Leonardo's Everyday Art & Physics

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INTRODUCTION

In mid-year I changed both schools and disciplines, going from middle school one-semester introductory art curricula, to elementary 4th grade classroom. Previously I focused on symbolism and issues of identity while emphasizing drawing skills to middle school students of widely disparate art backgrounds. I focused on art basics and drawing skills to ground their understanding of art and encourage confidence, while all along presenting Pre-Columbian influences on Modern artists of the 20th and 21st centuries to develop awareness simultaneously of cultural heritage and contemporary issues of identity.

Now I may need to find a new footing, but I am still hoping to teach art next fall. I will continue to introduce creative and artistic concepts, while enriching student synthesis of academic knowledge and heritage. Leonardo da Vinci epitomized the Renaissance man – a creative artist, architect, practical engineer, inventor, and investigative scientist of the natural world – who held no distinction between these roles. These were but informal titles representing his emergent interests – all rooted in the creative, dynamic world that he experienced, observed and investigated each day of his life.

Since my previous school was a magnet for both math and science, I aimed for a broader, a more integrated base in the arts incorporating the relevance of art to daily experience, including math and science. I will continue to incorporate visual literacy and the visual arts to strengthen student perception and learning in math, science, social studies, and writing.

How would developing a curriculum unit on Leonardo's everyday physics help me enrich my students' learning experiences? Thinking of middle school art students, they would experience cross-fertilization between science, math, and art in a hands-on, practical and creative activity. I think it would enhance their intellectual perception of "art," as well as get them involved with science and math in such a way as to foster a *desire* to know more about these disciplines! Previously my focus was the connection between physics and all that they appreciate and love in art – especially color, shadow, perspective and illusion. These very optical and color issues in physics that I have addressed in my art classes – color theory, color refraction, shadow and optical illusions, as well as perspective were all being investigated and studied during the Renaissance by creative artists, and particularly by Leonardo da Vinci. His notebooks detail experiments and conclusions that are insightful for his time, and he made use of them in his own artworks. While I would like to refer to these issues, I will, within the frame of the creative arts, primarily address Leonardo's inventive engineering activities that harnessed the work of simple machines.

OBJECTIVES

TEKS Objective – Nature Science:
Critical Thinking 6.3B, 7.3B, 8.3B: Student draws inferences based on observation/data
~ Students will record observations simple machines and the natural world in Journal/ Sketchbooks.

Critical Thinking 6.3D, 7.3D, 8.3D: Student evaluates impact of research in scientific thought/ society/ environment
~Student will explore impact of simple machines in development of Leonardo's inventions, such as the *Aerial Screw*. ~Students will explore impact of scientific perspective and proportional measurement in Renaissance architecture/painting.

TEKS Objective –Change: Inquiry 7.6A: Student demonstrates relationship force/ motion using simple machines/ calculates mechanical advantages levers/ pulleys/ inclined planes
~Students will explore/ construct simple machines and apply use to constructing polygonal table-top environments.

***TEKS* Middle School 6, 7 and 8 Grade Math Objectives**
TEKS OBJECTIVE 6: Underlying Mathematical Process/ Problem Solving Tools 6.11, 7.13A, 8.14A: Student identifies/ applies math to everyday experiences/ activities/ disciplines
~Students will construct/ demonstrate operation of simple machines
~Students will use measurement to construct polygonal table-top environments/ determine physical proportions for portraiture.

***TEKS* Middle School 6, 7 and 8 Grade Fine Arts Objectives**
TEKS 117.32.Art Grade 6, 117.35.Art Grade 7, 117.38.Art Grade 8 – Knowledge and Skills:
Perception 6.1, 7.1, 8.1: Student illustrates themes of personal experience/ imagination/ observation/ current events
~ Students will keep Journal/ Sketchbooks to record observations simple machines/ natural world and evaluate creative ideas and planning sketches.
Creative Expression/Performance 6.2, 7.2, 8.2: Student expresses ideas based on personal experience/direct observation/ imagination and demonstrates technical skills in variety of media/ using variety materials/ tools
~ Students will use personal observation in the natural world and everyday life to create finished artwork using mixed-media.
Historical / Cultural Heritage 6.3, 7.3, 8.3: Student compares artworks from variety of cultures/ analyzes cultural contexts
~ Students will compare physical science and art issues in the work of specific Renaissance/ 20th century artists.
Response/Evaluation 6.4, 7.4, 8.4
Student conducts in-progress analyses/ critiques of personal/ peer artworks using critical attributes/ forms conclusions on formal properties/ historical/ cultural contexts and intents
~ Students will work individually and in groups, developing their "Artist's Eye" to respond to and evaluate each others work, as well as that of artists/ architects presented in the unit.

RATIONALE

The natural world is not only our home, but really all we know – and all we do not know! Our human endeavors and preoccupations, no matter who we are or when or where we have lived are grounded in the natural world:

> The Renaissance gave new meaning to the axiom of the ancient Greek philosopher Protagoras: 'Man is the measure of all things that he is and that he is not.' The belief in people's ability to think for themselves engendered... self-confidence and enthusiasm for the integrity of each person's singular ideas... the spirit of the age... a symbol of this confidence... [is Leonardo da Vinci's study of the proportions of the human figure - *Vitruvius Man* his] image of a nude man with outstretched arms circumscribing both a square and a circle. (Shlain 57; da Vinci 42-59).

We observe natural laws and concepts of physics, but we do not always interpret them correctly. Our flawed vision influences others and stimulates both revisionists and new explorations. It is important that students have the opportunity to immerse themselves in experience, observation, and interpretation. This is the cornerstone of creativity in both art and science.

I want my students to explore, observe, and record the natural, everyday world of physics around them. What they find magical or perhaps take for granted will be transformed in their own minds by combining personal observations with Leonardo's own sketchbook observations. Just as everything he did was deeply rooted in his own observations of the natural world and of natural phenomena, I want my students to see how connected they are to the natural world.

By developing this groundwork of personally experienced knowledge, students will be able to synthesize their understanding of basic concepts of physics by making a model of one of da Vinci's inventive machines. By having student groups explore natural phenomena – observing and recording nature in their own investigative journals, using basic physics concepts in a creative product, such as da Vinci's *Aerial Screw*, they will be developing a conception of their own world, time and place as a continuum greatly influenced by Renaissance thought – that of the importance of individual perception and interpretation. As Leonard Shlain points out in his discussion of the usually linear cognitive processes, Leonardo da Vinci seemed to merge seeing and thinking, allowing an achievement of rare depth of perception as his mind worked with the duality of time and space (432-433).

Additionally, I want students to explore sculptural constructions using simple machines and basic concepts of physics, incorporated as part of their art object – construction – a domicile environment or mobile environment, referring to architects such as Buckminster Fuller or I. M. Pei. Dynamic and creative students develop their own world as they go through life; I want them to have an opportunity to explore questions of environment – how to use geometry and physics to construct environments with a polyhedron that not only involves architecture, but psychological/spiritual connotations of well-being. We might brain-storm how something like a polyhedron that is found in the natural world and used as a constructive unit in architectural design might impact our feelings of spirituality and connectedness to nature? Or how does science-fiction use such constructions to address human well-being in futuristic contexts as well as address environmental issues on another planet or moon? How do simple machines fit in with construction? How can a geodesic dome or pyramid be constructed using simple machines?

UNIT BACKGROUND

How will I teach this unit?

My lessons will incorporate experiments with force and motion, model sketches, and refer to the Renaissance ideas of Leonardo and his contemporaries. I plan on students creating their own sketch/journals with which to explore this unit, just as Leonardo used his own notebooks to explore his world – record natural phenomena, formulate ideas about physics concepts seen in the natural world, design machines, and create possibilities. The construction of these sketch/notebooks will offer students an opportunity to explore simple machines for cutting, hole-punching, floating hinges, and needle, grommet or bolt and screw binding.

The physics of simple machines – Force, Movement and Lift

Simple machines do work – they make use of the physical phenomena of force, movement and lift. *Force* and *Movement* occur when a push or pull influence is exerted on a separate body, such as water against a rock creating a turbulent movement of the water flow or air against a solid creating a lifting movement (Bloomfield 174-176; 541). *Lift* is the difference in pressure caused by the perpendicular force of a moving fluid, such as water or air, on a solid which causes a deflection of the flow – one side of the solid will then have a higher pressure of condensed fluid and the other side a lower pressure. The result will be the higher pressure lifting the solid, such as rushing air lifting a piece of paper (Bloomfield 188-189, 543; Hixson 20-21). In nature, force, movement, and lift might be observed when the wind blows through a tree's canopy, moving individual branches and leaves, or when a gust of wind sends a fallen leaf flying. Another example in nature would be wind blowing the gossamer umbrella seeds of a dandelion flower.

There are six simple machines that can be used by themselves or combined into complex machines:

Lever: A lever is a bar that pivots against a fulcrum or point. It does work by rotating against the point to *lift* something. Examples are the claw end of a hammer, a weeding tool, a shovel, a crowbar, tweezers, tongs, pliers, bottle openers, nutcrackers, see-saws, and scales (Baton; Tucker).

Inclined Plane: A plane is a flat surface, which when slanted to connect two different levels can help with the *movement* of an object across a distance using less *force*. Examples are ramps, slides, slopes, stairs, and dust pans (Baton; Tucker).

Wedge: The pointed edge of an inclined plane can be used to cut or *move* things apart. Examples are axe blades, chisels, knives, scissors, nails, staples, hole-punches, snowplows, scoops, and bows of boats (Baton; Tucker).

Wheel and Axel/Gear: A round wheel rotates a cylindrical axel through its center, causing *movement* of both together, and will *move* objects across distances. Examples are wagons, cars, bikes, roller skates, door knobs, egg beaters, and pencil sharpeners (Baton; Tucker).

Screw – A Wrapped Plane: An inclined plane that is wrapped around a cylinder causes *lift* by moving the plane through something else, such as wood. Examples are carpentry screws, bolts, a hand-drill, a corkscrew, jar lids, and paper or food presses (Baton; Tucker).

Macaulay explains that when something moves along a screw thread, like a nut on a bolt, it has to turn several times to move forward a short distance. *As in a linear inclined plane, when distance increases, the required force decreases*. A nut, therefore, moves along the bolt with a much greater *force* than the effort used to turn it… and like a straight-inclined plane used as a wedge, a spiral inclined plane can also move to push a load upward (62-63).

Pulley: A pulley is a wheel rotating a rope, cable or chain either up or down. It can be used to *lift* or *move* things up, down, or across short distances. Examples are flag poles, clothes lines, curtain rods, mini-blinds, and cranes (Baton; Tucker).

Leonardo's vocabulary of simple machines

Leonardo observed and studied the nature of natural phenomena – he was interested in ideas of force and motion and how they governed the shape and function of things, as explained in both the catalogue for the traveling exhibition *Leonardo da Vinci, Man - Inventor - Genius* currently at Houston's Natural Science Museum (Fink 88, 110) and Boston Museum of Science's online exhibition studies section *Virtual Leonardo: Machines*. Leonardo's studies of simple machines – levers, pulleys, wheel and axel, and inclined planes, including screws and wedges – resulted in standardizing what would be the integral building units (Fink 88, 110) in a vocabulary for the invention of complex machines, many for the specific needs of his patrons, such as warfare or civic welfare in the wake of devastating plagues, as well as his own visions of future flight.

As an apprentice in the studio of the artist Verrocchio, Leonardo observed and used a variety of machines. By studying them he gained practical knowledge about their design and structure. Many ancient machines were in common use in Leonardo's time. For example, water wheels turned millstones to grind grain, and Archimedes' screws lifted water from streams providing a ready supply for drinking and washing. Artists and craftsmen in Leonardo's time knew how to build and repair the familiar kinds of machines. The idea of inventing new kinds of machines, however, would not have occurred to them (Fink 40-41; *Exploring Leonardo*; Taddei 223-225).

Leonardo developed a unique new attitude about machines. He reasoned that by understanding how each separate machine part worked, he could modify them and combine them in different ways to improve existing machines or create inventions no one had ever seen before. Leonardo set out to write the first systematic explanation of how machines work and how the elements of machines can be combined (Fink 40-41; *Exploring Leonardo*; Taddei 223-225).

His interest in both air and water phenomena may appear as interchangeable applications, since his personal interest in flight coincided with much of his professional career inventing machines for hydraulic projects, such as dredging, maintaining waterways, digging channels and reclaiming marshlands (Taddei 157). Shlain reminds us that Leonardo believed "mechanics is the paradise of the mathematical science because by means of it, one comes to the fruits of mathematics" (74), and in his treatises on mechanical inventions Leonardo sought to unite mechanical theory, design, and aesthetics in order to elevate their traditionally inferior social status (Taddei 223-225).

Leonardo's sketchbooks, the physics of proportion and perspective

With a curious and questing mind, Leonardo was never at rest, but always observing nature and experimenting with ideas. He made his notations and sketched his observations, "... trusting only direct observation and his own experience (Strosberg 186)." He followed scientific procedure in observing nature and recording it, believing everything he was interested in would eventually come together and connect, such as his interest in motion studies of water and of birds in flight, muscle and skeletal anatomy, his painting and sculptures of humans and horses, and his inventions (Atalay 206-210; Herbert 18-20, 50; Shlain 74-79). Leonardo kept two kinds of notebooks – one with the finished drawings and notated sketches and the other a diary-like compilation of daily observations, ideas and doodling that reflected the many levels of his consciousness. Striving for clarity within these thousands of pages, Leonardo developed a new graphic style of text-wrapped imagery using left-hand, mirror-writing to help protect his ideas, research and inventions (Atalay 188-189; Hebert 32; Strosberg 187).

Just as brushes and paints were made by artists, so were their sketchbooks. Indeed, until the invention of moveable metal-printing type in the 15th century by Johann Gutenberg, most books were still copied completely by hand, as well as being hand-bound. The printed book revolutionized Renaissance thought and society, as a uniform and comparatively inexpensive media that unified discourse on philosophy, science, math and art throughout Europe (Atalay 2-3). *De divina proportione*, written by Leonardo's friend, the mathematician Fra Luca Pacioli, and published in Venice in 1509 with illustrations by both Leonardo (polyhedra, and the proportions of the human head in profile) and Piero della Francesca (Vitruvian font letters) was one such book (Atalay 86-87: Kemp 37). Piero, both an important painter and mathematician, wrote other treatises, such as the geometry of the five regular polyhedra and perspective. Among the important technical issues of the Renaissance, proportion and perspective were used to create the illusion of reality in three-dimensional space (Kemp 30-31; Shlain 53-55; Strosberg 147-148).

Like many theoretical Renaissance painters, Piero della Francesca strove to construct his paintings mathematically and scientifically using perspective, proportion, and shadow. This theoretically calculated approach was also important to Leonardo da Vinci – the painting was a precise geometric construction enlivened by light and shadow (Kemp 30-31; Shlain 53-55; Strosberg 147-148). It should be noted that in perspective (a revolutionary Renaissance idea placing the central focus on the viewer, whose position became individualistic and interactive), all sight lines drawn from a vanishing point converge on the viewer at a stationary location. The physics of perspective not only informed Renaissance painting and sculpture but the practical ...

military calculations of missile trajectories, cartography, navigation, and architecture (Shlain 48-54), all areas in which Leonardo contributed his own research and inventions.

Renaissance scholars sought out the ancient classical ideas of proportion, including the dynamic symmetry of Leonardo Fibonacci di Pisa's mathematical ratio of sequential terms resulting in "phi" – the golden ratio or golden rectangle of Euclid, the architectural theory of Vitruvius based on human proportions, to the natural symmetry of the spiral in nature (Atalay 14, 36-37,42-43, 93-94, 105-107). Leonardo da Vinci's illustration *The Vitruvius Man* is an example of his study of classical proportion. Because painters and sculptors also constructed, engineered, and designed things, they found that not only optics, but 3-dimensionality, proportion, and the aesthetics of the golden mean were important issues to master (Atalay 86-87, 93, 101-102; Shlain 57-58; Taddei 227). Architectural forms, whether domes, spiral staircases or buildings involved these same issues and often required the artist-engineer to re-design or invent machines needed for their construction as well.

During the Renaissance there was no distinction made between applied and fine arts – artists were foremost craftsmen, architects, and engineers, as well as painters and sculptors. Leonardo da Vinci epitomized the Renaissance Man, who was interested in many fields – the natural world, scientific investigation, city planning, architecture, music, painting, and sculpture – and like other creative thinkers, he was influenced by the availability of the printed word and the dissemination of ancient Greek knowledge, as well as the opportunity to observe the natural world (Atalay 185-192; Shlain 227-280; Taddei 224-225).

LESSON PLANS

Lesson One – Simple Machines

Objectives

1. Students will identify and investigate six simple machines (lever, inclined plane, wedge, wheel and axel/gear, screw and pulley).
2. Students will investigate how each one does work and the physical forces needed, focusing on *Lift*, *Force* and *Motion*.

TEKS: (TEKS objectives are discussed in the Objectives section of the narrative.)
Science – Critical Thinking 6.3B, 7.3B, 8.3B
Science – Change: Inquiry 7.6A
Mathematics – Objective 6: Underlying Process/ Problem Solving Tools 6.11, 7.13A, 8.14A
Fine Arts – Perception 6.1, 7.1, 8.1

Introduction

What is a simple machine? Where can we find simple machines? Why did Leonardo da Vinci study simple machines? In pondering these questions students will be asked to brainstorm a list of simple machines they might see everyday in the classroom or at school – machines that *lift* or *move* things to do work faster or more easily. Where can we see these simple machines combined into more complex machines?

To explore simple machines, students will visit six stations to do hands-on experiments with each machine, as well as explore some variations. As these simple machines can be combined to make more complex machines, students will have an opportunity to identify them within a more complex machine by Leonardo da Vinci. Each station will have a poster of one of Leonardo’s complex machine inventions with clues to find specific simple machines. Students will thus be able to recognize that with his own study of simple machines, Leonardo created a working vocabulary as the basis for his activities as an inventor and engineer (Taddei 223; *Exploring Leonardo*).

Concept Development

Phenomena: Lift, Force and Movement

<u>Physics Experiments</u>: Simple Machines – Lever, Inclined Plane, Wedge, Wheel and Axel/ Gear, Screw, and Pulley

Station – Lever

1. Students will use three different size tweezers or tongs to *lift* different objects (feather, corn kernel, metal washer, paper clip, and tennis ball).
2. Students will place a ruler on top of a small wooden block and try to *lift* various loads (metal washers) with one, two or three fingers and record position of fulcrum (closer or farther) for ease of work (difficult, slightly difficult, easy).
3. Students will use scales to experiment with *lift and balance* (metal washers, crayons, paper clips, and corn kernels).
4. Illustration of Leonardo's invention Viola Organista, *Folio 93r from Codex Atlanticus* 1493-1495 (Taddei 216-221)
5. Simple Machine Clues: Can you find lever keys, a drive lever, and a flywheel?
6. When and where might this machine be used in Houston?
7. Illustration of Lever (Baton; Tucker)

Station – Inclined Plane

1. Students will experiment with ramps of different steepness with wooden or *Lego* blocks and move an object (light, medium and heavy weights, such as metal washers, a small wooden block, and a box of crayons) up the ramp using one, two or three fingers, recording ease of work (difficult, slightly difficult, easy).
2. Illustration of Leonardo's invention: Swing Bridge, *Folio 855r from Codex Atlanticus* 1487-1489 (Taddei 146-155)
3. Simple Machine Clues: Can you find two ramps, two pulleys, winch wheels?
4. Which would be more useful in an urban environment - a draw bridge or a swing bridge? Why?
5. Illustration of Inclined Plane (Baton; Tucker)

Station – Wedge

1. Students will use a chisel, assorted nails and heavy-duty staples to push into assorted surfaces (wood plank, cork, cardboard, *Styrofoam*) and record contrasting difficulty of work needed (difficult, slightly difficult, easy).
2. Illustration of Leonardo's invention: Dredger, *Folio 75v from Manuscript E,* 1513-1514 (Taddei 156-159)
3. Simple Machine Clues: Can you find scoop wedges, bow wedges, wheel and axel?
4. How could this machine be used in the swampy bayous around Houston or the ship channel?
5. Illustration of Wedge (Baton; Tucker)

Station - Wheel and Axel/ Gear

1. Students will construct and roll small cardboard box "cars" using thick pencil/ or wooden dowel axles and CD-disc wheel.
2. Illustration of Leonardo's invention: Self-Propelled Cart, *Folio 812r from Codex Atlanticus* 1478-1480 (Taddei 188-195)
3. Simple Machine Clues: Can you find three wheels, two axels, two cogwheels, two cage-

shaped gears, and two springs?
4. Where have you seen a simple spring-wound propulsion system?
5. Illustration of Wheel and Axel/ Gear (Baton; Tucker)

Station – Screw

1. Students will use various sizes of screwdrivers to experiment with assorted sizes of screws (different numbers of threads and lengths) to screw into a plank of wood and record the degree of work needed (very difficult, slightly difficult, and easy)
2. Students will make a chart for different sizes of screws, classifying according to width, length and number of threads and record ease of work needed.
3. Illustration of Leonardo's invention: Aerial Screw, *Folio 83v from Manuscript B* c.1489 (Taddei 46-53)
4. Simple Machine Clues: Can you find a helical screw, a wheel?
5. What child's toy does this machine remind you of?
6. Illustration of Screw – A Wrapped Plane (Baton; Tucker)

Station – Pulley

1. Students will lift a heavy starch or laundry soap bottle with a cord wrapped through its handle and over a wooden dowel (broom) support that is securely taped down between desktops. Students will experiment and record the number of times the cord is wrapped through the handle and over the dowel to decrease the amount of effort needed to *lift* the object (Baton; Tucker).
2. Illustration of Leonardo's invention: Canal Excavating Crane, *Folio 4r from Codex Atlanticus* 1503-1504 (Taddei 176-183).
3. Simple Machine Clues: Can you find a central wheel pulley, two cranes?
4. How could this machine be used at construction sites around Houston?
5. Illustration of Pulley (Baton; Tucker).

Student Practice

1. Students will finish touring the stations in small working groups, investigating and discussing the activities using a teacher-prepared rubric.
2. Students working in small groups will choose one of the six simple machines to research, recording observations and investigations using a *Prediction-Hypothesis-Question-Procedure-Record of Results* format.
3. Students will find examples of this simple machine at home and will make a working sketch of the machine and record the investigation on worksheets that can later be pasted into Journal/Sketchbooks, using a *Household Example –Simple Machine – How It Works* descriptive format.
4. The group will organize and present their research with working sketches and actual examples to the class. They may use wooden or *Lego* building blocks to construct 3-dimensional models in class.

Assessment

1. Students will be assessed on their worksheet entries covering six line drawings showing the working machine, six basic descriptions with a written explanation of how each machine does work**,** and two household or classroom examples of each simple machine.
2. Students will be assessed on their group work using a teacher-prepared rubric addressing individual contribution to the group project, investigation, and presentation.

Closure

Students will take a mini-tour of the classroom or school buildings looking for simple machines –

ramps, door hinges, door knobs, pencil sharpeners, window shades/mini-blinds, both single and 3-hole punches, staplers…and sketch the examples they see.

Lesson 2 – Leonardo's Sketchbooks: Observation and Creative Interpretation

Objectives

1. Students will make Journal/ Sketchbooks to write, record and sketch observations, ideas, and conclusions.
2. Students will investigate the use of simple machines in constructing a Journal/ Sketchbook.
3. Students will explore bookmaking processes during the Renaissance.

TEKS:
Science - Critical Thinking 6.3B, 7.3B, 8.3B
Science - Change: Inquiry 7.6A
Mathematics – Objective 6: Underlying Process/Problem Solving Tools 6.11, 7.13A, 8.14A
Fine Arts - Perception 6.1, 7.1, 8.1
Fine Arts – Creative Expression/Performance 6.2, 7.2, 8.2
Fine Arts –Historical/Cultural Heritage 6.3, 7.3, 8.3

Introduction

How do you think Leonardo got his notebooks? Did he buy them or make them? From an early age Leonardo spent a great deal of time closely observing the natural world he lived in. He was always curious and asked himself questions about the physical phenomena he observed – how bird wings moved, how water moved in whirlpools and waves, how the atmosphere looked in the distance. He recorded his observations, thoughts, and deductions in his journals, with the feeling that everything he was interested in would connect eventually (Atalay 191, 276-277; Herbert 1-4, 32-37; Taddei 47).

What types of journals, diaries and notebooks have you seen? What makes any of them "personal" and interesting? How can we come to know about the person who keeps it? As we work on this lesson, we will share portions of our own journal/sketchbooks with the class to understand how each one is different and reflects an individual.

We will make our *Journal/Sketchbooks* using several book making and printmaking techniques to have a notebook that better serves our purposes of observation, aesthetics, sketching, and writing.

Concept Development

Phenomena: Lift, Force and Movement

<u>Physics Experiments</u>: Simple Machines

Station – Inclined Plane

1. Bone paper folder or burnisher for making smooth paper creases
2. Wooden back-stop for positioning a print-block
3. Printing-press bed

Station – Lever

1. Floating tape for attaching spine and cover in bookbinding
2. Printing-press

Station – Wedge

1. Awl, scissors, stapler, 3-hole punch or needle for stitch-binding book
2. Stylus or pencil for inscribing sketch on block in printmaking

Station – Wheel and Axel/ Gear

1. Printing-press

2. Brayer for rolling out ink in printmaking

Station – Screw

1. Metal screw/bolt and grommet for binding
2. Book press or clamps for flattening bound book

Station – Pulley

Leonardo's Printing Press, *Folio 995r from Codex Atlanticus*, 1478-1482
(Taddei 226-229)

Before the Renaissance books were laboriously handmade, handwritten and hand illustrated. One of the factors leading to the rebirth of culture and learning known as the Renaissance was the invention of the printing press and the subsequent publishing and dissemination across Europe of the knowledge of classical Greek antiquity (Herbert 18; Shlain 275-277; Taddei 227). Leonardo designed a faster printing press, using a vertical pulley, worm screw, toothed wheel, and inclined plane (Taddei 227).

Student Practice

1. Students will return to the *Simple Machine Stations* to identify the simple machines used in a printing press and in hand-printmaking.
2. Students will make a personal *Journal/ Sketchbook* (Tourtillott 18-35):
   ~Use a uniform-size sketch paper and choose to either 3-hole punch or use a bone paper-folder to carefully crease folds in 4-6 sheets and nestle them together.
   ~ Pierce the nestled sheets carefully with an awl to make sewing together with a needle and heavy waxed thread easier.
   ~Sets of sewn pages are attached with horizontal strips of tape and sewn through again to stabilize the spine of the journal.
   ~Construct covers using two pieces of heavy poster board or other card stock, measuring them to the size of the pages and either 3-hole punch or use tape to attach the two covers to a third "spine" measured to the width of the sets of sewn pages.
   ~Complete cover with a fancy paper, a piece of fabric, an old drawing, or collage with assorted remnants and memorabilia student has collected.
   ~Attach spine of sewn page sets to the cover with tape hinges.
   ~Covered hinges and inside book covers with fancy paper or old sketches.
   ~One cover should have an appropriately measured and folded paper pocket or envelope constructed and attached for miscellaneous cuttings, postcards or notes.
3. Students will make a printed illustration for their *Journal/ Sketchbook*:
   ~Transferring a sketch to a *Styrofoam* rectangle, trace its lines and shapes with a pencil.
   ~Gently press pencil to inscribe the *Styrofoam* with a variety of lines.
   ~Roll brayer evenly in about one teaspoon of printing ink or tempera paint in a small tray and apply to the inscribed *Styrofoam*.
   ~Lay a piece of sketching paper on top and rub the paper's surface carefully with the back of a burnishing spoon.
   ~Starting at one edge, lift paper carefully and place to one side to air-dry.
   ~Plate can be wiped and re-inked for another print if desired.
   ~Mount print in journal or incorporate as part of the collaged cover.
4. For inspiration, on the first page of the *Journal/ Sketchbook* students write Leonardo's "All our knowledge has its origin in our perceptions." and on the last page quote Leonardo's message from his own notebooks: "I shall continue" (Herbert 34, 78).

Assessment

1. Students will be assessed on neatness, use of tools and measurement, and the successful completion of steps in making their Journal/ Sketch book using a teacher-prepared rubric.

2. Students will be assessed on their *Styrofoam* print using a teacher-prepared rubric covering successful use of specific Art Elements and Principles of Design (line, shape, color, variety and unity) and print-making steps.

Closure

Finished Journal/ Sketchbooks will be displayed in the Library and on the school's web site.

Lesson 3 – Leonardo's Aerial Screw

Objectives

1. Students will recognize and follow the investigative process Leonardo used to Invent the *Aerial Screw*.
2. Students will construct/ demonstrate a model of *Aerial Screw*

TEKS:
Science – Critical Thinking 6.3B, 7.3B, 8.3B
Science – Critical Thinking 6.3D, 7.3D, 8.3D
Mathematics – Objective 6: Underlying Process/ Problem Solving Tools 6.11, 7.13A, 8.14A
Fine Arts – Perception 6.1, 7.1, 8.1
Fine Arts – Creative Expression/ Performance 6.2, 7.2, 8.2

Introduction

Convinced that man would someday fly, Leonardo acutely observed natural phenomena and studied flying creatures – dragonflies, birds and bats. The bat's wing gave him the idea for the skin-like linen-cloth covering that was sealed with starch. The helical structure itself, Leonardo designed to spirally cut into the density of air to create *lift*, just as the ancient *Archimedes Screw* cut into the density of water to create *lift* (Taddei 47). Leonardo's 15th century design for helicopter-like flight borrows from an ancient Chinese toy then common to Europe, and based on a string-pull spinning top. Although in Leonardo's model the starched linen spiral rotor whirled fast enough to sustain lift, the rotors make the whole craft rotate. His later designs incorporated spinning wings rather than screws (Taddei 47; "Leonardo da Vinci" *Wikipedia*).

Like Leonardo, where can we observe spirals in the natural world? Observing natural phenomena in our Houston area, we might see spirals in whirlpools, tornados and hurricanes, sea shells, sunflower seed heads, twining vines and tendrils.

Concept Development

Phenomena: Lift

<u>Physics Experiments: Air Density and Lift</u>

Bernoulli's Law

The faster air travels over a surface, the less time it has to push or exert pressure on that surface, so that less pressure on top of a wing created by rushing air means the pressure under the wing creates *lift* (Bloomfield 188-191; Hixson 20-21). Similarly Leonardo's observations of water and air led to his conclusion that air can be compressed if enough energy is exerted on it, and thus having material density a helical screw would create *lift*, the upward motion that is generated by using *force* - a push or pull through air, just as an Archimedes Screw lifted water (Baton; Taddei 47).

Flying Sheet

Holding a sheet of paper to your bottom lip, blow down and across to create lift (Hixson 21). Paper should rise away from your body.

Paper Helicopters

Cut a strip of paper 11 x 4 1/4 inches and fold it in half horizontally. Open and cut down the center almost half-way to the fold. At the fold cut-in about one-third of the way on both sides and fold them in, pinching and twisting the very end of the paper to create a "body." Bend down the two wings and angle them 20-30 degrees to the body. Hold high and release to "spin" to the ground. Make adjustments as needed (Hixson 36).

Physics Experiments: Simple Machines

Station – Screw

Leonardo observed that air had *density* just like water and thus, *lift* could be achieved by a spiral action of a screw, just like Archimedes's Screw lifted water. Students will go back to the *Simple Machine Station* - *Screw* to review the functional properties of a screw creating *lift* (Taddei 47).

Student Practice

1. Students working in small groups will enter notations in their *Journal/Sketchbooks* of their observations of the functional properties of a bat's wing and a simple screw machine from the *Simple Machine Station - Screw*.
2. Students will construct flying machines - paper versions of Leonardo's *Aerial Screw*, a maple leaf-like wing or paper helicopter and a paper glider (Hixson 32-33, 36; *NASA Explores*).
3. Students will enter notations recording their experiences constructing and flying paper versions of Leonardo's *Aerial Screw*, a maple leaf-like wing or paper helicopter and a paper glider.

Assessment

1. Students will be assessed on their *Journal/ Sketchbook* entries according to a teacher-designed rubric including 1-2 paragraph notations in complete and descriptive sentences for each corresponding sketch of a bat's wing, 1-2 simple machines (screw), and sketches of a flying machine (present, past, future, imaginary or toy).
2. Students will be assessed on their group work using a teacher-prepared rubric covering individual contribution to the group project, investigation, measurement and construction, presentation and flight.

Closure

Students will fly their paper models and measure how far each flew, making notations in their Journal/ Sketchbooks. Students will then formulate conclusions with their small working group before making a final written entry.

Lesson 4 – Renaissance Ideas

Objectives

1. Students will identify and explore some of the ideas that were important to both scientific and artistic thinkers during the Renaissance, such as city planning, architectural domes and arches, perspective, 3-dimensional forms, and proportion.
2. Students will design and construct personal environments based on polyhedrons.

TEKS:
Science – Critical Thinking 6.3B, 7.3B, 8.3B
Science – Critical Thinking 6.3D, 7.3D, 8.3D
Mathematics – Objective 6: Underlying Process/ Problem Solving Tools 6.11, 7.13A, 8.14A
Fine Arts – Perception 6.1, 7.1, 8.1

Fine Arts – Creative Expression/ Performance 6.2, 7.2, 8.2
Fine Arts –Historical/ Cultural Heritage 6.3, 7.3, 8.3
Fine Arts – Response/ Evaluation 6.4, 7.4, 8.4

Introduction

What were some of the ideas circulating in the 15th century that would have interested Leonardo da Vinci - perspective, proportion, spiral symmetry in nature? How might we use physics and simple machines to construct a personal study or studio environment with a repetition of polyhedrons that stimulate a feeling of well-being? We might first consider the golden rectangle of Euclid - the "divine proportion" of a rectangle that when subtracted of a square reveals another golden rectangle (Atalay 42-43). Regular polyhedrons are three-dimensional solids having identical surfaces, edges and vertices and are formed by regular polygons (Atalay 79-80). They include the dodecahedron (twelve sides), cube (six sides), tetrahedron (four sides), octahedron (eight sides) and icosahedron (twenty sides with fifteen golden rectangles spanning the interior) known as the Platonic Solids (Atalay 80).

Where do we see polyhedrons in the natural world (beehives) or used as a constructive unit in architectural design (Buckminster Fuller's geodesic domes)? Could we use similar designs to address environmental issues on another planet or moon? What do you think Leonardo meant when he said "On the site of the studio: small rooms or dwellings discipline the mind, large ones weaken it"(da Vinci 297).

Concept Development

Phenomena*:* Force, Lift and Movement

<u>Physics Experiment</u>: Simple Machines

Station – Lever

1. Pivoting against a fulcrum or point, a lever does work by rotating against the point to *lift* something. The *force* is the push or pull used that will determine the *movement* (Boles 6, 15; Baton; Tucker).
2. Examples for constructing an environment might include a crane, the claw end of a hammer, shovel, crowbar, and pliers (Boles 6, 15; Baton; Tucker).
3. Illustration of Leonardo's Fortress, *Folio 117r from Codex Atlanticus* 1507-1519 (Taddei 126-129).

Student Practice

1. Students will return to *Simple Machine Stations – Levers* to discuss constructions uses of the lever and investigate at a poster for Leonardo's Fortress.
2. Students will work in small groups to investigate Leonardo's Fortress, decide what geometric figures were used in its design and determine ways that simple machines could be used to build it. Following a teacher-designed rubric, all observations and deductions will be recorded in each student's *Journal/ Sketchbook*.
3. Students will continue to work in small groups to brainstorm environmental needs and possibilities, recording only those of personal interest and making an individual list of needs and desires (light, privacy, cocoon, opacity or transparency, color, etc.). After drawing designs that satisfy their personal list, students will share with their group, discussing and evaluating and sharing constructive suggestions.
4. Student groups will share/ critique in-progress and final works with class.
5. Students will construct a desktop-sized personal environment of poster board, based on a chosen polyhedron and their individual list of needs and desires.

Assessment

1. Students will be assessed using a teacher-designed rubric on their group work, individual *Journal / Sketchbook* entries, and constructive group-participation.
2. Students will be assessed using a teacher-designed rubric on desk-top size, imaginative design, neatness and the Art Elements and Principles (shape, color, repetition, unity) used in their personal environment.

Closure

Students will exhibit personal desk-top environments in the school library and on the school's website.

UNIT RESOURCES

Journal Materials

Rubrics, worksheets, cardboard for covers, assorted collage papers (color paper, wrapping paper, magazines) for covers, lined and unlined paper, envelopes, book press or clamps, awls, bone paper-folders, 3-hole punch, metal rings or grommet fasteners, glue, scissors, rulers, rubber stamps, stamping ink, posters for pages from *Leonardo's Notebooks* (da Vinci).

Printmaking

Rubrics, worksheets, *Styrofoam* sheets, printing ink or Tempera paints, brayers, burnishes, stylus or pencils, posters for illuminated manuscripts (*Book of Kells*) and Early Renaissance printed books (*Gutenberg Bible*).

Personal Environments

Rubrics, worksheets, poster board or cardboard, heavy scissors or cardboard cutters, hole punches, yarn, tape, paper, glue, rulers, bulldog clamps, plastic templates of assorted polyhedrons, posters for Leonardo's Fortress, I. M. Pei's *Pyramid at the Louver* and Buckminster Fuller's *Geodesic Dome*.

Books

Books Unbound: 20 Innovative Bookmaking Projects.
Making and Keeping Creative Journals
David Macaulay's The Way Things Work
Leonardo's Notebooks
Leonardo da Vinci for Kids: His Life and Ideas: 21 Activities
Unit: Polyhedron Origami

Web Sites

Exploring Leonardo. <http://www.mos.org/sln/Leonardo/>.
Leonardo da Vinci. <http://www.museoscienza.org/english/leonardo/>.

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A non-scholarly edited organization of Leonardo's sketches culled from his thousands of journal sketches and organized into accessible themes

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Hixson, B. K. *Bernoulli's Book.* Salt Lake City: Wild Goose Publication, 1991.
Lab skills worksheets for air pressure, Bernoulli's Law, and flying craft.

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These sculptural, 3-dimensional projects, with step-by-step photographic instructions, are adaptable to mixed-media artworks in this unit's lessons to facilitate dialogue and story-telling, or to incorporate writing.

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leonardo da vinci inventions | Labels: Art , Physics. Kids Art Wall Frames Prints Sketch Book Leonardo Da Vinci Inventions Artwork Graphic Art Drawings Art. gusset.co.uk. leonardo da vinci inventions | Labels: Art , Physics. Leonardo Da Vinci. "Giant Crossbow" Invention Drawing.Â Leonardo da Vinci Inventions: Im Grunde hat er als Engineer die Rechte auf die Fahrradkette. Ten Italian inventions that changed the world | Good Things From Italy - Le Cose Buone d'Italia. Sometimes people have really good ideas and they donâ€™t even imagine the consequences of their implementation in the everyday life. Iâ€™m sure Leonardo Da Vinci didnâ€™t expect us to use his inventions till nowadays, and in some cases we are still discovering new ways of applying them to the new technologies. The Leonardo, Salt Lake City, UT. 26,540 likes Â· 36 talking about this Â· 34,842 were here. Museum of Creativity and Innovation! www.theleonardo.org.Â You can now take a tour of the museum from anywhere! Virtually explore galleries and check out Leo at Home videos while you're there. Enjoy The Leonardo at home! https://bit.ly/2WhWSDD. 5. See All. Leonardo da Vinci is best known for his artwork, but he also invented many contraptions that were way ahead of their time.Â During his lifetime, Leonardo drew many sketches such as this one, depicting the muscles and tendons of the upper body. (Image credit: Leonardo da Vinci via Leonardodavinci.net). Humanoid robot. Many of da Vinci's inventions were before his time, but his designs for a humanoid robot were truly futuristic. Leonardo's Brain: Understanding Da Vinci's Creative Genius. Leonard Shlain. 4.4 out of 5 stars 78.Â "Leonard Shlain's Art & Physics is exquisite food for thought." -- - -Fritjof Capra, author of The Tao of Physics. ...one of the most interesting books on how we've developed an understanding of our world. It is the best book on physics you will ever read--and the best one on art history. By digging into our past, Shlain gives you a sense of how the politics, emotion, theory, and inspiration of art, science, culture, and technology mix. - - Reason, Nathan Shedroff. Leonardoâ€™s Brain: What a Posthumous â€œBrain Scanâ€ Six Centuries Later Reveals about the Source of Da Vinciâ€™s Creativity.Â Both art and physics are unique forms of language. Each has a specialized lexicon of symbols that is used in a distinctive syntax. Their very different and specific contexts obscure their connection to everyday language as well as to each other. Nevertheless, it is noteworthy just how often the terms of one can be applied to the concepts of the otherâ€¦ While physicists demonstrate that A equals B or that X is the same as Y, artists often choose signs, symbols and allegories to equate a painterly image with a feature of experience. Both of these techniques reveal previously hidden relationships.