Encouraging Student Creativity and Leonardo Da Vinci: Dreaming Up Inventions

Karen Yarnall

Unit Description

In this unit students will learn about the impact of ancient inventions like the arch upon newer inventions and the role of tools and technology throughout history. They will also examine ideas for inventions created by Leonardo da Vinci within the context of the Renaissance. The students will use their creativity to plan and draw designs for their own inventions. Upon the completion of the unit, these plans will be displayed along with students' explanations of their designs in an art exhibit. This unit integrates science, technology, engineering, math and art, adding the A for the Arts into STEM, making it a STEAM-driven unit.

Introduction

This unit is the result of my experience in Domenico Grasso's "Ancient Inventions" seminar, one of six offered in 2016 by University of Delaware in partnership with DTI (Delaware Teachers Institute). DTI offers a unique opportunity to learn content in a seminar setting with university professors and teachers from different grade levels and disciplines from five different Delaware public school systems. Each of us then has time to develop an in-delpth teaching unit that is made all the richer by the time we are able to devout to it and the input that we have from our peers and seminar leader.

As one of the three art teachers at Newark High School, I am part of a team of strong advocates for the arts and for the success of all students in public education. I plan to teach my unit to my Advanced Drawing class and my two Art Fundamentals classes. As an upper level course, Advanced Drawing consists mainly of 11th and 12th graders. Art Fundamentals is our introductory art course and consists predominantly of 9th graders. These classes range in size from 22 to 30 students. Newark High School is a Title 1 school with a population of over 1,175 students. It is classified as an urban school with over 60% of the students considered minority. Approximately 60% of our students are low income and approximately 14% are classified as special education students. Newark has an A/B rotating block schedule with classes that are hour and a half blocks. The students in my classes reflect our school's diverse population.

A team of staff members at Newark High School has been working on creating a focus on the principles of STEAM. Newark High School's definition of STEAM so far is, "STEAM is an engaging approach to enhance integrated creation and problem-solving

and student learning that fosters an environment of critical thinking and values creative thinking for success in the 21st century. The end results are students who take thoughtful risks, engage in experiential learning, persist in problem solving, embrace collaboration and work through the creative process..." (1)

Objectives

One of the objectives of this unit is for the students to use the steps for STEAM that were developed over the summer by a staff team at Newark High School. We looked at engineering and art models and adapted them to become a model that we think will encourage our students' critical and creative thinking. The steps include defining the problem, identifying criteria and constraints, exploring possibilities, selecting a design, developing a detailed design, creating models and/or prototypes, testing and evaluating, refining the process, and implementing and communicating the results. However, for this unit, the students will develop detailed invention designs but they will not create the actual models or prototypes that will be tested. That is because working models will not be able to be created for many (if not all) of their inventions. Since my students are in art classes and I am stressing creativity, I do not want the students to be grounded by what is only possible now. If you are an engineering instructor, perhaps you would adapt this so that your students would create working prototypes or models. I am trying to stimulate the creativity of the students. In a couple of the activities in this unit (including one included in this paper), the students will participate in design challenges in which they will actually brainstorm and experiment to create a solution to a problem in a group or individually. For those, they will create actual models.

Students will use their creativity to explore the unity of STEAM and art and the humanities so that they can use self-discovery to research and design their own inventions. They must find a need or market and create an invention to satisfy that need. This will be an example of product-based learning that has been student-driven.

The following objectives apply from the Rationale from the NGSS, "Engaging in the practices of science helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the wide range of approaches that are used to investigate, model, and explain the world. Engaging in the practices of engineering likewise helps students understand the work of engineers, as well as the links between engineering and science." (2) Additionally, using these, "…helps students form an understanding of the crosscutting concepts and disciplinary ideas of science and engineering; moreover, it makes students' knowledge more meaningful and embeds it more deeply into their worldview. The actual doing of science or engineering can also pique students' curiosity, capture their interest, and motivate their continued study; …" (3) The same can be said for exploration in the arts.

By the end of this unit, students should be able to answer essential questions that have been developed for this unit. These include, “Are we smarter than the ancients?” “Does technology include more than computers and cell phones?” “What does the study of ancient inventions have to do with me?” “How does previous knowledge affect inventions?” “What need will my invention fulfill?” “Will my invention make the world a better place?” “How do I use the elements of art and principles of design to create an effective drawing for my invention?” “Will color enhance my drawing?” “What are some of the most important inventions in the world?” “What are some of the most important inventions in the art world?” This last question can be tailored for a particular class. For example, the words “in the art world” could be replaced with “ceramics,” “painting,” “sculpture,” or “drawing,” or whatever your discipline may be.

Not only will the students’ illustrations along with their explanations and research be displayed in our art gallery at Newark High School, but the students will help prepare the exhibit. That addresses our national standards on presentation. During our school’s seminar period (similar to homeroom), the exhibit will be open to viewing by other seminar classes in the school and the student artists will be urged to stand by their drawings to offer explanations about their work.

Content

In Domenico Grasso’s Delaware Teachers Institute seminar description for *Ancient Inventions,* he wrote, “The recent and dramatic pace of technological change obscures the surprising fact that many of the discoveries upon which modern societies are based were made in prehistoric times. Ancient inventions provide insights to the type, depth and extent of thinking and capabilities of humankind well before the advent of calculators and computers.” (4) Domenico Grasso in seminar explained that we think that we have to have all this science to be successful inventors but that is not true and that people were so creative and brilliant back in the past. They invented what they needed. As the old proverb states, “Necessity is the mother of invention.” People see a need and then have to problem solve to come up with a solution. The on-line Free Dictionary of Farlex states this about necessity being the mother of invention, “When people really need to do something, they will figure out a way to do it. When the fan belt on Linda's car broke in the middle of the desert, Linda used her stockings as a replacement… Inventiveness and ingenuity are stimulated by difficulty. For example, The first prisoner to tie together bedsheets to escape knew that necessity was the mother of invention.” (5)

In seminar we have seen and discussed a wealth of ancient inventions along with how they have affected modern inventions. With such a wealth of material, it will be difficult to decide what to share with students because of limited class time. Students should enjoy an introduction to the concept of time. At Newark High School, home of the Yellow

Jackets, we have introductory activities called “Stingers” at the beginning of the class block that students do while teachers take attendance. A stinger for time could be having students in groups write down a list of common phrases dealing with time. These could include, “in due time, “running out of time,” and “time after time,” or it could involve a list of reasons of why keeping track of time matters to people. The reasons can involve knowing when to eat, when to plant crops, when to meet, when to go to class, and when to get up and go to bed. We also discussed the difference of accuracy and precision in seminar. Our seminar leader explained the concepts by saying that hitting the bullseye would be dealing with accuracy. Precision deals with no matter how many times you repeat something, it is the same. If you are shooting at the bullseye and every hit is 4” off from the center, then that is an example of precision but not accuracy (since he bullseye has been missed).

The progression of ingenious improvements of ancient devices used for telling time is a fascinating one. Ancient Egyptian obelisks were shadow clocks. Big Ben in London was a clock that was built as a timepiece for the whole community. Time measurements include sun dials, hour glasses with sand measuring time, pendulums, outflow water clocks, and others. Water clocks were like stop watches and were really just timers until inventors figured out how to make improvements to calibrate them to tell time. Our seminar leader explained that the phrase, “running out of time” was from the ancient water clocks used to give lawyers in court the same amount of time when speaking. When the water ran out of the device, their speaking time was up.

An interesting video on innovation is on the search for a reliable method to find longitude at sea. In the 1700s the English government offered $20,000 pounds to the solver of this problem after four of their treasured fleet ships sank. Newton is quoted as saying in the video, “I have told the world oftener than once that longitude is not to be found by watchmakers but by the ablest of astronomers. I am unwilling to meddle with any method other than the right one.” (6) Talk about inflexibility or “fixed mindset!” The person who came up with the answer was John Harrison from a small English village. He was not a formally educated man and was a self-taught clockmaker. After a lifetime of studying and experimenting with temperature, friction and gravity first on large-scale clocks and then on small watches, Harrison developed a timepiece that would accurately predict longitude on a ship voyage. He made some revolutionary discoveries such as combining two metals with different rates of expansion and contraction together so that the properties would cancel each other out. Unfortunately, his rival, an astronomer who was working on a lunar solution, and his cronies on the approval board, would not credit his discovery. Eventually the king interceded and Harrison was finally awarded the money. After discussing the invention in 1995 of the world-wide GPS system that uses

satellites, the video aptly closes with, “The secret to knowing where you are is knowing what time it is.” (7) At just under an hour in running length, the video might be too long to show in class but any particularly interested students could watch it on their own.

In seminar we watched a riveting power point on ancient medical practices. It is amazing how little some medical instruments have changed over the centuries but it is definitely good that modern patients are not subjected to some of the ancient practices such as trepanning, the practice of cutting away holes in the skull for various reasons including to relieve pressure, release evil spirits, and relieve headaches. It is amazing that many of the discovered skulls show regrowth of the bones in the skulls, indicating that the patients actually survived. The material reinforces the notions that necessity is the mother of invention and that ordinary people can come up with solutions. Scientists and learned men are not always the ones who come up with new inventions. An excellent example of that is in a short YouTube video reenactment on the removal of an arrowhead that was lodged 6 inches deep into the skull of 16-year-old Prince Henry, future King Henry the V of England. Wounded in the 1403 Battle of Shrewsbury, the arrow entered his face when he raised the visor of his armor during the heat of the battle. When someone tried to pull out the arrow, the shaft came out but the arrowhead remained. One of the most amazing parts is that they released a metalworker from prison just so that he could invent a metal contraption/instrument that could be inserted into the wound, poked around until it matched up inside the arrowhead and then expanded so that the arrowhead could be extracted. He was not a doctor or scientist. However, I would not recommend showing this video to younger students, especially since no anesthesia was used.

In seminar we discussed functional fixedness, a concept new but intriguing to me. It deals with finding different uses for objects. In the article *Why We Can’t See What’s Right in Front of Us*, author Tony McCaffrey writes,

> “The most famous cognitive obstacle to innovation is *functional fixedness* - an idea first articulated in the 1930s by Karl Dunker- in which people tend to fixate on the common use of an object. For example, the people on the Titanic overlooked the possibility that the iceberg could have been their lifeboat… Many people could have climbed aboard it to find flat places … Fixated on the fact that icebergs sink ships, people overlooked the size and shape of the iceberg (plus that fact that it would not sink).” (8)

Students can be taught strategies to become less rigid in their thinking. McCaffrey suggests that functional fixedness can be overcome by addressing and dealing with preconceptions. He wrote,

> "After studying creativity for many years, I've come up…what I call the g**eneric parts technique**. Break each object into its parts and ask two questions: Can it be broken down further? Does your description imply a use? If so, describe it more generically. Calling something an iceberg generally implies hitting and sinking ships. Describing it more generically as a floating surface 200-400 feet long does not. This technique systematically strips away the layers of preconceived uses from the object and all its parts. My data show that along the way, alternative uses more easily emerge." (9)

When talking about functional fixedness during seminar, Domenico Grasso gave the example of using army ants for stitches. In YouTube videos, the practice is actually shown. In one video, the speaker, Amy Greeson, says that the Spanish call army ants surgery ants and, using a friend's finger, "…shows how surgery ants were used by the natives to temporarily stitch wounds…" (10) After the ants' jaws clamp on either side of the wound, the ants' body is ripped off. The jaws remained as stitches. While this may not be the first choice for help, if one is bleeding profusely in the jungle, it would be an effective way to close up a wound until more professional medical assistance could be provided.

One of the activities included in this unit is an entertaining game in which teams pass around common objects and name additional uses for the objects. For example, a table scraper could be used as a fly swatter, pancake turner, or a paddle. This exercise encourages students to use their imaginations to see the possibilities beyond the functional fixedness of objects.

Some schools have been embracing the idea of growth mindset versus fixed mindset. Our students at Newark High School have grasped the concepts of the terms and I think that it helps them to be not so rigid in their perception of their abilities. It has also generated some meaty discussions. Carol Dweck in an article in *Education Week* wrote, "We found that students' mindsets-how they perceive their abilities- played a key role in their motivation and achievement, and that if we changed the students' mindsets, we could boost their achievement. More precisely, students who believed their intelligence could be developed (a growth mindset) outperformed those who believed that their intelligence was fixed (a fixed mindset)." (11)

Dweck also wrote, "Finally, we found that having students focus on the process that leads to learning (like hard work or trying new strategies) could foster a growth mindset and its benefits."(12) The strategies used to increase growth mindset can be applied to creativity. Some students believe that they are not creative. However, in art when students work on a project, they have to use their problem solving skills to explore multiple options. They are encouraged to explore different solutions until something works effectively.

Of the quotes by President Barack Obama the one that resonates the most with me is, "In addition to giving our children the science and math skills they need to compete in the new global context, we should also encourage the ability to think creatively that comes from a meaningful arts education." (13) As an art teacher and advocate for the arts, I totally agree. Art classes encourage students to find multiple solutions and to be persistent in their quests. Art teachers encourage students to be more creative in multiple ways. We stress that making mistakes is an important part of the process and that they pave the way to finding their future successes. They need to be persistent and not give up if their first ideas do not work out. Sometimes taking a break and doing something relaxing, fun or unrelated will encourage their brains to form new connections or put their ideas together in a new and interesting way. Often the subconscious will come up with new connections and ideas when one is not even consciously aware during sleep. If one awakens during the night, those ideas can be written down so they are not lost and sleep can once more be achieved. Alternate solutions and ideas can also be found by sharing with peers in class or even others who are distant from the problem. Those who are distant from the problem often have a very different perspective. Traveling to other places in person or via the web or observing people from other cultures or generations can spark creativity because others are not tied to our preconceptions. Also, youth often see things more creatively because they do not have the experience and fixed mindset to know that "that is not the way things are done." They often have more flexibility in their thinking. I have found that in art, little children tend to be freer in their art and do not feel as much of a compulsion to conform. For some assignments I will explain the activity but not show visual examples. If I do, sometimes students' work tends to be very similar to what I have shown. Art teachers want students to take risks. By making the classroom a safe environment, students are more willing to do just that. The classroom should not just be a physically safe place, but students should feel comfortable freely expressing themselves verbally and through visual images, music, movement and dance, and written words.

Creativity and inventions go hand-in-hand. Since I want to have an activity that involves students looking up inventions in art, I will share part of the journey of Dick Drew who worked for Minnesota Mining and Manufacturing Company. "Drew, … when the company was mainly a sandpaper manufacturer, overcame myriad problems by doggedly experimenting with a huge variety of substances until he succeeded, in 1925, creating a masking tape adhesive for automobile painting that could be safely removed without damaging the surface it covered. In 1928, he invented the first transparent tape, the precursor to an entire family of Scotch brand tapes." (14)

According to Jonah Lehrer in *Imagine, How Creativity Works*, Drew started out as a sandpaper salesman who saw the problems in shops that car mechanics had with masking off parts on cars for spray painting. The tape that they used would peel off the paint underneath so he experimented with creating a tape that was not so sticky. He eventually

created something but it stuck to everything until he had the epiphany of creating long strips of it and rolling it up onto itself. Since masking tape and cellophane tape have always been available to us in our lifetimes, I doubt that our students think twice about how they were developed. These ideas were pretty revolutionary at the time. The Minnesota Mining and Manufacturing Company changed its name to 3M and Lehrer wrote, "This emphasis on innovation has been a defining feature of the company ever since Dick Drew invented masking tape… And so McKnight (CEO) dramatically reorganized the company, investing the tape windfall in a brand new science lab…That, after all, was the lesson of Dick Drew: even a salesman could invent an important new product." (15)

3M has some interesting company policies in place that they believe foster creativity. Lehrer wrote of Larry Wendling, a vice president in charge of corporate research,

> "Wendling then tells me about the first essential feature of 3M innovation, which is its flexible attention policy, Instead of insisting on constant concentration… 3M encourages people to make time for activities that at first glance might seem unproductive… Daydream… Play a game of pinball… One important consequence of this approach was the invention of the 15 percent rule, a concept that allows every researcher to spend 15% of his or her workday pursuing speculative new ideas… The only requirement is that the researchers share their ideas with their colleagues." (16)

Lehrer explained that Joydeep Bhattacharya, a psychologist at Goldsmiths, University of London, "… has used EEG to help explain why interrupting one's focus- perhaps with a walk outside or a game of Ping-Pong- can be so helpful… When our minds are at ease- when those alpha waves are rippling through the brain- we're more likely to direct the spotlight of attention inward, toward that stream of remote associations emanating from the right hemisphere… That's why so many insights happen during warm showers." (17)

Leonardo da Vinci was a true Renaissance man in that he had an unquenchable thirst for knowledge and an inquiring and curious mind and was interested in a long list of subjects. He combined his love of art with nature, science, math, engineering, geology, anatomy, and other subjects to fill closely guarded notebooks filled with drawings of ideas and inventions. Many of these inventions never came to fruition but that does not diminish their uniqueness and worth. Since Newark High School is so close to University of Delaware, I plan to arrange a field trip for my upper level students to visit their rare books collection to see the limited edition life-size replicas of da Vinci's notebooks. Since we can walk, there will be no cost. They can also view some of their other gems

including Renaissance work that includes some of the writings of Ventruvia of Leonardo da Vinci's Vetruvian Man fame.

A short 5-minute video featuring the top 7 da Vinci inventions from #nowyouknow would be ideal for class to highlight some of da Vinci's work. The video lists the author's choices for da Vinci's most important inventions and includes da Vinci's sketches along with the modern reproductions of these inventions, most of which actually function when made according to his specifications. The list includes in reverse order of importance the self-propelled cart complete with steering and break capacity, the multi-barreled machine gun, the parachute, the Robot Knight, diving suit, armored tank, and flying machine (Ornithopter) which developed after his study of birds. (18) The web has a huge selection of good videos on da Vinci's inventions along with his paintings and anatomical studies. I looked at several and included on other lists were these 7 along with gravity and perpetual motion machines, areal crews and ball bearings. Ball bearings seem like a rather minor addition but their impact on machines is huge. On the ABMA website in the history of bearings is the information that in 2600 BC the ancient Egyptians used "a form of roller bearings to help move massive bricks during construction of the Pyramids" and in 40 BC an early example of a bearing was found on a scavenged Roman ship and in 1500 AD Leonardo da Vinci is credited with explaining a ball bearing type. (19) Unfortunately, the contents of da Vinci's notebooks were not common knowledge so the world did not know about many of his ideas until much later.

Leonardo da Vinci is one of the most recognizable artists in the world, famous for his paintings of Mona Lisa and The Last Supper, his inventions, anatomical drawings and other outpourings of creativity. In homage to da Vinci, there is a complex modern surgical machine named after him. From the website of Delaware's Christiana Health Care System is this description, "The da Vinci Robotic Surgery System enables surgeons to perform even the most complex and delicate procedures through very small incisions with extraordinary, state-of-the-art robotic precision… This essentially extends the concept — and the benefits — of laparoscopic surgery to a range of procedures for which traditional laparoscopic surgery is not available" (20)

Rivaling or even surpassing da Vinci for his inventiveness is the ancient genius Hero of Alexandria who lived much earlier during the 1st century AD, preceding da Vinci by hundreds of years. He actually made models of many of his inventions. Not as many are as familiar with his work even though he invented items as the first steam ball device. He was only a step away from inventing the steam engine. He invented a primitive military robot, pneumatic doors, the first machine gun that catapulted arrows, and also the first slot machine, a holy water dispenser/mechanical device into which people of the time inserted a drachma coin. Not understanding the mechanics, they were awestruck by its supposed magic. People were also awed by the powers of Hero's dishonest omen prophecy machine, the oldest confidence trick in the world. The prophecy machine had

wheels and mechanical singing birds and priests in temples manipulated them so that they answered yes and no questions for the amazed uneducated masses (for a price). Hero wanted to entertain people and his illusions included theatre constructions which included scenery that appeared to move on its own and automated sets. His were the precursors to modern computerized sets. Some of these inventions are captured in short History Channel videos. We think that we are so advanced now but what inventors like Hero could do back then in ancient times is fascinating.

A study of ancient inventions would not be complete without a mention of the ancient Antikythera, the oldest analogue computer and complex clockwork mechanism which consists of a series of gears. Found in the Antikythera shipwreck in Antikythera, Greece, this blob of metal from at least 100 BC was not first recognized as the amazing precision instrument that it was. It had multiple purposes connected to using the heavens to predict and chart events. The precision represented was not matched until centuries later in clock making. It makes one wonder how many ancient inventions existed but were lost to the ages with no record of their existence.

Teaching Strategies

To heighten student engagement and address different learning styles, I employ a variety of teaching strategies. Since I teach art, the majority (but not all) of my students are visual learners as opposed to audio or kinesthetic learners. I utilize a lot of visuals but also make sure that materials are used to appeal to the kinesthetic and audio learners. The visuals are often coupled with written information. The board is utilized for objectives, essential questions, and an outline of the day's activities. The word wall on my cabinet doors contains pertinent vocabulary words. Since I have insufficient bulletin board space, the cabinet doors work well as substitutes. Videos and power points will also be utilized along with differentiated student instruction.

The jigsaw activity is a cooperative learning method that enables more material to be shared in a shorter amount of time. Each group of students read and are responsible for summarizing and sharing the highlights of their article with the rest of the class. Another learning strategy that can be used is "Think Pair Share." If the class is larger, it is easier to create groups of students instead of pairs of students. The students read material and then share their thoughts together on it. In art, it is very effective to have students break into informal groups of two or more to do a mini-critique of their pieces of art together. For example, students who are working on their drawings can take a short break from drawing and look at each other's drawings. They can ask each other questions such as, "I have too much blank space so what do you think I should put in the background that will enhance my composition?" They are sharing their creativity and ideas with others.

As mentioned earlier, at Newark High School we have introductory activities called "Stingers" at the beginning of the class block that students do while teachers take attendance. This maximizes class learning time. An example of a stinger on functional fixedness for this unit could be, "A business has just donated 20,000 ping pong balls to your class. Besides being used to play ping pong, what are some other uses that you can find for these balls?"

Classroom Activities

Lesson Plan 1: Uses for an Ordinary Object Game:

This enjoyable activity is fast-moving and can help stimulate the imaginations of the students. The objective is to get students to look beyond the intended purpose of an object (functional fixedness). Fill a tray, tote, or shoebox with items found around the classroom. These can include common items such as a pencil, a stapler remover, a dustpan brush, a scraper, and a ruler. You will need at least three items per team.

Break the students into teams that contain three to six members. This can be changed to fit the number of students in your class since you will need a minimum of two teams. Select or have the students pick at least two timekeepers. In this digital age I no longer presume that my students can measure a minute on an analogue clock so I explain to the class that each round will last one minute (when the long hand revolves around the face of our wall-mounted classroom clock to end up on the number on which one started timing).

The first team will select an item such as the pencil. When the timekeeper says, "Go!" the first member will give a use for the object. For example, he or she could give its intended purpose which is a writing utensil. It would be handed to the next person who would think of another use such as a weapon. The next person could say that it was one of a series of rollers for moving blocks (as in the construction of pyramids). The next could say that it could be used as a straight edge. Other answers could include but not be limited to a wooden stake to kill a vampire, a Barbie bed post, a log for a cabin, a "pin" for a hair bun, a tourniquet pressure twister, as part of a string compass, and a drink stirrer. This would continue until the minute is up. Each answer would rate one point. If the next person cannot think of an answer, then he or she can say, "Pass." If the student gives a response that has already been given, then that response would not count and the next person must be ready. If the answer is too far out, then the judge (the teacher) would disqualify that answer and it would pass to the next in line. For example, the pencil could be used as the body for a butterfly sculpture but the pencil itself would not qualify as a

butterfly. When one minute is up, the teacher would say, “Stop!” and that round would be over. The total amount of points earned by Team 1 would be written on the board. Then each of the other teams would have a turn.

The number of rounds depends on the amount of time you want to spend on this activity. It can be used as an introduction to another activity on creativity. It can also be used as a type of creativity pre-test by the teacher because you can tell pretty quickly those who are willing to put some creative thought into the answers.

Lesson Plan 2: STEAM Design Challenge: Design a Chair out of a Single Piece of Paper

To introduce this activity, the students will have a 3-minute stinger. In that time frame they must break into their teams and list all of the types of chairs that they can. They may not use cell phones or computers for help. The first group to volunteer will read off their list. Then the next group will read off any ideas that were not included on the list of the first team. The rest of the groups will follow. Because the students will need the rest of the class to create their chairs, the instructor must keep the students very focused so that time is not wasted. Some of the ideas may include a bean bag chair, dining room chair, baby high chair, car seat, wing back chair, stool, throne, rocking chair, rocking horse, chaise lounge, beach chair, bench, and an easy chair. The group with the most types can be declared the winner. This activity should help students to broaden their scopes and consider ideas from a bigger pool than a straight back chair with 4 straight legs. Questions that the students should consider can include, “What makes a chair a chair?” “Does a chair *have* to have four legs?” From their lists they should have realized that chairs do not have to have any legs or that the number can vary.

Hand out a sheet to each group that has the directions, project limitations, criteria, and grading considerations. Explain the project and answer questions. Do not show samples because that will limit creativity. The objective is for students to create a chair that is both functional and visually appealing. It must be out of a single piece of 12” x 18” paper. No pieces can be cut off of that single sheet and then added on. Only paper and the light pencil lines can be used in the final product. It will look more professional if the pencil is erased off after the paper has been cut and folded (pre-assembly). No staples, glue, tape, paint, markers, colored pencils, or materials that are not from that piece of paper may be used. However, the students may bend, fold, roll, cut slits, slots, make tabs, or further manipulate the paper to achieve their desired results.

Materials that students may use include rulers, X-acto knives, cardboard for use under the paper so that they do not cut up the tables using the X-acto knives, compasses, 12” x

18” drawing paper, scrap paper, protractors, and pencils to draw out their designs. However, they may not use pencil, pens or colors to decorate their chairs. They must figure out a way to do that within the parameters of the rules. For instance, they could press into the paper with the edge of a ruler to create an incised design that is indented or flip it over so that the same design will appear to be embossed or raised. The students should use the provided scrap paper for prototypes so that they do not waste the good drawing paper. The good drawing paper is for their final designs.

Since this is a one-day project, the students have to brainstorm, work on prototypes, and come up with a finished chair by the end of class. They can work by themselves, in pairs, or in a group of three. They need to use their imaginations and creativity. The students will be given a reflective thinking sheet to evaluate their projects as homework. They will be due at the beginning of the next class. The statements will include what the student thought were the biggest challenges in the design process, how successful the chair design was, and what did and did not work well. If the students fill out their reflective thinking sheets after the critique, then their answers will reflect their peers’ thoughts and not just their own.

The beginning of the next class will be devoted to a class critique. The chairs will be displayed on a table. Since the students have participated in these before, they will know that the purpose is to have a safe environment where everyone is ensured that they can express their opinions. I will start by reminding them that the insights they share must be evaluative, analytical, thoughtful and more critical, and not a simple, superficial, “I like it. It is nice.” The critique will allow the students to see the multiple solutions that their peers used to solve the same design problem with which they were presented.

The considerations/categories in the grading rubric will include the visual appeal of the finished product, functionality, craftsmanship, stability, use of the elements of art (line, shape, value, form, texture, space, and color) and principles of design (balance, contrast, emphasis, movement, pattern, rhythm, and unity), use of time in class and contributions to the team, safe and responsible use of materials, and clean up.

Lesson Plan 3: Drawing Plans for a Leonardo da Vinci-Inspired Invention

As background preceding this lesson, students will learn some general information on the Renaissance and on some selected masters such as Michelangelo and Leonardo da Vinci. Michelangelo considered himself to be a sculptor who created works in Carrara marble such as The Pieta and David. He felt uncomfortable with painting but he is probably equally well-known for his paintings that cover the ceiling of the Sistine Chapel.

Leonardo da Vinci's most famous works would include the paintings Mona Lisa and The Last Supper. However, he was also an architect, sculptor, scientist, and inventor who had a curiosity and interest in many fields. The students are going to concentrate on da Vinci the inventor and will look at his notebooks and many of his inventions online. There are multiple great short videos on-line. The students will also take a field trip to the rare books collections at the University of Delaware. I will prearrange the trip and the books that I would like them to pull will include the limited edition copies of da Vinci's notebooks. They are expensive reproductions that are printed in the same colors and sizes as the real notebooks and are the next–best thing to seeing the originals. We have an advantage at Newark High School because we can walk over to UD, negating the cost of a bus.

Students will be asked to think of an invention that would improve their lives or the lives of those around them. On cheaper paper they will first roughly sketch five different concepts or ideas. The purpose of sketching five concepts is to generate different ideas and not just pick the first idea that pops into their heads. They will develop the most promising one and refine it, showing at least two viewpoints of this invention. Then it will be ready for a peer mini-critique. Before they start their final drawings, they will use the strategy of think pair share (or think group share) with their entire table. Each student at their table will present his or her own idea for peer review and input. Those ideas, concerns and comments will be taken into consideration before starting the final drawings. I will wander between the groups to listen to the dialogues. All must present their ideas and all will be encourage to give input on the others' designs.

The students will be given the choice of rendering their final drawings on parchment paper, large graph paper, or drawing paper (white, manila or an earth tone). The drawings must include the title of their inventions and their signatures and include at least two different views of the inventions (on the same page). Those conditions/criteria will be included in the 100-point grading rubric along with the consideration of different solutions and exploration of ideas, the sketches which will also be turned in with the final drawings, the aesthetic/visual appeal of the final product and its effective presentation, use of composition, the use of the elements of art and the principles of design, use of time in class and working to the best of one's ability, and the creativity and usefulness of the invention. Students will also fill out a reflection about their inventions when they are finished, evaluating the strengths and weaknesses with explanations of what, if anything, they would have done differently. They will also be asked what inspired them to come up with their idea and if they ever envision their invention becoming a reality.

Students will also be graded using a rubric worth 10 points on their artist statements that will accompany their inventions. These explanations should give the viewers some insight into the artists' works and their thought processes. These statements will be hung directly next to their works in the show. The students will help mount this exhibit in Newark High School's art gallery and they will help create the advertising and invitations for the exhibit. Parents and friends will be invited to the evening opening and the exhibit will also be open during our 30-miniute seminar periods during the school day. During the seminar periods students will stand by their works so that they can answer questions about their work.

We have created a locked gallery ballot box for a popular vote for Best in Show. Student exhibit monitors would hand each visitor one ballot to use for voting for each visitor's choice of the invention drawings that they consider to be the best in the show. There would be space on the ballot for an optional explanation of why he or she considers it to be the best. The winner and top choices would be announced in the participating classes.

Implementing the National Art Standards:

Delaware has adopted the new National Art Standards. A lesson plan does not need to address all of the standards but the above da Vinci lesson actually touches on all, some in more depth than others. The new standards are organized into the four categories of **Creating, Performing, Responding** and **Connecting.** All four categories are common to the visual arts, dance, media arts, music and theatre but each is then tailored to the specific discipline.

"**Creating:**
Standard 1: Generate and conceptualize artistic ideas and work.
Enduring understanding: Creativity and innovative thinking are essential life skills that can be developed.
Standard 2: Organize and develop artistic ideas and work.
Standard 3: Refine and complete artistic work.

Presenting:
Standard 4: Select, analyze, and interpret artistic work for presentation.
Standard 5: Develop and refine artistic techniques and work for presentation.
Standard 6: Convey meaning through the presentation of artistic work.

Responding:

Standard 7: Perceive and analyze artistic work of art.
Standard 8: Interpret intent and meaning in artistic work.
Standard 9: Apply criteria to evaluate artistic work.

Connecting:
Standard 10: Synthesize and relate knowledge and personal experience to make art.
Standard 11: Relate artistic ideas wand works with societal, cultural, and historical context to deepen understanding." (21)

The anchor art standards are reflected in the above da Vinci lesson. The standards for **Creating** are covered from when the students generate ideas in their first five initial sketches and explore the possibilities of their ideas through narrowing down and refining until they actually come up with finished products (in this case, finished sketches). They are also using the steps of the engineering/art model for problem solving and creative thinking as they go through this creative process. The NAEA website with the standards is a treasure trove of information. I included the above enduring understanding from their website for Standard #1 because of the strong message it represents about what is essential. More can be viewed online.

The **Presenting** standards are addressed when the students work together to organize and hang their work for display in the gallery. The students must decide how the drawings should be presented and the most professional way to hang the statements. Should both be matted? Does the art department own enough black poster board or matboard to make that a reality? Should the statements all be typed in the same font using a consistent size or are handwritten statements more "authentic"? The students must be led to discover that the art should come together as a body of work with a common theme while still retaining the flavor of the individual pieces. They should be hung at an optimal height for viewing and be spaced in a visually pleasing fashion. Traffic should be able to "flow" smoothly through the gallery. How will the advertising signs convey the meaning of the show and encourage people to attend and who will make them?

Through the students sharing their thoughts on their own individual works on their reflective thinking sheets and on their own and their peers' work during the group critiques, the standards for **Responding** are covered. The students will analyze, evaluate and reflect upon both the creative process and their work.

The standards that address **Connecting** will also be covered. When the students develop their invention ideas, they must use their personal experiences to develop an idea that they think will improve their lives or make the world a better place. To aid them in

this journey, they will first explore background material on ancient inventions and selected technology from ancient times to that of more recent times. These cover a breadth of different cultures, countries, and disciplines in history. The first two categories of standards also are addressed in Lesson 2 above involving the creation of a chair from a single piece of paper. The chair designs could also be displayed in the gallery along with the drawings and statements.

Notes

(1) Christina School District Website, Newark High School, www.christinak12.org/.

(2) Next Generation Science Standards- Appendix F- Science and Engineering Practices in the NGSS, www.nextgenscience.org/.../Appendix%20F%20%20Science%20and%20Engineering..., April 1, 2013, 1

(3) Next Generation Science Standards, 2

(4) Delaware Teachers Institute Website, https://www.cas.udel.edu/dti/participate/current-seminar-descriptions

(5) Necessity is the mother of invention definition, http://idioms.thefreedictionary.com/Necessity+is+the+mother+of+invention

(6) Nova Special, *Lost at Sea-The Search for Longitude*, https://www.youtube.com/watch?v=9rhFfB-vHm4

(7) Nova Special, *Lost at Sea-The Search for Longitude*

(8) McCaffrey, Tony, *Why We Can't See What's Right in Front of Us*, Harvard Business Review, May 10, 2012, hbr.org/21212/05/overcoming-functional-fixedness

(9) McCaffrey, Tony, *Why We Can't See What's Right in Front of Us.*

(10) Greeson, Amy, *Healing Seekers-Army Surgery Ant and Stitches* (YouTube video uploaded on Oct 29, 2009). *https://www.youtube.com/watch?v=EK65_PpEVzA*.

(11) Dweck, Carol, *Carol Dweck Revisits the 'Growth Mindset,"* Education Week, November 5, 2016, http:/ /www.edweek.org/ew/articles/2015/09/23/carol-dweck-revisits-the-growth-mindset.html?cmp=cpc-goog-ew-growth+mindset&ccid=growth+mindset&ccag=growth+mindset&cckw=%2Bgrowth%20%2Bmindset&cccv=content+ad&gclid=CIXkuZrWkdACFZFZhgodfXcEOQ

(12) Dweck, Carol, *Carol Dweck Revisits the 'Growth Mindset"*

(13) Obama, Barak,quote, https://quotefancy.com/quote/770914/Barack-Obama-In-addition-to-giving-our-children-the-science-and-math-skills-they-need-to. Accessed November 6, 2016.

(14) 3M website, http://news.3m.com/press-release/company/3ms-richard-drew-inventor-scotch-brand-masking-and-cellophane-tapes-inducted-n. Accessed November 27, 2016.

(15) Lehrer, Jonah, *Imagine, How Creativity Works*, Houghton Mifflin Harcourt, Boston, New York, 2012, pg. 28, 29.

(16) Lehrer, Jonah, *Imagine, How Creativity Works*, pg. 29, 30.

(17) Lehrer, Jonah, *Imagine, How Creativity Works*, pg. 31.

(18) *Top 7 da Vinci Inventions* #nowyouknow, https://www.youtube.com/watch?v=PwOlIGGDVjE

(19) American Bearing Manufactures Association http://www.americanbearings.org/?page=bearing_timeline

(20) Da Vinci Robotic Surgery, Christiana Health Care System, Helen F. Graham Cancer Center & Research Institute, http://christianacare.org/services/cancer/cancersurgery/davinci/

(21) National Art Standards, NAEA, http://www.nationalartsstandards.org/

Resources

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American Bearing Manufactures Association, http://www.americanbearings.org/?page=bearing_timeline (Accessed December 13, 2016).

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Top 7 daVinci Inventions #nowyouknow, https://www.youtube.com/watch?v=PwOlIGGDVjE

University of Vermont, https://science360.gov/obj/video/ac1e2fba-2193-485c-bd1a-62bf7ec05751/ancient-inventions. A short video of the inventions made by the University of Vermont students in Domenico Grassi's Ancient Inventions course.

Taddei, Mario, and Edoardo Zanon, editors, and Domenico Laurenza, text, David & Charles, *Leonardo's Machines: Da Vinci's inventions Revealed,* Cincinnati, Ohio, 2006.

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