Atoms to Art Supplies: Where in the world does art media come from?

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Introduction

How are pencils like diamonds? Is one kind of crayon better than another? Why doesn't glue stick to the inside of its bottle? Ultimately, the answers to all these questions stems from chemistry and the fact that everything is made up of atoms. The electronic structure of the atoms that make up the elements explains all of these whys! Students are not familiar with what is in the everyday materials they use to create art, or how art materials are formed and constructed. In this unit, through strategies in creativity, observation, critical thinking, and collaboration, the students will explore media used in creating art. In my elementary art classroom, I aim to build engagement and interest in the make up and components of the art materials. Through this exploration and learning, the students will have a better understanding of how to use the materials in their artwork. First, students will 'play' with art media to observe how they work, make marks on paper and learn ways to apply them. Lead by the teacher, students will form crayons from their basic ingredients and experiment with what ratio of ingredients makes the best crayon. Third, using a careful observation strategy, students will redesign art media.

I have always been interested in the way things are made and why they are made that way. Most students don't spend time wondering where the things they use everyday were created or invented. I enjoy watching the students' awe of an episode of Mister Rodgers presenting a visit to the Crayola Factory; the pouring of liquid and forming crayons reminds me of the innocence of children. Many say that the children of this generation don't spend enough time "being bored" or "exploring their own backyard." When I was a child, I loved to dig in the dirt and the sandbox. In my Marlton backyard, I had my own pit of marl, a clay-like mud that was mined in New Jersey in the 1800s.[1] What I know now that by letting my little mud sculptures dry in the sun, was an experiment with chemistry. Why did the blue marl stay in the shape I made when it dried and not crumble like the forms I made in the brown dirt? It's the chemical elements within the marl that make it different from soil.

Chemistry's role in art has been integral throughout time. From the ancient cave paintings to Crayola's YInMn, chemistry has influenced visual art in a myriad of ways. The earliest records of pigment chemistry date back to the Stone Age from 15,000 – 16,500 BC. In caves throughout Europe, humans made paintings of bison and other animals with red and yellow ocher pigments.[2] It was said, "Rand's tin tubes enabled the Impressionists to take full advantage of dazzling new pigments—such as chrome yellow and emerald green—that had been invented by industrial chemists in the 19th century."[3]

In the past year, the world was notified about the recent announcement of a new blue to the Crayola family. The color is inspired by a new blue pigment called YInMn (yin-min), which was discovered in 2009 by Mas Subramanian, a chemistry professor at Oregon State University.[4]

My unit is based on the origins and chemical composition of art materials that we use everyday in our art classroom, aligned with Visual Art Anchor Standard 2. This unit fills in gaps in my curriculum from the new National Core Arts Standards that were adopted in Delaware in March 2017. The Delaware State Standards for Visual Arts and the newly adopted National Core Art Standards are broken into four anchors – Creating, Presenting, Responding and Connecting. Part of the reason I love the new standards is what was/is missing from my curriculum, but I thought should be included. I intend to write a unit that provides a scaffolding approach to teaching Visual Art Anchor Standard 2: Organize and develop artistic ideas and work. This unit also aligns with the Common Core Standards in Reading, Writing and Listening, and the Next Generation Science Standards.

I enjoy collaborating with other disciplines in my school to foster deeper understanding in my content area of visual art and other areas, including Music, English Language Arts, Mathematics, Social Studies and Science. Integrating Art & Science is not a new concept, however, this unit will be different from the other ones I have written because this unit is based on chemistry. In my previous units I reviewed the list of scientists whose artistic talents aided in their achievements such as - Leonardo da Vinci, Galileo Galilei, Sir Isaac Newton, Samuel F. B. Morse, J. J. Audubon, Charles Darwin, Thomas Alva Edison, Nicola Tesla, and Albert Einstein.

One of the current trends in education is the emphasis schools have placed on STEAM education, Science, Technology, Engineering, Art, and Math. As it is used in STEAM, I intend for students to use the process of the scientific method to create their artwork. I hope that by presenting exploration of materials in the Art classroom students will begin to open their minds by asking ‘why,’ and approach problems with a whole new perspective. Additionally, explaining the chemistry behind everyday art materials will provide students with prior knowledge for future scientific lessons.

Rationale

The 2017 – 18 school year marks my thirteenth year as an elementary art educator in the Colonial School District. I am honored to work in a district and at a school where Visual Art is valued and supported.

At Harry O. Eisenberg Elementary all students in Kindergarten through fifth grade participate in Art class for a weekly 45-minute class period. Our current administration is supportive of staff, students and parents, and is working hard for our school to be successful by building a sense of community and strong educational mindset. Eisenberg

is a Title 1 School, where we receive federal funding due to the number of students who are struggling to meet the state standards for reading and math. With the new National Core Arts Standards recently adopted in Delaware and the new national Every Student Succeeds Act becoming a law, the arts are in a position to be recognized as the integral part in education that they are.

Harry O. Eisenberg Elementary of the Colonial School District faces many challenges of serving a population dealing with significant life struggles. Less than five miles south of Wilmington, Delaware, our school, while considered suburban, is on the edge of a very dangerous city. According to an analysis of the FBI's uniformed crime report, Wilmington was the third most violent of 450 cities of comparable size in 2012. It's the 8th most violent city of nearly 750 cities with a population of over 50,000. As you can imagine, the attitudes and priorities of our elementary students are similar to many other students across the nation - smart phones, fashion, video games, sports and music, but their exposure to the adult world at home is much more complex. Trauma, such as abuse, neglect, effects of poverty, separation from loved ones, having an incarcerated relative, and unpredictable parental behavior due to addiction or mental illness can all have an intense emotional impact on a child. Any of these traumas in early childhood has a significant effect on the development of the brain. One out of five kids in Delaware have experienced two or more Adverse Childhood Experiences (ACEs).[5] Nationally, 22.6% of children and youth have had two or more, as compared with 22.8% in Delaware, and 27.5% in the city of Wilmington.[6] School-age children (Ages 6 – 12) may exhibit difficulty paying attention, be overly quiet or withdrawn, exhibit frequent tears or sadness, have difficulty transitioning from one activity to the next, and fighting with peers or adults.[7] The 'Adverse Childhood Experiences Among Wilmington City & Delaware's Children' fact sheet states that "History is not Destiny" and "Resilience can be learned and buffers the negative impact of ACEs. Among kids with two or more ACEs, those who show resilience are much more likely to be engaged in school and less likely to repeat a grade."

The basic needs of food and shelter are still a priority for many of our students. The Colonial School District is addressing these aspects of the child's life. Eisenberg is the first elementary school in Delaware to have an on-site wellness center where students can receive supplemental professional services in behavioral health, pediatric services and social services. There are at least 10 families (~15 – 20 students who attend Eisenberg) who live in motels because their families cannot afford a security deposit and monthly rent. Our on-site food pantry of the Food Bank of Delaware serves between 10 – 15 Eisenberg families each month. Each Friday, over 40 students receive 'backpack food,' a large bag of non-perishable goods to take home for the weekend. At Eisenberg, 100% of students receive free breakfast, lunch and a fruit or vegetable snack every day. In addition, each year approximately 75 Eisenberg students receive a free backpack and over 50 students receive a winter coat.

The district serves approximately 10,000 students and has 8 elementary schools, 3 middle schools, one high school and two special needs schools. In my suburban elementary school of over 500 students, 44% of the students are African American, 31% Hispanic, 18% Caucasian, 6% multiracial, 20% are English Language Learners and over 18% are designated as requiring Special Education services.

As you can imagine, my students are typically not exposed to the same type of cultural experiences of visiting museums, seeing plays, and attending concerts that many others enjoy. Given the students' home environments, it is especially important for me to give my students an appreciation for the arts and culture to ensure their future success.I feel that I have an important job to not only teach the skills of visual art but also to help my students understand the world around them. As an educator, I try to encourage students to be better people and good citizens. Through this unit students will learn about how science, in particular chemistry, shapes how our art supplies work and demonstrate that these materials are just a small part of what makes up the world around us. The students will be able to create their own artwork, reflect on their work and display it.

My previous Delaware Teacher Institute and Yale National Initiative units were developed for second, third, fourth and fifth grades and I am interested in writing this unit and implementing it for all elementary grade levels, Kindergarten through 5th grade.

What Makes The World Around Us?

Chemistry

While man has practiced science all the way back to prehistoric times, the reasons behind and study of the practice was still considered somewhat magical and mystical. Not until the 5th century BCE, when Thales of Miletus is "credited as being the first man to seek natural explanations instead of attributing phenomena to the gods"[8] did it begin to evolve. Ensuing scientists, known as alchemists, were unlike the way we see modern research scientists. The alchemists' labs were private and secretive; they didn't want others to steal their ideas and discoveries. "At its heart, alchemy is based on statements and theories held to be true, even though they haven't been tested or proved."[9] Some of the alchemists were wealthy men who had little training in science but were motivated by fame and notoriety.

Isaac Newton is quoted as saying, "We are certainly not to relinquish the evidence of experiments for the sake of dreams and vain fictions of our own devising."[10] He and Robert Boyle set out to develop a series of steps to systemize and validate their findings. It is the system we know today as the scientific method. While the scientific method is an essential aspect of scientific research it also is very reminiscent of the process artists use to create their work. First, a scientist 'asks a question' or 'poses a problem,' followed by making a hypothesis or an educated guess of what they expect the problem answer or

solution to be. Third, the scientist conducts an experiment with a well thought out plan. As the experiment is taking place, the scientist makes careful observations records what happens. The fifth step is to draw conclusions by analyzing the results of the experiment and comparing it to their hypothesis. Finally, the scientist shares their conclusion as a success or circles back to the drawing board to try the experiment again with a different process or materials. For visual arts, the artist begins by thinking of an idea to express (problem) and make sketches or studies for the final artwork (hypothesis). The artist begins creating the artwork (experiment) with the chosen media. The artist critiques (analyze) their artwork and makes any changes necessary until they are ready to present their artwork (share conclusion).

Over much time and after extensive scientific research, it was discovered that an atom is the smallest elemental unit of any substance.[11] An sample of any specific element is made up of atoms of the same type or kind. When atoms of more than one element join together, they create molecules or compounds. As an example, I'll break down one of the most familiar molecules, which is H_2O. Hydrogen and oxygen are two separate elements. When two hydrogen atoms 'connect' with an oxygen atom, a molecule of water (H_2O) is created. The elements that we know are organized on the periodic table and were discovered at different times and in different areas of the world. Dmitry Mendeleyev "established periodic law and devised the first periodic table of elements" in 1869.[12] It was organized by the atomic weight of the element. The number of protons plus the number of neutrons equals the elements atomic weight. As of now, we know of 118 elements. Hydrogen was the first element created in nature, and was produced during the Big Bang.[13] Hydrogen has an atomic weight of ~1 and oxygen has an atomic weight of ~16. Chemistry has several branches, or subdisciplines. Once such branch is inorganic chemistry, which deals with all the elements of the periodic table and their compounds.[14]

Art Media

The art classroom or art studio can offer many different supplies or media (plural for medium) for student artists to use. There are several books on each single one of these media, which would provide too much content for this unit. I hope to provide a basic chemical background on a few of the most popular and basic media used in the classroom to help pique student interest. I will also provide access to other resources that provide additional information.

Pencils Are A Girls Best Friend

My favorite medium to write with has been a pencil since I entered college. Prior to that I loved taking notes in class with my multicolored pen, probably because before then, we were told what color and what media we had to use. Since then, it's been 23 years of collecting pencils at every museum and tourist attraction I've visited, and enjoying the complimentary pencil(s) at community fairs and other promotional events! In New York

City, there is a store dedicated to pencils, C.W. Pencil Enterprise, which I visited in 2016. However, it was not until I read Stuff Matters and The Pencil did I even know about the material science and chemistry of pencils. There are some very interesting famous people who are known for relationship with pencils. Thomas Edison was never with paper and a pencil. He even had custom pencils made for him by Eagle Pencil Company that had "very soft lead, thicker than average, and were only about three inches long."[15] These were made to fit into his pocket. Before writing Walden, Henry David Thoreau helped his father's business, John Thoreau & Co., the most successful pencil manufacturer in America by reformulating the amount of clay mixed in the graphite.[16]

Graphite and diamonds are both comprised of the same element, carbon.[17] Therefore, some would say they are the same. They are both allotropes of carbon. However, the connectivity of the carbon atoms in the two materials is very different. Graphite is made of sheets of carbon atoms connected in a hexagonal pattern while the diamond's pattern looks reminiscent of the Q*bert arcade game with carbon atoms connecting to form cubes that are then interconnected with other cubes. The chemical structure of the graphite also ultimately allows the layered material to be rubbed off onto paper.[18]

The pencil's name is probably derived from the Latin origin for brush, *peniculus*[19]. While we know the pencil is not a brush, the concept of writing on a page is probably why the name carried on and transformed into what we use today. There is evidence of ancient Greeks and Romans used metallic lead to make marks on papyrus.[20] We still call the part of the pencil that makes the mark lead. Today's pencils are not made of lead but of graphite and clay.[21] Pencil 'lead' was originally inserted into a cut out valley in wood. Then another piece of wood was laid on top to cover the graphite. Today, the wood is more like two pieces of bread that sandwich the graphite in the middle. A metal band called a ferule clamps together the eraser and the wood for eraser tipped pencils.

I believe my students will find the similarities between graphite and diamonds to be intriguing. In deconstructing pencils, I believe my students will have lots of ideas of how the manufacturers place the graphite in the wood and will be interested in learning it's actually made of two pieces of wood.

Stuck On You

Glue is used in so many products around us and without it our world would look totally different. Many of us even rely on glue to hold onto our own teeth! Glue or adhesives are integral to the manufacturing of so many of the things that make up our world and shape our lifestyles. From buildings to cars, TVs to surgical procedures, and books to solar panels! Sticking two things together is the main purpose of glue but many times it's also used for its water resistance.

The use of glue begins with Neanderthals using a tar-based adhesive to connect and secure axe heads and spears to wooden and bone handles over 200,000 years ago.[22] Adhesives can be made of a natural material (i.e., plant or animal based) or can be synthetic. Chemically, they are all polymers, molecules that together are hard to break apart. Adhesives can function via two pathways; by mechanically expanding and joining two separated pieces or chemically by creating covalent bonds. The traditional white glue used in school works by filling in the microscopic pores on surfaces and forming a bond. Each type of adhesive has different properties that make it better for one application over another. Many synthetic glues are created from petroleum. The chemical reaction of glue typically involves the polymers' interaction with air that turns it from a liquid substance to a hard semi-permanently or permanently cured bonded material. Superglue is a cyanoacrylate and hardens when exposed to water, and even the small amount of moisture in the air will cause it to cure. During the Vietnam War, cyanoacrylate was used to close wounds and stop the bleeding of injured service personnel before they were transported to infirmaries.[23]

Animal based natural adhesives are created from cooking hides of animals, and separating the collagen, which is a kind of protein, to form a sticky substance. Animal based glue can be traced back to Ancient Egypt where it was used to secure King Tut's tomb. Another type of natural adhesive is created from the sap of trees. Other types of adhesives were utilized by the Ancient Romans who used tar and beeswax to build their ships. In the early 1900s, starch glues became popular for adhering paper, especially wall paper. Starch glues are made using a combination of wheat, rice, corn, and water.[24] In the art classroom, glue is primarily used to join two pieces of paper together. When I was in elementary school, rubber cement glue and white paste in a tub were the popular classroom glues. Today, the most popular glues used in the classroom are glue sticks and white glue in squeeze bottles. Glue doesn't stick to inside the bottle because the interior is coated with a special material. In addition, the glue will not dry out by keeping the cap closed to keep the air out. Collage, an art form of combining different pieces of material together, became popular with artists Georges Braque and Pablo Picasso in the early 1900s. The word collage is derived from the French word *coller,* which means, "to glue"![25]

Another popular 'sticky' art classroom supply is adhesive tape. Originally invented in 1845 by a surgeon named Dr. Horace Day to adhere bandages to patients, its use became more widespread when 3M employee Richard Drew created masking tape to help car painters create straight lines in two toned cars in 1925. Drew later invented scotch tape. [26] In the art classroom, we depend on tape for so many techniques including repairing tears in paper, holding a stencil in place, prepping a surface to be covered in plaster of Paris, and as a decoration itself, to name just a few.

I think my students will be most interested to learn the types of natural glues that were used by ancient civilizations. It would be interesting to also make a glue out of natural materials with them.

Crayons

Crayons are a childhood staple and evoke memories of youth to all who smell their distinctive scent. The idea of combining wax with a pigment began in Ancient Egypt when artists were creating encaustic painting. “A similar method was used by the Romans, the Greeks and the indigenous people in the Philippines in 1600–1800.”[27]

While not the inventor or the only manufacturer, Crayola is probably the most well known supplier of crayons in the world. They began manufacturing a quality inexpensive crayon in America in 1903. The company began when cousins Edwin Binney and C. Harold Smith took over Edwin's father's pigment business in 1885. Initially, they were a pigment supplier for companies like Goodyear Tire. They supplied Goodyear with carbon black to make the rubber tires black and more durable, since tires were naturally white.[28] They also supplied many barns with the signature red oxide pigment. At this time, classrooms were still using chalkboards so Binney & Smith created slate pencils for students to use on their chalkboard tablets. To prevent the hazy cloud of dust in the classroom, Binney & Smith next manufactured dust-less chalk. In 1903, they began to manufacture wax sticks that were non-toxic, had brighter colors and were more durable. Binney’s wife was a school teacher and helped name the revised wax sticks as “Crayola”, combining the words craie for chalk in French and ola, which is from Latin for oily.[29]

Crayons are made mostly from two materials- pigment and wax. The chemical formula for paraffin wax is $C_{25}H_{52}$. [30] “Paraffin wax is a white or colorless soft solid derivable from petroleum, coal or oil shale, that consists of a mixture of hydrocarbon molecules containing between twenty and forty carbon atoms.”[31] The wax is melted to 62°C (143.6°F) and then a proprietary blend of powdered ingredients are added, including stearic acid. These ingredients add strength and improbe the crayon’s ability to be rubbed off on paper.[32] Because wax and water don’t mix, a powdered pigment is added to the wax to make the color instead of a liquid dye. The mixture is poured into a mold then cooled. A paper wrapper is glued to the crayon to provide extra durability, provide a comfortable grip to hold and identify the color and make of the crayon.

I find that students are very interested in learning how crayons are made. Perhaps this is because crayons are a substance they can’t easily identify like the wood of pencils? I believe they would enjoy inspecting the raw materials of paraffin wax and pigment.

Objectives

In the seminar *What Makes The World Around Us?*, I am exploring the particular ways certain art media is formed. Through this unit, the students will address the Enduring Understandings that *Artists and designers experiment with forms, structures, materials, concepts, media, and art-making approaches.* After the unit, students will understand *Artists use a variety of techniques and processes to manipulate media to achieve desired effects.* It is because of the chemical make up of these materials that one technique works better than another for a certain effect. During the unit, the students will think about the Essential Questions of *How do artists work? How do artists and designers determine whether a particular direction in their work is effective?* And *How do artists and designers learn from trial and error?*

Activities

Unit Enduring Understandings:

- Artists and designers experiment with forms, structures, materials, concepts, media, and art-making approaches.
- Artists use a variety of techniques and processes to manipulate media to achieve desired effects.
- Through art-making, people make meaning by investigating and developing awareness of perceptions, knowledge, and experiences.

Unit Essential Questions:

- How do artists work?
- How do artists and designers determine whether a particular direction in their work is effective?
- How do artists and designers learn from trial and error?

Activity 1: Play with media's properties on paper
Grade Level: KN – 5th
Length of Time: minimum of 1 class period (as long as needed for each media to be explored)
Concept: Explore Art Media
Lesson Essential Questions: How do different media make marks on paper?
Vocabulary: Artist, Colored Pencil, Crayon, Experiment, Marker, Material, Media, Medium, Oil Pastel, Pencil, Properties
I CAN statements: *I can* use my imagination to play with art materials. *I can* improve my art skills over time, by trying new materials and tools. *I can* be safe when using art supplies.

Higher Order Thinking Questions: How are _____ (material) and _____ (material) alike and/or different? How do artists learn from trial and error?
Summarizing Strategy: Exit Ticket- What makes one art material better to use than another? Why would you choose to use one art material over another to make your artwork?
Technology Tools and Implementation: Watch 'A Sketchy History of Pencil Lead' video
Procedure: Each student will receive a book made of drawing or copy paper folded in half with a different art material pictured and labeled at the top of each page. Either working in centers or as a whole group, students will use the pictured art material on the corresponding page. The teacher will give prompts accordingly such as "draw straight lines", "write your name very small", "mix two different colors". The teacher will ask questions such as "Is it easy or difficult to write words and details?", "Do the colors blend and mix together or turn black/brown?", "Does the art medium smear on the paper?", etc.

Activity 2: Make crayons from scratch
Grade Level: All
Length of Time: 2 class periods
Concept: Experiment Making Art Media
Lesson Essential Questions: How does the way art media is constructed effect the way it works?
Vocabulary: Beeswax, Crayon, Paraffin Wax, Pigment, Stearic Acid
I CAN statements: *I can* use many techniques and materials. *I can* explore different materials and tools.
Higher Order Thinking Question: How can the same art material made with different ingredients affect the final look of an artwork?
Summarizing Strategy: The students will write a reflection on how or why their prediction was correct or incorrect.
Technology Tools and Implementation: Watch 'Crayola Crayons' video
Procedure: Adapted from 'Making Wax Crayons' by David A. Katz. Students will learn that we will be making four different types of crayons using different amounts of ingredients. As a class, we will create a list of what properties we feel makes good crayons. Students will make a prediction about which of the four recipes will make the best crayons. The teacher will mix the crayons over a hot plate under a document camera so students can see the process. The four wax formulas are: 1) 7 g paraffin wax, 7 g beeswax, and 0.5 g stearic acid, 2) 5 g paraffin wax, 9 g beeswax, and 0.5 stearic acid, 3) 9 g paraffin wax, 5 g beeswax, and 0.5 g stearic acid, and 4) 14 g paraffin wax and 0.5 stearic acid. First, the ingredients are placed in a small aluminum pan over medium heat on a hot plate. The mixture is stirred with a wooden popsicle stick to ensure even melting of the wax. Pigment (0.25 g) is added to the melted wax and stirred. I would recommend using the same color pigment for all four recipes so that the variables between each formulation are the types and proportions of wax used and not the pigment which may impact the ultimate darkness or lightness of the resultant crayons' color. The melted

recipe is poured into a soda straw plugged with modeling clay or a silicon candy mold lightly sprayed with cooking spray. At least 15 minutes should be allowed for the wax to harden. While the wax is cooling, make a list of ways to test each crayon to see which recipe makes the best crayon. Once hardened, have several groups of students perform the tests and record their answers. Compare each group's results and pick a winner based on the criteria established by the class. Ask the students to reflect on their prediction and the 'best' crayon.

Activity 3: Explore art materials in depth – take apart and redesign
Grade Level: All
Length of Time: 3 class periods
Concept: Create New Art Media
Lesson Essential Question: What ways can we make our own art media better or different?
Vocabulary: Beautiful, Design, Effective, Efficient,
I CAN statements: *I can* explore and invent art-making techniques. *I can* use everyday objects as inspiration to make something new.
Higher Order Thinking Question: How might a redesigned art media change the lives of artists and affect art history?
Summarizing Strategy: Students will write an artists' statement or explanation of their redesigned art medium and it's improvements.
Technology Tools and Implementation: Watch 'How It's Made: Paintbrushes" video
Procedure: Adapted from Harvard's Project Zero Agency By Design lessons. Students will choose an art medium to investigate and redesign. Students can work alone or with a partner. Include pencil sharpeners, staplers, tape dispensers, and brushes as some of the art media they can choose from to redesign.

First, they will fill out a 3-2-1 Bridge worksheet, a routine for activating prior knowledge and making connections. On this worksheet, students will compare initial thinking and new thinking. In the column under 'Initial Thinking', the student will write three words, two questions, and one metaphor/simile or connection of what they know about the art material before learning about it. After learning about the art medium and recreating it, students will go back to the 3-2-1 Bridge worksheet and under the 'New Thinking' column will write three words, two questions, and one metaphor/simile or connection of what they've learning about the art medium. After reviewing both columns the students will complete the sentences starters at the bottom of the page "I used to think…" and "Now I think...".

As the student begins to explore their art medium they will ask themselves, "What are it's parts? What are its purposes? What are its complexities? In what ways could it be made more effective? In what ways could it be made to be more efficient? In what ways could it be made to be more ethical? In what ways could it be made to be more beautiful?" Students will then create a drawing of the art media redesigned.

Appendix 1: Implementing District Standards

As of March 17, 2016, the Colonial School District adheres to the Delaware National Core Arts Standards, which were adopted from the National Art Education Association Standards (NCAS). The NCAS were published in 2014. In the Creating Anchor Standard (Cr2.1), students will "Generate and conceptualize artistic ideas and works." In detail of each performance standard throughout the grade levels from PreK through 5th, the act of playing with media in discovery is satisfied by Standard VA:Cr2.1 to "use a variety of art-making tools" in preschool, in Kindergarten "through experimentation, build skills in various media and approaches to art-making", and in 1st grade "Explore uses of materials and tools to create works of art or design." Expanding into 2nd grade by having students "Experiment with various materials and tools to explore personal interests in a work of art or design" and in 3rd grade to "create personally satisfying artwork using a variety of artistic processes and materials." In 4th and 5th, the students will take their knowledge from the younger grade levels and make more choices in their work by "explore[ing] and invent[ing] art-making techniques and approaches" and "experiment[ing] and develop[ing] skills in multiple art-making techniques and approaches through practice."

Resources for Background and Research

Books and Journal Articles

"About Evesham Township." Evesham Township. Accessed December 18, 2017. http://www.evesham-nj.org/index.php/about-evesham-township.
Information about the marl pits in Evesham Township, New Jersey.

Aldersey-Williams, Hugh. *Periodic tales: a cultural history of the elements, from arsenic to zinc*. London, Penguin Books, 2012.
A great book for 'non-science' people with a lot of information on where the elements derived from.

"Art & Chemistry." American Chemical Society. Accessed January 22, 2018. https://www.acs.org/content/acs/en/education/students/highschool/chemistryclubs/activities/art-and-chemistry.html.
Links for learning about chemistry and art including activities and videos.

Charles, Oz. *How is a crayon made?* New York, Scholastic, 1988.
A picture book geared to younger elementary students.

Daley, Jason. "Experiments Show How Neanderthals Made the First Glue." Smithsonian.com. September 01, 2017. Accessed December 18, 2017.

https://www.smithsonianmag.com/smart-news/experiments-show-how-neanderthals-made-first-glue-180964718/.
An article about archeologists discussing how they predict glue was made by early man.

Finlay, Victoria. *Color: a natural history of the palette*. New York, Random House Trade Paperbacks, 2004.
One woman's journey to discover the origins and stories behind where colors came from.

Levy, Joel. *Incredible elements: a totally non-Scary guide to chemistry and why it matters*. New York, Metro Books, 2017.
An enjoyable, easy read with illustrations and pictures to explain the history of chemistry.

Marshall, Pam. *From tree to paper*. Minneapolis, Lerner Publications Co., 2013.
A picture book geared to younger elementary students.

Mayer, Ralph, and Steven Sheehan. *The artists handbook of materials and techniques*. 5th ed., London, Faber, 1991.
Detailed and thorough descriptions and how tos of making your own artist materials.

Miodownik, Mark. *Stuff matters: exploring the marvelous materials that shape our man-Made world*. Boston, Mariner Books, Houghton Mifflin Harcourt, 2015.
Entertaining yet knowledgeable discussion of the most common materials we encounter every day such as glass, pencils, concrete, steel, and paper.

Nelson, Robin. *From wax to crayon*. Minneapolis, Lerner Publications Co., 2013.
A picture book geared to younger elementary students.

"Never Underestimate the Power of a Paint Tube." Smithsonian.com. May 01, 2013. Accessed December 18, 2017. http://www.smithsonianmag.com/arts-culture/never-underestimate-the-power-of-a-paint-tube-36637764/.
An article about how paint tubes may have influenced artists.

Petroski, Henry. *The pencil: a history of design and circumstance*. Alfred A. Knopf, 2017.
A well researched and in-depth look at the pencil.

Rosenberg, Gabriel. "A Chemist Accidentally Creates A New Blue. Then What?" NPR. July 16, 2016. Accessed December 18, 2017. https://www.npr.org/2016/07/16/485696248/a-chemist-accidentally-creates-a-new-blue-then-what.
The story behind Crayola's new blue!

"Sticky Science – The Chemistry of Superglue." Compound Interest. October 15, 2015. Accessed December 18, 2017. http://www.compoundchem.com/2015/10/15/superglue/.
A short article that explains why glue is sticky and what makes superglue different than other glues.

Woods, Samuel G., and Gale Zucker. *Crayons from start to finish*. Woodbridge, CT, Blackbirch Press, 1999.
A picture book geared to younger elementary students.

Audio/Visual

NPRskunkbear. "A Sketchy History Of Pencil Lead | NPR's SKUNK BEAR." YouTube. October 11, 2016. Accessed December 18, 2017. https://www.youtube.com/watch?v=lrZMSyhzcXg.
A short four minute video discussing pencil lead from its elements to a finished pencil. Would probably be best for students in at least fourth grade and above.

Crayola History Video. March 06, 2017. Accessed December 18, 2017. https://www.youtube.com/watch?time_continue=293&v=1BjtCPGJ51c.
A Crayola produced video describing the process of making crayons. Appropriate for all ages.

DiscoveryTV. “How Crayons are Made | How It's Made.” *YouTube*, YouTube, 4 May 2017, www.youtube.com/watch?v=lmiRjmbnn8Q.
A short five minute video on the basic factory method of making crayons. Appropriate for all ages.

"How It's Made Pencils." YouTube. April 23, 2016. Accessed December 18, 2017. https://www.youtube.com/watch?v=BeJ0DL3-vPE.
A short five minute video on the basic factory method of making pencils. Appropriate for all ages.

Modern Marvels: Glue. A & E Networks, 2005. Online. http://www.history.com/shows/modern-marvels/season-11/episode-15.
An hour long documentary on glue. Appropriate for all ages, probably best in segments.

Notes

1 http://www.evesham-nj.org/index.php/about-evesham-township (accessed December 18, 2017)

2 Joel Levy, *Incredible Elements*, 13.

3 http://www.smithsonianmag.com/arts-culture/never-underestimate-the-power-of-a-paint-tube-36637764 (accessed December 18, 2017)

[4] https://www.npr.org/2016/07/16/485696248/a-chemist-accidentally-creates-a-new-blue-then-what. (accessed December 18, 2017)
[5] http://www.rodelfoundationde.org/digging-deeper-the-shocking-pervasiveness-of-aces-and-trauma-among-delaware-students/ (accessed December 18, 2017)
[6] http://childhealthdata.org/docs/default-source/local-area-synthetic-estimates/aces_wilmington_profile_030716_final.pdf?sfvrsn=2 (accessed December 18, 2017)
[7] https://www.childwelfare.gov/pubPDFs/child-trauma.pdf (accessed December 18, 2017)
[8] Joel Levy, *Incredible Elements*, 24.
[9] Ibid, 67.
[10] Ibid, 67.
[11] Ibid, 9.
[12] Ibid, 8.
[13] Ibid, 92.
[14] Ibid, 1.
[15] Petroski, 23.
[16] Ibid, 108.
[17] Mark Miodownik, *Stuff Matters*, 169.
[18] Ibid, 162-6.
[19] Henry Petroski, *The Pencil*, 15.
[20] Ibid, 17.
[21] https://www.npr.org/sections/ed/2016/10/11/492999969/origin-of-pencil-lead (accessed December 18, 2017)
[22] http://www.history.com/shows/modern-marvels/season-11/episode-15 (accessed December 18, 2017)
[23] Ibid.
[24] Ibid.
[25] https://en.wikipedia.org/wiki/Collage (accessed December 18, 2017)
[26] http://www.history.com/shows/modern-marvels/season-11/episode-15 (accessed December 18, 2017)
[27] http://www.chymist.com/Making%20Wax%20Crayons.pdf (accessed December 18, 2017)
[28] https://science.howstuffworks.com/innovation/science-questions/question563.htm (accessed December 18, 2017)
[29] https://www.youtube.com/watch?time_continue=293&v=1BjtCPGJ51c (accessed December 18, 2017)
[30] http://chemistry2013-14.tumblr.com/post/81251843374/relating-it-back-to-chemistry-crayons (accessed December 18, 2017)
[31] https://en.wikipedia.org/wiki/Paraffin_wax (accessed December 18, 2017)
[32] Ibid.