

Teaching Kindergarten Students about the Water Cycle through Arts and Invention

Latisha L. Smith

University of Northern Iowa

and

Deepanee Samarakoon

Cedar Falls Community School District

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Abstract

Research evidence for the benefits of arts integration is mounting. The purpose of this study was to determine if integration of the arts was an effective strategy for teaching the water cycle to kindergarten students. The study included lessons that supported both a science and an engineering standard of the Next Generation Science Standards and national arts standards. The phenomenological study examined the lived experiences of children as they learned and demonstrated understanding through drawings, watercolor paintings, dramatization of a water cycle poem, and the invention and testing of a waterproof boot. Participants were 12 kindergarten students (7 male, 5 female) aged 5-6 years, attending a public elementary school in the Midwestern United States. The three major themes that emerged from the phenomenological study were: 1) aspects of typical lessons, 2) art-enhanced learning, and 3) art-enhanced teacher understanding of student ideas. Findings revealed arts integration was motivating, engaging for the students, and an effective strategy for teaching about the water cycle. The art-based activities provided deeper insights about student understanding and misconceptions than traditional forms of assessment.

Key Words

Kindergarten, water cycle, arts integration, Next Generation Science Standards, STEAM, and invention.

Introduction

"Everyone is a visual, auditory, and kinesthetic learner" (Land, 2013, p. 549). Taking this into consideration, many students benefit from educational environments that allow them to see and hear information as well as be physically involved with content in some way. Nevertheless, the powerful nature of science education infused with the arts is often disregarded (Root-Bernstein & Root-Bernstein, 2013). Allowing students to utilize arts in the content areas promotes the development of skills in visual thinking, observation, and pattern formation. In addition, students can learn the value of perseverance along with trial and error when working with art materials. Students can be visually, acoustically, and kinesthetically connected to content when arts are used in teaching. According to Root-Bernstein and Root-Bernstein (2013), there is significant justification for integration of science and the arts if the goal of science education is to create students who are capable of active and creative participation related to science in our world. With the

implementation of the Next Generation Science Standards (NGSS), education professionals are in an ideal position to teach science content by infusing the arts while addressing content and engineering standards.

Many teachers are using the arts and emphasizing creativity to produce positive outcomes in their classrooms. One such investigation required students to create, design, and test their own invention. The teacher posed questions about the design of the invention, how it was related to existing products, and how the invention could be improved (Graca, 2012). Another study afforded students with the opportunity to learn about the properties of rocks by making a watercolor picture of the actual rock and writing a riddle about the rock (Poldberg, Trainin, & Andrzejczak, 2013). Both studies revealed high engagement by the students and made it known students with differing academic abilities could be successful when taught content using the arts (Graca, 2012; Poldberg et al., 2013).

The purpose of the current study was to add to research that suggests learning science content can be positively impacted by integration of the arts. This study also investigated how an understanding of the water cycle by kindergarten students could be conveyed by various forms of art, including a waterproof boot invention aligned with a Next Generation Science Standard (NGSS) engineering standard. Qualitative data for a phenomenological analysis was collected through drawings, paintings, photographs, dictation by kindergarten students, observation of student work, attitude surveys, and conversations with students.

To provide a foundation for the current investigation, the literature related to arts integration benefits will first be reviewed. Then, attention is turned to previous work on teaching concepts related to the water cycle to early childhood students. Because students often have misunderstandings related to science, misconceptions are explored next. The current project involved invention of a waterproof boot so existing studies that focused on young children's inventions are addressed next. Finally, the national standards addressed by the current project are considered.

Literature Review

Arts Integration

In recent years, many education professionals have viewed subjects such as mathematics and reading with the highest regard because they were addressed by standardized tests (Tienken & Zhao, 2013). However, data suggest teachers and students can be positively impacted by the integration of the arts into subjects such as science and social studies, thereby addressing more content areas within the elementary curriculum (Poldberg et al., 2013). According to Hardiman, Rinne, and Yarmolinskaya (2014) inclusion of artistic tasks may be beneficial not only for the sake of doing art, but may improve student outcomes and increase learning in a broad sense. Findings from Hardiman et al. (2014) support the notion that integration of the arts provides students with experiences that allow them to learn content in a manner that promotes long-term retention. For instance, rehearsal and enactment have been found to be effective means for content retention. Students must be asked to elaborate on their thoughts if rehearsal is to be effective. Through rehearsal, connections are made between pieces of information or to a student's prior knowledge (Rinne, Gregory, Yarmolinskaya, & Hardiman, 2011). Furthermore, engagement in the arts may be a way to promote elaborative rehearsal because students are more motivated to participate. According to Smithrim and Uptis (2005) integration of the arts is a proven method of increasing student motivation. Posner and Patoine (2009) agree that art related activities are linked to motivation and report that attention is also impacted (Rinne et al., 2011, p. 90). Enactment allows students the opportunity to use their bodies to act out content and results in improved recall when compared to traditional methods during which students hear or read content. Research has shown that remembering action phrases was more likely when individuals were able to engage in the actions that were discussed (Rinne et al., 2011).

Students with special academic needs, including those with challenges related to reading and writing, may show gains when exposed to content through an art medium (Hardiman et al., 2014). When working with students, a teacher needs to make connections between language,



images, and knowledge in the content area being studied (Poldberg et al., 2013). "Many students who are striving to succeed academically benefit from a non-text entry point into the curriculum" (Poldberg et al., 2013, p. 5). Research has shown enabling students to use art to express their ideas promotes vocabulary development as they attempt to give words to what they have created (Poldberg et al., 2013). Students are challenged cognitively and higher-order thinking skills are employed when students are encouraged to think in artistic ways. For this reason, art can be viewed as a means for students to understand abstract ideas and make meaning of the world around them (Poldberg et al., 2013). A study by Poldberg et al. (2013) found integration of science, language, and visual arts resulted in positive outcomes. Performance levels of students increased in all three content areas and students with differing academic abilities were successful, thereby addressing the achievement gap so often found in classrooms.

STEM, which stands for science, technology, engineering, and math, has developed into STEAM which includes "A" for integration of the arts. All students appreciate the opportunity to make connections when learning; research has shown that they are more successful with these endeavors when learning is enjoyable (Wynn & Harris, 2012). "Integrating the arts into the STEM curriculum provides pathways for personal-meaning making and self-motivation" (Land, 2013, p. 552). A recent study by Rule, Atwood-Blaine, Edwards, and Gordon (2016) helped female elementary students learn about women in mathematics through the creation of elaborate dioramas. The findings revealed motivation was linked to integration of the arts and students appreciated the opportunity to be creative and design the dioramas to incorporate their own ideas. When a learning environment is student centered and an opportunity to construct their own learning is presented to students, the possibilities for student success are endless.

Teaching the Water Cycle

Teaching the water cycle to young children can be challenging simply because, at an early age, children make sense of their world through concrete rather than abstract ideas. In a study of second graders in the United States,

researchers emphasized that the manner in which a student makes sense of his or her world should be perceived positively since it includes preliminary ideas that lead to explanation and thoughts about scientific concepts (Strang & Aberg-Bengtsson, 2010). Research by Strang and Aberg-Bengtsson (2010) found it may have been unclear to students that understanding the actual cycle of water was the goal of the lesson, rather than the individual parts of the cycle. Furthermore, although the teacher assessed what the students had learned about the water cycle, many children appeared to not understand what they were to address when posed with the question. Quite often, the children focused on a picture intently and described it, rather than discussing their understanding of the water cycle as a whole.

Another study addressing the water cycle (Chang, 2010) found young children benefitted from engagement with peers in a small group setting. Students learned from each other and had the opportunity to hear different perspectives when discussing content. The teacher discussed rain, puddles, and the sun when referencing the weather. The students were asked to draw a picture of the water cycle. Drawings included a tree needing water and a sun to dry it. The teacher then read a book on the water cycle and had the students place water cycle cards in the correct order. After the students had participated in the aforementioned activities, they were asked to draw another picture of the water cycle. Terms that emerged included water, sun, clouds, sky, and puddle; however, it was clear that the students did not truly understand the cyclic nature of water in the cycle. This study showed how drawings were an appropriate strategy when teaching the water cycle to young children. The drawings prompted students to illustrate conceptual understanding, promoted literacy, encouraged construction of knowledge, and provided motivation. "The use of drawing as a scaffolding tool made the interactive moments between the adults and children playful and relaxing. Yet, interactions were meaningful, purposeful, educational, worthwhile, and the learning gained through interactive communication was significant" (Chang, 2012, p.193).

Student Misconceptions

Researchers Paik, Kim, Cho, and Park (2004) revealed kindergarten students who attempted to make sense of their world through observations with their senses frequently did so without completely understanding the events taking place around them. This process often resulted in the development of misconceptions (Küçüközer & Bostan, 2010). Assessing the work of children to get to the core of their thinking is important. Often teachers can see how and why children think the way they do through different types of formative assessment and simply asking a child what he or she thinks. The way that children describe their world may be logical; however, it is typically characterized by scientific inaccuracies. A child's experiences and prior knowledge must be examined or misconceptions will not surface (Smolleck & Hershberger, 2011).

One study of more than 30 kindergarten students addressed the shape of Earth and sun as well as the day-night cycle. Many students identified the shape of the sun and earth as spherical; however, a few understood the shapes as hemispherical, disk-like, or pyramidal (Valanides, Gritsi, Kampeza, & Ravanis, 2000). These authors reported that although some misconceptions still existed, the number of initial misconceptions did decrease after instruction. Küçüközer and Bostan (2010) interviewed 52 kindergarten students to determine their views on day and night. Although almost 30% explained the earth turns on its axis, commenting that they learned this information from relatives, others gave incorrect explanations such as the sun going back into space at night and returning in the morning, the moon moving into the sun's place at night, or clouds obscuring the sun at night. The aforementioned research on children's idea of natural phenomena points to the importance of attempts by teachers to make sense of student understandings and misconceptions. By doing so, teachers will be in a position to cater their instruction and help students develop accurate scientific knowledge (Smolleck & Hershberger, 2011).

Students as Inventors

Teachers need to provide students with opportunities to think creatively and use higher order thinking skills so that they are able develop these abilities. Asking

students to solve a problem by designing an invention is one way to promote these types of skills. When students are presented with a problem, most often one single solution does not exist. Therefore, students are placed in situations that encourage decision making and creative thinking. With regard to pedagogy, engineering and art tend to support problem-based learning (PBL) which often allows for the inclusion of authentic learning opportunities for students (Bequette & Bequette, 2012). To integrate art and engineering, teachers should attempt to deliver problem-based lessons that address engineering topics. Efforts by teachers should promote creativity and encourage students to engage in experiments and take risks while doing so (Bequette & Bequette, 2012). As a result of their efforts, students construct their own learning (Land, 2013). Hussain and Carignan (2016) introduced the SCAMPER technique to fourth grade students who made inventions related to animal adaptations. Their study found students were excited about innovation and the creation of products they designed. Students were also observed taking initiative in the engineering aspects of their work and willingly engaged in hands on activities.

A study by Graca (2012) introduced kindergarten students to the topic of inventions. They engaged in scientific inquiry by posing questions and designing, creating, and testing an invention of their own. The students were excited to invent and creativity emerged as an important part of the experience. Although some inventions weren't realistic, an opportunity to invent something showed students their ideas do have value in the world (Graca, 2012). Students discussed the available items, selected what they wanted to use independently, and were engaged in the design of the invention longer than the time given. Additional outcomes from the study included no behavior problems during work time, engagement in the inquiry process, and creative solutions to real-world problems (Graca, 2012). "We teachers need to remember that implementing knowledge, even in the information age, must still be accomplished through inventions first constructed by hand" (Root-Bernstein & Root-Bernstein, 2013, p. 19).

More research is needed on how integration of the arts can promote deeper understanding in the content areas for young children, particularly in science. In addition, an emphasis on the engineering standards at an early age may

provide insight on outcomes that result as students are engaged in decision making and higher order thinking to solve real world problems. Future innovation in the real world will benefit from the skills that these students are learning in their early years of schooling.

National Standards Addressed

Several national standards were supported by the arts-integrated lessons about the water cycle. The National Core Arts Standards were addressed in many ways. The first standard (Visual Arts: Creating 3.1.K Standard a) states that students will explain the process of art while creating (National Coalition for Core Arts Standards, 2014). The students had several opportunities to explain their art process during the lessons examined by the current study. After the students had completed the watercolor painting of the water cycle, the researcher asked each individual student to describe his or her drawing and how it represented the water cycle. In addition, the researcher asked each student to share how he or she designed the boot including materials selected and what made the boot waterproof. A theatre standard (Theatre: Creating 2 – Kindergarten Standard b) states that with prompting and support, students will express original ideas in dramatic play. A guided dramatic experience occurred when the students worked with the researcher to develop actions for the water cycle poem (National Coalition for Core Arts Standards, 2014).

In addition to the above standards, art anchor standards were emphasized. Anchor standard one, generate and conceptualize artistic ideas and work, and anchor standard two, organize and develop artistic ideas and work, were apparent when the students used materials and their original ideas to design a waterproof boot. Finally, anchor standard six, convey meaning through the presentation of artistic work, occurred when the students demonstrated their understanding of the water cycle with a watercolor painting, through their responses to the questions posed when the poem slides were shared, and when they made comments while designing and testing their waterproof boots (National Coalition for Core Arts Standards, 2014).

The Next Generation Science Standards (NGSS) (Achieve, Inc., 2013) are new to education and many school

districts are working to address them in their science curriculum. Because teachers need example lessons that successfully incorporate the standards to use as models, the science and engineering standards of the NGSS were used as the foundation of the activities in this research study. The content standard, Kindergarten – Earth's Systems 2-1, states that students should be able to use and share observations of local weather conditions and describe patterns over time (Achieve, Inc., 2013). The students learned about the water cycle and how the path of water is continuous in our environment. The engineering standard, Kindergarten – 2nd grade – ETS1-1, states that students will analyze the data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs (Achieve, Inc., 2013). This standard was applied when the students tested the waterproof boots, made observations about whether or not the boot was waterproof, and explained why.

Method

The purpose of the study was to determine if integration of the arts was an effective strategy for teaching the topic of the water cycle to kindergarten students. The study also addressed the Next Generation Science Standards, including a content standard and an engineering standard.

Research Questions

The research questions that guided the study were the following:

- 1) What is the lived experience of children using the arts (painting, dramatization, invention of a waterproof boot) to represent their understandings of the water cycle? This will be determined from the attitude surveys, making observations of children while they work, and having conversations with children about their art, drama, and invention.
- 2) What benefits are evident when kindergarten students utilize creative arts to articulate understanding of the water cycle? This will be determined by participation in creating actions and reciting a poem, a watercolor

painting of the water cycle, description of water cycle, pre/posttest and attitude survey, photos, and invention.

3) Is the integration of creative arts an effective means for teaching science content and addressing engineering standards as outlined by the NGSS? This will be determined by photos, observations of the waterproof boot design and test, observations made by students after waterproof test, pre/posttest and attitude survey.

Participants and Setting

The participants in the study were 12 kindergarten students (7 male, 5 female) age 5-6 attending a public elementary school in the Midwestern United States. Approval for the study was obtained from the Human Subjects Committee at the university and the school's principal. Parents and students provided written consent for participation.

Research Design

The research design was phenomenology, or research that describes a lived experience. The task of the phenomenological researcher is to represent the nature of experience (Merriam, 2009). The study investigated the lived experience of the kindergarten students with regard to the use of art as a means to teach the water cycle. Table 1 shows the sources of data used in the study.

Lesson Procedures

Table 2 outlines the lesson activities aligned with the phases of the learning cycle. The researcher and classroom teacher worked closely to deliver the instruction. During the explanation phase, students interpreted the lines of a poem written by the first author, titled "The Water Cycle." The poem follows:

The Water Cycle

Water in our world goes around and around,
First you'll find it in a river, puddle, or on the ground.
With warmth from the sun,
It will go up to the sky.

It is evaporating, that's why!

Then water condenses and the clouds it will fill,
Next something happens, you can be sure it will!

It may start to rain, sleet, or snow,
And down, down, down the water will go.

What is the water cycle?

Now you know!

After utilizing the poem to learn about the water cycle, the students demonstrated their knowledge by creating a watercolor painting of the water cycle. In the next lesson, the researcher and teacher focused on rain as one part of the water cycle. The discussion centered on waterproof clothing that was used to protect students in wet weather. This discussion prepared students to think critically about the items that would be used in their invention of a waterproof boot. To prepare them for this task, they were shown many materials to use while designing a boot. These items included bubble wrap, shoe covers, duct tape, tissue boxes, shower caps, sealing wrap, tin foil, newspapers, felt, and plastic bags. Because arts was integrated into the lesson, students were also provided with tacky glue, ribbon, gemstones, colored pompons, and foam shaped stickers. It should also be noted that the duct tape was either fashion burlap or neon, thus contributing to the arts integration.

To meet the NGSS engineering standard, analyze the data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs, students were then asked to design a waterproof boot. After students were provided with ample time to design their waterproof boot, they had the opportunity to conduct a test to see if it was in fact waterproof. Each student stepped in a shallow pan of water and observed whether or not his or her foot got wet. The researcher and classroom teacher made observations while the testing took place. Students were asked to tell if their boot was waterproof and whether or not their design was effective and why. Photos were taken of the boot design process, the final product, and the test of the boot.

Table 1. *Data Sources*

Source	Phase or Activity	Specific Questions
1. Pretest attitude survey	Give the frowning to smiling face survey	Ask for explanations of reasons why and record.
2. Paper Pretest	Engagement Students are given a blank piece of paper to draw parts of the water cycle and write words that go with it.	Scan responses. Record ideas that students had. Walk around during pretest and ask for more explanation of what the drawings show and write notes on bottom of the page.
3. Student Comments	Exploration What do you know about the water cycle?	Write all ideas on a projected file. "What comes next?" "Explain that."
4. Comments during slide show	Explanation A slide show of photos that correspond to lines of a water cycle poem will be shown.	During the slide show, the teacher will ask students to tell their understanding of what the picture represents or portrays. They will be asked to share additional examples. "What is this picture showing?" "Can you think of other examples?"
5. Developing Actions for Song	More Explanation Phase The teacher presents the water cycle poem part by part.	Students are asked to create an action to represent each part of the poem. "How could we act out this part of the poem?" Show me how you would do that with your body. Which of these ways do you want to use and why?
6. Watercolor Painting	Closure. Students paint a picture of the water cycle.	Ask students to explain picture. Teacher records.
7. Clothing for wet weather	Expansion Show umbrella, boots, raincoat, rain hat, gloves, t-shirt, cotton hat, and stocking hat.	Students tell how items do and do not protect from wet weather. Students will be asked to explain. How do you know? Do you think this will protect?
8. Discussion of boot ideas	Expansion	Fill in a projected file titled "Materials for Waterproof Boot Invention." Will this work for the boot? How would you use this? Record ideas from students.
9. Boot invention	Teacher observations as students work to create their waterproof boot.	Why are you using that? Why did you not use this? Determine the criteria the student is using for a good product.
10. Boot testing	Teacher observations during testing.	Analysis of photos of results of boot testing. Student is asked to tell if his/her boot is waterproof and whether it worked or not and why.
11. Posttest attitude survey	Give the frowning to smiling face survey.	Ask for explanations of reasons why and record. Scan responses.
12. Paper Posttest	Students are given a blank piece of paper to draw parts of the water cycle and to write words that go with the images.	Record ideas that students had. Walk around during posttest and ask for more explanation of what the drawings show and write notes on bottom of the page.

Table 2. Lesson Procedures

Learning Cycle Phase	Activity
Pretest	Attitude Survey Pretest administered as a large group with teacher reading the questions out loud and teacher and researcher recording student responses to "why" for each item.
Engagement	Student creates water cycle drawing with crayons on paper. Teacher and researcher assess prior knowledge of students concerning the water cycle.
Exploration	Discussion of student ideas about what the water cycle is are recorded on chart paper.
Explanation	Students explain water cycle photos in slide show that correspond to the ideas in each line of the poem titled The Water Cycle and give additional examples in an effort to make connections with each part of the water cycle. Students develop actions and gestures for water cycle poem.
Closure	Students create watercolor painting to demonstrate their understanding of the water cycle.
Expansion Phase	Discussion of clothing for wet weather, including what items protect the body from wet weather and which do not. Items used included a rain poncho, umbrella, rubber boots, cotton t-shirt, and acrylic stocking hat. Discussion of waterproof boot ideas including items that are available to for students to use. Discussion of what items may or may not work and why. Students are provided with a variety of waterproof and non-waterproof items to design and invent a waterproof boot. Students will wear their waterproof boot and test it in a shallow pan of water. After they have tested the boot, each student will be asked to comment on their invention and if they believe it was waterproof and why or why not.
Posttest	Attitude Posttest Survey administered as a large group with teacher reading the questions out loud and teacher and researcher recording student responses to "why" for each item. Student creates water cycle drawing with crayons on paper. Teacher and researcher assess each student's understanding of the water cycle after all lessons and activities have been completed.

Instrumentation

The pretest attitude survey, shown in Table 3, was administered as a large group. The researcher read each

question aloud, one at a time. Students were directed to circle a face that best represented their feelings in answer to the question. The researcher and classroom teacher assisted individual students and recorded their written responses.

Table 3. *Pretest-Posttest Attitude Survey*

1. Circle a face to show how you feel about learning about the water cycle.



Tell why you feel that way (Teacher records response)

2. Circle a face to show how you feel about painting a picture of the water cycle.



Tell why you feel that way (Teacher records response)

3. Circle a face to show how you feel about reading a poem to learn.



Tell why you feel that way (Teacher records response)

4. Circle a face to show how you feel about acting out a poem to learn.



Tell why you feel that way (Teacher records response)

5. Circle a face to show how you feel about making an invention at school.



Tell why you feel that way (Teacher records response)

6. Circle a face to show how you feel about testing your invention to see if it works?



Tell why you feel that way (Teacher records response)



Methods of Data Analysis

Data sources are shown in Table 1. Data from the pretest attitude survey, drawing of the water cycle pretest, descriptions of the watercolor paintings of the water cycle, comments from the boot invention, boot testing, and the posttest attitude survey was divided entered into spreadsheets. The constant comparison method was used to sort these comments into categories. The constant comparative method is commonly used in qualitative research studies (Merriam, 2009). With this method, a determination is made between similarities and differences in the data, which are grouped and named. Categories begin to emerge the researcher is able to identify patterns in the data (Merriam, 2009).

Each time the researcher met with the students to conduct the lessons, student responses were recorded after students were asked, "What is the water cycle?" Student comments were recorded during the presentation of the slideshow describing the water cycle, when the actions to the poem were created, and when students responded yes or no to waterproof items and expanded on their thinking. The water cycle drawings that were done at the beginning of the first lesson as well as the water color paintings were photographed and comments from the students were analyzed. During the boot invention and testing, photographs and anecdotal records were kept for each student. Posttest drawings of the water cycle were photographed, analyzed, and compared to initial drawings.

Results and Discussion

Emergent Themes and Phenomenological Model

Figure 1 shows the major themes discovered through the qualitative analysis of data from the various sources identified in Table 1. The themes illustrate the lived experience of kindergarten students (Research Question 1) as they participated in instructional activities focused on the water cycle. Three main themes were identified: art-enhanced learning, art-enhanced teacher understanding of student ideas, and aspects of typical lessons. The first two themes had subparts. Subparts of art-enhanced learning were aspects focused on intellectual issues and those that revealed

emotional responses. A subpart of being able to identify misconceptions was found for the art-enhanced teacher understanding of student ideas theme.

Typical lessons. The gray circle in Figure 1 shows themes that emerged from typical lessons. Students were excited when the researcher arrived, and eagerly asked what they would be doing that day. The interest and excitement students had in learning something new was clearly conveyed. This curiosity is a characteristic often evident in early childhood classrooms simply because children are very interested in opportunities presented to them. According to Roseno, Geist, Carraway-Stage, & Duffrin (2015) in their early years of schooling children naturally acquire knowledge related to science because they are attempting to make sense of their world. There were several students that recognized the opportunity to learn something important about how the world works. Students remarked, "I am very happy we are learning this in kindergarten," and "...because I do want to learn about the water cycle."

During typical instruction, students moved from their tables to gather at their assigned seats in the group meeting area in front of a chart. The teacher asked students to respond individually to "What is the water cycle?" Typically, the same students raised their hands and these tended to be higher achieving students. Students who were shy or unsure did not respond, even when asked. There were students who repeated what others had stated. Other students did not attend to the lesson. The same behaviors were evident during the slide presentations. Many pre-assessments and assessments in general involve questioning as a whole class which at first might seem valid, but in reality only captures the understanding of those willing to share their ideas.

Many students were able to provide or recognize parts of the water cycle such as clouds, rain, and puddles. The discussion during the slide presentation revealed although many students did not associate these items with the water cycle at first, they were able to identify each one and discuss where they had seen them in the environment. Providing students with photographs and images is often an effective way to introduce new concepts and help students make connections between their prior knowledge and new knowledge.

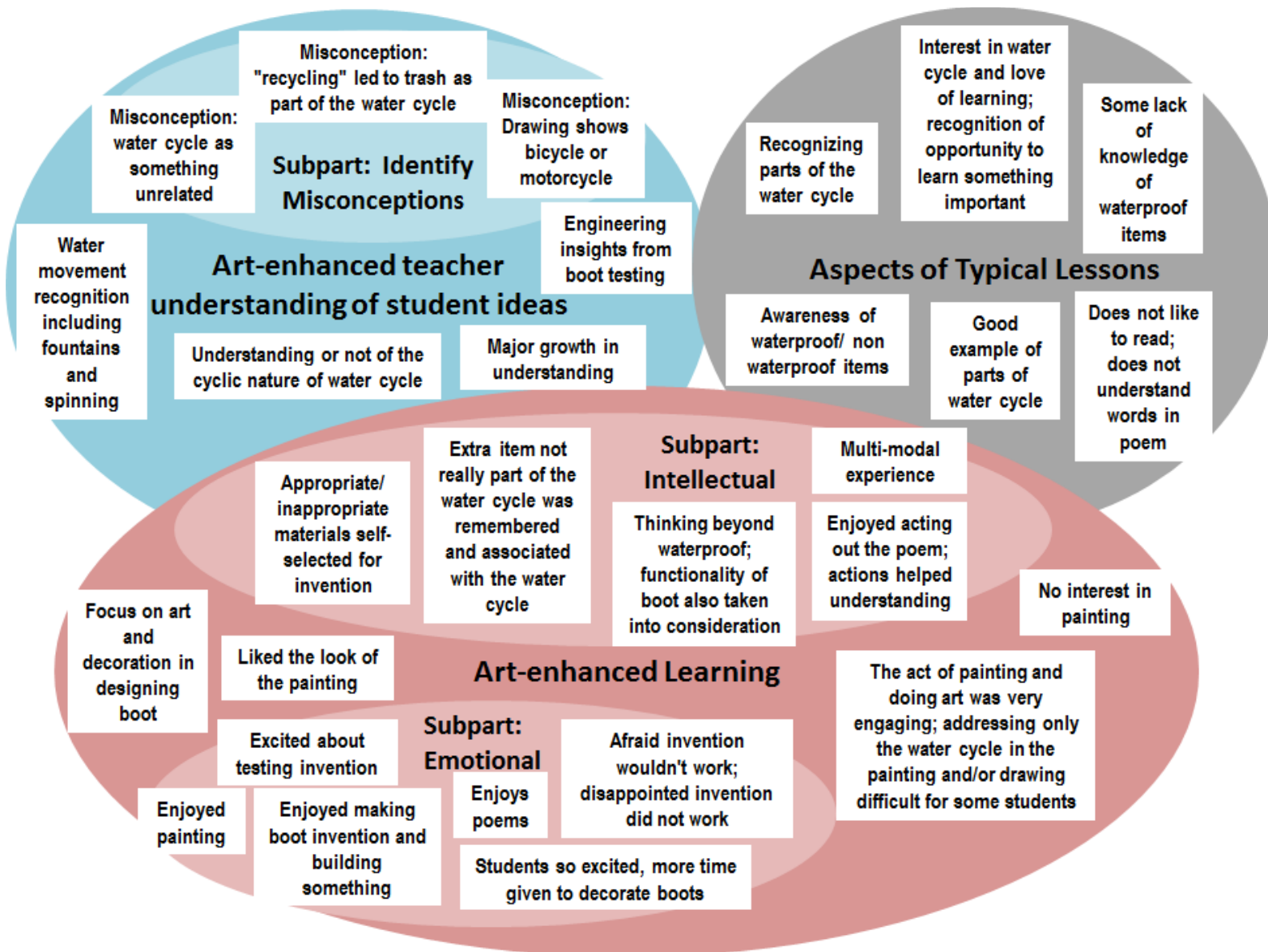


Figure 1. Phenomenological model of learning about the water cycle through typical and arts-integrated instruction



Several students were able to dictate good examples of parts of the water cycle when exposed to the slide presentation. When asked where water goes one student said up to the sky while another stated in rain clouds. When the discussion shifted to rain, one student commented that rain came from the clouds. Students were asked, "Where would you put a pool in summer, in the shade or in the sun?" One student responded with the sun because it warms it. The teacher reminded the students of a previous experiment involving water in a cup. When asked where the water went, students had several ideas. One student said it went to the sky, another said it got too warm, another thought it traveled to a stream or a lake, and one noted that it dried up because the sun was warm.

Students were also able to share their ideas related to evaporation. When asked where water from clothes on a clothesline or a puddle goes, students thought it dried up or went underground. Another student replied, "The sun is warm and it dries up." After the slide presentation students were asked, "What is the water cycle?" Some students agreed that it was all about the sun, clouds, and rain while others believed it involved a bicycle. Although many students were engaged and answering questions, the attitude survey revealed some students did not like to read or did not understand the words in the poem. This revelation could be attributed to the lack of involvement of some students during the reading and discussion of the poem. When the discussion shifted to waterproof and non-waterproof clothing items, many students were aware an umbrella and rain poncho were ideal for

protection from the rain. However, many students were inaccurate when asked whether a stocking hat and fashion boots were waterproof. The teacher needed to conduct an experiment with a stocking hat and water from a faucet to help students understand it was not a waterproof item. This revealed the importance of the lived experience of the students as the item needed to be tested before students were truly able to understand whether it was waterproof or not.

Art-enhanced learning. The pink ellipse in Figure 1 shows themes that emerged from art-enhanced learning opportunities. This theme illustrated some of the benefits of integration of the arts (Research Question 2). The opportunity to use watercolor paints was very engaging for the students (Figure 2). On the posttest attitude survey all student comments noted they liked painting in general and enjoyed painting a picture of the water cycle. During the activity, the students asked for more colors to utilize when painting and needed reminders to only paint items related to the water cycle on their paper. The opportunity to decorate the boot they invented was also very appealing to students. The teacher and researcher had planned to design and test the waterproof boots during one lesson; however, students were so engrossed by the art materials available to them, the decision was made to do the testing during the next lesson on a different day. According to Smithrim and Uptis (2005) integration of the arts is a proven method for motivating students. These findings are similar to those of Rule et al. (2016) who observed students working very intently on dioramas of women mathematicians.

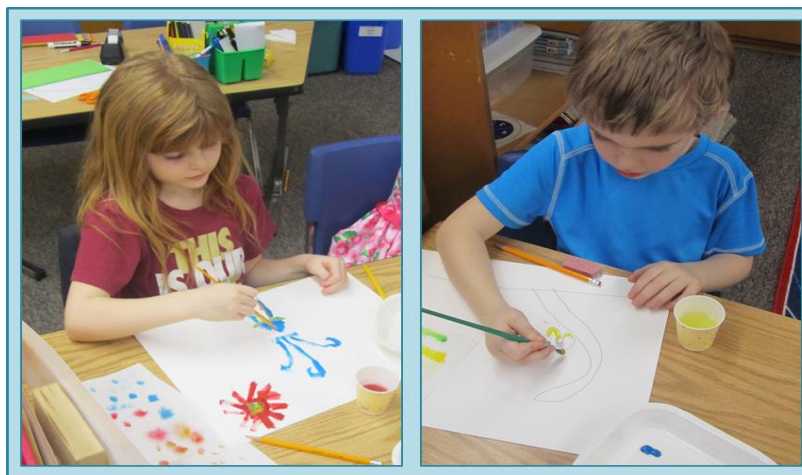


Figure 2. Students engaged in watercolor paintings of the water cycle.

There were two subparts to the art-enhanced learning theme. The first subpart was emotional involvement. This theme emerged during the boot invention and testing. One student commented, "I'm happy because I've never done a project different from other projects." Another student said, "I feel very, very, very happy because it is going to be exciting." Some students were hesitant about the unfamiliar invention and testing. One student shared that she didn't want to do anything wrong and another said that he would be shy. The second subpart addressed intellectual enrichment from art-enhanced learning.

Students recognized the multi-modal experience of acting out the poem. One student commented, "Because I really liked it when you read it out loud and we got to copy you." She also noted, "Because I really liked copying your actions. I was happy because we did the big cloud and went down to the floor [to simulate rain]." Another student noted that the actions really helped her understand the poem. The use of the poem and actions associated with science content supported Research Question 3. Photos of children acting out parts of the poem are shown in Figure 3.

The student comments revealed integration of the arts, a guided dramatic experience, was effective in teaching science content. Research by Rinne et al. (2011) pointed out remembering action phrases was more likely when individuals were able to engage in the actions that were discussed. The making and testing of a product prompted much intellectual growth. Several students spent a significant amount of time designing their boots and selecting materials to make it waterproof. Figure 4 shows examples of waterproof boots designed by students. One student (Figure 4b) made certain

her boot was shaped like an actual boot so it fit her foot. Another student (Figure 4a) made the outside of boot waterproof and continued to add materials to ensure it was also waterproof on the inside. He was one of the students who thought beyond the waterproof aspect of the boot and attempted to make it functional by adding padding for comfort inside the boot and felt to the outside so the bubble wrap wouldn't pop when he walked.

Comments from students provided solid evidence that allowing students to use creative materials to design their boot was beneficial to their exploration of what was being taught (Research Question 2). A study by Chang (2012) showed interactions with students were meaningful, purposeful, educational, worthwhile, and the learning gained through interactive communication was significant. This was certainly the case as students explained the reasoning behind the design of the waterproof boots. Two other students (Figure 4c and 4d.) had difficulty selecting appropriate materials to make their boots waterproof. Their use of the felt provided insight into their lack of understanding. This occurred with the watercolor paintings, too. It was interesting to note that some students added an item from the slideshow that was unrelated to the water cycle. A brown tent was depicted on the opening slide of the presentation and many students chose to add this object to their watercolor painting. The tent was one part of the picture and was included in the slideshow because it was next to a lake. Similarly, a study by Strang & Aberg-Bengtsson (2010) found children focused on one picture and described it instead of representing their understanding of the water cycle as a whole.



Figure 3. Students acting out the water cycle poem.



Figure 4. Example waterproof boots designed by students.

Art-enhanced teacher understanding of student ideas. The blue ellipse in Figure 1 shows themes that unexpectedly emerged from the study. This theme directly aligned with Research Question 2 because an examination of artwork allowed the teacher to clearly see what students understood about the water cycle. With traditional assessments, children are asked to verbalize their thoughts, but artwork can provide a more elaborate picture of understanding.

According to Smolleck & Hershberger (2011) a child's experiences and prior knowledge must be examined or misconceptions will not surface. One student's artwork (Figure 2) revealed understanding related to the water cycle as movement of water and a foundation. Several lingering misconceptions were identified by the teacher through artwork (Figure 6). Initially, some students associated the water cycle with a bicycle or motorcycle because of the word cycle. Ideas about recycling also emerged from discussion with students. The teacher assumed that these misunderstandings had been resolved, but examination of students' final drawings of the water cycle revealed persistent misconceptions. Küçüközer & Bostan (2010) found similar results in their research. Misconceptions existed even after instruction had taken place. Insights related to engineering materialized when the researcher conferenced with each child and asked if their boot was waterproof when they tested it (Figure 4 and Figure 7).

Hoisington, Chaloufour, Winokur, and Clark-Chiarelli (2014) emphasized that teachers shouldn't require one correct answer to a question. Instead, teachers should pose questions that foster investigation. Furthermore, those questions should help children explain their processes, the reasoning behind those processes, and the results of their investigations. One child replied, "Some got wet in the corner at the end. It was taped a little bit but there was a hole." One student put waterproof items *in* the box. He replied, "Yes, because I didn't feel any water because I put the rubber stuff *inside* the box."

One student made remarks about the design of another child's boot. He asked, "Did [another child's name] work right? I knew that it wouldn't because water can go through cloth and shirts and stuff so that's why it didn't work."

When he spoke of his own boot he noted it was waterproof because "there was bubble wrap and that's waterproof." He also pointed out functionality in his design. "I put something in there to make my foot feel warm." Another student stated an interest in testing another item. She said, "I should test one of my winter boots next time because those are really waterproof." Land (2013) pointed out that when students invent, they construct their own learning. This was certainly the case for the students as they designed a waterproof boot and tested its effectiveness.

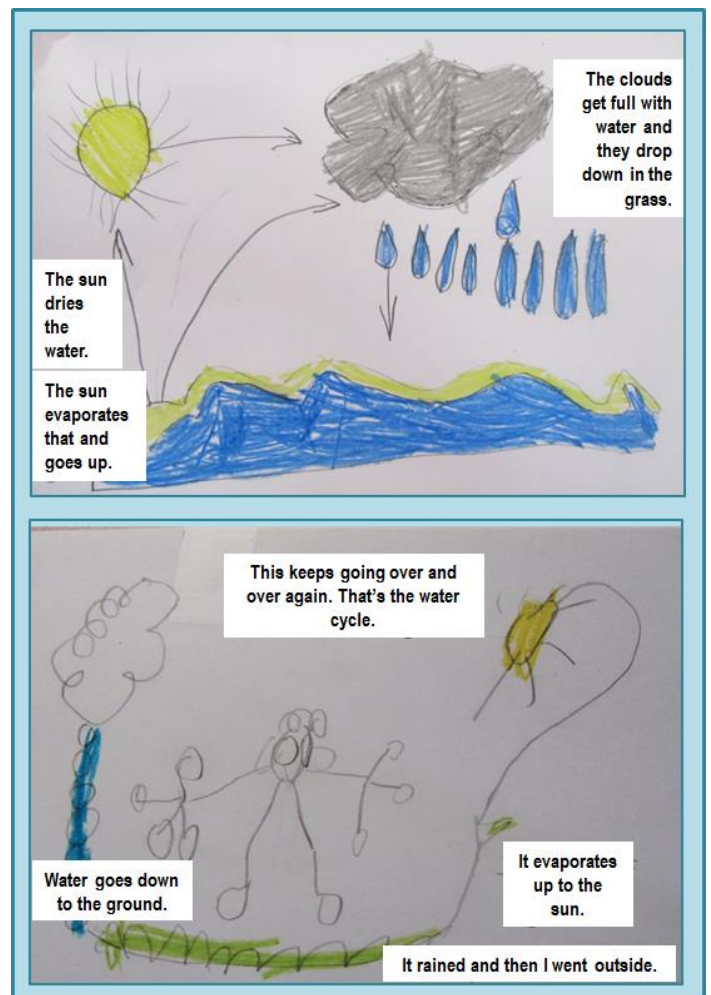


Figure 5. Posttest drawings of the water cycle depicting major growth in understanding.

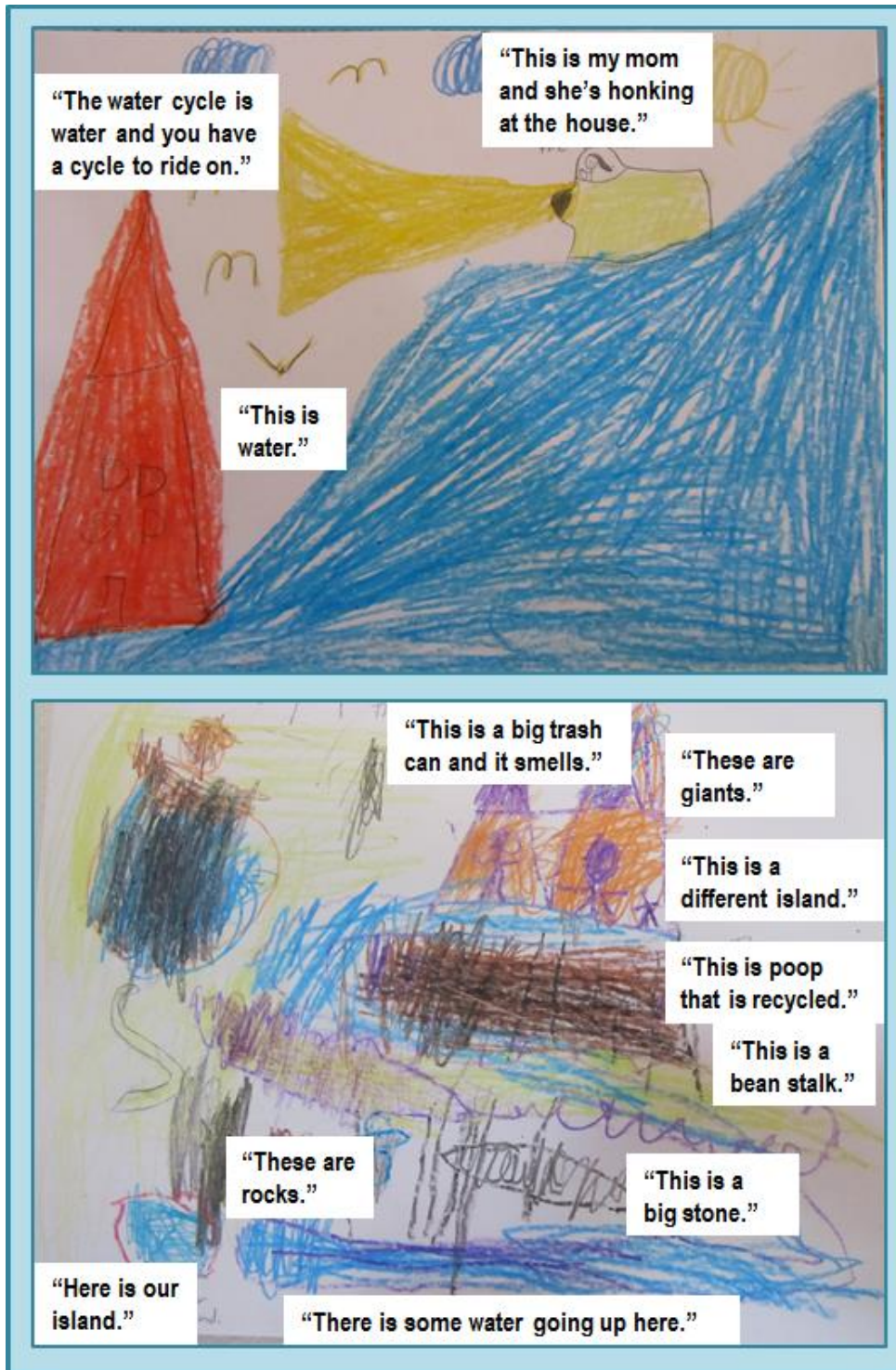


Figure 6. Posttest drawings of the water cycle depicting lingering misconceptions.



Figure 7. Children testing their boots in the water.

Conclusion

Summary of Findings

Research Question #1 was related to the lived experience of children using the arts to represent their understandings of the water cycle. The researcher found students were very interested in learning about the water cycle and content that was new to them. The multi-modal experience was appealing to many students and they showed excitement about the activities when they repeatedly asked, "What are we doing today?" Because inventing was a new experience for many of the students, some reported being

afraid their invention wouldn't work while others exhibited disappointment when it didn't work during testing.

Research Question #2 addressed benefits of the arts when learning about the water cycle. Arts integration was a motivating and engaging component of this study. A majority of students enjoyed making drawings and watercolor paintings; they were very excited to design and test their waterproof boots. The teacher benefited from the arts integration because the visual displays and elaboration by the students provided insight into student understandings. Students clearly demonstrated an understanding or lack of understanding of the water cycle through their watercolor paintings and drawings. Arts also allowed for recognition of misconceptions that would have been overlooked through verbal or written tests. Misconceptions such as bicycle or

motorcycle were clearly conveyed in student drawings. The watercolor paintings and drawings also showed growth in understanding from the first to the last lesson.

Research Question #3 asked if integration of the arts was an effective means for teaching science and addressing engineering standards outlined by NGSS. Students reported the actions in the poem helped them to understand the water cycle. The boot invention and testing was well received because students enjoyed self-selection of the materials for their invention and they appreciated being able to create something. The boot testing allowed students to articulate the process of designing their boot and their interpretation of the testing results. Some students unexpectedly thought beyond the waterproof aspect of the boot and addressed functionality. This clearly demonstrated a benefit related to the NGSS engineering standard.

Implications for Classroom Practice

The current study showed that kindergarten students are more than capable of engaging in science and engineering related activities aligned with the NGSS. Teachers can be encouraged by the results and attempt to address the standards in their own classrooms. Providing opportunities to invent has the potential to foster inquiry and creativity in young students. Well planned activities have the potential to motivate students and encourage higher order thinking skills.

The researcher found the drawings and watercolor paintings enlightening when gauging student understanding and revealing misconceptions. The invention of waterproof boot provided insight into the process of each student's design. The arts should be seen as a valid form of assessment by teachers because it is motivating for students and more beneficial than traditional forms of assessment. Arts can be used to examine the thinking of individual children and teachers can respond accordingly.

During the study it was realized more time is needed for lessons and activities that integrate the arts or require students to invent. The students were very engaged in the watercolor paintings. They were relaxed and took their time painting their pictures. When they designed their waterproof boot it took time to select the materials they wished

to use and they needed to think about how they would design their boot before beginning to work. After the boot was designed, many students worked intently on decorating it with pompons, gemstones, stickers, and ribbon. The students worked well past the time allotted and the teacher and researcher responded by moving the testing of the waterproof boot to the next day. Although challenging in a busy school day, teachers should make a concerted effort to spend more time on the activities rather than allowing time constraints to control the activities. It is important to note ample time should be allowed for the boot testing. The teacher and researcher conducted the testing on an individual basis. It may have been more beneficial to discuss the results as a large group after all students had a turn.

Suggestions for Future Research

The NGSS are new and few kindergarten teachers are utilizing the engineering standards in their instruction. More studies that explore how science and engineering standards can be integrated with art to produce positive outcomes are needed. Because the NGSS may be intimidating for early childhood teachers, experiences shared by other professionals can provide the confidence teachers need to design lessons and activities related to the standards. Young children are naturally curious about the world around them. It is crucial for teachers to take advantage of this curiosity and provide opportunities for students to invent and explore science content in an artistic manner. Early childhood experiences have the potential to positively impact later years of schooling and ultimately, an individual's success in the real world.

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