# CREATING INTEGRATED, INQUIRY SCIENCE LESSONS BASED ON EARLY CHILDHOOD SCIENCE ACTIVITIES

A PROJECT REPORT

Presented to the Department of Science Education

California State University, Long Beach

In Partial Fulfillment

of the Requirements for the Degree

Master of Science in Science Education

Option in Informal Science Education

Committee Members:

William Straits, Ph.D. (Chair)
Susan Gomez Zwiep, Ph.D.
Alan Colburn, Ph.D.

College Designee:

Lisa Martin-Hansen, Ph.D.

By Gabriela Chavez

B.S. 2011, University of California, Berkeley

May 2017

ABSTRACT

**CREATING INTEGRATED, INQUIRY SCIENCE LESSONS BASED ON EARLY CHILDHOOD SCIENCE ACTIVITIES**

By

Gabriela Chavez

May 2017

The purpose of this project was to develop early childhood science lesson plans from already existing Physical Science activities from *A Head Start on Science: Encouraging a Sense of Wonder.* The 5E Instructional Model, the Learning Cycle, and other Inquiry-Based teaching strategies were used as a guide for the development of two Physical Science lesson plans. The revised lesson plans were evaluated by experts in early childhood education and science education. The feedback provided from each early childhood expert was carefully analyzed. The feedback provided guidance on how to make the appropriate modifications on the Physical Science lesson plans in order for them to become a useful learning tool.

**ACKNOWLEDGEMENTS**

First I would like to thank my family. I am eternally grateful for my parents and my family who have always been there for me. Without their love and support over the years none of this would have been possible. Thank you for your unconditional love, support, and patience. I am greatly thankful for everything they have helped me achieve.

I would like to express my sincere gratitude to my advisor Professor William Straits for his continuous support, patience, and enthusiasm. I would like to thank my thesis committee members for their support and guidance on this project. Lastly, I would also like to thank the reviewers for taking their time to read over the revised lessons.

## TABLE OF CONTENTS

## LIST OF FIGURES

## LIST OF ABBREVIATIONS

| | |
|---|---|
| 5E | Engage, Explore, Explain, Elaborate, Evaluate |
| CSULB | California State University Long Beach |
| ECE | Early Childhood Education |
| ECSE | Early Childhood Science Education |
| HSELOF | Head Start Early Learning Outcomes Framework |
| HSOS | A Head Start on Science |
| NGSS | Next Generation Science Standards |
| NSTA | National Science Teachers Association |

# CHAPTER 1

# INTRODUCTION

## Overview of A Head Start on Science Project

The A Head Start on Science project was developed in 1996 with the support from the U.S Department of Health and Human Services. The Department of Science Education of California State University, Long Beach (CSULB) and the Head Start Program of the Long Beach Unified School District developed the A Head Start on Science (HSOS) project with the goal to have teachers engage students in science through fun and engaging activities. Their work resulted in the development of 89 hands-on science activities, which were grouped into seven science and nature topics (the senses, weather, physical science, critters, water and water mixture, seeds, and nature walks). The HSOS curriculum guide was published by the National Science Teachers Association (NSTA) Press in 2007 (Ritz, 2007). Each original activity has the following components: Investigation, Process Skills, Materials, Procedure, Follow-Up Activities, Center Connections, and Literature Connections.

These activities were created under the theme of how "a sense of wonder" is part of children's experience with the natural world. When a child is deeply captivated in an activity, they are intrinsically motivated to keep exploring. This idea was adopted from Rachel Carson's book *The Sense of Wonder*, where she wrote, "If a child is to keep alive his inborn sense of wonder… he needs the companionship of at least one adult who can share it, rediscovering with the joy, excitement and mystery of the world we live in" (1956, p. 45). HSOS encourages teachers to stay away from the traditional "instructor" role and serve more as a "facilitator" of learning. An important emphasis to encourage a sense of wonder in children is through science processes. Children should be able to have a more engaging experience on what scientists do.

With the use of their science processes, children are able to expand their perceptions of the world by making observations. When children talk about science with other children and with their adults, they make sense of their own thinking, listen to the ideas of others, become aware of multiple perspectives, re-think their own ideas, are able to evaluate another's ideas, and form their own ideas before finalizing their writing (Shanahan & Shea, 2012). Engaging in science processes is more important than just learning scientific facts.

The HSOS program aims to provide quality science resources and professional development for early childhood educators. HSOS provides professional development institutes in California, conferences, presentations, and workshops across North America. For more than 20 years, HSOS workshops have provided engaging, hands-on training for teachers to become comfortable and confident in delivering science through appropriate teaching techniques. Every summer, CSULB offers a 5-day professional development workshop designed to introduce a new approach for teaching science to early learners and to help adults understand ways to facilitate science education.

## Rationale for Project

The *A Head Start on Science* curriculum guide has been very helpful to educators in various early childhood education settings. These activities can be modified to be used in the classroom and at home, and they can be modified to expand the children's knowledge based on their interests. These original activities have great potential to be expanded into complete revised lesson plans with the intention to elaborate a deeper understanding of each activity.

This thesis project focuses on the development of two revised lesson plans from two original activities from the Physical Science activity section. The HSOS revised lesson plans were developed to help expand children's thinking with the assistance of their adults as their partners in exploring the natural world. The revised lesson plans from the original HSOS activities will help educators develop a deeper understanding of how to deliver each lesson plan using science processes, which will allow educators to not fall in traditional teaching. Each revised lesson plan for the Physical Science section was created with the "hands-on" component in mind and it was designed to be appropriate for all early childhood settings.

## Personal Rationale

I started my career in education as an Environmental Education Intern at Chabot Space & Science Center. I had the opportunity to assist in many of their standards-based classes for their school groups and summer camps. As a complete novice to education, I wanted to break out from the traditional teaching style and adopt this new hands-on instruction that informal settings, such as Chabot, were using. According to Crawford (2007), prospective teachers lack a clear idea of how to do science inquiry-based instruction in their classroom. This leads prospective teachers to develop beliefs that inquiry-based approaches are generally inappropriate for students' learning.

After my internship was over at Chabot Space & Science Center, I was able to find my first job in Los Angeles, California as an After-School Site Supervisor for Keeping Youth Doing Something, Inc. This after-school program provided inquiry-based science curriculum ranging from topics on life science, earth science, physical science, and astronomy. Although we had a variety of curriculums, the problem became delivering the curriculum in a successful way in which students would truly engage in the activities. The majority of our educators, if not all, were struggling in planning and delivering a successful activity, as the majority of the time was being spent in behavior and classroom management. A lot of times while delivering pre-designed activities from activities booklets, I found myself just doing what the book instructed me to do without any personal background knowledge; these science activities became time fillers for the after-school programs instead of actual learning experiences.

My philosophy of science education revolved around the concept of hands-on education; that children learn and understand science best from what they see, touch, and manipulate. From my previous education and work experience, I knew that science was about making observations, predicting what might happen, testing those predictions, and solving everyday problems through trial and error. In order to learn more about this "hands-on" teaching concept and in order to develop teaching knowledge, I intended to pursue my Master's degree in Science Education. Throughout my Master's education, I have learned that children learn best when they are at the center of their own learning. Children learn through a process of questions generated based from their interests, curiosities, and experiences.

With the development of these revised lesson plans, I hope to create understandable and useful physical science lesson plans by strengthening the potential of each activity in order to create a useful tool for educators in early childhood settings while teaching science. The main goal of the revised lesson plans is to help teachers feel more confident with the improvement of the science content through inquiry-based learning.

## Early Childhood Community Rationale

Educators that are familiar with the activities from the original book will find these revised lessons as useful models for expanding science activities into inquiry lesson plans. Although the activities from the original book are a great resource to early learner educators, there is a greater need to encourage children to make discoveries on their own. The first original activities from HSOS serve as a first step to engage students in a science topic. Engagement plays an important role in the development of these lessons. Based on Bybee's (1997) 5E

Instructional Model, we know that the Engagement phase allows children to make connections to their prior-knowledge through a series of questions based on the learning topic. Educators play a key role in extending the learning from their students by asking them questions that encourages them to use their thinking. The series of questions "allows teachers to diagnose students' conceptions and then structure future lessons with this in mind" (Colburn & Clough, 1997, p. 4). This practice of questions allows teachers to serve more as facilitators to guide students in creating their own questions, students become more engaged through this process.

The original activities from HSOS were an inspiration to develop revised lesson plans with the goal to help educators initiate a learning interest in students by exploring the natural world. These revised lessons will expose children to experiences that are hands-on and allow children to learn through fun interactive experiences. The main goal of creating inquiry science lesson plans based on early childhood science activities from the original book *A Head Start on Science* was to help educators expand their students' thinking and to understand a method for learning opportunities that encourages understanding. The revised lesson plans will provide confidence to educators to teach the improved science content through inquiry-based lessons.

There were two physical science lesson plans revised from early childhood science activities from HSOS, the revised lesson plans were, "What's Magnetic?" and "Which Magnet is Stronger?" Some sections of the original format of the HSOS activities were used for the revised lesson plans. However, there were several sections that were added to create the new format for the revised lessons. Figure 1 shows the format for each original HSOS activity, while Figure 2 shows the revised HSOS lesson format. Several changes were made to the introduction of the lessons. On the revised lessons, the section on Learning Objectives was added to help teachers have a clear understanding of the goals to strive for throughout the lesson.

**Introduction**

- **Investigation**
- **Process Skills**
- **Materials**

**Procedure**

- **Getting Started**
- **Questions and comment to guide children**
- **What children and adults will do**
- **Closure**

**Follow-up Activities**

**Connections**

- **Center connections**
  - art
  - sensory
- **Literature connections**
- **Family Science Connection (English/Spanish)**

**Assessment Outcomes & Possible Indicators**

- **What to Look For (Rubric)**
- **Head Start Child Outcomes Framework**

**FIGURE 1. Original HSOS activity format.**

**Introduction**

- **Lesson Summary**
- **Learning Objective**
- **Materials**
- **Safety**
- **Teacher Content Background**

**Procedure**

- **Getting Started**
- **Investigating**
- **Making Sense**
- **Extension Activity**
- **Science Vocabulary**

**Connections**

- **Reading connections**
- **Writing connections**
- **Math connections**
- **Child's Life Connection**
- **Center Connections**
  - art
  - sensory table
  - dramatic play
- **Family Activity (English/Spanish)**

**Assessment**

- **What to Look For**
- **Standards**

  -Head Start Early Learning and Child Development Framework

  -Next Generation Science Standards

  -Common Core State Standards – English Language Arts

  -Common Core State Standards - Mathematics

**FIGURE 2. Revised HSOS lesson format.**

The section on Safety was added to help ensure the safety of children. To wrap up the Introduction, the Teacher Content Background (relative to each lesson topic) was provided to give teachers a better background to understand the science content and to improve teachers' competence and confidence in each lesson plan. The procedure for the revised lesson was mostly reorganized as Getting Started, Investigating, and Making Sense to create a process to generate children's interest, engage them in an investigation, and allow them to try out new ways to communicate their discoveries. The Extension Activity was added to provide suggestions to teachers on how to deliver the similar lesson topic through a variation of activities to help children further their understanding and make additional discoveries. The last section on procedures is Science Vocabulary, note that this section was added after the lesson. This was done with the purpose to allow children to first engage with the concept and become familiar with the process. Children should not be forced to memorize the vocabulary, instead, teachers need to encourage vocabulary development and encourage children to naturally use it during conversations about the topic.

There were also several changes to the connections of each lesson. Science does not need to be taught as an individual subject. Science naturally connects to other subjects such as math and language arts. In each lesson there is a Writing Connection and a Math Connection for children to expand their learning. There was also a Child's Life Connection added to optimize learning and to make it meaningful. Dramatic Play was added to the Center Connection to allow children to develop skills in abstract thinking by exploring different roles and situations to learn about their surroundings. Last, the assessment section was modified, What to Look for and Standards were the last revised sections. The What to Look for section provides a list of questions that teachers can ask themselves in order to measure children's progress in each relevant topic. Each revised lesson also provides the most relevant Standards from Head Start Early Learning Outcomes Framework (HSELOF), the Science and Engineering Practices (SEP) of the Next Generation Science Standards (NGSS), and the Kindergarten or first grade Common Core State Standards for Mathematics and English Language Arts.

## Keywords

*Inquiry-Based Learning:* The *National Science Education Standards (NSES)* refers to inquiry as "the diverse ways in which scientists study the natural world and propose explanations based on the evidence derived from their work" (National Research Council [NRC], 1996, p. 23). Inquiry-based learning practices include making observations, posing questions, planning investigations, analyzing, and communicating the results. It is a process and at all stages of inquiry, "teacher's guide, focus, challenge, and encourage student learning" (NRC, 1996, p. 33).

*Early Childhood Education:* The term early childhood education refers to "group settings deliberately intended to affect developmental changes in children from birth to 8 years of age" (Gordon & Browne, 2013, p. 3). Early childhood education often focuses on guiding children to learn through play, through this process children are exposed to hands-on educational experiences. Early childhood education produces significant gains in children's learning and development. It helps children form a "foundation for later development, physically, intellectually, socially, and emotionally" (Gordon & Browne, 2013, p. 31). This period is considered the most valuable and crucial in a person's life.

# CHAPTER 2

## LITERATURE REVIEW

### Inquiry-Based Learning

The NRC, the NSTA, and the American Association for the Advancement of Science (AAAS) all support the use of inquiry-based learning in order for students to succeed in science. There is a high promotion of inquiry-based science teaching by the science community. National reform documents promote inquiry based instruction as an effective way to help students learn science content, comprehend the nature of scientific inquiry, and engage in the inquiry process (AAAS, 1993, 2000; NRC, 1996, 2000).

Bybee's (1997) 5E Instructional Model has been effectively used to design inquiry-based lesson plans. The 5E model consists of five phases and all of them begin with the letter "e"; the model consists of the following phases: engagement, exploration, explanation, elaboration, and evaluation. The model can be used to help frame the sequence and organization of programs, units, and lessons (Bybee, 1997).

The Engagement phase is important as at this point students make connections between past and present learning experiences. Students gain access into their prior knowledge, predict new ideas, and generate curiosity through a series of questions that initiates learning. According to Carr, Sexton, and Lagunoff (2006), the 5E Instructional Model explains that during the Exploration phase students think creatively to "test predictions and hypotheses; form new predictions and hypotheses, try alternatives to solve a problem and discuss them with others" (p. 6). They move on to the Explanation phase where students "explain possible solutions or answers to other students; listen and try to comprehend explanations offered by the teacher" (Carr et al., 2006, p. 6) As for the Elaboration phase, students "use previous information to ask questions, propose solutions, make decisions, and design experiments; draw reasonable conclusions from evidence" (Carr et al., 2006, p. 6). The 5E Instructional Model ends with the Evaluation phase where students "answer open-ended questions by using observations, evidence, and previously accepted explanations; demonstrate an understanding or knowledge of the concept or skill" (Carr et al., 2006, p. 6). Overall, the 5E Instructional model allows students to explore, engage, explain, elaborate, and evaluate; they have the opportunity to talk to different students in the class and gives each student an opportunity to share and listen to various answers and language structures (Shea & Shanahan, 2011).

The 5E Instructional model is a modification of the Learning Cycle, both used for inquiry-based science teaching. Although the names of the Learning Cycle phases have evolved, today the Learning Cycle is known by the three following phases: Explore, Introduction of Concepts, and Application of Concepts (Goldston, Dantzler, Day, & Webb, 2013). The teacher prepares students for the exploration phase by posing questions and introducing them to an activity in which based from their experience they will be able to construct science concepts. Following the exploration phase is the introduction of concepts phase. To have this phase succeed, the teacher needs to involve the students in an interactive discussion. In order for a class discussion, Marek (2008) provides a script of scaffolding questions crafted to:

> (1) use all of the students' data; (2) assemble the collective data into a class chart, graph, or summary; (3) guide students to interpret their collective data; (4) disequilibrate students as they search for trends or meaning in their data, if they haven't disequilibrated previously; (5) allow students to accommodate the new science concept (reequilibrate) or, stated differently, understand the new science concept; and (6) introduce the scientific terminology associated with the concept. (p. 64)

The interactive discussion is important for students as teachers are introducing them to the appropriate concepts and use of vocabulary based from their exploration phase. Teachers cannot accommodate the concept for students, instead, students must construct meaning of a concept based from their experiences, observations, and data (Marek, 2008). This leads us to the last phase of application of concepts. This last phase of the learning cycle is designed to encourage students to apply their newly acquired concepts to different situations.

As previously stated, both the 5E Instructional Model and the Learning Cycle have been used as guides for inquiry-based learning. Goldston et al. (2013) explain how both models reveal that the phases of the 5E model align with the learning cycle as follows: "*Exploration* (5E- Engage and Explore), *Concept Introduction* (5E- Explain), and *Application of Concepts* (5E- Elaborate and Evaluate)" (p. 532). There is a strong connection between these two models, and both show how learning cycles are an effective way to design inquiry-based learning. According to Marek (2008), "a learning cycle moves children through a scientific investigation by encouraging them first to explore materials, then construct a concept, and finally apply or extend the concept to other situations" (p. 63). These same three concepts will be adopted for the development of the physical science lesson plans as *Getting Started, Investigating,* and *Making Sense.*

## Early Childhood Science Education

Science by itself is not an activity, but instead it is an approach to doing an activity. This approach includes the process of inquiry. Science is more than knowledge and information, it is a process of exploring the natural world. Children are constantly observing and exploring the world around them, taking in new information and processing their own ideas about the natural world. Whether we introduce children to science or not, children are already doing science.

Early learner teachers often suggest the following for why preschool students should be exposed to science: (a) Science is about the real world and (b) Science develops reasoning skills (Eshach & Fried, 2005). The first statement focuses on conceptual knowledge, in the idea that children better interpret and understand the world around them by understanding specific concepts. The second statement focuses on the procedural knowledge, the idea of "doing science" and the development of general skills. In order for children to have positive attitudes towards science, teachers must introduce science in a way that will stimulate their curiosity and encourage their enthusiasm. Eshach and Fried (2005) suggest that:

> designing learning environments in which young children are exposed in a paced and controlled way to scientific phenomena, may help children organize their experiences so as to be better prepared to understand the scientific concepts that they will learn more formally in the future. (p. 22)

This early exposure to science could lead to better understanding of scientific concepts when children are introduced to the concepts with care. Therefore, it is important to make sure teachers have an understanding of how to effectively teach science to children.

It is important for teachers to understand children's competence with scientific concepts and find an interactive, enjoyable, and educational way to engage and guide them in scientific play. As children learn and play, they build a foundation of knowledge that helps them in solving other tasks and developing further interest in science. Nayfeld, Brenneman, and Gelman (2011) stress how crucial is it to understand the knowledge of children's learning and reasoning skills in order to provide the scaffolds necessary to support and foster further knowledge building through both spontaneous and planned instructional interactions. Unfortunately, teachers lack confidence in their ability to engage students in science activities. Many early learner teachers become hesitant about introducing science in their classrooms as sometimes they are unsure on how to do it, they feel unprepared to promote science inquiry and learning in their classrooms (Chalufour, 2010).

Pre-service and in-service professional development is critical for supporting educators to improve their own knowledge of science, their understanding of how children learn science concepts, and their own knowledge of how to best support children's further science learning through effective instruction (Nayfeld et al., 2011). This type of support for teachers will help them provide successful, fun, and interactive science inquiry lessons. Science is an appropriate part of early education and with the proper guidance, preschoolers are able to engage in scientific logical thinking.

## Constructivist Learning Theory

Learning is a process that involves active participation. Children learn more, and enjoy learning more when they are actively involved, rather than being passive learners. The process of learning works best when it concentrates on thinking and understanding, rather than on pure memorization. According to von Glasersfeld (1995), "concepts cannot simply be transferred from teachers to students- they have to be conceived" (p. 2). Constructivism concentrates on learning how to think and understand. This process guides children to be active participants in the learning process. There are two approaches to constructivism: cognitive constructivism and social constructivism (Fosnot, 1996). Cognitive constructivism is associated with Piaget's work and social constructivism was introduced by Vygotsky. Both approaches focus on the main idea that children learn from constructing their own knowledge, however, their work of emphasis differs. Piaget's cognitive constructivism approach focuses on the importance of the mental processes. While Vygotsky's social constructivism approach focuses on the interaction between learners and the interaction with the natural world. However, we cannot have cognitive constructivism without social constructivism, and vice versa. As Foston (1996) describes, "we cannot understand an individual's cognitive structure without observing it interacting in a context, within a culture. But neither can we understand culture as an isolated entity affecting the structure" (p. 28).

Vygotsky believed learning to be developmental and constructive, however, he differentiated between two kinds of development: "spontaneous" concepts and "scientific" concepts (Foston, 1996). He defined "spontaneous" concepts as concepts that are constructed by children based from their everyday experiences. "Scientific" concepts are concepts constructed by society first and then passed on by adults to children. This distinction is important in science teaching since both "spontaneous" concepts and "scientific" concepts require the teacher to play different roles. Bächtold (2013) explains that:

> unlike scientific concepts, children can construct spontaneous concepts by themselves, so the teacher's role is only to facilitate the corresponding construction process. Scientific concepts, on the other hand, cannot be constructed by children on their own, so the teacher has to impart them. (p. 2486)

Both concepts are highly connected, as children begin to reach a certain level of understanding of a "spontaneous" concept, they begin to understand a related "scientific" concept.

# CHAPTER 3

# METHODS

## Lesson Components

Early Childhood Science Education (ECSE) should not be a series of isolated activities that occupy children. Instead children should be engaged in activities that allow for free exploration, where they can interact with others and engage in prolonged investigations. ECSE experiences begin with children's interest and curiosity. With exposure to organized science lesson plans, children learn more efficiently and gain more knowledge about the natural world.

The original activities from HSOS were an inspiration to develop revised lesson plans with the goal to help educators initiate a learning interest in students by exploring the natural world. The main goal of creating inquiry science lesson plans based on early childhood science activities from the original book *A Head Start on Science* was to help educators expand their students' thinking in an area of interest and to help them understand a method for learning opportunities that encourages understanding. The revised lessons will expose children to experiences that are hands-on and allow them to learn through fun interactive experiences, including play and social interactions. The revised lesson plans will provide confidence to educators to teach the improved science content through inquiry-based lessons.

There were two physical science lesson plans revised from early childhood science activities from HSOS, the revised lesson plans were, "What's Magnetic?" and "Which Magnet is Stronger?" Some sections of the original format of the HSOS activities were used for the revised lesson plans. However, there were several sections that were added to create the new format for the revised lessons. Figure 1 shows the format for each original HSOS activity, while Figure 2 shows the revised HSOS lesson format. Several changes were made to the introduction of the lessons; for example, on the revised lessons, each lesson plan begins with a brief description of the Lesson and a listing of the Learning Objectives to help teachers have a clear understanding of the goals anticipated in each lesson. The lesson also provides a section of required Materials and Safety considerations. In addition to that, each revised lesson plan has a Teacher Content Background section to help teachers understand the science content and to expand their knowledge and confidence in each lesson plan.

Inspired by the learning cycle, the procedure for each revised lesson plan was reorganized into: Getting Started, Investigating, and Making Sense. This reorganization was done to create a process to generate children's interest, engage them in an investigation, and allow them to try out new ways to communicate their discoveries. Each of these sections serves an important purpose in the development of new knowledge. In the first section, Getting Started, teachers tap into children's prior knowledge by prompting questions on the topic of interest. Children have the opportunity to consider the topic and start developing initial explanations behind their reasoning. In the Investigating section, children become actively engaged with materials to develop new understandings. Children become involved in collecting data through experimenting, observing, measuring, and documenting. Teachers help to guide this investigation by asking prompting questions to children. Once children have collected their data, they can begin to analyze it. This also requires teachers to encourage children's thinking by prompting questions. The last section is Making Sense, where children have an opportunity to share their results and discuss what they discovered during their investigations. It is important for children to reflect on their investigations, as this helps them develop critical thinking skills and a long-lasting understanding of what they learn. In this section, children are also encouraged to apply their new knowledge that they acquired during their investigations to similar and/or different experiences.

In order to give children an opportunity to build on what they have learned, each revised lesson has a section called, What's Next?. This section provides Extension Activities that are related to the Making Sense section where children will be able to expand their learning. The Extension Activities are not as detailed as the lessons, it was added with the intention to provide suggestions to teachers on how to deliver the similar lesson topic through a variation of activities to help children further their understanding and make additional discoveries. The last section under What's Next is Science Vocabulary. This section was provided after each lesson with the intention to allow children to first engage in the learning exploration and become familiar with the process. The goal is not for children to memorize the vocabulary, but instead to encourage vocabulary development during conversations between teachers and students.

There were also several changes to the connections of each lesson. Science does not have to be taught as a single subject, it can be connected to other subjects in order to extend the learning process. In order to make connections with other subjects, the revised lesson provides the Integration to other Content Areas section to provide ideas on how to incorporate it across the subjects of reading, writing, and math. Even more ideas connecting the science lesson are provided in Other Connections. The ideas are provided to find connections to the Child's Life, Child-Centers, and Family Activities in order to optimize learning. Last, the assessment section was modified, What to Look for and Standards were the last revised sections. The What to Look for section provides a list of questions that teachers can ask themselves in order to measure children's progress towards their learning goals. To wrap up each revised lesson, the most relevant Standards are provided from the Head Start Early Learning Outcomes Framework (HSELOF), the Science and Engineering Practices (SEP) of the Next Generation Science Standards, and the Kindergarten or first grade Common Core State Standards for Mathematics and English Language Arts. These revised lessons are not intended to be taught in full or all at once. Instead, they are made of a number of components to give teachers the tools to engage children through multiple opportunities to explore each science phenomenon.

## Development of Revised Lesson Plans

For this project, two activities from *A Head Start on Science* were converted to integrated, inquiry-based lessons. The two selected activities, "What's Magnetic?" and "Which Magnet is Stronger?", served as a guide to convert them into lesson plans. There are 24 life science activities from HSOS that have already been converted into integrated, inquiry-based lesson plans. All of the revised lessons follow the same format, which includes all the lesson components previously listed. These life science lessons served as models for the development of the revised physical science lesson plans. Several of these life science lessons were reviewed in order to gain an understanding on the content of each section of the lessons, as well to understand the appropriate format of each lesson plan. Both revised lessons were converted to an integrated, inquiry-based lesson after having a deep understanding of the format and after carefully reviewing the activities from HSOS. After all sections of the lessons were converted, they were first reviewed by expert in early childhood science education. Once reviewed, his expert feedback led to revisions and modifications before sent out to the review committee for full revision.

## Review of Lessons

After the modifications of the two revised physical science lessons, the lessons were revised in full one last time by a review committee. Once completed, these two lessons were evaluated by a review committee comprised of experts and practitioners. Specifically, two early childhood teachers– a veteran preschool teacher and a veteran 1st grade teacher, and two early childhood science education experts– a professor of early childhood education and a professor of science education, served on the review committee. Reviews were completely open ended; reviewers were free to comment on what they thought was needed. Feedback received from each member of the review committee was collected, analyzed, and used to inform final revisions to each lesson. The final lessons were submitted to Master's project committee for consideration.

# CHAPTER 4

# REVIEWS

## Lesson Overviews

Two separate, but related, lessons were developed for this project. The first lesson, “What’s Magnetic?” serves as an introductory exploration of magnetic and nonmagnetic materials. The aims of this lesson are to guide children to learn about the property of magnetism by exploring various objects with magnets. Children predict whether each object is magnetic or not, and then test their predictions. This lesson is supported by several “connections” that provide opportunities for children to explore non-fiction text about magnets, create Venn Diagrams with objects to represent their findings, represent and interpret data using ten-frames, explore objects with magnets around their classroom, and use magnets to paint, search for “treasures” and become imaginary life-size magnets to tell stories. The second lesson, “Which Magnet is Stronger?” is a lesson designed to follow the “What’s Magnetic?” Lesson. This lesson focuses on investigating the strength of different magnets. The goal of this lesson is to explore the strength of multiple magnets by recording and analyzing data to determine which magnets are stronger. This lesson is reinforced with fun learning "connections" that equip children to study non-fiction text about the properties of magnets, communicate their observations orally and through drawings, illustrate their findings through a bar graph, understand that forces are all around us, and manipulate magnets to determine their strengths, create magnetic puppets, and perform a play at their puppet theater.

## Lesson Reviews

Reviewers provided valuable insight, comments, questions, and concerns for each lesson. Feedback from the four reviewers, summarized in Appendix A, was organized into four categories. The first category, called “Overall” summarized reviewer ideas that pertained to the overall structure and flow of each lessons. The category, “Introduction” included the Lesson Summary, Learning Objective, Materials, Safety, Teacher Content Background, and Science Vocabulary sections. The category “Lesson” consisted of the Procedure for the science lesson, including the Getting Started, Investigating, and Making Sense sections, and the Extension Activity. The “Connections” category included the Reading, Writing, Math, Child’s Life, Centers and Family connections as well as feedback related to the What to Look for and Standards sections of the lesson.

Overall feedback for "What's Magnetic?" said that the motor skills needed for this lesson might not be developmentally appropriate for preschool children. There is a concern that children might need too much adult assistance for some sections of the lesson. Therefore, it is suggested to simplify some sections in order to give an opportunity for children to engage more independently in the lesson. Feedback about the Introduction focused primarily on the Materials needed for this lesson plan. There were some concerns that the preschool children might be exposed to a hazardous situation with the small objects. Also, there was a suggestion to simplify the language of the Safety procedures and be more specific on the materials needed for this lesson. Reviewer comments about the lesson suggested that children did not work in partners as it can be difficult for them to take turns or share with others. There was positive feedback about the Extension Activity on how engaging it can be, however, there were concerns on how the fishing rod could be difficult for children to assemble as their motor skills might not be strong or fully developed yet to make knots. Reviewers provided many different comments about the Connections. The Writing Connection received positive feedback about the Venn Diagram hula hoops. However, there were some concerns about the paper version of the Venn Diagram. The reviewers suggested that children should be drawing pictures to express their understanding instead of having them write down their thoughts. In the Child's Connection there was also a suggestion to have children draw magnetic objects that they found during the activity. The Math Connections also received feedback on having children document their findings through drawings. One of the suggestion was for children to created a graph of magnetic and non-magnetic objects. The other suggestion was to have children count the number of magnetic objects and have them draw them on a graph or tally them as this promotes children's learning about tallying, counting, and comparing. In the Center Connection it was advised to make sure that all children have the opportunity to be actively and equally engaged throughout the lesson. The What to Look for and Standards sections of the lesson did not receive any comments from the reviewers.

Overall feedback for "Which Magnet is Stronger?" said that some of the content might not be developmentally appropriate. There were various concerns on how children might not be prepared to write down their observations. Instead of writing down in paper, drawing and manipulating objects was strongly encouraged as a form of documentation in order to engage and further understand the lesson. Also, it was pointed out that the lesson should remain focused on the original topic and not introduce a new topic that might shift focus from the lesson's content. There was only one suggestion about the Introduction, a reviewer suggested to slightly clarify further on Teacher Content. Reviewer comments about the lesson suggested to provide further explanation on Investigating. It was also suggested to provide open-ended questions on Investigating in order to encourage children to use their own knowledge and gather information on the question in order to formulate an answer. For Documenting, it was suggested to provide a worksheet with photos of the magnets on the paper the children will use to document their findings. Reviewers provided many different comments about the Connections. The Writing Connection was the biggest concern in this section of the lesson. The reviewers commented on how preschoolers are not expected to be writing down words at this grade level. The preschool children might be in need of too much adult assistance and therefore lose sight of the lesson's objective. Drawing was again suggested as a form of documenting children's observations rather that writing down words. Also, it was mentioned that the Writing Connection lost focus of the topic. It was suggested to use the Extension Activity as the writing prompt to remain focused on the strength of magnets and not its' features and structures. Although there were some suggestions on creating a graph for the Math Connection for "What's Magnetic?," there was a small concern about using a bar graph for the Math Connection. It was suggested to use a different form of measure that is more relevant to children, it was said that anything can be used as a form of measurement as long as it is the same length. The What to Look for and Standards sections of the lesson did not receive any comments from the reviewers.

Analyzing the comments received from these two lessons illuminated some common themes. The reviewers were concerned that preschool age children were not developmentally ready to perform some of the activities that required them to have advanced motor skills. In addition, all reviewers were concerned about the writing expectations for some of the Connection activities. Reviewers explained how children at this age are more comfortable documenting their observations through drawings or by communicating with an adult. Overall, both lessons received the suggestion to keep all the standards in mind while making the necessary revisions.

# CHAPTER 5

# CONCLUSION

## Final Lessons

Feedback received from review committee resulted in several positive revisions to each lesson. There was great feedback provided by the reviewers in each of the lessons. There were sections that received similar feedback by most, if not all, of the reviewers. There were some sections that did not receive any feedback and instead received some editing and sentence structure suggestions. The feedback received helped make the lessons be more focused and developmentally appropriate. Although there was a great detail of suggestions, comments, and concerns, not all of the feedback was adjusted in the lessons. The resulting, final lessons are more focused, interactive, and developmentally appropriate. These final lessons are provided in Appendices B and C.

## Lesson One

### Introduction

The first lesson, "What's Magnetic?" was revised with all the spelling edits, as well as all the suggestions on sentence structure. The feedback on Introduction suggested to remove the pennies from the Materials section as it can be a hazardous situation if children were to put the pennies in their mouth. Also under materials, reviewers wanted to know what type of specific magnet to use for this lesson, so it was clarified to use a ring magnet. There was also a suggestion to simplify the language for Safety, however, there were no changes made.

### Lesson

Reviewers comments about the lesson suggested that children did not work in pairs as their might be some struggles with sharing objects, therefore the Investigating section was modified to provide each child with their own materials. The Extension Activity received similar feedback by more than one reviewer. The reviewers were concerned on how the fishing rod could be difficult to assemble for preschool children as their motor skills might not be fully developed to make knots. Therefore, it was suggested for teachers to have the fishing rods assembled prior to starting this activity.

**Connections**

The reviewers provided many different comments and suggestions about the Connections. The idea of using hula hoops to create a Venn Diagram received very positive feedback. It was an easy tool to visually understand the differences between magnetic and non-magnetic objects. However, there was a concern with using the Venn Diagram worksheet as reviewers were concerned that children might not be able to write down words to describe the differences and therefore they suggested that drawings should be used instead. However, the way the Writing Connection was originally written it suggests drawing as the option to document children's observations and it encourages children to write down words if possible. Since the Writing Connection already meets the desired suggestions, there were no changes made to this section.

The Math Connections also received feedback on having children document their findings through drawings. Two reviewers suggested to created a graph of magnetic and non-magnetic objects rather than using the ten-frame. However, since graphing was already being used as a math tool for "Which Magnet is Stronger?," in order to provide a different learning tool, it was not considered as an option for "What's Magnetic?" lesson. The only revision for the Math Connection was a brief description of the benefits of using the ten-frame in order to promote children's counting and comparison skills.

The Child's Life Connection was completely recreated based on the feedback received from the reviewers. One of the concerns in this connection was the lack of excitement and engagement as it only had children explore the classroom and make predictions on which items they believed were going to be magnetic. Therefore, it was recommended to add creativity and further engagement by creating a magnetism scavenger hunt. With this addition, children now explore the objects through a scavenger hunt and document their observations as they test different objects.

The concern of children working in pairs and sharing objects came up again in the Center Connection. Reviewers recommended that all children had more ownership of their own supplies in order to be more actively engaged in the activities. Therefore, children at the art center will now have their own set of supplies rather than sharing with a partner. As part of their art center activity, children are using aluminum food containers to keep all the paint inside of it and remain neat. However, a reviewer suggested to use the sensory table instead using the container. I added a note to this section explaining teachers that if they have strong magnets that can move the objects from underneath the table to go ahead and use the sensory table. However, teachers still have the option to use the aluminum food containers or any other type of containers they prefer (as long as the container they use is thin enough to make the magnet move the objects). The last recommendation for this lesson was so make dramatic play more interactive by having children work in small groups. The connection has children break into smaller groups rather than just having one child be the magnet and it also encourages children to share their investigations with each other through stories. The What to Look for and Standards sections of the lesson did not receive any comments from the reviewers, for that reason, there were no changes made to that section.

## Overall

Overall feedback for "What's Magnetic?" focused on how the motor skills needed for this lesson might not be developmentally appropriate for preschool children. In multiple sections of the lesson, it was encouraged to use drawing as a form of documenting observations, however, the lesson still encourages children to write down their thoughts, if possible, as a form of documentation. Also, throughout the lesson it was suggested that children manipulated their own supplies in order for children to engage more independently in each activity and avoid any issues with sharing.

# Lesson Two

## Introduction

The second lesson, "Which Magnet is Stronger?" was also revised with all the spelling edits, as well as all the suggestions on sentence structure. There was only one request on the Introduction, a reviewer suggested to slightly clarify electromagnets on Teacher Content.

## Lesson

Reviewer comments about the lesson resulted in some rearranging of sentences and procedures. On Getting Started, reviewers needed some clarity to understand how children could make predictions about the magnets' strengths, therefore, it was simplified to have children make predictions and arrange the magnets from strongest to weakest. Reviewers suggested to provide further explanation on the experimenting section of Investigating as there was a lot of confusion on how to set up the children's workstation. They suggested to further explain how to set up the workstation or to provide a drawing of the set up; the revision for this section consisted of further explaining how to properly set up the area. The documenting section of Investigating lacked a tool to record the observations. A table was added to this section to explain to teachers how to set up their documenting worksheet using the table provided as an example. Children now have two section to document their number of paper clips one by tally marks and the other by writing down the number of tally marks. The Investigating section was also revised to offer open-ended questions to encourage children to formulate answers based on their own knowledge.

**Connections**

The Writing Connection was the biggest concern in this section of the lesson. The reviewers commented on how preschoolers are not expected to be writing down words at this grade level. The connection offers both an opportunity for children to describe their findings through drawings and through writing. The wordings at the end of the connection asked children to write down their observations in a journal entry, but it was revised to encourage children to write down their observations in their drawings. Also, it was mentioned that the Writing Connection shifted focus to a new topic about the features and structures of the magnets. Reviewers recommended to use the Extension Activity as the writing prompt instead in order to remain focused on the topic about the strength of magnets. However, after much consideration, there was no reorganization of the Writing Connection in relation to the Extension Activity. The What to Look for and Standards sections of the lesson did not receive any comments from the reviewers.

**Overall**

Overall feedback for "Which Magnet is Stronger?" recommended that the content be developmentally appropriate for children. There was a lot of clarification needed on multiple sections of the lesson in order to fully understand what was expected while teaching this lesson. Although there was great feedback provided by the reviewers, not all the feedback received was revised in the lesson, as a result, there were some sections that remained the same.

## Implication for Project

Science learning experiences are important in early childhood education. This project focused on creating, integrated science lessons based on early childhood science activities from the book, *A Head Start on Science: Encouraging a Sense of Wonder* (Ritz, 2007). Both lessons, "What's Magnetic?' and "Which Magnet is Stronger?," provide developmentally appropriate content designed for early learners. Throughout each lesson, children are exposed to fun and interactive activities that encourages them to constantly be engaged.

These revised lessons provide teachers with opportunities to focus on the importance of children engaging in science processes rather than learning science facts. Children learn about science through play; these lessons were extended to provide opportunities for children to interact with peers, their teachers and family members; learn from one another; and know that trial and error are natural parts of the scientific learning experience. Through the Connections section we learn that science processes can occur in all parts of the classroom and outdoors. In these lessons, observation was a fundamental science process skill. Children are naturally amazed and curious about the natural world. As children utilize their natural curiosity, engage in hands-on experiences, and observe objects using one or more of their senses, they develop scientific knowledge. The revised lessons were also designed to help teachers understand a method for sequencing learning opportunities that promotes understanding.

Transitioning from a traditional education teaching classroom into an inquiry-based classroom could be overwhelming for both teachers and students. Inquiry-based learning provides both teachers and students an opportunity to learn something new. However, in many cases, teachers spend a great deal of personal time researching for the best methods and practices to present instruction. The lessons provided in this project serve as a great resource for teachers to limit their personal time researching and planning lesson plans. The revised lessons serve as a great tool for teachers to move from an isolated activity approach of their science teaching into an interactive learning approach that engages children in science inquiry. This inquiry-based learning approach provides students with the opportunity to develop new skills and apply what they have learned to other areas of their future learning. These revised lessons allow teachers to take risks and try new teaching methods. Also, teachers have the opportunity to use their professional judgment to make the necessary changes to the lessons, if needed, in order to meet their students' needs.

Throughout my short career, I have come across many educators that struggle integrating science inquiry-based concepts to their lesson plans, including myself. I have always wanted to break out from the traditional teaching style and learn how to adopt and implement science inquiry-based instruction. In my recent teaching experience, I found myself teaching pre-designed activities from activity booklets without having any personal background knowledge on the content being taught.

This project has taught me that the process of developing integrated inquiry science lessons is not an easy task. There are many concepts that need to be kept in mind while developing new lessons, it is very easy to oversee a procedure and assume that your audience will understand each section. While developing "What's Magnetic?," I found myself extremely engaged in making sure each section of the lesson was fun, interactive, and interesting. It did not cross my mind that there might be challenges that both teachers and students were going to face for this lesson. However, these challenges became very clear once I received the feedback from the reviewers, hence, why there were more revisions made to this lesson. Working on this project has definitely caused a positive impact in my personal growth. I noticed that the way I was putting together the lesson plans became very internalized, the way the lessons were written before being sent out to the reviewers made perfect sense to me. However, after receiving the feedback from the reviewers, I realized that there was a lot of confusion on what I was trying to articulate in each section. Receiving the feedback from reviewers and deciding on what revisions to make became the most valuable part of this project. At first it was very discouraging to know that there were a great number of suggestions, comments, and concerns. It was really hard to reflect on each lesson with a positive attitude as it felt as if I was starting from scratch all over again. Although the lessons may not have made complete sense as I had expected, I was able to recognize that there were successful sections in each lesson that received positive feedback. I was able to make the necessary revisions and be more detailed on the procedures and expectations in each section of the lessons. As a new educator I have learned that while developing lesson plans it will be hard to anticipate where a lesson might go wrong. I have learned that creating lesson plans for early childhood learners goes beyond just content. I have gained a better appreciation of the abilities of young children and the considerations that need to be made in designing instruction for this age group. Therefore, everything in a lesson might not go exactly as planned as it cannot anticipate every child's reaction, responses, and behaviors, but this gives teachers an opportunity to reflect on their lessons make the necessary changes and identify what could have been done differently.

My philosophy of science education revolves around the concept of hands-on education; that children learn and understand science best from what they see, touch, and manipulate. I believe children learn through a process of questions generated based from their interests, curiosities, and experiences. I truly believe this reflects on each of the lessons provided in this project. With the development of these revised lesson plans, I was able to provide efficient physical science lessons for educators in early childhood settings teaching science.

## Limitations

The development of integrated, inquiry science lessons took a fair amount of time and effort. But even though each lesson has been fully revised and completed, the development of the lessons could continue. Both lessons allow for monitoring students' progress. Throughout each lesson, assessment takes place before, during, and following each activity in order to understand student needs and focus on their optimal learning. The information gathered from the Assessment section about how students are progressing could indicate if some reordering of the sequence of activities might be necessary. This can be later revised by the teachers who have tried the lessons in their classrooms. Although reviewed by experts in the field, these lessons were not actually taught.

In summary, successfully integrating inquiry science lessons make the learning experiences valuable and more meaningful for students. The revised lesson format will have children actively engaged in each activity and as a result children will reach a deeper understanding of each science topic. Lastly, active engagement in these revised lessons can lead students to become more interested in science and have a more positive attitude towards it. Teachers will feel more confident in delivering the revised lessons as the content background will provide knowledge about the lesson's topic. These lessons give teachers the opportunity to adjust the lessons based on students' needs and it gives them the freedom to focus on what is more productive for their classrooms. The revised lessons will allow both teachers and students to learn from each other.

# APPENDICES

# APPENDIX A

# SUMMARY OF REVIEWER FEEDBACK

## APPENDIX A

## SUMMARY OF REVIEWER FEEDBACK

| What’s Magnetic? | |
|---|---|
| Overall | P1: There are a few concerns with the motor skills needed for some of the activities. Most of the feedback suggest that children might need adult assistance while assembling some of their work. Also, the writing level for this lesson might not be appropriate for this age group.<br><br>P2: Most of the feedback suggest simplicity in terms of describing the overall lesson. There are also some suggestions to be more specific on what to do for each activity within the lesson.<br><br>E1: The feedback suggest to consider the motor skills needed for this lesson. Some children might not be ready to complete parts of this lesson. There are also a few concerns about children having to pair up for some activities. It is suggested to make sure that all children are actively and equally engaging in the lesson.<br><br>E2: The main concern is that content might not be developmentally appropriate if using standards for Kindergarten or higher. Children should not be writing on paper yet, instead encourage them to document by drawing. |
| Introduction | P1: **Materials**- "I would take out pennies for preschoolers. Can be a hazardous situation, children might put pennies in their mouth."<br><br>P2: **Materials**- "Do you have any suggestions on the best types of magnets? Should a teacher stick with one type of magnet or use different types of magnets? After reading Which Magnet is Stronger I’m thinking you would suggest teacher only use one type of magnet."<br>**Safety**- "You might want to end the topic with something like this 'The best rule is to keep magnets in the learning center which is away from computers, other electronic devices or sharp pieces of metal.' I know this sounds simple but sometimes simple is good."<br><br>E1: Editing and sentence structure.<br><br>E2: N/A |

| | |
|---|---|
| Lesson | P1: **Investigating**- "This part of the experiment might be a bit challenging to some younger children to do with a partner. They need to be able to have assistance throughout the experiment, working with a partner might be challenging because some preschoolers have a hard time sharing or taking turns." **Extension Activity**- "For preschoolers the fishing rod needs to be already assemble ready to go. Preschoolers fine motor skills are not strong or fully developed enough yet to make knots or ties."<br><br>P2: **Making Sense**- "This will be hard for the students but teachers can come back to review and discuss these ideas."<br><br>E1: Editing and sentence structure. Concerned about how the finishing rod might be difficult for students to put together.<br><br>E2: "If using Kindergarten standards or higher, then that activity is not developmentally appropriate." |
| Connections | P1: **Writing Connection**- "The Venn Diagram on paper could be confusing for some preschoolers. Their visual discrimination might not be fully developed. Preschoolers might be more confused with a paper diagram. The hula hoops sound the best for the younger kids."<br><br>P2: **Math Connection**- "I really like the idea of the tens frame. We are now using tens frames to teach addition. They are very powerful. Another option would be to make a graph of magnetic and nonmagnetic." **Family Activity-** "A suggestion: students could bring to school one object that was magnetic that was surprising to them."<br><br>E1: **Child's Connection- "**This Connection doesn't sound too exciting. Maybe re-work it as a magnetism scavenger hunt. Children can use magnets to test different objects and take (or draw) pictures of the magnetic items/structures/etc. they find." **Art Center - "**Doesn't seem like a great partner activity. One child sits there watching and holding a container, while the other uses a magnet to create a painting." **Dramatic play** usually small groups of children working independently.<br><br>E2: **Writing Connection- "**The children should not be writing their thoughts or writing the list of items on the paper. Instead, they can draw pictures and the teachers document the child's words." **Math Connection-** "Perhaps asking the children to count the number of items and then drawing them on a graph or tallying them - they will learn about tallying, counting, and comparing." |

Summary of Reviewer Comments for the "What's Magnetic?" lesson. Practitioners are coded as P1 and P2. Experts as E1 and E2.

| Which Magnet is Stronger? | |
|---|---|
| Overall | P1: Younger preschoolers might need assistance from an adult in the Writing Connection due to their not full develop of fine motor skills. Children might not be prepared to write down their observations.<br><br>P2: There are a couple of suggestions to provide pictures or diagrams of how to set up some of the activities. Also, questions should be open-ended to offer children opportunities to expand their thinking.<br><br>E1: Further clarification is needed in some sections of the lesson. The lesson should remain focused on the topic and try not to introduce any new topic that might cause confusion.<br><br>E2: The main concern is that content might not be developmentally appropriate if using standards for Kindergarten or higher. Children should not be writing on paper yet, instead encourage them to document by drawing. Children should manipulate objects instead of drawing graphs in order to understand and engage in the Math Connection. |
| Introduction | P1: N/A<br><br>P2: N/A<br><br>E1: Clarify Teacher Content<br><br>E2: N/A |
| Lesson | P1: N/A<br><br>P2: **Introduction**- "Could you put the question 'How can we find out which is the strongest?' at the end of that section." **Experimenting**- "A diagram, photo or diagram of how to set up the workstation would help." **Documenting**- "It might be nice to have photos of the magnets on the paper the students will use to document their findings." **Extension Activity**- "Students can try the same investigation with different size paper clips (if the first investigation was with small paper clips, the second investigation could use large paper clip)." |

| | |
|---|---|
| | E1: Editing and sentence structure. Further explanation in **Investigating.**<br><br>E2: "If using Kindergarten standards or higher, then that activity is not developmentally appropriate." |
| Connections | P1: **Writing Connection**- "For younger preschoolers due to their not strong of fully develop fine motor skills might need assistance from an adult."<br><br>P2: **Family Activity**- "A diagram, photo or drawing would help parents know what to do."<br><br>E1: Editing and sentence structure. **Writing Connection- "**Maybe using the extension activity as your writing prompt will keep us focused on the strength of magnets and not the features/structure of magnets." **Math Connection** clarify the scale of the graph.<br><br>E2: **Writing Connection- "**There is a writing development stages. Preschoolers are not expected to be writing words or in prose. Again, drawing pictures is a great way for them to document their findings. Teachers can help by writing the child's words on the paper/drawing." **Math Connection- "**As for the bar graph - vertical and horizontal axes? - perhaps instead of a ruler, use cubes that are about an inch or a form of measure that is relevant to them - list same length forks or spoons. The standard is using a form of measurement - anything can be used as a form of measurement as long as it the same length." |

Summary of Reviewer Comments for the "Which Magnet is Stronger?" lesson.

Practitioners are coded as P1 and P2. Experts as E1 and E2.

## APPENDIX B

## FINAL "WHAT'S MAGNETIC?" LESSON

## Appendix B
## Final "What's Magnetic?"

Introduction

**Lesson Summary**: An introductory exploration of magnetic and non-magnetic materials.

**Learning Objective:** Children learn about the property of magnetism by exploring various objects with magnets. Children predict whether different objects are magnetic or not, and then test their predictions.

**Materials:** Several identical sets of various objects (be sure to include some metal objects that are magnetic and some that are non-magnetic and avoid objects that are made of different parts (e.g., clothespins); objects to consider include: pennies, feathers, rocks, plastic cups, paper clips, thread, rubber bands, tin cans, aluminum foil, crayons, staples, and bobby pins, etc.), labeled picture cards of each object, one ring magnet per child.

**Safety:** Magnets can attract sharp pieces of metal, be aware of how children are using the magnets to not cause any injuries. Also, magnets can cause permanent damage to electric equipment. Don't use magnets on computers and other electronic devices as it could damage the magnets inside of them. Make sure children keep a distance of these devices or keep out of the reach of children.

**Teacher Content Background:** A magnet is an object that has the ability to attract certain materials. The two ends of a magnet are called the north and south poles. These are the parts where the magnets are strongest. The north pole of one magnet attracts the south pole of a second magnet, while the north pole of one magnet repels the other magnet's north pole. So we have the common saying, "unlike poles (i.e., opposites) attract." Only certain metals are attracted to magnets, these include iron, cobalt, and nickel. Some of the best magnets are alloys (mixtures) of these elements with one another and with other elements. However, other metals like aluminum, copper, silver, and gold are non-magnetic. Magnets are found in many different household objects. If we had no magnets, we would have no electricity and as a result no computers, telephones, lights, and televisions.

## Procedure

### Getting Started

*Introduction:* If children have not already had opportunities to play with magnets in your class, give children magnets and let them explore. [Note: Be sure to caution children against using their magnets near computers, cell phones, and other electronics.] During this open exploration children will make all sorts of discoveries on their own. Only after these important, initial explorations you should begin a more formal investigation into the properties of magnets.

*Prior knowledge:* Show children a magnet and begin a discussion with children. Prompt children to share what they know about magnets and encourage responses from all children by asking questions such as, “What does a magnet do? Have you ever used a magnet at home?” During this conversation, children should share that magnets stick to things, but not to all things. Demonstrate this idea, and prompt additional conversation, by showing a magnet in action, placing one magnetic and one non-magnetic object against your magnet and letting go. Explain to children that they will be exploring several different objects, testing each to determine if it is attracted to a magnet or not. Show children each of the items they will be testing and have students predict which items will be attracted to the magnet and which will not. In a place visible to children, use words and pictures to record the children's predictions based on their observations.

**Investigating**

*Experimenting:* After having all children make their predictions, provide each child with a bag of objects to test. [Note: Children should not have magnets at this time.] Ask children to carefully observe the objects. After initial observations, ask children to sort the objects, grouping them based on properties they have in common (e.g., size, shape, texture, color, etc.). Once children have observed all of their items, provide a ring magnet to each child to allow them to explore the objects.

*Observing/Documenting:* Make sure the children have visual access to the predictions made during the Getting Started as they begin to test their predictions. Allow children to explore all of the items and assist their investigating by asking questions such as, "Is that object attracted to the magnet? How does this compare with your prediction? Why do you think your magnet was attracted/not attracted to that item?" Once children have tested each item have them sort the items into two categories, the objects that are attracted by magnets and the objects that are not.

**Making Sense**

*Describing findings:* Remove the magnets and prompt children to observe and compare just the objects that were attracted to the magnets. Use open-ended questions to promote a discussion, asking, "What similarities do you notice among the objects are attracted by the magnet?" or "What properties do these objects have in common?" During this sharing, children will have the opportunity to listen to their classmates' observations, which will allow them to have a deeper understanding of their investigation. After children have shared their ideas, shift their attention to the non-magnetic objects and again prompt them to observe discuss similarities. As children engage in these discussions, they should notice and share that all of the magnetic are metal and that only some of the non-magnetic objects are metal.

*Application:* Hold up a new (one not used during children's investigation) plastic object. Ask children if they think it is magnetic or not and encourage children to explain their thinking. Refer children to their findings, to help them to think about and describe the possible magnetism of the new object. After discussion, children can test the object and place it in the non-magnetic category. Then hold up a new metal object and ask children if they think it is magnetic or not and encourage children to explain their thinking. Children may have more disagreement with this object, as there are magnetic and non-magnetic metal objects in their investigation. Emphasize student thinking and explanations throughout these discussions. If children's interest persists, repeat this with several additional objects. To increase student thinking and discussion, consider including objects with metal and non-metal parts (e.g., plastic-handled scissors, clothespins, etc.).

What's next?

**Extension Activity:**

A variation of the lesson described above involves a imaginary magnetic fishing rod. [Note: Before starting this activity, assemble the finishing rods for the children by tying one end of the string to the ring magnet and the other end to a pencil, this will create the magnetic fishing rod!]. Provide children with a box that includes various magnetic and non-magnetic objects. Provide each pair of children with a box for them to explore. Explain to the children that they will be "fishing" for objects in their boxes. Provide children with a bowl or tub to hold all the items they catch. You can also extend this activity outside the classroom by telling children that they will be going on a fishing trip to the playground. There, children can test different objects with their fishing rods to see which ones attract to the magnet and which ones do not. Once back in the classroom, have a discussion about what children were able to catch and not catch with their fishing rods. Read to the class, *What Makes a Magnet?* by Franklyn M. Branley and have children compare their experiences with the story.

**Science Vocabulary**

| Science Word | Definition/Description | "Familiar" Words for Children |
|---|---|---|
| Attract | To move together or stay together | Attach |
| Magnet | A material that can attract certain pieces of metal | |
| Magnetism | A force that pushes and pulls certain metals | |
| Metal | Shiny, dense, hard, and strong materials that allow heat and electricity move through it | |
| Repel | To move something away | Push |

Connections

**Reading connections**

Children can learn more about magnets through books such as *What Magnets Can Do* by Allan Fowler, *Magnets: Pulling Together, Pushing Apart* by Natalie M. Rosinsky, *Experiments with*

*Magnets* by Dale Marie Bryan, *A Look at Magnets* by Barbara Alpert, and *Magnetic and Nonmagnetic* by Angela Roystone. There non-fiction texts briefly describe the properties and behaviors of magnets: what it is, what materials are magnetic, uses of magnets, etc. These books also encourage children to have an understanding of the vocabulary they have been exposed to throughout the activities. In the Extension Activity children read, *What Makes a Magnet?* by Franklyn M. Branley, and related their investigations to the book as they replicated part of the story. Information-filled books such as *Magnets* by Anne Schreiber are a great resource to introduce students to more in-depth knowledge about magnets. *Magnet Max* by Monica Lozano Hughes does an amazing job at explaining magnets in a clear and easy to understand language. Throughout all these books, children's curiosity will come to life as they explore the wonders of magnetism.

**Writing connections**

Children can create a Venn Diagram to document their findings from their Investigating. The diagram will be used to record the children's work to later display the information to share with their classmates. Provide a Venn Diagram worksheet to each pair of children with one side labeled "Magnetic" and the other side labeled "Non-Magnetic." Children can draw pictures on each side depending on their findings, if possible, encourage them to write down the words of each item instead. During sharing information, everyone can come together as a group to make a class Interactive Venn Diagram. Overlap two hula hoops to form a Venn Diagram. Have children sort, compare, and contrast their items. Once everything has been placed in the diagram, have children explain their reasons for their sorting.

**Math connections**

At the end of the Investigating section, children separated items into two categories, the objects that were attracted by magnets and the objects that were not. Children can use a ten-frame as a graphic tool to record the number of items from each category. You can create a ten-frame using colored tape to make ten sections on a baking sheet or tray. [Note: You can number each section to help children visualize the numbers within the ten-frame.] Before you begin the activity make sure each child has a magnetic labeled picture card that they used during Getting Started. As a class, you can begin with the first category of objects that were attracted by the magnets. Call one child at a time stand up and place their labeled picture card in the ten-frame if it is magnetic. [Note: Make sure that there are no more than 10 items per category.] Repeat the same procedure for the objects that were not magnetic. The ten-frame will help children build number sense by helping them keep track of counting, learn addition to 10, and understand place value. As they play with the magnetic labeled picture cards and the baking sheet, they are adding from a magnetic surface.

**Child's Life Connection**

Children will be going on a magnetism scavenger hunt! Have children use magnets to test different objects around the classroom. Remind children to not test their magnet on computers as it could cause permanent damage. As children are exploring, ask them "Do you think that object will stick to the magnet? What makes you believe that?" [Note: There should be various magnetic objects that children can test in the classrooms (e.g., white board, chairs, legs of the table, scissors, keys, etc). However, if needed, set out a small collection of different magnetic objects throughout the classroom for children to explore.] Encourage children to document their findings by drawing pictures of the magnetic items they found. Once they have tested a few items, gather the children to have a discussion about which new objects attached to the magnet and what did not.

**Center Connections**

At the *art center*, children can use magnets to paint pictures. Have children use an aluminum food container, paper, paint, a metal object, and a magnet to create their work of art. Inside the aluminum food container should be a blank white piece of paper, a small amount of paint, and a small magnetic object in the paint. [Note: If you have strong magnets, you can use the sensory table for this activity. Place the magnet under the table and all the other supplies on top of the table and proceed with the activity.] Children move the magnet beneath the container in order to move the magnetic object to create a masterpiece! Encourage children to try different paint colors and different magnetic objects. In the *sensory table*, children will go on a treasure hunt. Fill a box with rice (or sand if preferred) and mix various magnetic and non-magnetic items in it. Provide a magnet wand for each child. Let children explore the sensory box discovering which items are magnetic and which ones are not. Children can use their magnet wands to find the magnetic treasures buried in the rice and then use their hands to uncover the nonmagnetic items. During *dramatic play*, children can become life-size imaginary magnets! Children can work in small groups to imagine and act out being a magnet. Some children can be assigned to be the magnets, while the rest of the class will get one of the magnetic labeled picture cards. Encourage children to create stories about which objects the magnet will be attracted to and which objects it will not. Children can describe one of their investigations from the previous activities and compare how it was similar or different from another classmate's investigations.

**Family Activity**

In school your child has been exploring magnets. You can increase your child's understanding and interest in magnetism by asking him or her to talk about the different activities we are doing at school. Show your child how you may find magnets at home, perhaps, holding notes on the refrigerator or maybe even securing cabinets closed. Many household items are made of materials that are attracted to magnets. Some of these items are refrigerators, bed frames, and washing machines. Magnets are easy to use, safe, and fun! Talk over some ideas with your child about what he or she think might be magnetic. Then begin the investigation! Explore together with your child to test different household items and determine which are magnetic. Be sure to encourage him or her to try different items in each room of the house. As part of their exploration, encourage your child to make predictions along with you about which items they think might be attracted to the magnet. What type of things in your house do you think might stick to the magnet? Will it stick to the doorknob? What about to the towel hanger? These activities allows the whole family to look more closely at magnetism and around your home!

Assessment- What to Look For

**Can children describe the properties (magnetism) of different objects based on observations?** (using sense to gather information, identifying properties, using complex patterns of speech)

**Can children compare objects to identify similarities?** (identifying/comparing properties, explaining based on evidence, using new/complex vocabulary)

**Can children communicate their learning through speech, writing, and/or drawing?** (using new/complex vocabulary, listening to and understanding speech)

Standards

**Head Start Early Learning Outcomes Framework**

P-SCI 1. Child observes and describes observable phenomena (objects, materials, organisms, events, etc.). "Makes increasingly complex observations of objects, materials, organisms, and events. Provides greater detail in descriptions. Represents observable phenomena in more complex ways, such as pictures that include more detail."

**Next Generation Science Standards**

SEP 6. Constructing explanations and designing solutions. "Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena."

**Common Core State Standards – Math**

1.MD.C.4. Represent and interpret data. "Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another."

**Common Core State Standards – ELA**

SL.K.1. Comprehension and collaboration. "Participate in collaborative conversations with diverse partners about kindergarten topics and texts with peers and adults in small and larger groups."

# APPENDIX C

## FINAL "WHICH MAGNET IS STRONGER?" LESSON

## Appendix C

## Final "Which Magnet is Stronger?" Lesson

Introduction

**Lesson Summary:** Investigating the strength of different magnets.

**Learning Objective:** Children will explore the strengths of multiple magnets and realize that some magnets are stronger than others. Children will record and analyze data to conclude which magnets are stronger.

**Materials:** Magnets of varying size and type that can be held by a clothespin (e.g., ring magnet, bar magnet, disc magnet, cylindrical magnet, etc.); 60 large paper clips per group; 1 clothespin per group.

**Safety:** Magnets can attract sharp pieces of metal, be aware of how children are using the magnets to not cause any injuries. Also, magnets can cause permanent damage to electric equipment. Don't use magnets on computers and other electronic devices as it could damage the magnets inside of them. Make sure children keep a distance of these devices or keep out of the reach of children.

**Teacher Content Background:** The force exerted by a magnet is called magnetism. Force is a push or a pull that can change the position of objects, various forces act on contact while others act without touching the object. The push or pull of magnetism can act at a distance, which means that the magnet does not have to touch an object to exert a force on it. Generally large magnets are stronger than small ones, but not always. Magnets that are made of different materials have differing degrees of magnetic force. A magnetic field is a force exerted on objects around a magnet. The magnetic field of one magnet will interact with another magnet or a piece of material that can be magnetized. Strong magnets are made from neodymium, boron, and iron.

Neodymium magnets are by far the strongest type of permanent magnets. Magnets made of neodymium are less likely to be demagnetized compared to other magnets. A smaller strong magnet has a stronger pull than a much larger common magnet. The strength of a magnet depends on the size, shape, and components of the magnet.

## Procedure

### Getting Started

*Introduction:* Attach a strong magnet to a metal object and invite children to attempt to separate them. Use this experience to prompt a discussion about the strength of magnets. Ask children questions such as, "Do all magnets have the same strength? How can you tell if a magnet is strong? Are bigger magnets stronger than small ones?" Explain to children that they will be exploring the strengths of different magnets.

*Prompting questions/Initial explanations:* To start this investigation, show the children the different magnets that they will be exploring and ask them, “Which of the magnets do you think is the strongest?” Have children make predictions and arrange the magnets in order from strongest to weakest. Once children have made their predicted and arranged their magnets ask them, “How can we find out which is the strongest?” Ask children to explain their reasoning to the prompting questions and make predictions to which magnet they think will be the strongest.

### Investigating

*Experimenting:* [Note: Before children begin their investigation, set up their workstation. Tape a clothespin to the edge of the table. Once the clothespin has been taped, open the clothespin and place one of the magnets in between the wooden sticks. Once that has been set up, form a hook with a paperclip and attach it to the magnet that is fasten in the clothespin. Demonstrate to the children an example of how to conduct their investigation.] Children will manipulate different magnets and see how many paper clips attract to each one. Divide children into groups of 4 and have a station for each group with the 4 different magnets and paper clips. Let children know that they will explore which of the magnets can hold the most paper clips. Encourage children to take turns within their group and carefully add one paperclip at a time to the hook. As children are conducting their investigation, guide their exploration by asking them, "Why do you think this magnet was able to hold more paperclips? Where there any magnets that held the same amount of paperclips?" Make sure that each child has an opportunity to test each magnet.

*Observing/Documenting:* Provide a data table similar to the one below for children to document how many paper clips held onto each magnet before it was too heavy for the magnet to hold. [Note: Make sure to add the pictures of Magnets 1-4 based on what you decide for your lesson.] Ask children to compare within their group if they were able to hang the same amount of paper clips for each magnet. Have children determine if the results were the same or different. Encourage children to discuss some possible explanations for why that is. During Getting Started, children predicted which magnet they thought was going to be the strongest, ask, "Have you changed your mind about which magnet is the strongest? Why have/haven't you changed your mind?"

| **Picture of Magnets** | **Tally Marks of Paper Clips** | **Number of Tally Marks** |
|---|---|---|
| Magnet 1 | | |
| Magnet 2 | | |
| Magnet 3 | | |
| Magnet 4 | | |

**Making Sense**

*Describing findings:* Gather the whole class together and encourage children to talk with different groups about their observations. Promote their understanding that there are different types of magnets and the different type of magnets have different strengths by asking, "Did all the magnets hold the same number of clips? Which magnet held the most paper clips? Which magnet held the least paper clips? Was the largest magnet the strongest? Was the smallest magnet the weakest?" [Note: Each magnet is not going to hold up the same number of paper clips in each group. It is important to acknowledge each child's response, as it might differ from group to group. With older children, prompt them to discuss the possible reasons for the differences.] Ask children, "How did you decide which magnet was the strongest?" Ask them to reflect on their initial prediction about which magnet they thought would be the strongest. Have them compare their initial explanations to the results of their investigation.

What's next?

**Extension Activity**

Children can further experiment with their different magnets to test which magnet is the strongest. Children can begin a new investigation by measuring which magnet can attract something from the furthest distance. Ask children, "Which magnet will attract say a paper-clip from the furthest distance?" Have children place a paper clip at the end of a ruler at the 0 inch mark and place one of their 4 magnets in the other end of the ruler at the 12 inch mark. Children can slowly move their magnet closer to the paper clip. Once the magnet attracts the paper clip ask children to record how far down the magnet have to move to attract the magnet. Make sure they do this with all 4 magnets. Promote a discussion with all children by asking, "How can we tell which magnet was the strongest? Were all of the magnets the same in strength?"

**Science Vocabulary**

| Science Word | Definition/Description | "Familiar" Words for Children |
|---|---|---|
| Attract | To move together or stay together | Attach |
| Investigate | To make an observation or prediction and then find out what happens | |
| Magnet | Shiny, dense, hard, and strong materials that allow heat and electricity move through it | |
| Strength | How strong something can be | |
| Repel | To move something away | Push |

Connections

**Reading connections**

Early literacy skills can be supported throughout this lesson. Children can learn more about the different kinds of magnets and how they are used through books such as, *Learn About Magnets* by Steve Parker. This book provides a variety of experiments and other activities children can try at school and/or at home to continue learning about magnetism. In *The Science Book of Magnets* by Neil Ardley, *Magnetism* by Mari Schuh, *Magnets* By Karen Bryant-Mole, *All About Magnets* by Stephen Krensky, and *Magnetic Electricity! The Power of Magnets and Their Role in*

*Electricity* by Baby iQ Builder Books, children will learn about the properties and behaviors of magnets through fun interactive readings!

**Writing connections**

Children will discover which part of their horseshoe magnet is the strongest. Have children link paper clips together and see how many paper clips the end of the magnet can hold and how many paper clips the center of the magnet can hold. Children will organize the paper clips according to their ability to be attracted by the magnet. Provide a blank sheet of paper for children to draw the magnet they will be using. On their picture have them draw the number of paper clips they were able to hold in the center of the magnet and at the end of the magnet. You can have a class discussion by having children use their pictures to describe what they learned. Ask them, "What part of the magnet held the most paper clips? What does that tell you about the magnet? What was interesting?" [Note: If children have advanced writing skills, along with your help, encourage them to write their answers on their drawings.]

**Math connections**

In Investigating, children documented how many paper clips each magnet held up. This information can be used to make a bar graph. Children can use the bar graph to compare how many paper clips each magnet picked up and decide which one is the strongest based on which magnet has the most paper clips. Draw the vertical and horizontal axes to make your graph. On the horizontal axis draw the type of magnets that were used during Investigating. Label the vertical axes with the number of paper clips. You will be using a scale of 1. Have children count the number of paper clips they picked up with each magnet and color in the correct number of squares in each column of the bar graph. Children can also tape the correct number of paper clips to each column of the bar graph. The bar graph is an easy representation of their data and, in this case, it will allow children to know that the longest bar will represent the strongest magnet as it held the most paper clips. Using the bar chart as a documenting tool can allow students to try new magnets and compare them to the existing ones they have been working with, it will be easy to compare data at a glance.

**Child's Life Connection**

Forces make objects move, some forces act by touching and other forces can act without touch. In the Extension Activity children explored how an electromagnetic force can cause paper clips to move, and were likely amazed as this invisible force caused the paper clips to jump onto the magnet. Forces are all around us - any time there's motion, it has been caused by a force. Children can search for forces at work in their everyday life, from pushing their pencils as they write their names to pulling a handle to open a door. The book, *Forces Make Things Move* by Kimberly Brubaker Bradley is a great way to explain to children how forces make things move, but they also make things stop. They will also learn how forces can be very strong, but it can also be weak! As this lesson focuses on the strength of magnets, this book will allow children to understand how forces are all around them. Remind children that a force is a push or a pull; engage children in a discussion by asking them how they use forces at home or at school.

**Center Connections**

In the *sensory table* challenge children to continue exploring the question, "Are some magnets stronger than other magnets? How can we find out?" Provide several magnets and magnetic objects at the table. Allow children to discover which magnet is stronger by having them place a magnetic object between two magnets. Ask children, "How will you know which magnet is stronger?" Children can try pulling apart the two magnets. Have them repeat this process multiple times to verify their results. Children can explore this activity by trying it with different magnetic objects to see if the results are the same. During *dramatic play* children can create a puppet story by creating a story using magnet puppets. But first, in the *art center*, give children index cards to draw and color puppet characters that they will be using for their story. Children will cut out the puppets and tape a magnet to the back of each index card, creating a "magnet puppet." On a large section of cardboard, children can draw some scenes from the story that they will be sharing about how magnets are strong. During *dramatic* play, have children use magnets behind the cardboard scene to move the puppets while someone narrates the story out loud to the class.

**Family Activity**

This week at school, your child has been learning about magnets. Children have explored how strong magnets can be by testing different magnets and trying to pick up the most paper clips. Your child has been sent home with a magnet and paper clips to try a fun activity with you at home! Your child knows that paper clips will stick to their magnet, but now we want to test how strong their magnets will be if they had a small barrier. You and your child will add 3-5 pieces of masking tape to the bottom of your magnet and see how many paper clips you attach to it (make sure the paperclip touches the tape and not another part of the magnet). Repeat the process by adding 3-5 pieces of masking tape each time. Encourage your child to make observations by asking them, "What do you notice about the paper clips as we add more tape? Is the magnet able to hold more, the same, or fewer clips? Do you think that the tape is causing this? Why?" Keep in mind that the goal of this activity is for your child to notice what happens to the strength of the magnet as you add more layers of tape.

Assessment-What to Look For

**Can children design an experiment to compare the strength of magnets?** (comparing properties, planning and carrying out investigations)

**Can children record data about which magnet is the strongest?** (documenting and representing findings, using computational thinking)

**Can children use data to support their decision on which magnet is stronger?** (identifying patterns and causality, explaining based on evidence, using complex patterns of speech)

Standards

**Head Start Early Learning Outcomes Framework**

P-SCI 5. Child plans and conducts investigations and experiments. “With increasing independence, engages in some parts of conducting complex investigations or experiments. Uses more complex ways to gather and record data, such as with adult support, makes a graph that shows children's favorite snacks.”

**Next Generation Science Standards**

SEP 3. Planning and carrying out investigations. “Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question. Make observations (firsthand or from media) and/or measurements to collect data that can be used to make comparisons.”

**Common Core State Standards – Math**

1.MD.C.4. Represent and interpret data. “Organize, represent, and interpret data with up to three categories; ask and answer questions about the total number of data points, how many in each category, and how many more or less are in one category than in another.”

**Common Core State Standards – ELA**

W.K.3. Text types and purposes. “Use a combination of drawing, dictating, and writing to narrate a single event or several loosely linked events, tell about the events in the order in which they occurred, and provide a reaction to what happened.

# REFERENCES

## REFERENCES


American Association for the Advancement of Science. (1993). *Benchmarks for science literacy*. New York, NY: Oxford University Press.

American Association for the Advancement of Science. (2000). *Designs for science literacy*. New York, NY: Oxford University Press.

Bächtold, M. (2013). What do students "construct" according to constructivism in science education? *Research In Science Education*, *43*(6), 2477-2496.

Bybee, R. W. (1997). *Achieving scientific literacy: From purposes to practices*. Portsmouth, NH: Heinemann.

Carr, J. W., Sexton, U., & Lagunoff, R. (2007). *Making science accessible to English learners: A guidebook for teachers*. San Francisco, CA: WestEd.

Carson, R. (1956). *The sense of wonder*. New York, NY: Harper & Row.

Chalufour, I. (2010). Learning to teach science: Strategies that support teacher practice. In *Early Childhood Research and Practice: Collected Papers from the SEED Conference, 10*. Retrieved from http://ecrp.uiuc.edu/beyond/seed/chalufour.html

Colburn, A., & Clough, M. P. (1997). Implementing the learning cycle. *Science Teacher*, *64*(5), 30-33.

Crawford, B. A. (2007). Learning to teach science as inquiry in the rough and tumble of practice. *Journal of Research in Science Teaching, 44*(4), 613-642.

Eshach, H., & Fried, M. N. (2005). Should science be taught in early childhood? *Journal of Science Education and Technology*, *14*(3), 315-336.

Fosnot, C. T. (1996). Constructivism: A psychological theory of learning. In C. T. Fosnot (Ed.), *Constructivism: Theory, perspectives, and practice* (pp. 8-33). New York, NY: Teachers College Press.

Goldston, M. J., Dantzler, J., Day, J., & Webb, B. (2013). A psychometric approach to the development of a 5E lesson plan scoring instrument for inquiry-based teaching. *Journal of Science Teacher Education*, *24*(3), 527-551.

Gordon, A. M., & Browne, K. W. (2013). *Beginnings & beyond: Foundations in early childhood education*. Belmont, CA: Cengage Learning.

Marek, E. A. (2008). Why the learning cycle? *Journal of Elementary Science Education*, *20*(3), 63-69.

National Research Council. (1996). *National science education standards*. Washington, DC: National Academy Press.

National Research Council. (2000). *Inquiry and the national science education standards*. Washington, DC: National Academy Press.

Nayfeld, I., Brenneman, K., & Gelman, R. (2011). Science in the classroom: Finding a balance between autonomous exploration and teacher-led instruction in preschool settings. *Early Education And Development*, *22*(6), 970-988.

Ritz, W. C. (2007). *A head start on science: Encouraging a sense of wonder*. Arlington, VA: NSTA Press.

Shanahan, T. B., & Shea, L. M. (2012). Incorporating English language teaching through science for K-2 teachers. *Journal of Science Teacher Education*, *23*(4), 407-428.

Shea, L. M., & Shanahan, T. B. (2011). Methods and strategies: Talk strategies. *Science And Children*, *49*(3), 62-66.

von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. Steffe & J. Gale (Eds.). (1995). *Constructivism in education* (pp. 1-10). Hillsdale, NJ: Lawrence Erlbaum Associates. Retrieved from http://www.vonglasersfeld.com/172