.	
7. My feedback to students is timely, descriptive, constructive, and frequent, aiding students to know how to improve.	
8. My students are actively and consistently involved in assessment, including learning skills of self-assessment.	
9. My students actively and consistently communicate with others about their learning and improvement.	

Source: Adapted from *Classroom assessment for student learning: doing it right-using it well* (pg. 51), by Stiggin, R.J., Arter, J. A., Chappuis, J., & Chappuis, S., 2004, Portland, OR: Assessment Training Institute.