Biocubes: Doing Science by Studying a Sample of the World

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This curriculum unit is recommended for:
Third, fourth grade and fifth grade science and math

Keywords: science, math, animal adaptations, plants, ecosystems, measurement, graphing, observation, field journals, citizen science, guided inquiry, constructivism

Teaching Standards: See Appendix 1 for teaching standards addressed in this unit.

Synopsis: This unit allows students to explore the flora, fauna and factors that impact flora and fauna such as soil, temperature, sunlight, and moisture of several one cubic foot areas on the school grounds. Students will take measurements, make observations and draw conclusions from those observations. Biocubes will be placed in several locations on campus and data from the various biocubes will be compared and contrasted in order to learn how environmental factors impact flora and fauna. Biocube data can be shared with the Smithsonian biocube project so that students can participate in citizen science. Teachers can easily adapt the ideas in this project to fit their campuses.

I plan to teach this unit during the coming year to 130 students in fourth grade science.

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Ted Miracle

Introduction

Educators intuitively know that children (and adults) learn best by doing things rather than just reading about them, watching videos or being told about them. Many research studies over time have shown that students learn best by constructing knowledge through experiential learning and guided inquiry projects. This is especially true in regard to science. As Carl Sagan said, "Science is a way of thinking much more than it is a body of knowledge." (1)

There are several things that can make it hard for educators to design and implement lessons that include student hands-on experiences. Some teachers may avoid science lessons due to a personal lack of scientific knowledge. The pressures of high stakes testing can result in lessons that emphasize memorization of content knowledge while greatly reducing or eliminating opportunities for hands-on lessons that capitalize on student interest.

In spite of these challenges, there are many in the educational community who welcome hands-on, experiential learning. There are many educators who understand students learn more when they are engaged in their learning and go beyond reading about science to actually doing science in ways that are meaningful to students. These educators understand learning by doing coupled with high quality reading and writing experiences can translate to strong results on high stakes tests.

I teach fourth grade at Endhaven Elementary School. Endhaven is located in south Charlotte near the Ballantyne community. For the 2016-17 school year, Endhaven has approximately 726 students overall and 125 students in fourth grade. This is my sixth year at the school. I teach science and social studies to all fourth grade students. The makeup of the student body has changed a lot in the past few years. Endhaven served an overwhelmingly white and high socioeconomic demographic when it opened in 2002. Endhaven is now very diverse in terms of culture, race, and socioeconomic status. About 30% of our students receive free or reduced price meals. Our student body is 17% Asian (mostly Asian Indian), 15% Hispanic, 14% African-American, and 51% white students. Our English as a Second Language population has grown tremendously in the past two years. The school has 1.5 ESL teachers. Largely due to the transitions the school has seen in recent years, Endhaven is among the first group of schools in the district whose staff is receiving cultural proficiency training. One of the school's shared beliefs is that cultural diversity can increase student understanding of different people and cultures.

Endhaven is a school whose administration, staff, parents, and students strongly support STEM education. We have a variety of STEM education efforts during the school day and co-curricular science programs such as science lab as a special area class, outdoor gardens, Engineering is Elementary, Science Olympiad, Science Fair, Camp Invention, Green Club, Girls Engaged in Math and Science, robotics, chess club, and a maker space. Several of our teachers have participated in district science leadership groups and have presented at district, regional, and state science conferences.

I am sure this curriculum unit featuring biocubes will be well received by our students and parents. The unit will provide students with opportunities to explore the biology of areas around the campus. In doing so, they will apply observation skills in an authentic way. The educational experiences students will receive in this curriculum unit are supported by science teaching models.

The 5E Lesson Model

The 5E lesson model is widely accepted among science educators. The 5E lesson model is designed to enhance student engagement and promote hands-on learning experiences that help students construct science learning. The 5E model is a useful tool for creating lesson plans. The 5E science lesson plan model provides a framework for teachers who want to write high quality science lesson plans.

The first E in the 5E model is engage. Characteristics of the engage portion of the lesson plan are to introduce a topic to capture students' interest and curiosity. Teachers are not seeking a right answer. Teachers include student background knowledge and current understandings.

The second E in the 5E model is explore. Hands-on problem solving activities or experiments can be used to learn more about a topic and make connections to other concepts. The teacher acts as a facilitator by guiding students.

The third E in the 5E model is explain. Teachers help students observe patterns, analyze results, and draw conclusions. Students demonstrate how they understand science concepts through demonstrations, written work, written reflections, and discussions. Teachers need to use and define vocabulary accurately and clearly explain any concepts, processes, or skills related to the lesson topic to students.

The fourth E in the 5E model is elaborate or extend. In this part of the lesson, students build on the concepts and ideas they have observed and learned. Students also make connections and application to other situations and concepts related to the main topic.

The fifth E in the 5E model is evaluate. Students need to be able to assess their own understanding of what they are learning. The evaluation can be a formal assessment such as written quiz or test or an informal assessment such as the teacher listening to student conversations or students performing a task to gauge understanding (1).

It is important to note that not all elements of the 5E lesson have to be present in one lesson. They can certainly take place over the course of several days as part of a series of lessons.

Two pedagogical strategies teachers can use to promote authentic science are directed inquiry and guided inquiry. Both are inquiry based, but directed inquiry is more teacher directed while guided inquiry is more student directed. Both hold a great deal of potential for assisting students in doing science.

Directed Inquiry

In directed inquiry, teachers provide students with clear questions and specific resources. Students are given the opportunity to interact with resources to investigate and learn. Directed inquiry can lead to guided inquiry. A key difference between the two approaches is students have more independence in designing questions, choosing resources, designing experiments, gathering data, and explaining findings in guided inquiry. (2)

Guided Inquiry

Guided inquiry refers to teaching practices that promote student learning through guided and independent activities. The teacher assists students in learning by helping students complete their own investigations rather than just relying on learning about someone else's investigations (3).

Guided inquiry turns students into student scientists. It promotes student learning through investigation. The process begins with an inquiry question. The teacher or students can provide a question to answer, situation to explore, or problem to investigate. Good data collection, correct vocabulary use, and using graphic organizers to describe findings are all important elements of guided inquiry. After effective guided inquiry, students should be able to clearly describe findings in writing and/or verbally (4).

Guided inquiry lends itself to helping students experience how science is done rather than just memorizing scientific information. The cornerstone of this curriculum unit is a project that fits guided inquiry and allows students to participate in scientific research that aligns well with North Carolina science and math essential standards for grades 3-5.

North Carolina Science and Math Standards

The life science strands for grades 3-5 in North Carolina have a strong correlation in regard to plants, animals, and ecosystems. Third grade has an essential standard for learning about how plants adapt to their environments. Fourth grade has an essential standard for how animals adapt to their environments. Fifth grade combines these two in the study of ecosystems. Students who build background knowledge about plant adaptations in third grade and animal adaptations in fourth grade will be well positioned to have sufficient background knowledge to apply to the study of ecosystems in fifth grade.

This curriculum unit supports fourth and fifth grade math standards for measurement. Students are expected to use measurements and convert different measurements within a measurement system. This curriculum unit will provide students with real opportunities to apply these math skills.

Curriculum Unit Overview

The curriculum unit is broken into three main parts. The first part will teach students about the importance of making accurate observations. It will use two children's books to build student understanding of when conclusions are made using observable results and when inferencing is used to draw conclusions. It will also teach students about measurements that will be used in the culminating activity featuring biocubes.

The second part of the curriculum unit will use models built by the teacher. The models for this part of the unit will be constructed from various items. Students will use journals to write and draw descriptions of the model. The observations will include various measurements that will be used with the biocubes.

The third part of the curriculum unit will feature biocubes. The biocube is a one-foot cube built from CPVC tubes. The biocubes will be placed in various locations around the campus. Students will observe the plants and animals that pass through each biocube. They will describe them in writing and through drawings in journals. Students will take measurements of as many items as possible that are in the cube. They will also measure the temperature and wind speed within the biocube. Students will compare data for different biocubes located in different habitats and data from different times of the day. The final activity for each biocube will be to remove plants and animals from the area at the bottom of the cubic foot and study it in detail in a lab setting. The types of plants and animals found within biocubes from different habitats will be compared.

Using Children's Literature to Enhance Observation Skills

The National Science Teachers Association (NSTA) prints a monthly article about children's science literature in the professional journal Science and Children. The book *Picture-Perfect Science Lessons: Using Children's Books to Guide Inquiry, 3*-6 by Karen Ansberry and Emily Morgan is a collection of those articles (5). The book contains ideas for using two children's books that provide inquiry-based lesson ideas for making observations about properties such as size, weight, shape, color, and temperature and using tools for making measurements such as rulers, thermometers, and balances. One of the books is *Dr. Xargle's Book of Earthlets* (6). The other is *Seven Blind Mice* (7).

In *Dr. Xargle's Book of Earthlets*, Dr. Xargle is a teacher who is an alien from another planet. Dr. Xargle is teaching his students about human babies. He draws conclusions about babies based on his observations. Some of the conclusions are based on inferences and are humorously incorrect. The activities include discussions about the importance of making accurate observations, how inferences differ from observations, and how to draw accurate conclusions.

In *Seven Blind Mice*, the mice are trying to identify a creature. Each mouse crawls over a different part of the creature and draws a conclusion based only on the part of the creature each mouse explores. The final mouse takes the time to walk over the entire creature, correctly identifies it as an elephant, and explains this to the other mice. A key point in the discussion of this book is the importance of looking at all of the data before making a conclusion.

After reading and discussing *Seven Blind Mice*, students will complete an activity in which they receive a mystery item inside a container. Mystery items may include things like a cotton ball, a penny, some rice, a paper clip, or a small pebble. They may shake the container, but may not open it to see the contents inside. Students will make predictions based on the information they can glean. Students will then open their containers to see if their predictions are correct. There will be discussion with students about how they determined the identity of their mystery items.

Biocubes

The cornerstone project for this curriculum unit is biocubes. The Smithsonian provides information for building and using biocubes (8). My curriculum unit has adapted ideas from the Smithsonian National Museum of Natural History website. I will register my biocubes with the Smithsonian as directed from the website http://qrius.si.edu/biocube/how-to so my students may contribute to the Citizen Science project of the Smithsonian biocube project. This website gives specific directions for how to record and send data to the Smithsonian. I will adapt worksheets from the site for this curriculum unit and will use videos on the website to help my students understand how to complete the biocube project.

Biocubes provide students the opportunity to observe and study nature within a one-cubic foot area. Students will look for living things and evidence of living things that have passed through the biocube. Evidence of animals passing through the cube could include footprints, animal waste, and insect tracks. Evidence of animals inside the cube when it is observed could include insects, animal homes such as anthills or beehives, and spider webs. Hand lens will be used to magnify items found inside the biocube. Students will also make observations about factors that impact living things such as temperature, sunlight, wind speed, and water availability. A fifth grade teacher may want to measure humidity because that aligns well to fifth grade standards. Students will draw and describe what they observe on data sheets that will be placed in a field journal. A composition book will be used as a field journal. Field guides will be used to identify as many plants and animals as possible. Students will draw conclusions from their observations and will write those in the field journal.

I will construct the biocubes from ½" CPVC pipe, ½" CPVC elbow joints, duct tape, and tent stakes (see Figure 1). Each biocube will be one cubic foot in size. CPVC pipe and elbow joints are typically used for plumbing. They are inexpensive and available at home repair stores such as Lowe's and Home Depot. The pipes I purchased are five feet in length. I will use a hacksaw to cut five 12" pieces from one pipe. I will make four sides for each biocube. A side will be constructed by using L-shaped elbow joints to make three sides with the bottom side being left out in order to allow animals to pass through the cube. Sides will be placed at right angles. Two sides at a time will be

Figure 1: My biocube

taped together with strips of duct tape. A tent stake will be attached to the bottom of each of the four sides with duct tape to allow the biocube to be securely placed in the ground. A rubber mallet will be used to hammer the tent stakes into the ground. A piece of wood will be placed over the biocube while it is hammered into the ground to avoid shattering the CPVC pipe.

I will show students how each side of the biocube is one foot long and teach them to apply the formula for finding volume (l x w x h) to determine the biocube measures one cubic foot. I will show one biocube that is already built, share the directions for how it was built, and allow students to assist with building the biocubes that will be used.

There are a few basic procedures to review with students prior to placing and observing biocubes. First, students need to observe the biocube from a short distance to watch for birds, small mammals, and large insects that may enter the biocube. I will show my students videos from the Smithsonian website about biocubes to help them understand how to observe a biocube. Second, students will observe close up to the biocube and gently move plants to look for insects or other small animals. Third, we will take a picture of the things inside the biocube for further study. Fourth, students will be instructed about how to complete a Biocube in Context worksheet that will include the time and date of the observation, temperature, cloud cover, sediment/soil type, moisture level, sunlight level, and environment (8).

Prior to placing biocubes outside, I will use the frame of a biocube with a model created from things like Lego blocks, plastic insects, leaves, grass, and fake deer droppings made from modeling clay. Students will practice taking the temperature, observing whether the area is shady, sunlit, or mixed sun and shade, and the amount of moisture in the bottom of the model as dry, moist, and wet. Students will draw and describe in writing the animal evidence in the biocube model. The field notes from the Biocube in Context sheet will be analyzed for quality. Data from this model will be placed on chart paper and will be used to discuss how to successfully record observations and use them to create reports with the real biocubes.

Students from each science class I teach will record data and make observations. I currently teach five science classes. The data will be used to record differences and similarities between living things found in the biocubes at different times of the day as well as factors such as temperature. Each class is only 45 minutes long. For this reason, it will take several days for students to observe a different biocube each day. Data will be collected over a four-day period. On the fifth day, data from all groups will be compared and contrasted to find differences and similarities. Topics that will be discussed will include how the data changes during the day.

Biocubes will be placed in four different locations on campus. Each location will have unique characteristics. One area is a grassy area that is on a slight embankment near the back of the school property that adjoins an interstate highway. This area will receive a significant amount of sunlight because there are no trees nearby. The grass is quite long because the mowers do not cut the grass here. I think it will be interesting for students to observe the types of plants and animals that interact in the one-square cube area next to the interstate.

The second location where I will place a biocube is in a patch of several of acres of woods that is behind the school. I want to place this biocube on the forest floor. The forest floor is littered with leaves with little or no grass. The area has a trail that runs through it. I want to place the biocube in a part of the area that has little or no direct human contact.

The third location where I will place a biocube is in the bottom of a gully that fills with water when there is a heavy rainfall. I would consider the area a wet weather creek. This area is part of the woods and trail area. The grass in the bottom of the gully is lush with grass in many places. The major difference between this area and the biocube on the forest floor is the greater quantity of water from runoff. I think it will be interesting to find out if this area has a widely different mix of animals and plants and different temperature and moisture conditions than other biocubes.

The final biocube location will be an area near the road at the front of the school. I may have to place the biocube in a garden area that has mulch rather than grass because I cannot place the biocube in an area where mowers may run over it. This area will probably have more evidence of human activity than any other biocube area. It will be interesting to find out if this area has markedly different data observations in regard to temperature, animal and plant species, and other factors because of the probability of greater amount of human intervention on the this part of the environment. I suspect it may be hotter than other areas.

A culminating activity will be to remove about two inches of material from the floor of the biocube. This will be the final student activity. The material will be taken into the school so students can examine the plants and animals found there. This will be an opportunity to look closely at what is in the soil found just under the surface of the ground. Students will have the opportunity to sort and identify insects and other organic material found in this sample. Data from this observation will be placed on chart paper and may be included in citizen science reports to the Smithsonian biocube project.

Students will use field journals to make notes about each area. They will also complete forms adapted from the Smithsonian website that are for the express purpose of recording data. These notes will include the animals and plants that are observed inside the cube as well as evidence of animals such as droppings. We will check the temperature inside each cube and compare the temperatures of areas in the sun and woods as well as the biocube that is near the parking lot. Students will draw their own comparisons regarding the animals and plants in each place. One topic of discussion will be the human impact of the things observed in the biocube. It will be very interesting to see if the things inside the biocube near the interstate are significantly different from the ones in a more natural area (woods and gully) and the one near the parking lot.

As it is currently designed, this curriculum unit will take approximately two weeks to complete. Time constraints may make it difficult to do, but it would be interesting to replicate this curriculum unit at different times and seasons of the year. While there may not be enough time to reteach the entire unit, it would be interesting to repeat key parts of the curriculum plan to compare and contrast data from different times of the year.

This curriculum unit is applicable to any teacher who teaches life science in grades 3-5. The teacher who utilizes this unit will need to locate suitable locations on campus that will not be disturbed while the biocubes are being observed by students. The unit is cost effective. I can construct a biocube for about $10. The two children's books are readily available and relatively inexpensive. A model to use in the classroom could easily be created from another resource rather than Lego bricks. The unit is flexible in that teachers can choose biocube locations that make sense at their own school locations. I recommend at least two biocubes be used so students can compare two or more sets of data and observations.

In my opinion, this sampling of the biological world at Endhaven through the biocubes project is how science is really done. The answers are not known in advance. Students will answer the mysteries of what lives in different habitats at the school.

Appendix 1: Implementing Teaching Standards

North Carolina Science Essential Standard 3.L.2: Understand how plants survive in their environments.
North Carolina Science Essential Standard 4.L1: Understand the effects of environmental changes, adaptations, and behaviors that enable animals (including humans) to survive in changing habitats.
North Carolina Science Essential Standard 5.L.2: Understand the interdependence of plants and animals with their ecosystem
http://www.dpi.state.nc.us/docs/acre/standards/new-standards/healthful-living/3-5.pdf
North Carolina Math Standard 4.MD.1: Know relative sizes of measurement units within one system of units
http://www.dpi.state.nc.us/docs/curriculum/mathematics/scos/4.pdf
North Carolina Math Standard 5.MD.1: Convert among different-sized standard measurement units within a given measurement system (e.g, convert 5 cm to 0.05 m), and use these conversions in solving multi-step, real world problems.
http://www.dpi.state.nc.us/docs/curriculum/mathematics/scos/5.p

Appendix 2: Earthlets Word Sort Cards

Read the book *Dr. Xargle's Book of Earthlets* with students. Discuss the differences between inferences and observations with students. Define an inference as drawing a conclusion using prior knowledge to explain our observations. Build student understanding of inferences by telling them a dog comes in from outside and you observe its fur is wet. Ask students to turn and talk to partners about what happened to the dog. Possible inferences are it is raining outside, the dog jumped into a creek, or someone gave it a bath. Point out to students these inferences are based on the observation that the dog is wet and prior knowledge about how dogs can get wet. Instruct students to divide the word sort cards into things that can be observed and things that cannot be observed. Use a T chart titled observations and inferences and identify which cards belong in which side of the T chart and why they belong there. After the word sort is done, identify the observations and inferences and lead a discussion about whether or not Dr. Xargle's inferences were correct. One example would be to discuss that we know people pat babies to burp them or calm them. Dr. Xargle thought it was so they would not explode. Use Dr. Xargle's experiences to discuss the importance of making accurate observations and using observations to make accurate inferences. The word sort task is from the book Picture-Perfect Science Lessons: Using Children's Books to Guide Inquiry, 3-6.

The parent Earthling dries the Earthlets.	Earthlets are sprinkled with dust.
Earthlets are fed through the mouth, nose, and ears.	Earthlets are dried so they won't shrink.
The parent Earthling mashes food.	Earthlets are patted and squeezed.
Earthlets are patted and squeezed so they won't explode.	Earthlets are sprinkled with dust so they won't stick to things.

Appendix 3: *Seven Blind Mi*ce Activity

Read the book *Seven Blind Mice* to students. Lead a discussion about the importance of making as many observations as possible before drawing a conclusion. Discuss how all of the mice except the last one drew conclusions based on only observing part of the elephant. Give students a mystery bag made with small paper bags containing various items selected by the teacher. If available, film canisters are great for mystery items, but those may be hard to obtain due to the decline of film photography.

Tell students they may not open the paper bag or film canister. They may shake the bag or canister and hold it to get data. Students are to try to determine what is inside the bag or canister. Discuss how difficult it is to determine what is inside the bag or canister based only on listening to the bag when it is shaken and using the weight. Reinforce the moral of the book by reminding students of the importance of using all of the senses and gathering good data through observation to make good conclusions.

Appendix 4: Biocubes in Context Observation Sheet

Group/Student Name ____

Date ___________________ Time ____________________

Which biocube are you observing?

_____ front of school _____ walking trail _____ creek bed _____ near interstate

Temperature ___________ Wind Speed _____________

Is the sky sunny, cloudy, or partly cloudy? ________________________________

Is the biocube in the shade, sun, or partly shady area? __________________________

What kind of soil/sediment is at the bottom of the biocube? _____________________

____

Where is the biocube located (forest, grassy area, water)? ______________________

____

Describe any plants you see in the biocube.

Describe any animals you see in the biocube.

Describe any evidence of animals you see in the biocube. This can include tracks, poop, fur, feathers or anything else left behind by an animal.

Describe sounds you hear.

Describe smells you smell.

Describe any evidence of human impact.

Draw a sketch of the cube from above.

Draw a sketch of the cube from the side.

List of Materials for Classroom Use

Annotated Bibliography

(1) Chitman-Booker L., and K. Kopp. *The 5Es of Inquiry-Based Science*. Huntington Beach, CA: Shell Education, 2013.
This book describes the 5E model of science teaching. The 5Es are engage, explore, explain, elaborate or extend, and evaluate.

(2) Discovery Education Science. *Directed Inquiry Versus Guided Inquiry*. http://static.discoveryeducation.com/techbook/pdf/DirectedInquiryvsGuidedInquiry.pdf (retrieved September 10, 2016)
This article from Discovery Education discusses differences between directed inquiry and guided inquiry. This article is pertinent to CMS teachers because Discovery Education is a widely used resource in the district.

(3) North Carolina State University. First Year Inquiry Program. *What is Inquiry Guided Learning?* https://fyi.dasa.ncsu.edu/fyi-instructors/what-is-inquiry-guided-learning/ (retrieved September 10, 2016)
This website describes elements of inquiry guided learning at North Carolina State University. The website gives clear basic information regarding inquiry guided learning.

(4) University of Michigan, Michigan State University, Great Lakes Observing System, Eastern Michigan University, National Oceanic and Atmospheric Administration, Center for Ocean Sciences Education Excellence-Great Lakes, and the NOAA Great Lakes Environmental Research Laboratory. Teaching Great Lakes Science. *Guided Inquiry Process*. http://www.miseagrant.umich.edu/lessons/teacher-tools/guided-inquiry-process/ (retrieved September 12, 2016)
This website describes attributes of the guided inquiry process in teaching science.

(5) Ansberry, Karen, and Emily Morgan. *Picture-Perfect Science Lessons: Using Children's Books to Guide Inquiry, 3-6 (2nd ed.)*. Arlington, VA: NSTA Press, 2010.
This book is a collection of articles from the journal *Science and Children*. The book provides ideas for science lessons built on children's books.

(6) Willis, Jeanne. *Dr. Xargle's Book of Earthlets*. London: Andersen Press, 2002.
This is a children's book about a space alien named Dr. Xargle. Dr. Xargle is teaching a lesson about mysterious human babies to his students.

(7) Young, Ed. *Seven Blind Mice*. New York: Puffin Books, 2002.
This children's book is a fable about blind men discovering different parts of an elephant and arguing about its appearance.

(8) Smithsonian National Museum of Natural History. Q?rius: Science Education at the Smithsonian's National Museum of Natural History. *Biocubes: Exploring Biodiversity*. http://qrius.si.edu/biocube (retrieved September 18, 2016)

This website from the Smithsonian Institute provides a tremendous amount of information about biocubes. It explains the purpose of biocubes and gives detailed information for teachers about how to build and use biocubes. It includes informational videos.