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Inquiry-Based Learning Science Curriculum For Kindergarteners

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INQUIRY-BASED LEARNING SCIENCE CURRICULUM FOR

KINDERGARTENERS

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CHAPTER ONE

Introduction

Chapter Overview

At the very beginning of the capstone project process I felt very overwhelmed about where to begin. What will I write about? What do I want to research? Then I read Mills' *Action Research: A Guide for the Teacher Researcher* (2011). Chapter 3 "Deciding on an Area of Focus" described the most important criteria for selecting an area of focus for my capstone project. Mills (2011) encouraged writers to find something that focuses on their practice and teaching, something in their control, something they feel passionate about, and finally something that they want to change (Mills, 2011). The idea of exploring science curriculum in the Kindergarten classroom kept running through my head. As teachers, we are always told the importance of STEM (Science, Technology, Engineering, and Math) learning in the classroom, but I rarely feel supported in how to be successful and implement these seemingly overwhelming lessons. Chapter one provides an introduction to my capstone project to explain my planned curriculum unit for kindergarten science, to provide information on my teaching experience, and to share a personal story about my desire to implement engaging science lessons in the classroom.

Kindergarten Science Unit Plan

The goal of this capstone is to create a science unit plan for Kindergarten classrooms to support the Next Generation Science Standards of Energy, Engineering and Earth's Systems (Next Generation Science Standards, 2019). My unit will provide opportunities students to explore, investigate and solve problems. My questions is: *How* *can teachers utilize inquiry-based learning while assessing success in kindergarten science education?*

My unit plan will address the following standards taken from Next Generation Science Standards (NGSS) (2019):

Students who demonstrate understanding can:

- K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3. Analyze data from tests of two objects.
- K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface.
- K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.
- K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.
- K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs (Next Generation Science Standards, 2019).

Teaching Experience

In my teaching experience, I have discovered a passion I never would have guessed I possessed. I love teaching Kindergarten. I have the privilege of spending my days with these little ones who show up in August not knowing how to sit, raise their hands or hold a pencil. These are the same little ones who leave in May reading and doing simple addition and subtraction, all while sitting with a pencil in their hands. I never expected to love this grade level so much, but here I am choosing to explore the importance of allowing their minds to explore the world around them through inquiry and exploration. I left my teacher certification program thinking I would look for a job in upper elementary. I moved across the country to Atlanta, GA for my husband's job and started my job search. It was February, and my options were mostly limited to long term substitute positions. I interviewed for a position teaching Kindergarten until June, with the possibility of coming back the following year as a contract teacher. I loved the school, the principal, and the other teachers. I decided to go for it. I discovered I loved it! I also had the benefit as a newly licensed teacher to take over a class that had already been up and running. I learned the importance of routines and organization by seeing how an experienced teacher runs her classroom.

While this was an amazing school on paper, it was also very traditional. The kids were very well behaved and the parents were very involved and supportive, but even the Kindergarteners sat in rows and did lots of worksheets. I did not want to become this kind of teacher. I had just completed my teacher licensure program and had so many ideas I wanted to implement. I wanted to be the teacher that challenged my students to think, had high student engagement, and I wanted to enjoy going to work each day! I knew that I could start fresh the following August and implement lessons with inquiry, differentiation to meet all their needs, and lots of fun. I was very lucky to have a supportive principal and teachers that were open to trying something new. After leaving Georgia I was lucky enough to find wonderful teaching jobs as I moved across the country. I am lucky enough to have also taught in Colorado and California. I have taught Kindergarten at every school. I feel I have found my niche. I know I will not always be lucky enough to stay in Kindergarten, but I am enjoying it while I can! I like to tell my students that they are now ready for first grade, but I must stay here in Kindergarten.

Teaching in several schools around the country has allowed me to learn from many other amazing educators. I took advice, tips, and tricks from everyone I have shared a wall or hallway with over the past four years. I feel thankful to all of those amazing teachers I have been blessed to work with! I learned the importance of exploration, especially for Kindergarteners. Students come into school with amazing imaginations and questions. Sadly, I feel that some schools train this excitement out of children. I currently work as a nanny for a wonderful family with two small children. The youngest daughter is almost 3 and going through the "why" phase. I can relate to parents feeling tired of answering this question, but the truth is she is learning to explore the world around her. Her constant questions are not to annoy me, but to wonder about what is going on. As exhausting as it is explaining why we must stop at the gas station every week to fill up the car, she is learning! I feel that the classroom should also support the "why." Asking questions is a wonderful skill children can develop throughout their school years and use into adulthood. Education should not just be filling out worksheets and taking assessments, but to allow children to explore their interests and ask questions about the world around them. It can be difficult to manage this with too many children and limited resources. This dilemma has inspired me to create a science curriculum to support students and teachers. I want teachers to feel prepared and confident, and I want students to ask "why" and test their ideas.

Personal Story

My first full year teaching Kindergarten my school implemented the Next Generation Science Standards into the curriculum. Many of us were nervous to implement these new standards because of a big, scary word – ENGINEERING. How can we possibly expect five and six-year-olds to create a model to solve a problem? I, like many teachers, turned to the two most important tools of creative teaching: Pinterest and Teachers Pay Teachers. I know my strengths as an educator and creativity are not on the list. I often rely on borrowing other teacher's ideas to help strengthen my own lessons. I found a wonderful resource by teacher-author Sue Cahalane. She created a unit plan to address the NGSS titled "Weather and Temperature" (Cahalane, 2013). Her lessons allowed the children to learn about weather, while integrating those intimidating engineering standards.

One of her ideas is to have students create a shelter for their "monsters" to provide relief from the sun on a hot day. The monsters are a student created toy. The purpose of the monster is for the students to have a tangible item for this project. I decided this was the perfect way to have some hands-on learning for my students. I sent home a letter asking parents to send in all the tissue boxes, paper towel rolls and cereal boxes that they could. I put my students into small groups and allowed them to get to work to create a shelter. Some of my students struggled to share ideas and compromise effectively, some of them struggled to figure out how to even start, and some of them just went right to town on building without working together. I, being the perfectionist I am, decided to step in and bring the class back to the carpet. I modeled how to build a structure by creating an example made of cardboard and toilet paper rolls. Then, I released the kids back to their groups. Thirty minutes later I had five new shelters being built in my classroom, but they looked just like my example. I did not allow the students to explore and try new ideas. I saw they were not immediately successful and stepped in.

Unfortunately, I do not feel I am the only teacher to make this mistake. I know now I should have allowed the kids more time to experiment and work together. I feel this story exemplifies the importance of having great resources for teachers to use, along with the professional development and background knowledge for them to be successful. I want to create a unit plan based on Callahan's ideas but incorporate information about implementation and support for teachers.

Conclusion

My teaching experiences over the past four years have encouraged me to try new ideas and allow my students to explore and ask questions. I want to create a science unit plan for myself and other teachers to feel confident in implementing lessons with elements of inquiry, exploration and engineering. In my experience, teachers are often told that STEM is the future and we need to be integrating these elements into our curriculums, but rarely are given support to do so effectively. Support can be resources such as: time, money, extra adult help, and curriculum. I cannot provide extra time, money, aides or English Languages teachers in classrooms but I can create an easy to implement science unit. My teaching experience has been at Catholic schools with limited funding, so I feel confident in creating these ideas with limited resources. I want to encourage students to explore while giving myself and other educators the confidence to guide their students effectively.

I want my capstone project unit plan to create a balance between allowing students to explore and ask questions while still demonstrating success in meeting the Next Generation Science Standards for weather, engineering and the Earth's systems. Chapter two contains a review of the academic literature available relating to my capstone project. The following chapter provides information on the research of the Next Generation Science Standards, inquiry-based learning, and assessments. I plan to use this research throughout the writing process to plan my curriculum in order to align with best practices for these three areas.

CHAPTER TWO

Literature Review

Chapter Overview

This literature review will review the research surrounding the question: *How can teachers utilize inquiry-based learning while assessing success in kindergarten science education?* The research will cover the topics of the Next Generation Science Standards, inquiry-based learning and assessments. The Next Generation Science Standards section will provide background information surrounding these standards issued in 2013, the challenges facing teachers as they plan lessons to support them, and the impact of these new science standards on education. Inquiry-based learning research will explore inquiry-based learning through background information, integration with STEM (Science, Technology, Engineering, and Mathematics), and the challenges facing teachers as they implement the concepts of inquiry-based learning into their science curriculum. Finally, the section on assessments will outline several different types of strategies that can be used for kindergarten science units such as observation, feedback, developmental, blended, and assessment for learning.

Next Generation Science Standards

The Next Generation Science Standards (NGSS) were released in 2013 as a new set of science standards created by education groups in many states across the country (Robelen, 2013). The goal of these standards is to create deeper understanding of science and engineering concepts in K-12 students. The standards are used in 19 states (Sadler & Brown, 2018) and focus on inquiry-based learning for all students. The basis of these standards is STEM. The goal is for students to create meaning from their learning to be able to use this knowledge beyond the classroom. This section explores the background, challenges and impact of the Next Generation Science Standards.

Background. The Next Generation Science Standards are a set of standards for science education in grades K-12. The standards were created to help teachers incorporate STEM education and inquiry-based learning into the science classroom on a more frequent basis. The goal is to increase science learning across the three dimensions of learning. These three dimensions are science and engineering practices, crosscutting concepts, and disciplinary core ideas (Robelen, 2012).

Science and engineering practices are used to encourage students to interact with conceptual ideas from their science curriculum. The goal is to provide more "depth over breadth" (Robelen, 2012, p. 1). Students will have lots of opportunities to work with science concepts to create deep understanding. Engineering concepts will be integrated with all science standards to ensure students are given opportunities to use critical thinking and problem-solving skills.

Students will be able to use the concept of three-dimensional learning to use these science and engineering practices to apply their learning throughout the curriculum, a concept NGSS calls cross-cutting concepts. The standards promote learning that crosses multiple science disciplines allowing the students to develop true understanding by creating their own meaning to solve problems, explain the world around them and make informed decisions (Roseman & Koppel, 2014). Cross-cutting concepts are the ability to look for patterns and use tools to find connections in the sciences (Roseman & Koppel, 2014). According to Fulmer, Tanas, and Weiss (2018), this branch of three-dimensional learning helps students explain findings and information through science (Fulmer et al., 2018).

The third aspect of three-dimensional learning is disciplinary core ideas. These are the core concepts in science education. The core ideas come from the fields of physical, life, and earth sciences and include concepts of technology and engineering (Fulmer et al., 2018). Together with crosscutting concepts and science and engineering practices, learning will become more meaningful to the students. Students will create a solid base in disciplinary core ideas through their exploration.

Another unique aspect to the NGSS is the performance expectations. Prior to the implementation of these standards most standards were writing in the language of "Student will be able to…" or "Students can…". The new performance expectations follow the language of "Students who demonstrate understanding can…" (Roseman & Koppel, 2014). This shift represents the emphasis on showing their interpretations and meanings as opposed to memorizing and listing. The NGSS also provides examples of what the students should be able to show to meet that standard (Fulmer et al., 2018).

Fulmer, Tanas, and Weiss (2018) explained that the best science lessons integrate all three of these learning dimensions. They share the best examples can be seen in design problems. When a student must create something to solve a problem they are using all three dimensions of learning. They must use the disciplinary core concepts to have a solid base of knowledge to build on. The students will use science and engineering practices to solve the problem. They also will need to use cross-cutting concepts such as cause and effect to see what will happen with their hypothesized solutions (Fulmer et al., 2018).

A successful science curriculum will enhance the students' learning through these three dimensions. There is much discussion over how to assess the quality of a new science curriculum and its adherence to the NGSS. The NGSS provides a lesson scanner for educators to evaluate lessons (Achieve, 2016). It looks for qualities such as explaining concepts or designing solutions, the three dimensions of learning, authenticity, incorporation of student ideas and building on student prior knowledge (Roseman & Koppel, 2014).

Challenges. There are many challenges facing educators as they implement and teach science lessons to support the Next Generation Science Standards. Many teachers want to teach science in a better way, but cite many challenges for reasons why they are not able to use these standards effectively to guide their science instruction. According to Miller, Curwen, White-Smith, and Calfee (2014), the lack of professional development and focus on literacy and mathematics are some of the challenges facing today's educators.

The NGSS are a big change from the previous science standards used in most states. The focus has changed from developing an understanding of core concepts to also including science and engineering practices and cross-cutting concepts. This change results in students needing more time and materials to explore science concepts at a deeper level. Teachers need to be educated on how to implement these lessons. Unfortunately, hands-on activities are only present in about half of all middle school and elementary science lessons (Roseman & Koppel, 2014). The NGSS requires a lot of hands-on learning for the students to be successful. Roseman and Koppel (2014) also found that teachers lecturing core concepts is the most used method of teaching science.

The NGSS do not align with this method of instruction. These are the reasons teachers need more professional development on implementing NGSS.

Studies have shown that science professional development is often the first curriculum area that is cut when making budget cuts to professional development. In fact, 85% of teachers in California (one of the leading states in creating and adopting NGSS) have not received any science professional development over the period from 2011 – 2014 (Miller, Curwen, White-Smith, & Calfee, 2014). NGSS was the state science framework from 2013 to present. This is several years of NGSS implementation with little to no professional development for educators to implement NGSS. Miller, Curwen, White-Smith, and Calfee (2014) described a possible solution:

> Project SMART (Science, Mathematics, Reading and Technology), a grant-based teacher professional development program, offered a research-based design aligned with Common Core State Standards' recommendations to teach science to young children in conjunction with literacy and mathematics, in order to increase instructional efficacy through integrated curriculum. (Miller et al., 2014, p. 318)

Many teachers have cited success from Project SMART, not only through providing the much-needed professional development, but by teaching science along with literacy and mathematics (Miller et al., 2014).

Providing support to educators so they can integrate the NGSS into literacy and mathematics instruction addresses a big challenge facing today's teachers. Many teachers feel they simply do not have enough time to teach science (Miller et al., 2014). There is a lot of pressure on teachers for students to be successful in literacy and mathematics. Most standardizing testing places most of the emphasis on these two subject areas. Teachers cite not having enough time to fit in other subject areas as a huge hindrance to a successful science curriculum (Miller et al., 2014). The pressure is so intense that many early elementary classrooms do not even teach science on a regular basis anymore. Prior to the implementation of Project SMART in the California school district teachers and the schools were only assessed on the scores from their students' math and reading standardized testing (Miller et al., 2014). Science was not even part of the conversation. Project SMART and the NGSS are working to change this focus, and include science in the elementary classroom as a focus area. Integrating science into math and literacy curriculums will provide opportunities for the NGSS to be implemented in many science curriculums in the United States.

Many researchers cite other challenges facing the NGSS and the potential impact these standards will have on elementary science education. The two most common ones found besides professional development and focus on literacy and mathematics instruction are issues with aligning curriculum and political clashes. Finding a strong science curriculum aligned to the NGSS is a struggle in many school districts across the country. Teachers are creating their own lessons and assessments to adapt current science curriculums to include the three-dimensional learning standards. This lack of alignment is hurting a successful implementation of the NGSS (Fulmer et al., 2018). Political debate and pushback is a struggle in many parts of the country as well. The issues cited have been instruction of evolution and climate change (Robelen, 2013). Finding a compromise and middle ground is a struggle for certain states that are pushing back on the NGSS.

The Journal of Research in Science Teaching (2018) published an article that summarized many of the challenges facing the NGSS. The authors stated:

> The challenge facing classroom teachers is not so much whether students' three-dimensional engagement with phenomena is desirable; the question is whether this is possible. With the curriculum materials being used in most classrooms today, the answer to this question is clear: No; without much better scaffolding students cannot use NGSS practices, cross-cutting concepts, and disciplinary core ideas to investigate and explain phenomena. (Anderson et al., 2018, p. 2)

Schools and teachers will need support in the form of professional development, the gift of time to teach science and a strong curriculum to successfully implement the NGSS in the elementary classroom.

Impact. As mentioned above, most educators feel the goal of the NGSS and using three-dimensional learning to develop deep understanding of scientific concepts is valuable. However, the issue comes with how to accomplish this lofty goal (Anderson et al., 2018). Many states are already successfully using a science curriculum aligned with the NGSS however most would agree that there are issues with implementation and curriculum (Roseman & Koppel, 2014). Roseman and Koppel (2014) pointed out that the quality of these newly created curriculums aligned to NGSS is the most important factor to the success of NGSS. The next section provides information into the impact on classrooms that are currently using NGSS aligned lessons and ones that will do so in the future.

Project SMART provided professional development to many teachers in California to help them be better equipped to teach lessons aligned to the NGSS. The test group showed that the teachers felt more prepared to teach science after having more professional development. As a result, the teachers created more lessons following the three-dimensional learning approach, integrating science and engineering practices, cross-cutting concepts, and core disciplinary ideas (Miller, Curwen, White-Smith, & Calfee, 2014). Miller et al. (2014) summarized the successes of Project SMART:

> Upon integrating more science instruction, teachers recognized a change in their students' affect, noting the quality of questions and authentic engagement in the classroom. One teacher reported science was now a unifying element in her classroom. In her estimation, this inclusive aspect was vital for the English learners who were able to engage in the universal language of scientific exploration, thus ameliorating differences between cultural groups. (p. 322)

This school had wonderful successes in improving science instruction, but also by uniting different culture groups within one classroom. This success story demonstrates the goal of NGSS for teachers to create a learning environment that would connect content knowledge and inquiry resulting in greater student interest and achievement (Roseman & Koppel, 2014). NGSS is a good tool towards helping students accomplish a solid understanding of science content, high engagement and ability to apply knowledge. A strong curriculum is a necessary addition to ensure the success of the Next Generation Science Standards.

Inquiry-Based Learning

Inquiry-based learning is an important part of today's science instruction. This pedagogy method encourages student-centered learning, as opposed to the teacher delivering all the information. This section will explore inquiry-based learning through background information, integration with STEM (Science, Technology, Engineering, and

Mathematics), and the challenges facing teachers as they implement the concepts of inquiry-based learning into their science curriculum.

Background. In the year 2000, the National Research Council published a book titled *Inquiry and the National Science Education Standard.* This book explained the importance of integrating inquiry-based learning into the science classroom, from kindergarten through 12th grade. The research supported the importance of students being able to explore science, to truly grasp the science concepts and demonstrate understanding on assessments. This book predated the NGSS but supports the importance of inquiry in the classroom (NRC, 2000). The NRC gives a clear definition of inquiry-based learning through five features:

> (a) students engage in scientific questions which are posed by the pupils themselves or by their teachers
>
> (b) students provide responses that prioritize evidence
>
> (c) students propose explanations based on evidence
>
> (d) students evaluate their proposed explanations in light of alternative explanations and accepted scientific knowledge
>
> (e) students communicate and justify their proposed explanations. (NRC, 2000, p. 22)

Using these five criteria is a solid measurement for educators to use to evaluate their science instruction. If the goal is inquiry-based learning it should address these five features.

Research shows inquiry-based learning is the best way for students to learn science, even beginning in the early elementary years (Zacharia, Loizou, &

Papaevridpido, 2012). There is also research that shows pre-kindergarten and kindergarten are the best times to introduce inquiry because the students have developed the skills necessary to be successful. Zacharia, Loizou, and Papaevridpidou (2012) found "evidence that young children have the skills – cognitive, affective and psychomotor – required for engaging in science learning processes" (p. 447). The same study also found that young children also have the interest in science learning further justifying the importance of introducing students to this learning early in their academic careers. They also found the importance of integrating physical experiments and manipulatives into science education. Students have a positive impact on learning and memory when there is a physical interaction with materials, in science but also in literacy and mathematics (Zacharia et al., 2012). These physical interactions enhance the cognitive learning by allowing students the opportunity to practice these skills and effectively process the information (Zacharia et al., 2012). Inquiry-based learning can be explained as taking the science concepts from traditional lecture-based instruction and integrating these ideas with incorporates with active learning activities. The goal is the integration of new knowledge with existing, prior knowledge (Eckhoff, 2016).

Integration with STEM. Inquiry-based learning and STEM curriculum overlap in methods and design in many areas. STEM is an approach to learning that takes the conceptual learning from science, technology, engineering and mathematics and integrates them with real-world lessons and learning (Lantz, 2009). Many STEM lessons take ideas from more than one of the content areas. For example, a science lesson integrating STEM concepts will also include components of engineering into the lesson design. These lessons will provide the content knowledge with a hands-on approach to create deeper understanding on the standards.

An important aspect to STEM learning is the ability for students to have time to explore and create meaning for themselves. Research has found STEM to be successful because it allows the students to have ownership in their learning (Wheatley, Gerde, & Cabell, 2016). One way to provide this ownership is through recording observations. Wheatley et al. (2016) explained this idea by stating that by recording their own observations allows the students to observe patterns and compare results. This will create ownership and allow a deeper understanding of the results. Another idea for implementing STEM learning is to allow the students to design their own investigation (Flannagan & Rockenbaugh, 2010). The students can find answers by researching online or reading books and interviewing knowledgeable adults. This is a good example of integrating STEM concepts with inquiry-based learning.

Research shows it is important to begin STEM instruction at the early elementary level. The integration of cross-disciplinary functions such as technology and engineering into science instruction supports the play-based programs supported in many preschool and kindergarten programs (Tippett & Milford, 2017). This structure allows the children to explore science and make observations in a way that creates meaning for the students to use in their future learning. Tippett and Milford (2017) explained the importance of STEM in early education, "children's early STEM experiences should be hands-on and allow them to experiment and explore with safe everyday materials in meaningful ways; these types of experiences are related to later academic and social success" (p. S69). The same study also provided evidence to support the idea that STEM experiences at the early elementary level will lead to success in science throughout high school and university (Tippett & Milford, 2017). Despite all this sound evidence supporting STEM and inquiry-based learning in the elementary classroom, there is still some pushback against these learning systems. They will be explored in the next section.

Challenges to teachers. For many educators' inquiry-based learning can be a big shift their personal experiences of learning science. For that reason, it can be a challenge to implement something new and different. The biggest challenges facing teachers and their ability to successfully implement inquiry-based learning are time, control, and professional development.

The lack of time dedicated towards science education is a struggle for science educators across the United States. The section on the Next Generation Science Standards outlined the focus on math and literacy instruction, with much of the focus on increasing test scores in those core areas often results in decreased time for science education. Tippett and Milford (2017) conducted research to see how much time is being devoted towards science compare to math and literacy at the early education level. They found only 19 minutes per day is used for STEM related instruction, compared to 89 for literacy and 54 for math (Tippett & Milford, 2017). This is comparable to my personal experiences in teaching early elementary. The minutes required are much lower and due to the pressure to succeed in testing for literacy and math, science education is often put aside.

Another struggle found in the research for inquiry-based learning is the lack of control teachers feel they need to relinquish for these lessons. Inquiry-based learning requires the teacher to take a side seat in the learning process. They are no longer just delivering information for the students to absorb, but creating experiences and learning opportunities for them to gain knowledge. Teachers are not supposed to be giving the right answers and telling their students what to do, but should encourage them to try new ideas and experiment (Oliveira, 2009). Oliveira (2009) also noted that in this model, the students take on new roles as well. They are the ones asking questions and evaluating results. This is great skills practice for the student but does require the teachers to give up some control. The importance of strong classroom management and routines will be crucial when implementing inquiry-based learning. It will be very important for the teachers and students to have clear expectations and guidance when beginning these lessons (Oliveira, 2009).

Another challenge facing teachers as they implement inquiry-based learning is the lack of professional development available to teachers. Many teachers avoid teaching inquiry-based lessons due to their own lack of science content knowledge (Weiss et al., 2001). Teachers feel more comfortable teaching from a textbook and following along with a carefully scripted curriculum when they are not completely confident with the material (Weiss et al., 2001). If teachers had more professional development they might feel more confident in their science content knowledge. When teachers have more confidence in their own understanding of the material they are more likely to incorporate inquiry-based learning and experiment with new ideas and lesson (Weiss et al., 2001). One study followed a group of newly licensed teachers as they learned how to implement inquiry-based lessons and activities into their science curriculum. The study found:

> Through the development and implementation of a responsive, science inquiry project, the PTs (preservice teachers) created a learning environment that not only

> helped scaffold the children's scientific understandings of seasonal change but also allowed the PTs to explore their roles as teachers and learners of science. Throughout the semester, the PTs came to challenge their own beliefs about science, science education during early childhood, and their own teaching skills and abilities by working through the challenges presented by an inquiry-based project… Providing PTs with challenging and supportive inquiry-based teaching and learning opportunities during their teacher preparation program can ultimately assist in strengthening their understandings of their role as supportive educators in developing science learning experiences that are based upon current research recommendations for best practices in the classroom. (Eckhoff, 2016, p. 220)

This study shows that despite the challenges facing teachers as they implement inquiry-based learning we can see that this style of learning is beneficial to the students and the teachers.

Inquiry-based learning is a necessary component to a successful science curriculum. Students need opportunities to explore, question and evaluate their findings to develop a solid understanding of the science standards. Integrating inquiry-based learning with STEM subject areas is a good way to create meaning in science education.

Assessments

Assessment is the measurement of a student's learning based on observation and demonstration of knowledge. This section will explore the best practices for authentic assessment of a kindergartener's science learning. The research also covers different types of assessment and how these assessments can be used to demonstrate understanding in a kindergarten science curriculum. This section will outline several different types of assessment strategies that can be used for kindergarten science instruction such as observation, feedback, developmental, blended, and assessment for learning.

Kindergarten assessment. Kindergarten teachers face a unique challenge when assessing their students. There is a struggle between what the research shows is developmentally appropriate and necessary for five-year-old students and the high academic expectations set by state standards (Gullo & Hughes, 2011). Teachers want to create a balance in their classrooms, by setting high expectations yet allowing their students to explore and play (Richards & Han, 2015). Gullo and Hughes (2011) described the need for assessment: “Within the current context, teachers are expected to integrate assessment data throughout instruction to monitor student achievement and guide decision-making to meet mandated standards” (p. 324). There are many different types of assessment, formative and summative alike. This section outlines several different strategies used by kindergarten teachers to assess their progress. Gullo and Hughes (2011) also provided a list of criteria for effective kindergarten assessment. The following principles will be applied to the different strategies of assessment:

(a) assessment should be a continuous process

(b) assessment should be a comprehensive process that involves multiple formats that yield information on diverse learning

(c) assessment should be an integrated process with learning goals and instructional periods. (Gullo & Hughes, 2011, p. 325)

Observation. Most teachers integrate observation into their assessment practices. Observation can be used in a formal setting or just an informal check in with students. Observation is particularly beneficial in assessing understanding in science because the constant and direct measurement is needed to assess understanding (Zucker, Williams, Bell, Assel, Landry, Monsegue-Bailey, & Bhavsar, 2015). In my experience assessing by observing can be a good assessment tool because it can be done often, quickly, and effectively to monitor student progress and understanding of standards. The National Research Council (NRC) also pointed out the need for observation in science lessons by explaining the importance of the students have direct interaction with the content in science education. Observing how a student reacts to an experiment or STEM challenge provides the teacher with information of their understanding of the science content knowledge (NRC, 2012). Monteira and Jiménez (2016) also pointed out the importance of using observation to assess student learning in the early elementary years because purposeful observation "supports students in collecting and interpreting data, in the transformation of data into evidence, and in using evidence in order to revise their understandings" (p. 1243).

Feed up, feedback, and feed forward. Fisher and Frey (2011) wrote about an assessment strategy they call "feed up, feedback, and feed forward" (p. 26). This strategy is explained:

> Feeding up establishes a substantive line of inquiry that compels learners to engage in investigation and inquire. It also forms the basis for the assessments that follow. Once students understand the purpose and begin to work, they receive feedback that is time and scaffolds their understanding. Based on their responses, the teacher gains a sense of what learners know and do not know. These practices drive a feed forward system that informs the teacher about what needs to be taught, or what students need to experience, next. (Fisher & Frey, 2011, p. 30)

A benefit to this assessment strategy is the ability to make changes to instruction in the moment. When teachers give feedback throughout instruction they can make changes according to the students' learning. This is beneficial because many misunderstandings can be fixed immediately instead of waiting until the teacher sees the mistakes on their summative assessment later (Fischer & Frey, 2011). Fischer and Frey (2011) also stressed the importance of using this information to guide instruction. By utilizing their model of "feed forward" teachers are benefitting from the tool of assessment to help make their students more successful (Fischer & Frey, 2011). Fischer and Frey (2011) also emphasized the connection between "feed up, feedback, and feed forward" and inquiry-based learning. The connection comes from the need for the teachers to adjust their instruction to meet the students' needs and guide them to new learning experiences.

Developmental. Pyle and DeLuca (2013) outlined several different assessment strategies and how to best use them in the kindergarten classroom. The first is called developmental assessment. These types of assessments put the focus on child-centered assessment to judge individual student readiness (Pyle & DeLuca, 2013). This assessment document student learning and readiness through checklists and observation. The focus is on developmental stages and seeing where the child is at. An example of developmental assessment would be a list of student names and a checklist of how high they can count to meet the Common Core standard of counting to 120.

Blended. The second assessment type described by Pyle and DeLuca (2013) is called blended assessments. These assessments include social development as described in the developmental assessment but also stress academic development. Teachers are free to incorporate different teaching strategies as they see fit to meet the standards. There is a focus on following the traditional sequence of assessment: find the baseline, complete formative check-ins during instruction, and then provide a summative assessment at the end. These types of assessment use standardized tests, but also incorporate teacher created assessments to meet individual student needs (Pyle & DeLuca, 2013). An example of a blended assessment is the Developmental Reading Assessment (DRA). They measure growth by assessing students in reading accuracy over time but also allow for differentiation (Pyle & DeLuca, 2013).

Assessment for learning. The final assessment strategy described by Pyle and DeLuca (2013) is called assessment for learning. Assessment for learning is closely tied to the standards. These assessments take student learning and incorporate their own self-assessing abilities to encourage growth and development. An example of assessment for learning is peer assessment and self-assessment tools created by teachers (Pyle & DeLuca, 2013).

The research shows the importance of assessing student's progress and knowledge in all areas of learning, but also how to use the information gathered from assessments to guide your instruction, planning and future assessments. Proper assessment will lead to successful implementation of a new science unit. Without assessment, teachers will not be able to evaluate the success of their students in terms of meeting the standards and demonstrating understanding.

Conclusion

There is much support for the importance of integrating the Next Generation Science Standards, inquiry-based learning, and effective assessments into the early elementary classroom. The challenges facing today's educators are related to a lack of professional development and effective curriculum to accomplish these goals. With proper professional development and a solid science curriculum, teachers will feel more prepared to teach science from the lens of inquiry-based learning that will lead to an increased demonstration of understanding for the Next Generation Science Standards. Proper professional development and a solid science curriculum will allow teachers to answer the question: *How can teachers utilize inquiry based learning while assessing success in kindergarten science education?* I plan to use this research to create an engaging science curriculum for kindergarten students. This unit plan will meet the NGSS on engineering, weather, and Earth Science. Chapter Three describes the methods I will use to create a science unit for teachers to use inquiry-based learning to teach and assess understanding of the NGSS on engineering, weather, and Earth science. The following chapter provides background information on the setting of the school, the students, the curriculum design model, and the content and format of the unit plan.

CHAPTER THREE

Methodology

Chapter Overview

Chapter three will provide an overview of my capstone project. I plan to create a science unit plan for kindergarten students to explore the Next Generation Science Standards of weather, engineering, and Earth science. This chapter will provide background information on the setting of the school, the students, the curriculum design model, and the content and format of the unit plan.

My curriculum will incorporate inquiry-based learning to engage the students with science content knowledge. My goal is for the students to meet the science standards provided by the NGSS with high engagement and an ability to demonstrate understanding of the content. My research question is: *How can teachers utilize inquiry-based learning while assessing success in kindergarten science education?* My curriculum will provide a unit plan for teachers to implement in their classrooms to encourage inquiry and demonstrate understanding through student assessment.

The Setting and the Students

I am not teaching this year so I will use my last school as my projected audience. I taught at a small parochial school at a large city on the West Coast during the 2017 – 2018 school year. The school has a student population of 250 in grades kindergarten through 8th grade. Each grade is a single grade classroom, meaning there is only one kindergarten teacher and only one first grade teacher, all the way through middle school. The school also employs full time teaching assistants in grades kindergarten through fourth grade. The students have access to physical education, music, drama, and library classes a few times a week.

The image that comes to mind when you hear of a private parochial school is probably quite different from the reality of this particular school. This city is a unique city with extremely high costs of living with many supporting their lifestyles with careers in technology, sales, and engineering. The school I taught at was the exception to this lifestyle. Most parochial schools in this region cater towards upper and upper middle-class families, because those are the groups that can afford to stay in the area. My school was in a very low-income area of the city. Families have been there for generations and can afford to stay by having multigenerational family units living in one small house. It was not uncommon for my students to live in a house purchased by their grandparents' decades ago. They shared a room with their siblings and parents. Down the hall would be the same scenario with their aunt, uncle, and cousins.

The school is funded by a group of religious sisters called the Daughters of Charity. The Daughters of Charity subsidized the cost of a private and religious education to keep the school open in this low-income area. This allowed the students to attend school at a low out of pocket cost. Most of my students were from Hispanic and Asian families (California Department of Education, 2017), and many parents cited a faith-based education as important to them. The parents had to work hard to afford the small monthly payment to allow their children to attend this school. The majority of the students qualified for free and reduced lunch (California Department of Education, 2017). My class for the 2017 – 2018 school year had 20 students. There were 8 boys and 12 girls. Eleven of the students had never attended preschool or any formal education setting prior to kindergarten. Seventeen of the students were classified by the Archdiocese as English language learners because they spoke a second language at home. Of those 17 students, three of them had never spoken English prior to the first day of kindergarten. Due to the budget limitations of a low-income area parochial school the school does not employ English language teachers. Classroom teachers are given small amounts of professional development throughout the school year to support our English language learner students.

Science instruction is required for 60 minutes per week according to the requirements for the district. This unit will require more time. I did not find that to be an issue when teaching in this district because the minutes required are designed for a half-day kindergarten program while my school was a full day program. There were about two hours of wiggle room every day to allow for additional time in whatever content area required it. Some weeks the additional time was for science or social studies, sometimes it was used for supplemental religion instruction around Christmas or Easter, and it was often used to cover the time for school assemblies and other activities.

Parochial schools in this area follow the Next Generation Science Standards model for science instruction. They take these standards and integrate them into their own district curriculum. The district standards use the Next Generation Science Standards and the Common Core Standards as their base standard, and usually add on from there. This unit plan will follow the NGSS as I used those standards for science instruction while teaching at this school.

Curriculum Design Model

This unit will be created following the *Understanding by Design* model created by Wiggins and McTighe (2011). This curriculum design model follows a backwards design approach. The lesson is created with the result in mind. For this science unit plan, I will start with the standards I want my students to demonstrate understanding of and work backwards from there.

Wiggins and McTighe's *Understanding by Design* (2011) explains three steps to creating lessons that follow the backwards design approach. The first stage is to identify desired results (Wiggins & McTighe, 2011). During this stage, the teacher will need to select the standards the students will need to demonstrate understanding of the content knowledge. The backwards design approach works very well with inquiry-based learning and the Next Generation Science Standards because of this focus on the first stage. Starting with the learning goal, or standard, is a great way to ensure focus on the NGSS. The focus on the standard will also lend itself well to the integration of inquiry-based learning while ensuring those activities provide value and engagement with the core science knowledge.

The second stage of Wiggins and McTighe's curriculum design approach is to determine acceptable evidence (Wiggins & McTighe, 2011). This stage requires the teacher to think of different demonstrations of understanding. What evidence presented by the students will demonstrate learning? This step will have the teachers think of the different types of assessment and what will be considered proficient for accomplishing that specific standard.

The third stage is to plan learning experiences and instruction (Wiggins & McTighe, 2011). Teachers will now work towards creating valuable lessons and inquiry-based activities. Since this is the last step teachers will be focused on creating lessons that focus on the standards and creating authentic assessment.

I will follow this curriculum design model by following these three stages towards creating authentic and engaging science units. By working from the standard, to the assessment, and finally to the activities I will be sure my lessons are focused on helping my students demonstrate understanding of the science content knowledge. Wiggins and McTighe's backwards design (2011) will help me answer my research question: *How can teachers utilize inquiry based learning while assessing success in kindergarten science education?*

Curriculum Content and Format

I will create a science unit plan for Kindergarten classrooms to support the Next Generation Science Standards of Energy, Engineering and Earth's Systems. My unit will allow students to explore, investigate and solve problems. My question is: *How can teachers utilize inquiry based learning while assessing success in kindergarten science education?*

My unit plan will address the following standards taken from Next Generation Science Standards (2019):

Students who demonstrate understanding can:

- K-2-ETS1-1. Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

- K-2-ETS1-2. Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.
- K-2-ETS1-3. Analyze data from tests of two objects.
- K-PS3-1. Make observations to determine the effect of sunlight on Earth's surface.
- K-PS3-2. Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area.
- K-ESS2-1. Use and share observations of local weather conditions to describe patterns over time.
- K-ESS2-2. Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.

This curriculum will be a two-week science unit for kindergarten students in the month of January. There will be ten 30-minute lessons in the unit plan. The unit can be used at other times of the year, but I am creating my lessons with that time frame in mind to account for what is realistic for a kindergartener to accomplish about 100 days into the school year. I would not recommend this unit for early in the school year. I would recommend waiting until the class is comfortable with the routines and procedures for inquiry-based learning and group work.

My units will be based on a lesson packet available on Teachers Pay Teachers. This unit is created by teacher-author Sue Calahane (Calahane, 2013). She created a unit plan to address the NGSS titled “Weather and Temperature.” Her lessons allowed the children to learn about weather, while integrating those intimidating engineering standards. I plan to use some of her original ideas to support my activities to achieve the goal of authentic assessment of the NGSS while using inquiry-based learning activities.

Conclusion

This chapter has supplied information on the methodology of my science unit plan for kindergarten students to explore the Next Generation Science Standards of weather, engineering, and Earth science. The chapter also provided background information on the setting of the school and the students that this unit is intended for the curriculum design model, and the content and format of the unit plan. Chapter four summarizes the curriculum writing process to answer the research question: *How can teachers utilize inquiry-based learning while assessing success in kindergarten science education?*

CHAPTER FOUR

Conclusion

Chapter Overview

The goal of my Capstone project was to answer the research question: *How can teachers utilize inquiry-based learning while assessing success in kindergarten science education?* I created a two-week unit plan for kindergarten students to answer this question. I worked to create ten lessons that will address the Next Generation Science Standards in engineering, weather, and Earth science. My lessons provide teachers with a framework following Understanding by Design (Wiggins & McTighe, 2011) to integrate inquiry-based learning into their science instruction.

Chapter four reflects on the curriculum design process for my Capstone project. First, I address what I have learned from this process. Next, I reflect on my literature review and how that shaped my curriculum. Then, I write about the limitations and implications of my project. Finally, I write about the benefits my curriculum will provide to educators.

Major Learnings

I found the Capstone writing process to be a valuable experience to me, as a student and as a teacher. As a student, I was reminded of many academic behaviors lost on me since leaving the classroom as a student five years ago. I spent a lot of time revisiting APA guidelines and using databases to search for academic articles. It was good to brush up on these skills. I feel it is important for teachers to be up to date on research skills to find good academic sources to guide choices in the classroom. Teachers can use this information to make sure they are using the best practices to educate their students.

As a teacher, I was reminded of the importance of backwards design (Wiggins & McTighe, 2011) with lesson planning. In my teaching experiences, I found it can become so easy to get wrapped up in the daily tasks. I found myself teaching the same lessons, giving the same quizzes, and falling into the traps of the picture perfect and Pinterest worthy crafts and activities. This process reminded me of the importance to start with the end goal and work backwards. I used this Capstone writing process to refocus my lessons on identifying desired results, determining acceptable evidence, and to finally plan learning activities (Wiggins & McTighe, 2011).

In terms of inquiry-based learning, I was able to use this Capstone writing process to remind myself of the importance of inquiry. Students need to be able to explore concepts with interactive activities to help them develop greater understanding. My literature review reinforced this importance. Much of the research I found stated the importance of inquiry-based learning and showed evidence it is the best way to teach science concepts to elementary students (Zacharia et al., 2012).

Literature Review

The literature review was essential to my research about inquiry-based learning in the kindergarten classroom. I was able to learn about different research studies conducted on science education in the early elementary school years. I used this research to guide the creation of my science unit plan.

One article I kept coming back to was titled “Kindergarten, Can I Have Your Eyes and Ears?” The author, Oliveira (2009), stressed the importance of inquiry-based learning. As I was writing my unit plan I kept remembering the idea of the teacher needs to take a side seat in the learning process for inquiry-based learning to result in increased student achievement. This is important for the students to have a stake in their learning. They need to be engaged, asking questions, and guided their own learning. It was a good reminder for me as I tried to create a unit plan that gave a lot of choices and control to young students. It is okay for the learning to not be perfect. The goal is to demonstrate understanding of the NGSS standards not to have the picture perfect product. This research helped me focus on this goal.

Limitations

I feel I have created an engaging and education unit plan to meet several of the NGSS. However, any unit plan is subject to limitations. The most significant limitation of my unit plan is the time required to teach these lessons. Unfortunately, not all kindergarten classrooms have thirty minutes a day to devote to science education. Most school districts have a huge focus on literacy and mathematics (Miller et al., 2014) and have limited time available to teach science. One study found only 19 minutes per day is used for STEM related instruction, compared to 89 for literacy and 54 for math (Tippett & Milford, 2017) I am lucky to have taught for school districts that provide a lot of autonomy to classroom teachers. I have always been able to devote time to teach science units on a regular basis in my classroom. However, not all school districts are so flexible. This will be a limitation of my unit plan.

Implications

The most significant policy implication from my Capstone project is for school districts, states, and our country to bring a focus to science education. Unfortunately for our students, inquiry-based learning is often an extra added step and not seen as the necessity for science learning. Standardized testing is often focused on mathematics and literacy, not even touching science (Miller et al., 2014). There is a lot of research that shows the importance of STEM and inquiry in the elementary classroom (Zacharia et al., 2012), but not a lot of curriculum, time, and professional development available to support teachers to do so.

Benefit to Educators

I hope my unit plan for engineering, weather, and Earth systems will benefit kindergarten teachers. Many teachers cite lack of professional development and effective curriculum as a reason for shying away from teaching inquiry-based lessons in science (Miller et al., 2014). I feel this unit plan will be a good beginning point to help those classroom teachers. I wanted to create a resource that will help teachers effectively teach inquiry in the kindergarten classroom. I feel this unit plan will benefit these teachers by providing an outline of ten lessons to help meet the kindergarten NGSS. I hope this will also encourage teachers to implement their own inquiry-based learning ideas once they see it can be done with young students with organization and creative thinking.

Conclusion

This chapter summarized the curriculum writing process to answer the research question: *How can teachers utilize inquiry-based learning while assessing success in kindergarten science education?* In this chapter, I addressed what I have learned from the Capstone process. I wrote to reflect on my literature review and how that shaped my curriculum. I addressed some of the limitations and implications of my project. Finally, I shared the benefits my curriculum will provide to educators.

I enjoyed the Capstone writing process, I was able to grow immensely as a student and as a teacher. I feel more prepared to go back into the classroom and implement lessons that will result in a deep understanding of the kindergarten standards for my students. I feel encouraged to continue to use the backwards design model created by Wiggins and McTighe (2014) to create meaningful lessons, activities, and assignments. I hope to share my unit plan with many other kindergarten teachers to continue to foster an environment of sharing and collaboration with my colleagues.

REFERENCES

Achieve (2016). EQuIP rubric for lessons & units: Science (Version 3.0). https://www.nextgenscience.org/sites/default/files/EQuIPRubricforSciencev3.pdf

Anderson, C. W., de los Santos, E. X., Bodbyl, S., Covitt, B. A., Edwards, K. D., Hancock, I. J. B., Welch, M. M. (2018). Designing educational systems to support enactment of the Next Generation Science Standards. *Journal of Research in Science Teaching*, *55*(7), 1026–1052. Retrieved from EBSCOHost.

Cahalane, S. (2013). Weather and temperature. Retrieved from https://www.teacherspayteachers.com/Product/Weather-and-Temperature-Aligned-with-NGSS-K-PS3-12K-ESS2-12K-2-ETS1-12-786898/

California Department of Education (2019). Demographics. https://www.cde.ca.gov/ds/sd/index.asp

Eckhoff, A. (2017). Partners in inquiry: A collaborative life science investigation with preservice teachers and kindergarten students. *Early Childhood Education Journal*,*45*(2), 219–227. Retrieved from EBSCOHost.

Flannagan, J. S., & Rockenbaugh, L. (2010). Curiosity + kindergarten = future scientists. *Science & Children*, *48*(4), 28–31. Retrieved from EBSCOHost.

Fisher, D., & Frey, N. (2011). Feed up, feedback, and feed forward. *Science & Children*, *48*(9), 26–30. Retrieved from EBSCOHost.

Fulmer, G. W., Tanas, J., & Weiss, K. A. (2018). The challenges of alignment for the Next Generation Science Standards. *Journal of Research in Science Teaching*, *55*(7), 1076–1100. Retrieved from EBSCOHost.

Gullo, D. F., & Hughes, K. (2011). Reclaiming kindergarten: Part I. Questions about theory and practice. *Early Childhood Education Journal*, *38*, 323–328.

Lantz, H. B. (2009). Science, technology, engineering and mathematics (STEM) education: What form? What function? What is STEM education? Retrieved from EBSCOHost.

Miller, R., Curwen, M., White-Smith, K., & Calfee, R. (2015). Cultivating primary students' scientific thinking through sustained teacher professional development. *Early Childhood Education Journal*, *43*, 317–326. Retrieved from EBSCOHost.

Mills, G. E. (2011). *Action research: A guide for the teacher researcher*. Boston: Pearson.

Monteira, S. F. & Jiménez, A. M. P. (2016). The practice of using evidence in kindergarten: The role of purposeful observation. *Journal of Research in Science Teaching*, *53*(8), 1232–1258. Retrieved from EBSCOHost.

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

National Research Council (NRC). (2012). A framework for K-12 science education: Practices, crosscutting concepts, and core ideas. Washington, DC: National Academies Press.

Next Generation Science Standards. (2019, February 11). Retrieved from https://www.nextgenscience.org/

Oliveira, A. W. (2009). "Kindergarten, can I have your eyes and ears?" Politeness and teacher directive choices in inquiry-based science classrooms. *Cultural Studies of Science Education*, *4*(4), 803–846. Retrieved from EBSCOHost.

Pyle, A., & DeLuca, C. (2013). Assessment in the kindergarten classroom: An empirical study of teachers' assessment approaches. *Early Childhood Education Journal, 41*(5), 373-380.

Richards, J., & Han, H. S. (2015). Play-based kindergarten: No problem aligning with English language common core standards. *Journal of Reading Education, Fall 2015,* 31-37.

Robelen, E. W. (2012). Public gets glimpse of science standards. *Education Week*, *31*(31), 1–15. Retrieved from Retrieved from EBSCOHost.

Robelen, E. W. (2013). States soon to weigh science standards. *Education Week*, *32*(19), 1–13. Retrieved from EBSCOHost.

Roseman, J. E., & Koppel, M. (2014). Aligned or not? *Educational Leadership*, *72*(4), 24–27. Retrieved from EBSCOHost.

Sadler, T. D., & Brown, D. E. . (2018). Introduction to the special issue: A critical examination of the Next Generation Science Standards. *Journal of Research in Science Teaching*, *55*(7), 903–906. Retrieved from EBSCOHost.

Tippett, C., & Milford, T. (2017). Findings from a pre-kindergarten classroom: Making the case for STEM in early childhood education. *International Journal of Science & Mathematics Education*, *15*, 67–86. Retrieved from EBSCOHost.

Weiss, I., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). Report of the 2000 survey of science and and mathematics education. Chapel Hill, NC: Horizon Research.

Wiggins, G. & McTighe, J. (2011). The understanding by design guide to creating high-quality units. Alexandria, VA: Association for Supervision and Curriculum Development (ASCD).

Wheatley, B. C., Gerde, H. K., & Cabell, S. Q. (2016). Integrating early writing into science instruction in preschool. *Reading Teacher*, *70*(1), 83–92. Retrieved from EBSCOHost.

Zacharia, Z. C., Loizou, E., & Papaevridpidou, M. (2012). Is physicality an important aspect of learning through science experimentation among kindergarten students? *Early Childhood Research Quarterly*, *27*(3), 447–457. Retrieved from EBSCOHost.

Zucker, T. A., Williams, J. M., Bell, E. R., Assel, M. A., Landry, S. H., Monsegue-Bailey, P., Bhavsar, V. (2016). Validation of a brief, screening measure of low-income pre-kindergarteners' science and engineering knowledge. *Early Childhood Research Quarterly*, *36*, 345–357. Retrieved from EBSCOHost.