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Teaching Place-Based Science in Kindergarten

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Teaching Place-based Science in Kindergarten:
An Action Research Project

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Abstract

This action research explores how kindergarten students learn about forces and motion through inquiry-based, place-based methods. The learning took place as part of an existing day spent learning outdoors, known as Forest Monday, that includes extended time for free play. The three sub-questions addressed 1) science content learning, 2) science practice application, and 3) the incorporation of science content and practices into free play time outdoors. It was a mixed-methods study, with science assessment data supporting observations and interviews. The participants were 12 kindergarten students in a rural elementary school. All students were assessed and interviewed but observations were focused on a subset of three students. Analysis used predetermined categories from science topics and practices. Critical findings were that 1) students met content learning expectations, 2) students used extensive investigation practices, some analysis, and little planning, and 3) students incorporated science content and practices into play with varying levels of awareness and more often during longer periods of play. At a time when kindergarteners get little time for inquiry science or play, this action research provides evidence that play can support students in meeting science learning goals. It serves as an example of teaching in a way that connects students with their place and local phenomena.

Keywords: place-based education, place-based science, inquiry-based science, outdoor learning, environmental education, kindergarten science, Forest Kindergarten

Introduction

Most kindergarteners look forward to Monday when they go back to school after the weekend, see their teacher, and play with their friends. But my students are especially eager for Mondays, especially if there has been a big snowfall or it's a particularly warm and sunny day. Soon after arriving at school, we dress into waterproof gear and head into the woods behind our school for an entire day of outdoor learning. The students carry their backpacks along a difficult trail involving stream crossings, steep hills, and pricker bushes. They help each other with the challenges of this hike and then spend the day engaging in meaningful play, social navigation, physical movement, and inquiry into the happenings of the natural world. One daily routine is visiting Sit Spots, where each student returns to the same spot and uses all their senses to take in their surroundings, gaining valuable self-regulation skills and connecting with nature.

This is the background for an action research project which aimed to enrich my students' existing experiences with outdoor learning. My regular "Forest Monday" program aims to address many complex and intertwined issues. Kindergarten students face increasingly high academic demands and children start school already behind. These children often lack social, emotional, and motor skills. Children are spending less time outside and more time on screens, which is not helping them gain skills in any of these areas. And the connection to nature that many in previous generations took for granted is not always present for children now.

As literacy and math become the focus of instruction, science often takes a backseat. This is not new—in American public schools, science only became a common elementary school subject starting in the mid-twentieth century. In those days students may have spent more time outdoors on their own, and thus been exposed to more of the natural and physical world. But when science was taught in school, it was very textbook-based. The standards movement of the

'90s brought science standards into the picture, and in 2013 the Next Generation Science Standards were exactly what their name says. NGSS includes science practices and cross-cutting concepts alongside traditional content, declaring that learning how to do science is just as important as mastering science information.

With my background in outdoor, place-based education, I wanted to challenge myself to bring intentional science teaching into my existing Forest Monday program. It laid the foundation for outdoor learning, but I wanted to enrich it with engaging science content and authentic science practices.

Though Maine has not adopted NGSS as a state, my district is beginning to prioritize science instruction at the elementary level. We have recently started a slow roll-out of inquiry-based science materials called Stemscopes. I can see that much of the content is relevant to what my students are experiencing outdoors and that the units would be better taught in connection to our local animals, plants, and physical phenomena. I have been eager to find the time to begin to implement place-based practices in a systematic way. Science, with its increased support from the district as well as easily connected to the outdoors, seemed like a good way to incorporate place-based practices into my instruction.

I know there is interest across the district in incorporating more outdoor learning into science. My hope is that this action research can serve as an example to other elementary (and especially kindergarten) science teachers. Another goal is to provide direct academic connection to Forest Days, further validating the emerging program.

As a practitioner, I wanted to see what it would be like to teach a place-based, outdoor science unit within an existing Forest Day program. By implementing place-based, outdoor science, I wanted to see if my students retained the science content, could use the science practices, and could incorporate their new learning into their free play outdoors. My hope was that it would make science relevant, authentic, and engaging for them as well as enrich the connection to nature that they have been building all year.

Literature Review

This action research project lies at the intersection of Forest Kindergartens, place-based education, and inquiry science. Child development experts place five- and six-year-olds in the stage of early childhood and Piaget puts them in the pre-operational stage where they are acquiring the language and experience they need to think more abstractly. Yet policy requires children to enter formal schooling by age 6 or 7, though most start earlier, where they join older children who have different needs. Thus, because it serves the youngest students, kindergarten is different from the rest of elementary school and presents a unique opportunity to blend pedagogy and practices from early childhood and elementary.

This literature review will start broadly with inquiry science in kindergarten, move into project-based science, place-based education, and finally narrow to Forest Kindergarten. I will summarize the relevant history of these pedagogies, describe the findings of relevant studies, and discuss implications for my own research. Because my action research is nested in these areas, I searched the literature for all of them and selected a few from each category. Of the twelve pieces of literature I include, half relate mostly to place-based education: a book (Sobel, 2013), two program evaluations (Powers et al., 2004 and Rote et al., 2015), one encyclopedia entry (Smith, 2017), a book that is a meta-analysis (Marzano, 2003), and a piece of teacher action research (Endreny, 2009). I include two studies on kindergarten inquiry science: a quantitative, year-long study with a control group (Samarapungavan et al., 2011) and an ethnographic study (Siry, 2013). For project-based learning, I use a qualitative meta-analysis (Hasni et al., 2016).

And to look at Forest Kindergartens specifically I have three sources: another book edited by Sobel (2016), a program evaluation (O'Brien and Murray, 2007), and another ethnographic study (Anggard, 2010). This collection represents the breadth of work and methodology around the intersection of Forest Kindergarten, place-based education, and inquiry science.

Inquiry Science

Effective science teaching invites students to be scientists and investigate problems, search for solutions, make observations, test out ideas, and share their learning: this is inquiry science. For the past few decades, research has shown that inquiry-based learning leads to deeper conceptual understanding in science as well as an awareness of the nature of science (Samarapungavan et al., 2011). Furthermore, inquiry science methods have been advocated for in recent policy documents and they are central to the most up-to-date standards, the Next Generation Science Standards. In short, inquiry science is well-known to be highly impactful on student learning, although in the climate of Common Core and focusing on literacy and math, it is often not taught in this manner in many schools (Siry, 2013).

Samarapungavan et al. (2011) conducted extensive research on the learning of kindergarteners through inquiry-based science. Through a large, federally-funded research program—the Science Literacy Project—public school kindergarteners participated in a yearlong curriculum of six inquiry-based science units. The researchers used a control group of kindergarteners from schools that did not implement the SLP curriculum. Using a pre- and post-test model, they measured science content and inquiry process learning through two assessments and portfolio rubrics. They found that the students who learned through the inquiry-based model made significant gains in all of the measures of science learning and significantly outperformed their peers.

This study is the closest I have found to the inquiry science aspect of my action research and has some practical as well as theoretical implications. First off, it shows that students as young as kindergarteners can “at least partially simulate authentic scientific inquiry” (p. 462). While this is promising in terms of the ability of kindergarteners’ ability to undertake high-level practices, I do not agree with Samarapungavan et al.’s view of this age group in comparison to adult scientists. In contrast, Siry (2013) showed how kindergarteners can produce complex knowledge using inquiry methods in their own right, without comparing them to fully developed adult scientists. Using ethnographic methods, Siry (2013) explored the way that kindergarteners can produce knowledge when engaged in open-ended, investigative activities. The inquiry science on sinking and floating that Siry’s students accessed was much more open-ended, play-based, gave the students much more time with the materials, and was less teacher-directed. Siry’s (2013) research stance assumes that children’s playful and everyday interactions with the world “embody the ideals of scientific inquiry” in a developmentally relevant manner (p. 2).

The contrasting science programs and research methods from Samarapungavan et al. (2011) and Siry (2013) provided me with practical ideas for working with my own kindergarteners. Samarapungavan et al. (2011) include extensive lesson excerpts, both from teachers using inquiry methods and from teachers who were not. These showed me the clear distinction between inquiry science and “hands-on” science, which these teachers considered to be any activity with materials or manipulatives. Many of these “hands-on” activities were themed around science but ranged from cutesy to downright counterproductive, such as pasting mini marshmallows as teeth onto two arcs drawn on paper when learning about dental hygiene. From the inquiry science lessons, excerpts and subsequent analysis showed how these teachers modeled aspects of the inquiry method that students were not doing or not aware of. They did this naturally through discussion of a book or experience that the students had had together, naming and modeling *questioning, predicting, and inferring.* It was clear that the discourse norms of inquiry science allowed the students to share disagreements comfortably.

A strength of Science Literacy Project program units for kindergarten was also that inquiry did not necessarily mean formal manipulated experimentation. Samarapungavan et al. (2011) discuss that formal experimentation is easier to do in the upper elementary grades and at the secondary level. In fact only a little of the inquiry that the kindergarteners did was experimentation. Much of it was naturalistic and semi-naturalistic observation such as in the life sciences. The authors stated that the goal of the program was not to expect kindergarteners to complete a full cycle of inquiry but to expose them to and give them practice with some of the skills that are part of a complete cycle.

One critique that I have of this program is that the inquiry is still very structured and teacher directed. In contrast, Siry's (2013) thick description showed how a more open-ended process can lead to complex learning results. In some cases in the Samarapungavan et al. study, the teachers tried to structure discussion too tightly and ended up stating their own misconceptions (without knowing they were misconceptions). It also focused explicitly on knowing the *names* of the formal inquiry method, which I do not think are as important in the early grades as simply teaching students how to use them. Siry makes no mention of the formal scientific inquiry process, though does describe the same parts (*questioning, predicting, inferring)* that Samarapungavan et al. emphasize. Other critiques of the teaching methods in Samarapungavan et al. are solved by substituting place-based topics (e.g., a conceptual approach rather than an organismal one, few outdoor experiences, and very tightly structured ones at that, more knowledge oriented than sensory oriented.)

Siry emphasized the importance of repeated action in the play of kindergarteners as they interact with new materials. She described how what may be everyday interactions around water (such as in a sink or bathtub) are brought into new light when given importance at school and when teachers show true curiosity towards students' evolving ideas. She emphasized plenty of *time* for student investigation and follow-through as well as teachers who are watching closely, asking open-ended questions, and carefully suggesting ideas to gently nudge students along their own investigations. This is very much in the vein of Duckworth's (2006) methods of "critical exploration." Siry warned against the danger of overly simplified sorting activities posing as investigation (e.g. find out which objects sink and which objects float) because this reduces science to a question-and-answer problem rather than relevant investigation of complex ideas. Siry shows that kindergarteners are able to grapple with complex ideas (such as buoyancy) when given the opportunity.

When I modified the existing Stemscopes unit, I became aware that it did not teach inquiry methods explicitly the way the teachers in the Samarapungavan et al. study did nor did it give much open-ended time for investigation the way Siry recommended. But this question of time and student-directed, open-ended investigations is something I will return to in the discussion section.

Project-based Learning and Place-based Education

A subset and related area to inquiry-based learning is "project-based learning," where teachers turn inquiry methods towards real world problems for their students to investigate. Project-based learning includes more collaboration between students, teachers, and community members and involves students creating some kind of artifact of learning at the end of their work. In a large, recent meta-analysis of project-based science and technology education, Hasni et al. (2016)

found that this method positively impacted student learning and achievement as well as their motivation and interest in science. The researchers conducted qualitative analysis on a set of 48 K-12 peer-reviewed studies on project-based learning in science and technology. These studies were mostly middle and high school, but included six elementary school examples.

Some of the studies in the meta-analysis describe guiding principles for designing project-based curriculum materials. This was only slightly relevant to my action research because I adapted an existing unit rather than developed a full curriculum. But something that was important for me to keep in mind was the concept of *contextualization*—making sure to explicitly connect the learning goals to the students' own experiences and real world problems. Hasni et al. (2016) cite one study that describes this process as teachers "create demand" for the science content through the problems they orient the students towards.

Most project-based learning examples are from the upper grades because, like place-based learning, that is when the pedagogy in its full conception is developmentally appropriate. I'll move into a discussion of how the methods of place-based learning translate into the kindergarten level, but first: What is place-based learning or place-based education (PBE)?

Place-based education shares many of the instructional approaches to project-based learning, but it adds on the higher goal of social and environmental justice. It goes beyond the inquiry methods, collaboration, final artifact, and real world problems of project-based learning by being concerned with the health of the greater community and environment. PBE is a kind of teaching and learning which roots itself in the students' unique local culture, history, economy, and natural environment. It uses *place* as a springboard for learning along a continuum from the scale of inviting community members into the classroom as guest speakers to an entire integrated, problem-based curriculum. At its most basic level, PBE invites learners to ask these questions: "*Where am I? What is the nature of this place? What sustains this community?*"

Many of the same concepts of PBE have been called by different names: environment as an integrating context (EIC), civics education, community-based learning, environment-based learning, sustainability education, project-based learning, and expeditionary learning. They all share an interdisciplinary approach to learning that uses the local community and environment as the basis for projects. The ultimate goal of PBE and many of these related pedagogies is to forge stronger attachments in children to their communities and to teach action skills in order to promote civic engagement in light of social and environmental injustice.

Place-based education has roots in the early 20th century. Longtime PBE researcher and historian Smith describes it as a response to the newly widespread public education in the 19th century, whose goal, he claims, was "to diminish children's and young people's affiliation with particular communities and places in order to better prepare them to participate as citizens of nation-states and mobile workers in emerging industrial economies" (2017). For the last century we have been recovering from industrialization: with Dewey's call for "learning by doing," his student Kilpatrick who coined the term "project-based learning" and Hahn and the early years of Outward Bound.

From the 1970s we gained environmental education (EE), and in one sense PBE can be seen as an "extension and refinement of EE" (Powers et al., 2004). Environmental educators knew that students needed to learn the facts about environmental degradation. And in the 1990s, place-based educators continued to respond to the increasing globalization, resulting environmental and social issues, and homogeneity in education that they saw compounding the other problems. They claimed that to truly engage with the vast environmental and social problems on a manageable scale, students needed a deep local knowledge of place. This knowledge could then be related to larger national and global phenomena as developmentally appropriate (Sobel, 2013). In the early 1990s Zucker-Lane and Elder of the Orion Society of Massachusetts coined the term "place-based education" and helped inspire a growing grassroots effort to support teachers in adopting place-based practices.

In Smith's entry in the Oxford Research Encyclopedia of Education on PBE, he writes that in the big picture, this kind of education is nothing new:

> It is an attempt to reclaim elements of the learning processes most children encountered before the invention of schools. Throughout most of humanity's tenancy on this planet, children learned directly from their own experience in the places and communities where they lived. They explored their world with peers, imitated the activities of adults, participated in cultural and religious ceremonies, and listened to the conversations and stories of their families and neighbors…. In this way, children grew into competent and contributing members of their society, able to care for themselves and for others in ways that sustained the community of which they were a part. (2017)

For the past twenty-five years, PBE has continued to grow slowly as part of environmental education centers, nonprofits, informal education, and schools. A scattering of K-12 private schools exist that focus on place-based education, and some public schools are adopting aspects of it. Since Sobel and the early 1990s, place-based educators and organizations have been promoting PBE by citing improvements in the triad of student achievement, community vitality, and ecological integrity. Program evaluations and reports abound, but because PBE is so holistic, its goals so lofty, and its projects so underfunded, the body of peer-reviewed research around it is still lacking. Proponents of place-based education see its positive results around engagement, learning, community, and environment, and the program reports and evaluations show this anecdotally. But in the era of No Child Left Behind and the Common Core, PBE's credibility must also come from showing school administrators and policymakers how it increases student achievement.

Marzano has shown the clear link between student achievement and motivation: if students are motivated to learn, there is a good chance that they will achieve well in that subject area (2003). Thus, the program evaluation of place-based education initiatives often focuses on the effects of PBE on motivation and engagement, expecting that this will lead to increased student achievement (Powers, 2004; Rote et al., 2015). One of the most landmark reports in this area is still the 1998 report by Lieberman and Hoody who looked at 40 schools in California who used environment as an integrated context, which is essentially PBE. This report was collaboration between many states' boards of education and the PEW Charitable Trust. Based on data collected from teacher interviews and surveys and mostly teacher-reported grades and achievement on standardized tests, it found overwhelmingly that students learn more effectively through PBE. The serious limitation was that of the 40 schools, they only received firsthand achievement data from 14; the rest of the data was teacher reported.

Peer-reviewed studies on PBE's effects on student learning and achievement are rare, and of them, elementary examples are even rarer. Siry briefly alludes to PBE in her work looking at the ability of kindergarteners to learn complex science concepts, summarizing Kohn's ideas: "when experiments are relevant to children's experiences, interests, and theories, [they] can actually understand the relationship between density and buoyancy" (Siry, 2013, p. 31).

Endreny (2009) found that a place-based unit on watersheds helped urban 5th grade students learn science content towards standards. Endreny is a university researcher with classroom teaching experience who came into two different classrooms to teach this watershed unit. In this way, her work was the closest I could find to my action research. Using qualitative methods and a variety of qualitative assessments (including science journals and interviews), Endreny coded for different science concepts and described the increases in concept knowledge present in the students' work after the unit. Their direct experience with the watershed combined with supporting indoor lessons—all under the umbrella of inquiry—allowed all of the students to make progress towards the standards.

Because of the age difference in our students, Endreny's study doesn't have direct practical implications for my methods. It does provide an inspiring example of a place-based unit taught in elementary school and shows how PBE "can positively influence standards-based curricula instead of detract from it" (p. 515). By its nature PBE follows the developmental abilities of students, so it looks quite different at different grade level bands. Sobel's (2013) research is based on how children's relationships to the natural world change as they develop. He divides childhood up into three stages: The early childhood years (ages 4-7) where the focus of education is *empathy with the natural world*, the early elementary years (ages 8-11) where the focus is *wider exploration*, and early adolescence (ages 12-15), where the focus is *social action*. It is important for all practitioners to understand PBE's whole trajectory, even though in early childhood it looks vastly different from the action-oriented approach of the upper grades. In early childhood, one of the most holistic ways to teach in a place-based manner is the Forest Kindergarten model.

Forest Kindergartens

Forest Kindergartens are of the same vein of PBE, but were developing in Europe before PBE had a name. One of the first and most influential programs in Sweden in the 1950s was part of the greater European outdoor school movement that had waxed and waned over the last century. In the mid-nineteenth century, Froebel asserted the importance of young children playing and learning in the natural world. One of his most famous contribution to education is in fact the idea of kindergarten, quite literally, a garden for children to play and learn in. The kindergarten teacher is a “gardener,” who in a sense “prepares the soil” by providing the things necessary for the children to grow, but allows them to grow on their own (Anggard, 2010). Other progressive educators like Montessori and Steiner also emphasized nature’s benefit to young children. And the constructivist approach from Piaget and Vygotsky is central to Forest Kindergarten pedagogy.

Throughout the ‘70s and ‘80s these outdoor kindergartens spread throughout Scandinavia and to parts of Europe, and more recently to the United States. More and more recent research has shown benefits to children’s behavior, creativity, and health (Sobel, 2016).

In Europe, Forest Kindergarten encompasses the ages of two to seven, and is essentially a form of what Americans would consider preschool. It includes five- and six-year-olds in countries where children do not start formal schooling until age six or seven, such as Denmark. It is non-academic and students spend most or all of their time outdoors every day, in all weather. Forest Kindergartens may have a small heated shelter where younger students can nap during a full-day program, or it may only have a simpler unheated tarp or teepee structure to keep out rain. Programs use the closest available woodland or natural area, which may be part of a park or behind a school. They may have trails, campfire circles, child-made forts, thickets, climbing trees, streams—a diversity of places to explore. European Forest Kindergarten teachers take their role as facilitator seriously as they sit back and let the children dictate their own learning. Teachers offer activities like fire-building, whittling, and building projects using natural materials, but teach by showing and inviting rather than requiring students to participate.

In the United Kingdom, especially Scotland, both preschool-aged Forest Kindergarten programs and an elementary-aged model called Forest Schools have grown and been endorsed by the government. In the Forest School model, public school children go out to a nearby “outdoor classroom” one day a week. O’Brien and Murray (2007) offer an important study in the Forest School/Kindergarten movement. They evaluated a three-year long Forest School project in England and Wales, including different groups of preschool and school-aged children. They found benefits to students encompassed by six themes: confidence, social skills, language and communication, motivation and concentration, physical skills, and knowledge and understanding. These are some of the executive functioning skills that students so desperately need. O’Brien and Murray (2007) also found other positive impacts on teachers and family members—namely that teachers gain new perspectives on students through Forest School and there is a ripple effect as children bring enthusiasm for their experiences home to their families who then engage in more outdoor activities with them.

O’Brien and Murray relied on action research that included the relevant stakeholders (parents, teachers, administrators) in “telling the story of how Forest School was working in their area” (p 254). Both during and at the end of the program, they held collaborative workshops and pulled the themes from the discussions. They also used teachers themselves to collect qualitative data on their own students using a rubric, which offered valuable in-depth information despite potential bias. This is the kind of data I collected during my students’ free play, and I used their rubric as a starting point for developing my own.

Anggard’s (2010) study of a Swedish “all-weather” school, as directly translated, gives insight into the different ways young children use nature. She finds three major themes: that they use it as a classroom, a home, and an enchanted world or “fairyland.” Her work was helpful to me because few other studies look at how preschool- and kindergarten-aged children learn science specifically as part of an outdoor program. As a participant observer, Anggard used a variety of ethnographic methods in this exploratory study, describing student investigation as the primary mode of learning. Teachers use a variety of pedagogical methods but emphasize direct, multi-sensory experience of nature. Anggard describes one days' visit to a nearby lake in the summer, students wading in rubber boots and with nets, "appear[ing] as small researchers who investigate, invent and discover various elements of nature. They are intensely busy exploring their findings. They are used to this kind of activity" (Anggard, 2010, p.12). She juxtaposes this scene with another group present at the lake from a non-outdoor preschool, with teachers and students are lounging in the sand, a few swimming or digging with plastic shovels.

This Swedish program and Anggard's work was important for my own work as I tried to keep the exploratory, observational, and multi-sensory elements present in my science unit despite the somewhat prescribed nature of the Stemscopes program.

The European Forest School model has been adopted by teachers scattered across the U.S., but more concentrated around leaders in Vermont public school kindergarten. A pair of Vermont teachers put up a website, forestkinder.org, naming their weekly program after the original European name. Their practice has been inspiring other kindergarten teachers and a small professional community is forming. It is where I gained much of the inspiration for my own Forest Monday program.

Research Questions

What effect does place-based, outdoor science have on kindergarten students' achievement of learning goals and Forest Day free play?

Sub-questions:

1. What effect do place-based, outdoor lessons have on kindergarten students' understanding of forces and motion?

2. What effect do place-based, outdoor lessons have on kindergarten students' ability to plan, carry out, and analyze a simple investigation? (Science Practices from NGSS)
3. In what ways does formally incorporating science into an existing weekly kindergarten Forest Day help students transfer content understanding and science practices into their free-play time outdoors?

The constructs I investigated were 1) place-based science, 2) science content understanding, and 3) science practice application. The intervention variable was the place-based, outdoor science lessons and I observed the achievement of science learning goals (content and practices) and behavior during free play. I used the following learning goals from the Next Generation Science Standards (NGSS):

- Performance Expectation: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object.
- Core Disciplinary Idea: (Forces and Motion) Pushes and pulls can have different strengths and directions.
- Practice 1) Plan for an investigation
- Practice 2) Carry out an investigation
- Practice 3) Analyze data

Methods

Research Design

The setting for this action research was a rural elementary school in midcoast Maine with predominantly white students, 46% of whom qualify for free or reduced lunch. The sample was the 12 students in my kindergarten class, aged 5.5 to 6.5. I sent a letter sent home to notify families of the research.

I used an embedded mixed-methods design in which the quantitative strand supported the qualitative. Observations and interviews made up the bulk of my data with regards to outdoor play and science practices (Sub-questions 2 and 3). The observation allowed me to understand the nuances of play in my unique Forest Day model and watch students closely during investigation lessons. I used a checklist for both outdoor play and investigation lessons with the practices along the side column and space for me to take running notes of events and dialogue.

I focused my observations on a representative sample of three students (GJ, IA, and CA), chosen to span the breadth of abilities in my classroom. GJ and CA were paired for the partner work of the investigation lessons, which meant I observed them more than IA.

I interviewed all 12 students before and after the unit, which gave me their perspectives on science, how they do science, and how they use science in their play. This was important data to pair with my observations for greater validity and to see what students were conscious of or not.

Assessment data from the Stemscopes materials was to measure content knowledge (Sub-question 1). I used the CER (Claim, Evidence, Reasoning—which does not include the Reasoning section in kindergarten) and a multiple-choice assessment. The two assessments address similar content but in different ways, strengthening the validity of the combined results. I conducted these assessments individually, orally, as is the usual procedure for assessing my kindergarteners.

The Stemscopes unit I taught, as suggested for this time of year by my district, was called "Pushes and Pulls," an introduction to forces and motion for kindergarten. I adapted the inquiry-based lessons to make them place-based. The overarching focus was engagement with and interest in *our unique place:* the woods of our outdoor classroom.

We used the learning from the unit to support a goal of improving our play area outdoors. At the end of the unit, I presented the problem to the students of designing a better play area with both human-made and natural materials that includes more opportunities for motion—i.e. "including more pushes and pulls." We toured the playground and existing play elements in the woods to get ideas. The students then created designs through drawing and writing. We chose a few ideas of feasible additions—mostly swings and rope climbing structures—and will be implementing them soon.

Procedure

The following is an outline of the unit and data collection:

1. Students engaged in outdoor free play as part of Forest Monday. Conducted pre-intervention observations.
2. Conducted pre-intervention interviews.
3. Taught Access Prior Knowledge and Hook: Let's Play Ball! (Outdoors).
4. Taught Investigation Lesson 1: Cross the Finish Line (Indoors). Conducted observations.
5. Taught Picture Vocabulary.
6. Taught Investigation Lesson 2: Pull! (Outdoors). Conducted observations.
7. Students engaged in outdoor free play as part of Forest Monday. Conducted observations.
8. Watched video "What is a Force?" and discussed.
9. Introduced play area design.
10. Toured playground and woods, discussed play area design.
11. Students engaged in outdoor free play as part of Forest Monday. Conducted observations.

12. Students created and shared play area designs.

13. Together, with parent volunteers, set up new play elements in outdoor classroom.

Table 1 describes the Stemscopes lessons and how I adapted them to make them more place-based. I used the following criteria for adapting the lessons: 1) provides a multi-sensory experience, 2) uses natural materials and local examples, and 3) includes meaningful, relevant work when possible. See Appendix A for examples of Stemscopes paper handouts and modified materials.

Table 1: Place-based Modifications to Stemscopes Lessons

Lesson	**Name**	**Stemscopes Version**	**Place-based Modifications**
1 Forest	Accessing Prior Knowledge	Push / pull sort	Replaced with place-based pictures: e.g. bear hanging on branch, hawk carrying a fish, kid making a snowman
	Hook	Moving a paper ball with different types of pushes/pulls	Replaced ball with hemlock cone, used natural objects (thin stick, thick stick) to push/pull
2 Inside	Do 1: Cross the Finish line	Using a straw to blow air at paperclip and block to see which requires more force to push it over the finish line	Replaced paperclip with acorn cap
3 Inside	Explain: Picture Vocabulary	Push, pull Strength, direction	Replaced with place-based pictures
4 Forest	Do 2: Pull!	Pulling boxes with different objects in them and determining which are easy to pull, which are hard to pull.	Replaced objects in boxes with big sticks, rocks, mud (heavy) and leaves, pine cones, twigs (light)
5 Inside	Explain: What is a force?	Video of athletes	No changes

6 Inside	Explain: Communicate Science	Design a playground that includes at least three pushes and at least three pulls	Design a play area – human made and nature made – that includes at least three pushes and at least three pulls. Incorporate design into real changes in Forest Classroom (e.g. Swings, climbing ropes, more cut logs, fort frames)

Data Collection Tools

I used six data collection tools: two Stemscopes assessments, two observation checklists, one scripted interview, and a researcher journal (See Appendix B).

The Stemscopes multiple-choice assessment has pictures of scenarios that have to do with forces on an object and asks the student to choose one out of three answers. The Stemscopes CER (Claim-Evidence-Reasoning) Assessment asks students to make a claim about an object they can move and give evidence in the form of a picture. This has a simple rubric to score the assessment from 1-3. CERs are becoming a common form of science assessment and this simplified version for kindergarten is exposing students to what they will use more rigorously in the upper grades. These two assessments clearly address Sub-question 1: the science content. Though the NGSS Performance Expectation includes practices and Stemscopes claims to teach them, the assessments did not address them explicitly. Thus, I focused on my observation data to assess the students' use of practices.

The two observation data sheets were quite similar. The outdoor data sheet allowed me to indicate other aspects of the children's play, such as what they were playing and with whom. The indoor data sheet had more possible teacher prompts because I knew I would be observing the student at closer range and be able to engage them for longer with questions. I used language directly from the Science and Engineering Practices from the NGSS and wrote kindergarten-friendly questions. I left space to draw what the students did with the materials. These checklists address Sub-questions 2 and 3: science practice learning and integration into free play.

I developed a brief interview to address Sub-question 3 from a student perspective. I first asked students what science means to them and then how they feel they "do science" outside and in their play. After the unit, I asked them a further question about how they think learning about science affected their free play.

Data Analysis

I scored all of the CER and multiple-choice assessment data (see Table 2). The rubric included with the CER uses a three-point scale: "does not meet" (1), "partially meets" (2), and "meets" (3). After scoring the multiple-choice assessment, I used my own discretion to decide whether students met or partially met based on how many of the five questions they answered correctly.

Each day after observing in the field, I typed my observations into field notes with thick description. I coded these with pre-existing categories from the science content and practices. These categories were the following: 1) any mention of forces and motion, 2) planning an investigation, 3) carrying out an investigation, 4) analyzing results of an investigation, and 5) science in play. The "forces and motion" category often overlapped with the "science in play" category.

I coded the interview data the same way. Though I was looking for existing categories from the science practices, I was also open to emergent categories. I discovered the category of "learning" which came up often when I asked the students about the meaning of science.

Within each category I then looked for themes and found quotations to support each theme. I also re-created a presence/absence checklist for the science practices for each student I was observing. It was often hard to do this during data collection, and easier after the fact to go back and see what behaviors fit into which science practices. (For an example of one student see Table 3.)

Results

Sub-question 1: What effect do place-based, outdoor lessons have on kindergarten students' understanding of forces and motion?

According to the Stemscopes assessments, almost all of my students met the expectation for content knowledge of forces and motion from the Pushes and Pulls unit (see Table 2). Only three students had one or more score below a 3, and two of those three had a 3 on at least one assessment. One student (IO) did not meet either, and this is a student who has extensive speech and language difficulties. He certainly made gains over the course of the unit, but it is hard to tell what he understands because he has such limited language as well as significant articulation difficulties. The results of Sub-question 1 support my hypothesis. I predicted that most of my students came into the unit already possessing much of the content understanding. The concepts in the assessment are fairly simple, simpler than the level of complexity in the lessons, our discussions, and many of the applications we discovered in play.

Table 2: Stemscopes Assessment Data

Student	CER 1	CER 2	Multiple Choice
IO	3	2.5	2.5
OG	3	3	2
GJ	3	3	3
AL	3	3	3
CA	3	3	3
IB	3	3	3
AJ	3	3	3
HJH	3	3	3
IA	3	2.5	3
WM	3	3	3
PY	3	3	3

DO	3	3	3

These assessments match the observations I made during the investigation lessons as well as my journal entries based on our discussions afterwards. The students were able to articulate much more than comparing the direction and strength of a push or pull. They discussed their ideas about the reasons certain objects were easier or harder to move. This is where content and practices blend, and I will discuss this more under Sub-question 2.

The interview data also gave light to the students' ideas about the nature of science and how concepts of forces and motion fit in. Of the ten students who were both pre- and post-interviewed, most had no change in their general conception of science. Interestingly, the students who changed their conception of science or added in concepts of forces and motion were the ones who had nothing to say about science in the pre-interview. IO, who has an extreme speech and language disability, went from expressing no idea about science to a literal description: "you push or pull." AJ also gave me the blank stare when I asked her about science the first time, but in the post-interview described it as "when you figure out different things." When I asked her how she did science, she was the only student who described anything remotely connected to physical science or forces and motion:

> I put sticks on other things and see if it will tip…. If they tip, that means it's heavier. If they just stay that way, that means they're the same weight. Or I put a giant log on one round log and then I put something on one side and something else on the other side and if it tips one way, that means that thing is heavier. If it tips the other way, that means the other thing is heavier.

AJ was describing a homemade balance to compare the weights of different objects. I'd watched her set this up in the woods a few days before.

Concepts of forces and motion did not come up in the pre-interviews at all. In the post-interviews, most students did not bring up concepts of forces and motion on their own. A few students included pushes and pulls when asked about how they do science themselves. But when asked directly, all students could name examples of pushes or pulls, either specific times or more general examples. HJH thought of a time from the last Forest Monday: "I was pushing in that car game, I was pushing that [stick] to the big log." PY described an example we'd talked about, but I'm not sure she has ever done: "If you want to pull a rope, if you're playing tug of war, if you want it to come towards you, you pull." This also includes a tidbit on the direction and effect of a pull (versus a push).

Sub-question 2: What effect do place-based, outdoor lessons have on kindergarten students' ability to plan, carry out, and analyze a simple investigation?

From the checklists for both the structured investigations and the free play, I found that individual student differences accounted for a lot of the variation in data. Students tended to interact with materials and play in similar ways each time. I surprised myself by picking my focus students across a real range of engagement with science practices. GJ engaged extensively in ways that related to science. CA did some science, and IA very little. Of the three categories of practices, manipulating objects (i.e. carrying out an investigation) was the most common activity, analyzing second, and planning the least most common activity. Table 3 shows an example of one students' use of the three categories of practices and the types of behaviors I was looking for.

Table 3: Presence of Science Practices (Student GJ)

	3/19 Pre Play	3/20 Investig	3/26 Investig	4/2 Post Play	4/9 Post Play
P1) Pausing to plan					

P1) Thinking aloud to plan	x		x	x	
P2) Manipulates objects in ways relevant to question	x	x	x	x	x
P3) Shares observations of comparisons (same/different)		x	x	x	
P3) Answers teacher questions on comparisons (same/different)		x	x		
P3) Shares observations of patterns					
P3) Answers teacher questions about observations of pattern		x			

The observation data showed more depth. Two of the three Stemscopes investigations were so highly structured that there was no real need for planning. Students did not stop to think or talk about what they were doing, but rather immediately started manipulating their materials. GJ, being naturally more methodical and cautious, did refer to his data sheet to check what he needed to do next, but this was the exception rather than the norm.

Though students certainly dove in and got their hands on the materials, the types of pushes and pulls the investigations asked the students to do were generally very highly-structured. There was not much room for extension. Despite this, students showed lots of energy and joy while carrying out the investigations, often finding creative ways to do things in spite of the boundaries created for them. While trying to move a block of wood across the table with blows through a straw, GJ ran into some trouble:

> After many very spitty blows, and the block still only a few inches from the edge of the table, he observed, 'It's not working. It's wet.' I asked him how he could solve that problem. He kept trying to blow. 'It's still not moving. It still has water.' I asked him and CA again: 'What could you do about the water?' GJ went up to get some paper towels and wiped down the table and the block. But even then, the block was still damp on the side that had been down and wasn't moving.

I saw extensive persistence in all of my three focus students. GJ eventually figured out to turn the block to the other side and get it to move. The data collection tables were hard for them to use, but that did not stop them from taking them seriously and trying to fill them out in some way, as I noted in my researcher journal:

> GJ mixed up the columns in his data collection table, but got the idea of filling out more rectangles for more puffs. Despite the structure and rules of the investigations, the manipulative nature of them created a playful air. While pulling the "mystery boxes," "CA immediately started running across the field towards the woods with one of the light boxes, yelling out, 'This one's lighter!' " Later, when she was pulling one of the heavy boxes, "pull harder!"

While students did not usually analyze out loud on their own, they all responded correctly and logically to questions I'd pose. GJ was an exception. A few times I heard him make an analytical comment. After he blew air through his straw to push his acorn cap across the table, "which took him 10 puffs, he said, 'I did a lot more than her.' I asked him 'What was different or the same between you and CA moving the acorn cap?' He said, 'She took two puffs, I took 10. That's different.'" During the "mystery box" pulling, he also started sharing about how he was able to lift such heavy things with ease, a point of pride quickly taken up by others:

> One box was clearly the heaviest, and after watching some students mark it 'heavy' on their charts, GJ tried it and said, 'It's not very heavy for me.' For the rest of the investigation he was very vocal about being able to lift the heaviest box. During our discussion, when we passed around the objects inside (small logs), he showed how he could lift the log up with one hand. Others copied this behavior.

Thus, despite this unit in Stemscopes not emphasizing science practices explicitly, I found that the students were using them naturally. They may not have been aware of what they were doing, or able to label it with scientific vocabulary, but they were certainly doing the work of carrying out an investigation and beginning to analyze their results.

Interviews

Despite not being aware of when they were using science practices, most students saw investigation of some kind as integral to their definition of science, both pre- and post-intervention. Here is a sampling of their descriptions:

- HJH: Science is when you find stuff and try to figure out what it is.
- AJ: When you figure out different things.
- GJ: You have labs and you look at stuff and you draw them and you learn about them.
- AL: Science is when you look for stuff. Search down and up to look at stuff and take pictures and look on the ground and take some more pictures.
- DO: When you think about stuff, look at it and study it to discover what it is… If you know what it already is, then you don't do science with it. Remember that snakeskin? I already knew what it was.
- IB: I look at stuff and I observe them closely.

In the pre-intervention interviews, a few students shared examples of their own investigations (albeit, not related to forces and motion). CA said, "I listen for bird drums. Look for woodpecker holes." AL told me, "I look for bugs." Post-intervention, fewer students cited examples of their own investigations. This seems to have been replaced by giving examples of when they pushed or pulled. As a whole, although most students got the concept of investigating and some got the fact that pushing and pulling is part of science, these two concepts did not cross over. In other words, students did not see investigation as part of the activity surrounding pushes and pulls. According to them, it seems that you just "do" pushes and pulls. They didn't describe any "figuring out," "looking closely," or "asking questions" in conjunction with the content. Only AJ's description of balancing objects on a homemade balance (described under Sub-question 1 Results) was related to forces and motion. I'm not sure she was connecting it to pushes and pulls. All other descriptions of investigations were biological in nature— around birds, animals, "figuring out what something is" in nature.

Planning only came up once in a post-intervention interview. AL described wondering about something, i.e. "stopping to think," which was one of the behaviors I looked for, but did not often see. When AL was asked how she does science in the woods, she said, "I usually look up and at my Sit Spot and I see a paper thing almost looking like a bird or a nest. And I usually think, 'How did it get up there?'"

Sub-question 3: In what ways does formally incorporating science into an existing weekly kindergarten Forest Day help students transfer content understanding and science practices into their free-play time outdoors?

Observations

During the analysis process, it became clear that this question was two-pronged. First, what transference of content and practices occurred that students were *conscious of*? And second, what transference of content and practices were they *unconscious of*? The interviews helped elucidate what they were most conscious of, because during observation it was hard to tell. That being said, especially if they know someone is watching, kindergarteners usually share out loud what they are thinking.

In general, my kindergarten students engage with the forest surroundings in a very fluid way, blending between play and work as well as blending socialization and individual projects. There are many ways in which they play, but when asked what they are playing they usually describe it in terms of a game or specific imagination story. They do play a lot of imagination games, but also use exploratory play involving the manipulation of objects, building projects, and finding nature objects—all often involving a lot of repetition. Because they are interacting with open-ended, malleable and breakable materials (often called loose parts)— mud, sticks, snow, leaves, hills, trees, logs— there is a lot of opportunity for moving things and using forces.

Even during the pre-intervention observation, I was pleasantly surprised at how much pushing and pulling work the students were doing without being aware of it. And from the post-intervention observations, they engaged in even more pushing- and pulling-related activities, many of which they were conscious of. Play-related pushing and pulling content both pre- and post-intervention included the following: trying to break ice by stomping on it or hitting it with sticks; going through ice by mistake; getting feet stuck under snow, buried branches, or in trees; moving sticks or rocks; and climbing trees or bending over small saplings to straddle and bounce on.

Before and after the unit, students did a lot of manipulating materials in their environment, much of which fit into the category of carrying out an investigation. Some investigations were short-lived, others longer, such as poking a stick into a waterfall, finding paths over crusty snow and ice on the wetland, figuring out the best way to move a large stick, or figuring out what kind of sticks one can pick up compared to other kids.

Pre-intervention, I observed more unconscious use of science content and practices, but there was plenty of unconscious use post-intervention as well. An example of unconscious use was when one student got "stuck" under a branch. "I came down to see what was going on. Her foot had gone through the snow and hooked under a branch that was also stuck in the snow. GJ and HJH and a few others were nearby. HJH was saying, 'She won't let us help, we are trying to lift it up.' " I had seen students get stuck plenty of times, but had never paid attention to specific language around the solution. In this situation, a few students were gathered around and trying to pull the half-buried branch up near to where the girl's foot was. It was GJ while exploring further who "noticed something at the end of the stick. 'I found the problem,' he announced. 'That's why we can't get it up— it's stuck.' The thinner end of the branch (really a small alder, growing) was bent over and also stuck in the snow. No matter how much they lifted the thick end, it wouldn't go up all the way." This was an example of forces (pulling) content as well as investigation and analysis. It happened completely naturally when an observant student (GJ) was faced with a real problem. But none of the students offered scientific explanations for the kind of work they were doing.

With the line between play and work being a fine one, I found it interesting to watch students engaging in what was not obviously a specific imagination game but more of what I decided to call "playful work." On the pre-intervention day, while the students were exploring the cracking ice, "GJ was the one yelling, 'It's a flood, it's a flood!' over and over. His face was so lit up. Later, he was traveling up the stream with a bunch of kids, hitting the ice over and over with a stick: 'Break it! Break it!' HJH had an even longer stick and was hitting the ice with it like an ice chisel, up and down." I didn't hear language that would suggest they were pretending to be anything other than themselves. But they were certainly choosing to do what they were doing and enjoying it in a playful way.

As mentioned under Sub-question 2 with the investigation lessons, I also saw less analysis-related talk during play even when students were doing investigative work. I often asked students what they were doing, what they noticed, to compare, or why they thought something happened. In these cases, the logic or correctness of students' answers fluctuated. On the pre-intervention observation day, "CA was the one to break through the ice. I asked her afterwards what happened. 'I almost rolled in the puddle,' she said. 'I slipped and I falled and I almost fell in. Everyone followed me onto the ice and it just started to crack.' I asked her why it started to crack. 'Because there was too much weight,' she said. I asked her what else could happen? 'I think it's gonna crack again.' Later, I heard her yelling from upstream, 'Guys, get off! It's gonna crack again! No!! No!! It's gonna crack!' " Her explanation was an example of one that made logical sense.

As in the investigation lessons, in the woods I also saw less planning than pure investigation. But elements of planning were sprinkled in. Students did talk about their plans to move objects and sometimes talked hypothetically about what would happen in a situation. For example, I watched GJ at the stream: "[He] told me this was the place they had built a dam before, and now, 'Look, all the water pushed through it.' He pointed to a little stick held in place by mud and small rocks that had flowed downstream. 'And look, <u>if we take this stick out, it will all go down</u>' " (emphasis added).

This example also shows how students used more language around pushing and pulling: "Look, all the water <u>pushed</u> through it" (emphasis added). It is hard to tell if GJ knew he was talking about forces and motion in connection to our science learning, but he certainly was applying the concepts. This seemed like the middle ground between unconscious use and fully conscious use. Other times, I would be the one to notice a connection between their work and would ask them what they were doing, with them answering with pushing and pulling language.

The "bouncy tree" shows that line between unconscious and conscious use of pushing and pulling. Three girls, IA, CA, and AL, were playing on what we call the "bouncy tree." It is a small maple sapling that has been pulled down and used repeatedly for its springy properties. One favorite activity is to straddle it and bounce up and down— hence the name. Over the year, it has become stripped of its branches and has mostly died, but it still retains its spring. It was a popular play spot in the fall, but has only been used sporadically all winter.

At first, CA had been using the tree's spring to launch another stick off into the woods, like a catapult. AL and IA joined and the game evolved into a more full body affair: "All three girls straddled the sapling lined up, all facing the same way. One would stand next to or at the end and pull the sapling down, and try to "launch" the others off. But the sitters were too heavy to be moved by the slight force of the sapling bouncing back up. I asked IA what they were doing, and she told me what I could see: 'We're trying to bounce on it.' "

It soon evolved further, consisting of:

> [O]ne girl laying on the ground underneath and lined up with the sapling, feet at the root end. Sometimes she would hold the sapling, pulling it down with her. But that took quite a lot of strength and coordination, so other times she would lie down and call to the others, "Bring it down to me!" or "Push it towards me." Once the sapling was in hand, the girl on the ground would wrap arms and legs around it, partially lifting herself off the ground. They rotated through, taking turns lying on the ground. Soon, one girl, while waiting, got the idea: "Let's pick you up!" They'd lift up their friend as high as they could, before laughter got the better of them. The one clinging to the stick was laughing the whole time, until she fell off or let go on purpose.

The whole time conversation was rich with language around pushing, pulling, and movement. This was definitely "playful work," where they had evolving goals but not a specific imagination game. Though it was informal and playful, it definitely fit the category of investigation: trying to figure out how to do something. Afterwards, I asked IA about it. She told me, "My idea is we could lay down and hold onto the branch and close our eyes. Then somebody could pull them up and not let them know."

Another example shows a similar level of investigation shared between students, but with more analysis and definite conscious use of pushes and pulls:

> HJH, GJ, and DO were near the stream. DO had the initial idea: 'Let's make a bridge.' The other two eagerly agreed. HJH reminded them, "Remember when we threw big

sticks down?" *(Referring to throwing big sticks down the hill for other construction projects.)* HJH and GJ moved up the hill. DO stayed down by the stream. GJ found a big stick and started picking at the bark of it. 'Look, I can rip off skin from trees.' HJH said 'Let's get that one,' and moved to the other end on the downhill side. GJ was kicking the root end, which was partially lodged in the ground still. Thus began the stick moving process. This was a log about 15 feet long, 6 inches wide at the thick end. GJ continued to kick at the root end, then switched to pulling at it with his hands. 'Ms. Atkins! I just moved it!' Then addressing HJH, GJ called out, 'You need to move it to the side or help me lift it up.' HJH was still on the other end. The rest of the narrative went as follows:

HJH: Keep pushing GJ.

GJ: Keep moving, keep pushing. (*The root end came out)* Wow— look at all that mud! We pulled it out of the gravel! HJH, we need DO!

HJH: DO!

DO: Ok (*Coming over)*

GJ: We need big strong muscles.

DO: Like me when I pulled that long rock out.

HJH: But this one's heavier. DO, go help GJ. GJ, help on the back. (*DO went up to help GJ for a minute)*

GJ: We need to get it over there. *(Pointing to the side)*

HJH: (*Pulling, falling over, laughing)* We are!

GJ: You're just pulling! (*HJH was pulling it downhill, not to the side where GJ was pointing and where it needed to go to clear the existing log bridge)*

HJH: Push it on the other side.

GJ: This will make a perfect bridge.

DO: I was talking about a rock bridge (*Went back down to the stream, walking on the log they were trying to move)*

GJ: HHJ, pull!

HJH: I am! You push!

GJ: We're doing a push! And a pull! Ms. Atkins!

HJH: When he pushes, I pull!

GJ: It's like that saw, push and pull!

(They were moving it more efficiently now, carrying the log together down the hill. HJH crossed the stream with his end)

GJ: Now we have to stick it in the ground. *(A pause)*. I can't. I'm too sweaty and it's too hard.

HJH: Let's get some more.

Of course, this situation was the shining example that every teacher wishes for all of her students, for them to naturally and consciously connect content to real life examples that they encounter. This was the most significant time I found that it happened over the course of this unit. Students did make other small connections (such as IA reading "SoftPull" on the paper towel dispenser, and exclaiming, "Ms. Atkins! Look! It says 'Pull' just like we are learning about!"). I wonder what other connections that they made that I was not there to witness.

GJ, HJH, and DO were also involved in work, perhaps more purposeful than playful, and certainly less playful than the bouncy tree example. They used planning when they talked about how to move the stick, especially when giving each other suggestions: "You need to move it to the side or help me lift it up." There was some analysis going on too. GJ compared the stick's actual movements to what he wanted it to do, communicated to HJH about how to change his pulling, and solved the problem of navigating around obstacles.

The bouncy tree and the stick moving brought up new patterns beyond the practices I was looking for. Over and over again, students worked collaboratively with pushes and pulls. They explored into new areas (such as the cracking ice on the wetland) and revisited old play areas (such as the stream and bouncy tree), bringing new ideas and projects to them.

Interviews

The interviews showed what students were conscious of when it comes to using science in their play. Based on their responses, many students saw science work as separate from play. Pre-intervention, there was no mention of pushing or pulling as part of science at all. By the end, all could name ways they push or pull when asked directly, but only three out of eleven post-interviewed brought it up on their own when asked about science in general or science in their play. Though they often saw science as separate from play, the line between pushing/pulling and play was often closer. HJH tentatively described science as something he stops play to do: "I don't do science in my play. —Oh! I do. I play and I might find something and I ask [my friends] to stop and try to figure out what it is." DO also described science investigation similarly: "Run around until you find something that you don't know what it is. Bring it in or leave it outside and figure out what it is."

IB had an interesting answer to how he does science in his play: "Oh, this is something that basically that we play. It was basically a project, but to me it was play. So you blow the block with the straw and then you blow an acorn top with a straw and you figure out which one takes more puffs to move." He was describing one of the Stemscopes investigation lessons, not as science, not as pushing and pulling, but as play.

Of the ten students who were both pre- and post-interviewed, seven had no real change of what science is and how they use it in their play. Two went from expressing no idea of what science is or saying they never do science to having a clearer idea of science and how they use it. And one student broadened his conception of science, but still says he does not use it in his play. Interestingly, this was GJ, one of the most investigative and astute when it came to noticing pushes and pulls during play. Overall, this does not show a lot of change in the students' awareness of science in their play, despite the fact they were using science content and practices.

Summary of Main Research Question: What effect does place-based, outdoor science have on kindergarten students' achievement of learning goals and Forest Day free play?

Overall, students were able to meet content and practice learning goals through this simple place-based unit. Transference into their play was two-pronged: that which was conscious and that which was unconscious. Both before and after the intervention, students were naturally using science practices as part of their free play—play which can be generally characterized as fluid, complex, repetitive, and full of manipulation of objects. Most often their activities fit into hands-on investigation, with some analysis and little planning. When probed with analytical questions, students could usually answer them logically. They used analysis on their own less often. Time played a role in the amount and depth of higher-level science practices like planning and analysis.

Because students did not have the scientific vocabulary for the practices they used, these were more often used unconsciously. The few instances of conscious science-related activity were around the content of pushing and pulling. When asked, most students did not see pushing and pulling as part of their own science work, though they could name examples of pushing and pulling. Most saw science as separate from play and this concept changed little over the course of the unit. Though many students thought of investigation practices as part of science, this did not include investigation of *pushes and pulls* specifically. They saw pushing and pulling as more closely connected to play.

Discussion

Limitations

Time: The short nature of this action research was an inherent limitation. I only collected pre-intervention observation data once and, because of behavior and coverage issues, was only able to collect post-intervention data twice. The pre-intervention day was also a unique Forest Day because students had gone through the ice and were getting wet. While it was an incredibly exciting time for everyone, with lots of manipulating the environment and carrying out investigations, it was cut short. This may have been why I observed less planning and analysis.

The end of the session was teacher directed as I rounded everyone up and we went inside to warm up.

Based on my anecdotal observations of my students outside all year, I think most of the type of play that I observed post-intervention were also present pre-intervention, even though I did not observe them on that particular shorter play time.

Teaching: Noticing my students' connection between pushing/pulling and play but separating play from science, I wonder whether they saw pushing/pulling as part of science. I realized that most of the time I may have referred to the unit as "our pushing and pulling learning" rather than "our science learning." It is interesting if a small change in language could limit the connections made.

Weather: Collecting data on cold and windy days in March made for cold hands. I had to often stop writing to warm my hands, which meant I definitely missed some conversation and behavior.

Coverage: Usually on a Forest Day one adult volunteer is sufficient, but I realized that when I am engaged in focused observation, two seasoned volunteers are essential. They can take charge of clothing and gear issues, toileting, managing the fire, supervising climbing students, and small conflicts.

Interviews: Originally, I planned to ask a post-interview question about science practices. However, because the fact that "scientists solve problems" was something never explicitly discussed in the unit, I omitted that question. Therefore I only got data on practices from observation. This could explain why students did not relate any investigation descriptions to pushing and pulling.

Recommendations for Practice

Stemscopes: After using the Stemscopes lessons for teaching place-based science, I have a few suggestions for further use with kindergarten students. First of all, many of the paper handouts were too text heavy, unnecessarily complicated, and difficult for my students to use independently. Assessments were similar. I would remake them and simplify them. And when it comes to teaching kindergarten students to collect data, I would remember the old adage of "expose, expose, expose," and not worry about if they use the sheet correctly. It is more important to teach them that scientists collect data and let them approximate as best they can.

Inquiry science: While the Stemscopes investigations present good questions, they are also rather simplified and often do not allow for enough extension once students are finished. Based on what I saw, kindergarteners are capable of dealing with a lot more complexity. Siry (2013) argued this in her work with kindergarteners' floating and sinking knowledge development.

Based on this action research I definitely suggest all teachers use inquiry science methods, but be sure to allow for more open-ended investigations with more room for students to come up with their own questions and pursue them creatively. The Pushes and Pulls Hook was an exception, with more of a student-directed approach. And, as much as possible, it is important for teachers to take the time to show interest in their students' thoughts and developing knowledge, listen carefully, and follow their thinking in order to help them think more deeply, as shown by Siry (2013) and Duckworth (2006).

This unit is also clearly the first in the series of physical science units, and I did not realize it did not teach inquiry science practices explicitly. I would not teach them up front, but give students experience using them, as they did in this unit, and then introduce them. It would also be helpful to include discussions about what science is and what scientists do, in relation to the inquiry process. Even about this young age students are beginning to solidify their conceptions of science.

Place-based education: I would recommend science as a starting place for rural elementary teachers wanting to use more place-based methods in their classroom. Nature is usually close by and it is easy to make place-based connections to existing science units.

To early childhood teachers wanting to start a Forest Day, I'd recommend incorporating intentional science units only after routines are strongly in place. It was easy to add science into our Forest Mondays because the students had already learned safety and behavior expectations. I would recommend that teachers who use science in conjunction with Forest Days help their students become more conscious of how they do science outdoors.

Play: I observed richer investigation that included planning and analysis during periods of longer play or longer, more-open ended access to the materials. One possible explanation is that students simply need time to get to these higher level skills. They need to be familiar with the basic uses of the materials before they can make comparisons, notice patterns, discuss hypothetical situations, and plan for their own investigations.

Thus, I would strongly encourage teachers, especially those in early childhood, to give students plenty of time for open-ended investigation work and open-ended play.

Nature-based early childhood educators often say—and I often repeat—that children need a lot of time to enter into deep, meaningful play. I have noticed anecdotally that short periods of free play can result in shallower, more frenetic play, in contrast to that which comes from long uninterrupted blocks. But though the work of Anggard (2010) and Siry (2013) reminded me to keep investigations open-ended, exploratory, and with plenty of time, I did not think about it in terms of play for this research. I did not notice it until I analyzed at the data in the context of the specific days I observed.

Providing students with extended periods of uninterrupted time is a simple recommendation, but complex when it comes to scheduling. Most elementary students' opportunities for play, if they have them at all, are 30 minutes or less. That was about the length of the ice-breaking observation day. The other two observation days took place over 60 to 90 minutes. I realize that carving out even a 60 minute period for play is difficult within the constraints of most kindergarten teachers' schedules. But schedules can reflect what teachers and administrators prioritize.

Recommendations for Future Research

Methods: Any teachers conducting qualitative research in an outdoor setting would benefit from a 1:4 teacher/adult ratio. Volunteers can help achieve this ratio, but they must be trained for them to be the most helpful in the unique outdoor setting. And, because of the holistic nature of outdoor learning, I highly recommend qualitative methods for any research on it. Sample sizes are already small and there are constant opportunities to describe situations that are unique but relatable to other outdoor teachers.

Questions: To help schools prioritize long periods of play for young students, more research is necessary to explore how long stretches of uninterrupted time affect play. In what ways does play deepen? Does longer playtime consistently include higher-level thinking skills? There are a myriad of directions to go with this, into the social-emotional realm as well as the cognitive. How do long periods of play affect conflict resolution? Creativity? Engagement? Other life skills?

As kindergarteners are just beginning to gain meta-cognition and simultaneously developing their concepts of “work,” “science,” and “play,” I would recommend to ask them explicitly about the differences between these concepts. I wonder how using different language about the importance of play, or emphasizing play time as as important as work time, would affect the kind of play young students engage in. And how do kindergarteners learn “what scientists do”? How do students’ concepts of science practices build as they get older?

This research also brings up the question of whether older students also benefit from extended periods of investigation or developmentally appropriate play.

Summary Reflection

Overall, I found it satisfying to have a hunch about teaching place-based science and finding that it in fact worked similarly to how I thought it would. I was not surprised that my students learned and were able to use science practices, but I was fascinated by the details around their investigations, learning, and play.

One of my primary goals was to create another academic connection to Forest Days, and I am glad I did. I knew when I started Forest Days they would start out small and continue to grow; this is one such way. This action research helped re-energize me around Forest Days and gain motivation to continue to develop place-based science units in coming years.

Through this action research I learned that I love observing children in their play. I love taking their play seriously and I have a feeling that when they see me with clipboard in hand, scribbling away, they take their own play more seriously too. They say and do the most fascinating things. I would like to build observation and note-taking into my regular practice as a teacher.

I also remembered how much I thrive engaging in conversation with other educators on research topics. My peers were indispensable throughout this project for sharing ideas and general inspiration. I hope to continue to build relationships around outdoor learning with other teachers at my school.

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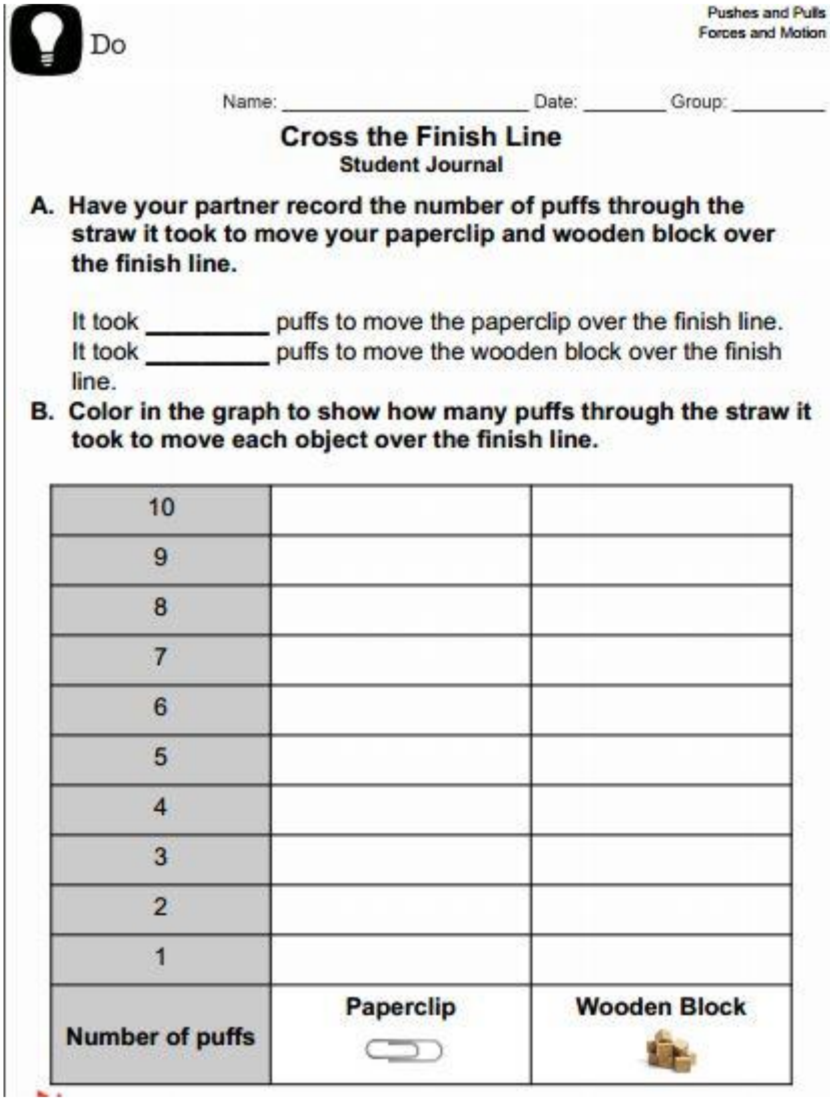
001.0001/acrefore-9780190264093-e-95

Appendix A: Stemscopes Instructional Materials

Figure 1: Place-based picture showing a pull to replace existing Stemscopes pictures.



Do

Pushes and Pulls
Forces and Motion

Name: ______________________ Date: ________ Group: _________

Cross the Finish Line
Student Journal

A. Have your partner record the number of puffs through the straw it took to move your paperclip and wooden block over the finish line.

It took _________ puffs to move the paperclip over the finish line.
It took _________ puffs to move the wooden block over the finish line.

B. Color in the graph to show how many puffs through the straw it took to move each object over the finish line.

10		
9		
8		
7		
6		
5		
4		
3		
2		
1		
Number of puffs	**Paperclip**	**Wooden Block**

Figure 2: Stemscopes Investigation Lesson 1

Do

Pushes and Pulls
Forces and Motion

Name: ______________________ Date: ________ Group: _________

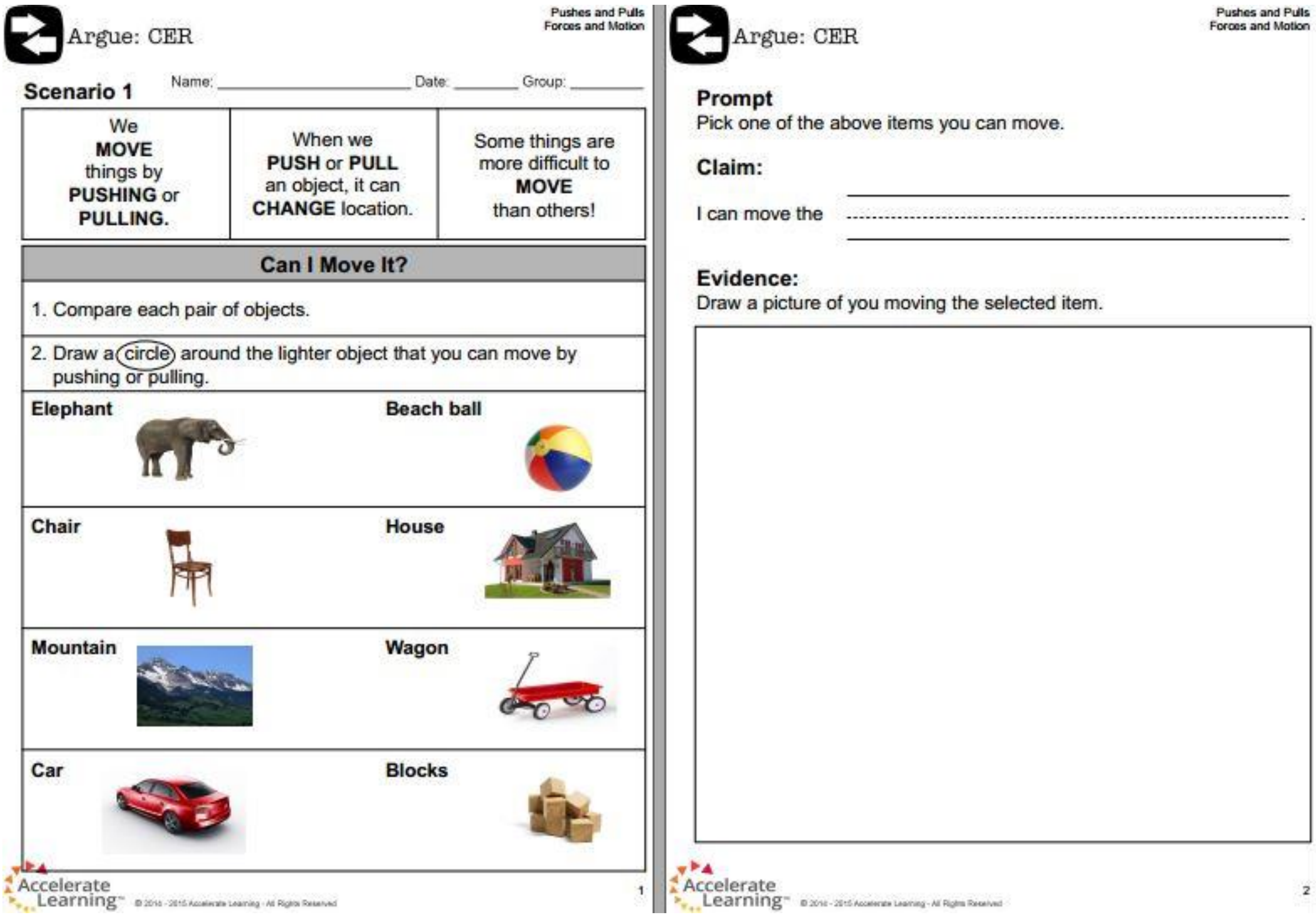
Pull!
Student Journal

Put a **check in the box** to show whether the box was easy or hard to pull.

Station Number	Easy to pull	Hard to pull
1		
2		
3		
4		
5		
6		

Figure 3: Stemscopes Investigation Lesson 2

Appendix B: Data Collection Tools



Argue: CER

Pushes and Pulls
Forces and Motion

Scenario 1 Name: ____________ Date: ________ Group: ________

We **MOVE** things by **PUSHING** or **PULLING.**	When we **PUSH** or **PULL** an object, it can **CHANGE** location.	Some things are more difficult to **MOVE** than others!

Can I Move It?

1. Compare each pair of objects.
2. Draw a circle around the lighter object that you can move by pushing or pulling.

Elephant	**Beach ball**
Chair	**House**
Mountain	**Wagon**
Car	**Blocks**

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Argue: CER

Pushes and Pulls
Forces and Motion

Prompt
Pick one of the above items you can move.

Claim:
I can move the ______________________.

Evidence:
Draw a picture of you moving the selected item.

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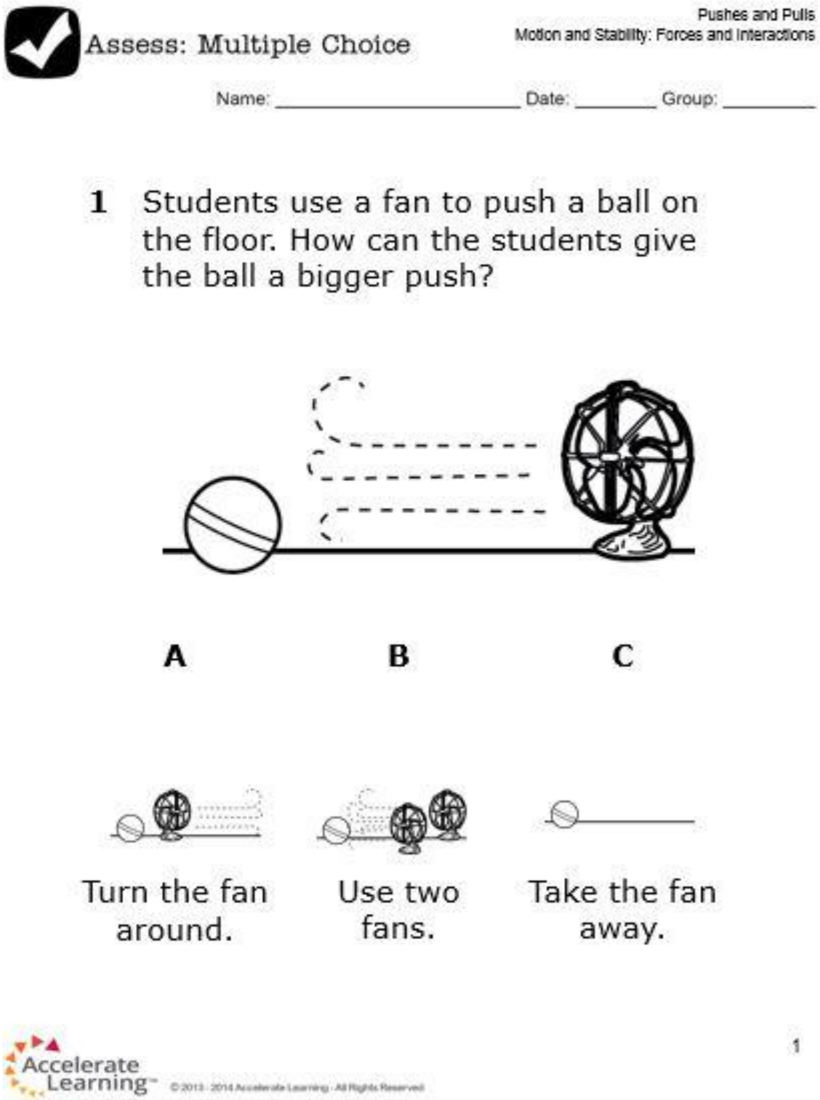
Figure 4: A Stemscopes CER


Assess: Multiple Choice

Pushes and Pulls
Motion and Stability: Forces and Interactions

Name: ____________ Date: ________ Group: ________

1 Students use a fan to push a ball on the floor. How can the students give the ball a bigger push?

A
Turn the fan around.

B
Use two fans.

C
Take the fan away.

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Figure 5: Sample from Stemscopes Multiple-choice Assessment

Outdoor Play Observation Checklist *Probing questions in italics*

Child______________________________ Date___________ Weather__________________________
____

pre-intervention or post-intervention

Behavior (Science Practice)	Observed	Notes
Playing alone		
Playing with others		
Description of play		
P1) Pausing to plan		
P1) Thinking aloud to plan		
P1) Manipulates objects in ways relevant to question *Why are you doing that?*		(Draw)
P2) Shares observations of comparisons (same/different)		
P2) Answers teacher questions on comparisons (same/different) *What was the same about what happened with your pushes/pulls? What was different?*		
P3) Shares observations of patterns		
3) Answers teacher questions about observations of patterns *What patterns do you see?*		

Figure 6: Outdoor Play Observation Sheet

Investigation Lesson Observation Checklist *Probing questions in italics*

Child______________________________ Date___________ Indoor or Outdoor

Behavior (Science Practice)	Observed	Notes
P1) Pausing to plan		
P1) Thinking aloud to plan		(no prompt)
What object are you investigating?		
What is your goal?		
What will cause the push or pull? How strong or weak will it be? What direction will it be in?		
What do you predict (think) will happen to the object?		
How will you change the push or pull if you need to?		
P1) Manipulates objects in ways relevant to question *Why are you doing that?*		(Draw)
P2) Shares observations of comparisons (same/different)		
P2) Answers teacher questions on comparisons (same/different) *What was the same about what happened with your pushes/pulls? What was different?*		
P3) Shares observations of patterns		
3) Answers teacher questions about observations of patterns *What patterns do you see?*		
Did your plan work?		

How will you record what you saw?		

Figure 7: Investigation Lesson Observation Sheet

Interview Questions

Pre-intervention

1. What does science mean to you?
2. Tell me about how you do science outside in the woods.
3. How do you use science in your play?

Post-intervention

Above, plus:

4. We have been learning about pushes and pulls. How has that learning changed or not changed the kind of things you do during free play outside?

Appendix C: Raw Data Samples

or so, I called them back up and asked them to play up where it was drier. She then joined the group of boys climbing on a newly discovered apple tree amidst some pricker bushes. A few minutes later, she wasn't climbing after all and I found her down by the "fort" ("tent" as she calls it) with AL and IA again. I heard her crying and turned away, but standing prominently, letting her know I was there if she needed me enough to come all the way up the hill. She didn't and the three of them worked it out.

My real observation of CA came later when she, IA, and AL discovered new uses for our old "bouncy stick," a sapling of about an inch in diameter that over time the kids had bent over, bounced on, stripped the branches and leaves, and killed. It still stands up, with plenty of bounce in it, and sometimes a few kids will use it. But it got more use this day from IA, AL, and CA than I have seen in a while. They were pulling it back and using it as a catapult to launch a smaller, u-shaped stick. CA was in charge of this small stick. She would hook it around the sapling, points towards her, and pull the sapling back, then let go, letting the stick fly off. I watched her do it over and over, and mostly the u-stick fell to the ground quite close. She kept trying. But once, it flew 30 feet or so forward, presumably where she had been aiming each time. She had to look for it hard, eventually found it, and was right back at it. AL and IA had been playing with her, with her in charge of the stick and the pulling, they moved on to other things nearby.

In a lull, I asked her what had been different about the different times she had tried. "One time it worked, other times it didn't," was her explanation.

Later on, with AL and IA back, they started a new game. I didn't see who started it or how it got started. My observations at this point re-focused on IA, since I had been watching CA so closely with her catapult stick.

IA: (Continued from above) I think the game was an offshoot of more "bouncing"—straddling the sapling in a group of two or three lined up, all facing the same way. One would stand next to or at the end and pull the sapling down, and try to "launch" the others off. But the sitters

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Figure 8: Coded Observations Sample

c. IA: Today I had all of this fizzy stuff and I added water and I made an explosion. (Where? At home?) Yes. Like finding different things and like snow and mud and I mix it together and I put acorns in it. It's like science to me.

d. IB: You push or pull. (Anything else?) Nope

e. AJ: When you figure out different things.

f. GJ: You have labs and you look at stuff and you draw them [redacted]. It's about numbers. It's almost like math.

g. AL: Science is when you look for stuff. And that is down and makes it big. (What do you mean?) Search down and up to look at stuff and take pictures and look on the ground and take some more pictures.

h. WM: We learn about…. I don't know.

i. PY: It's about math, and responsibility [redacted].

j. IB: It is, like, [redacted] and, well that's basically what it is.

k. DO: When you think about stuff, look at it and study it to discover what it is

2. Tell me about how you do science out in the woods.

a. CA --- (Do you do science out in the woods?) No.

b. HJH: I find stuff and wanna know what it is. That was a long time ago that I did that.

c. IA: That's what I just said. (Like finding different things and like snow and mud and I mix it together and I put acorns in it. It's like science to me.)

d. IB: You push or pull. You climb a tree and slide down.

e. AJ: I put sticks on other things and see if it will tip. (Can you tell me more?) If they tip, that means it's heavier. If they just stay that way, that means they're the same weight. Or I put a giant log on one round log and then I put something on one side and something else on the other side and if it tips one way, that means that thing is heavier. If it tips the other way, that means the other thing is heavier.

f. GJ: You put sticks and you take them away (Can you tell me more?) Last time when we were in the woods.

g. AL: I usually look up and at my Sit Spot and I see a paper thing almost looking like a bird or a nest. And I usually think, How did it get up there?

h. WM: I only do pulls. I pull sticks. Big sticks. And little sticks. And sticks that are heavy.

i. PY: By counting from 10 to 20, and counting sticks.

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Figure 9: Coded Interview Response Sample