Lofty Living

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OVERVIEW

My intent is to combine mathematics (geometry) with science (physics) in order to provide my students with a challenging yet fun learning experience. I would like the theme to revolve around, or evolve from, the recent building boom in condo and loft residences here in Houston. As opposed to the norm of renovating old factories and commercial buildings to turn them into loft apartments or condominiums; in Houston most are built new from the ground up and designed to look like old commercial buildings. I am not sure how I expect the exteriors of the students' completed loft units to look, as my main objective focuses on the interior space, the furnishings, and the electrical circuitry.

Understanding geometry and spatial reasoning concepts as well as being able to demonstrate how electrical circuits are constructed are part of our 5th-grade curriculum. Therefore, by having the students design their own "shoebox lofts," we will be able to incorporate these two student expectations in a cross-curricular unit.

I work with two classes (50 students) of fifth-grade, culturally diverse, Vanguard students who, for the most part, are enthusiastic learners. They enjoy creative and challenging projects. I would like my "Lofty Living" unit to be exciting enough to involve all the students, whether they feel creative or not. There are some students, particularly the boys, who are not enthusiastic about "cutesy" projects, but really get involved in electrical circuitry and building models. My objective is to have the Lofty Living project engage all of my students in producing a practical and aesthetic product.

This unit will enhance the students' academic knowledge by using an investigative approach to learn about geometry, then using geometry to create a realistic product. While reviewing electrical circuits, the students will be able to experiment with parallel and series circuits and then use the system that works best in their unit.

I have noticed that my students are able to determine area, perimeter, and volume through the use of formulas, but that they do not understand the practical applications of what these formulas represent. I feel that this project will give them a real understanding of area, perimeter, and volume, as opposed to simply knowledge of the formulas. For example, in using tessellations to cover a plane, students are in fact covering an area with their designs. However, when asked to define "area" in their own words, they often use the word "space" rather than "surface" and appear unsure or vague. Burton defines tessellation as "an arrangement of shapes that completely covers a plane, with no gaps or overlaps" (H102).

Why Teaching This Topic Is Important for My Students

Introducing his book, *Discovering Geometry*, Serra states that:

> The mathematics we learn and teach in school changes over time, driven by new scientific discoveries, new research in education, changing societal needs, and by the use of new technology in work and in education. The effectiveness of *Discovering Geometry*'s investigative approach has been substantiated in many thousands of classrooms and is reflected in the *Principals and Standards for School Mathematics*, the guiding document of the National Council of Teachers of Mathematics (NCTM) (iv).

I believe that by investigating the advantages and discovering the many applications of geometry, my students will benefit threefold. First, they will be introduced to the fascinating geometric works of artists such as M.C. Escher, then required to create designs pleasing to themselves rather than those mandated by a teacher. Second, they will be applying the concepts of measurement as well as reinforcing the knowledge of electrical circuits in a practical and purposeful setting. Third, by designing a working model of a living space in which they would one day enjoy living, they acquire true ownership of their product.

Serra, in his textbook, *Discovering Geometry*, describes a discovery approach as one that "presents concepts visually, and students explore ideas analytically, then inductively, and finally deductively—developing insight, confidence, and increasingly sophisticated mathematical understanding" (iv). I believe this project incorporates all of these attributes.

How the Houston Teachers Institute (HTI) Has Impacted My Plan

By being introduced to, and engaging in, hands-on exploration of geometric models, terms, and concepts, I have been able to see how my knowledge base has been challenged, expanded, and enhanced. I currently share what I am leaning in Dr. Field's at night, with my students the next day. Giving my students the same handouts and web addresses that I receive has produced results far superior to those I have been able to construct on my own or with prior classes! My biggest learning curve has been to be able to accept this and know that it's OKAY! My job, as I see it, is to inspire and encourage my students just as this course has empowered and inspired me. It is reassuring to know that I do not need to be the "expert"—because I am NOW able to introduce the students to the work of experts and, through the Internet, to the experts themselves. It has been exciting for me to see how mathematics and geometry in particular can be expressed in such diverse and remarkable art forms. Dr. Field's symmetrical drawings and George Hart's geometric sculptures are two examples, and through talking with other teachers about this project, I have been made aware of other art-in-math or math-in-art connections. I discovered three interactive websites for the Dutch artist Piet Mondrian, Jr., who was a Dutch abstract painter of spare, precise, geometric art, mostly in primary colors. He called his style neoplacticism. In addition, I have been introduced to the online photographs of snowflakes (symmetry in nature) by Wilson Bentley and to a website for M.C. Escher. Escher is a fascinating figure in the world of art and math:

> To enter the world of M. C. Escher is to set foot into unknown and unsettling territory. His extraordinary pictures of logic and perspective fool the brain into believing the impossible – that staircases can climb forever, that fish can morph into birds, and that water can run uphill. His unique vision created extraordinary images that are instantly recognisable (sic) as being from his hand (Forty 5).

As I stand in my classroom, surrounded by student-crafted, miniature, colored buckyballs (which, according to Serra [504], were named for Buckminster Fuller's carbon atom molecules, which also have the symmetry of a soccer ball); dodecahedrons, which are regular polyhedron with 12 faces; prisms; pyramids; and icosahedrons (polyhedrons with 20 faces) attached to our GEOM e TREE (a bulletin board tree onto which we attach solid shapes), with the window blinds covered with the students' "tessellations and symmetry names," hearing one student exclaim, "I didn't know math could be so much fun," I realize how important this HTI course has become—even before executing my "grand design project." And to be truthful, what student at any level can resist a word such as "hexahexaflexagon"!? Through the inquiry process, we look up definitions and examples of such words, for in this way we "build student understanding of how we know what we know and what evidence supports what we know" (Dow 13).

In designing differentiated units for gifted learners, Vantassel-Baska encourages teachers to "focus on key concepts and scientific principles taught through hands-on, real-world, problem-solving approaches" (196). She continues with the caution that "[b]oredom and lack of academic challenges will hinder progress toward the national goal of first-place status in mathematics and science" (231). The author addresses the value of using manipulatives as well as the constraints of time that are inherent in any hands-on approach to teaching science or math concepts. Therefore, the fact that two key curricula – mathematics and science – are addressed in this one project makes it a particularly desirable venture.

TEACHING THE UNIT

The following strategies will help me define what I want my students to learn, as well as serve as a resource for their projects. The first thing they will need to do is to define and understand the nomenclature in the fields of geometry and electrical circuits. Rather than learning definitions by rote, I feel that a student who can illustrate the meaning of a word will internalize that meaning and be more able to apply it in an appropriate setting, Therefore, they will create a "pictionary" of geometric and electrical terminology – an illustrated dictionary that uses illustrations to give meanings to the vocabulary terms. Next, they will compile a portfolio of student-made samples of designs, transformations, polyhedron nets (patterns for creating 3-D figures), tessellations, and tile patterns. They will also include blueprints, floor plans, pictures of electrical appliances, furnishings, façades, and other geometrically inspired architectural details found in the "Home" section of newspapers or "shelter" magazines. Additionally, the students will become familiar with use of tools such as measuring tapes, meter sticks, yardsticks, and graph paper in order to accurately measure and record information in journals and create graph-paper blueprints with two- and three-dimensional drawings.

Types of Student Assignments

The students will create their own loft unit in a shoebox that is approximately 11.5 inches long, 6.5 inches wide, and 4.5 inches high (30cm x 6cm x 11 cm). Using a scale of one centimeter equals one foot, the students will create a floor plan, indicating the placement of furniture and one of the façade (front-facing), showing the size and placement of windows. The teacher or adult helpers will use this as a pattern to cut out the windows. The students will create their own furniture to fit the scale of their unit. They will design floor and wall coverings for their units. The students will include a working circuit using the following: a switch, battery holder, D-cell battery, bulb and bulb socket or holder, and mini holiday or fairy lights. The 25 units from each class will stack up to create two "loft buildings," each five units across by five units high.

In order to accomplish this task, the students will first sketch their bedrooms from memory and show the placement of three pieces of furniture (estimating dimensions). For homework, they will measure and record the actual measurements of their room, and in class the next day, will make a floor plan of their room using their accurate measurements. This will be drawn to scale and will include at least three pieces of furniture. The students will compare the two drawings (estimated and accurate measurements) and discuss floor plans and scale models. They will need to redraw their rooms using a different scale and will learn that when they double the scale, the area will increase four times. For example, when they double the scale from ¼ inch = one foot to ½ inch = one foot, the new area will not be twice as big, but four times as big as the first area. This is a concept that works well when tested on graph paper. The students will measure their shoeboxes (condo units), discuss scale and the consequences of using different scales, and as questions such as: What real life size will the condo represent if a one centimeter equals two feet scale is used? Will making furnishings be easier or harder? The class will then determine the most suitable scale to use. For a uniform look, everyone will use the same scale. Asking the students to supply their own shoeboxes with the above mentioned dimensions and a 1cm = 1ft scale will result in a small-scale representation of a space that is approximately 16 x 31 feet. All the shoeboxes should be approximately the same size to give continuity to the completed loft units. It will be their choice to decide what type of room or rooms they wish to create inside their unit.

Teacher note: Stop by a shoe store and ask for "ladies-size" shoeboxes. Have about 12 extra on hand in case some students show up with huge tennis shoe-sized boxes; or, to keep the project uniform, begin collecting them early in the year so that each student can have an identical-sized shoebox. Discount shoe stores are usually quite willing to part with the boxes.

The students will need to consider how they will wire their lofts, what they intend to illuminate and how many bulbs will work from a single D-cell battery. They will need to create a working circuit, using at least one light and a functioning switch. Once they complete the original circuit consisting of a battery, light and switch, they can experiment by introducing the mini-lights into the circuit. Here is where they will learn to differentiate between series and parallel circuits. They will need to know what they intend to illuminate in order to include the wiring (circuits) in their plans. Once the teacher has determined that they can do this, then will be ready to begin using tessellations and tilings (repeating patterns) to produce wall and floor coverings, and using their knowledge of polyhedron assembly (figures with three dimensions – length, width and height) from nets (patterns) to create furniture to scale. They are now ready to assemble their lofts, which can be done in class or at home.

BEGINNING THE UNIT

I have included the concepts I wish to emphasize with my students. This culminating project can be adjusted to create more or less sophisticated units depending on your students. The idea for this unit came from the teacher I replaced at my school. She used large cartons similar to the ones in which reams of paper are packaged, and she concentrated on electrical circuits. The Parent Teacher Organization (PTO) provided enough money to cover the cost of the electrical supplies. I did not want 50 large cartons in my room, and I wanted to include math objectives as well. The PTO still covers the cost of the electrical supplies, which means that each student gets to keep his/her completed project. If there aren't funds available each year, then the students can possibly work in pairs, use the large cartons, design furnishings, and create a working circuit. The final products could be photographed and kept on a disc or in a scrapbook. In this way the electrical supplies could be recycled each year, and each student could receive a photo of their work.

Prerequisites

Please note: The students have been keeping a portfolio of samples of their work, as well as an illustrated Pictionary of terms from the beginning of school (see Suggested Terms section below).

Part A

The students have completed the required curriculum physical science concepts relating to electrical energy, and have demonstrated that electricity can flow in a circuit and can produce heat, light, sound and magnetic effects, through hands-on experiment labs, as well as worksheets (TAKS fifth-grade science).

Part B

The students have completed the required math curriculum concepts relating to measurement (length, width, height), using graph paper to determine area; making models to show volume and geometric concepts of two- and three-dimensional figures; and understanding and using translations, transformations, reflections, tessellations, tilings, and symmetry (TAKS fifth-grade math).

The students will have completed measurement (perimeter and area) of non-traditional shapes such as leaves as well as of their hands and feet using graph paper and counting squares. They will begin the year with an activity that requires they to make their own meter tapes as well as measure and record their height, weight, and the length of their noses, ears, arms, calves, waists, etc. These finished products will be kept in their portfolios.

The Lofty Living project will be the culminating activity that demonstrates to the students how all of these concepts pertain to real-world situations through the construction of their model loft. If the students do not have supplies or adequate support at home, this project can be completed in class; however, with my students, I get much more creative results if they are *only* allowed to complete these types of projects on their own time.

Suggestions for the Pictionary of Terms

Most of these terms can be found in the glossaries of students' science or mathematics textbooks. For additional terms, see the listings of helpful texts in the Annotated Bibliography. My students enjoy researching new terms, which we add to our "Geaux Phynd Owt" list (the non-standard phonetic spelling of "go find out" appeals to them). Have the students briefly define the following terms. Their explanations should be in their own words and should include how each is used or where it is found (real world examples) and include an illustration. Their illustrations of the different nets that are used to create solid shapes will serve as a valuable resource for when it comes time to make furniture for their loft units. Suggested terms, organized by broad categories, follow:

Electricity

Circuit	Parallel circuit	Series Circuit
Battery and holder	Bulb (show filament)	Bulb Holder (socket)
Switches	Wire (will you discuss different gauges?)	

Measurement

Congruent	Similar	Parallel
Perpendicular	Line Segment	Scale (ratio)
Length	Width	Height
Depth	Area	Perimeter

Volume
Angles: acute, obtuse, right, and straight

Geometry

Tilings	Tessellations	Pattern
Two-dimensional figures	Polygons, regular and irregular	Tangrams
Hexagon	Octagon	Polyhedrons
Pyramid	Tetrahedron	Cube
Octahedron	Icosahedron	Rectangular prism

Nets (flat patterns that are folded into 3-D shapes)
Transformations: reflections, rotations, translations, point of rotation
Triangles: acute, scalene, isosceles, obtuse and right
Quadrilaterals: trapezoid, parallelogram, rectangle, square, rhombus
Solid shapes or three-dimensional figures: Face, edge, vertex

LESSON PLANS

The teacher will show the students a sample loft unit or pictures of previous years' projects (if applicable) and discuss how to use "found" materials such as bottle caps, peanut shells, food containers, packaging materials, thread spools, film canisters, magazine pictures, postage stamps (they make great "paintings" for walls), paper clips, etc., in their lofts. All students will need transparent or translucent plastic for their windows, (take-out food containers, plastic wrap, and wax paper are some suggestions). The windows will be constructed in class. So the students need to begin collecting these items now. All items should be kept in Zip-lock bags. The exterior "finish" will also be completed before the students take their units home for completion. Poster paint will stick to some, but not all, shoeboxes. The windows need to be cut before the boxes are painted, and the plastic should be "installed" last.

Determine penalties for late work and how students who are absent can make up missing work. The following eight lessons are sequential. Each activity must be completed before the next one can begin. They should be teacher directed. Perhaps they can be completed over a two-week period to allow for unforeseen occurrences. Lesson Eight is the final product, and it can be completed at home.

Lesson One—Estimating Length, Width, and Height

The concept being addressed in this lesson is how to utilize "benchmarks" to help estimate lengths, widths, and heights. By comparing a "known," non-standard unit of measure, e.g. the length of one's foot with shoe on, to a known, standard unit such as 12 inches, one can step off approximate distances . . . The foot becomes the benchmark, defined in one Webster dictionary "as a point of reference from which measurements of any sort may be made."

Materials

"Home" sections of newspapers	Blueprints
Home furnishing (shelter) magazines	Paper
Rulers	Pencils

Measuring devices like meter sticks, yardsticks, meter wheels, etc. (to confirm estimates)

Method

The teacher will (TTW) introduce the concepts of a blueprint by having students bring to class and examine new and model home "blueprints" found in the Sunday "Home" section of the newspaper. TTW discuss "footprints" – the outline or indication of objects that take up floor space, as indicated on floor plans.

The students will (TSW) sketch a floor plan of their bedrooms from memory. TSW use estimation skills to determine the approximate length and width of their rooms and four major pieces of furniture (bed, dresser, desk, and at least one other piece). They will include the four pieces of furniture that take up floor space in their room sketch. Doors and windows will need to be indicated as well. The students may use classroom's measuring devices to "validate" their data. For example, if they think their room is 30 feet long – ask, "Do you think it is longer or shorter than this classroom? Measure the classroom to verify your estimation." They should determine benchmarks to help with their estimation skills. Is the classroom desk or bookcase longer, shorter, as high as, or shorter than their dresser, desk, or bed at home?

After estimating the general dimensions of their rooms and furniture, students will use rulers to create an "estimated" floor plan of their room (straight lines, right angles, reasonable door openings, etc.). The teacher will collect the sketches and checks to see if the instructions were followed. A grading rubric listing the above steps may help to keep students on-track, as well as provide information for the teacher.

Lesson Two—Homework: Accurate Versus Estimated Measurements

The concept being addressed in this lesson is collecting, recording, and comparing accurate measurements with estimated measurements, hopefully helping the students to gain better insight into the different units of measurement used and become more adept at estimating dimensions.

Materials

Paper measuring tapes made during previous activities
Rulers
Yardsticks or measuring tapes (optional)
Paper
Pencils

Method

The students are to use their paper measuring tapes to record the actual measurements of their room and the items they included in their rough draft. They will need to record the length, width, and height of the room, of each piece of furniture, and of each door and window opening. The students may include a sketch of their room if it is oddly shaped, for example if there are alcoves, rounded walls, etc. Parent help is encouraged. They will use these measurements to create a floor plan in class the following day.

Lesson Three—Creating Floor Plans and Blueprints

The concepts that are being addressed in this lesson are how to use graph paper and scale to represent data.

Materials

Graph paper
Pencils
Homework from Lesson Two
Rulers

Method

The students will (TSW) produce a blueprint of their room on graph paper, using their actual measurements. TSW use a one square equals one-foot scale for the initial blueprint. This should stimulate the debate about "scale" if the students have different types of graph paper (centimeter, quarter-inch, or 16th-inch, etc.). Let them discover what happens if there are not enough squares. This can happen with centimeter paper. On the other hand, if there are so many squares that a 16-foot room is represented by one inch on the paper, drawing the furniture outlines becomes impossible. Scale and a key defining what the blueprint represents become important issues as students draw the room dimensions, indicate door and window openings and include the length and width of four pieces of furniture (bed, desk, dresser, and something else).

The teacher will (TTW) give the students their original estimated dimensions sketch so that they may compare their estimations with their actual measurements. Have them record their comments. What was easy? What was difficult? Were there any surprises? Class discussion will follow. TTW collect the original sketches, the actual measurements homework, and today's blueprints and checks the work to see if the instructions were followed. A grading rubric (check list for students) would help keep everyone on task.

Lesson Four—Doubling Length and Width Equals Four Times the Area

This lesson reinforces the concept of just how perimeter and area of a rectangle changes when the dimensions change.

Materials

Pencils
A sample unit
Centimeter graph paper (2 sided or enough for 2 sheets per student)
Rulers and shoeboxes of the same length for each student
Lofty Living Building Code

Method

Have the students practice drawing rectangles of different lengths and widths on one side of their graph paper to determine area. Then, ask them to predict how the area will change if the length and width are doubled. Tell them to double the dimensions and check the new areas. They have each increased four times.

Have the students measure and record their shoeboxes' interior dimensions in centimeters. Using a 1cm=1ft scale, the students determine the lengths, widths, and heights of their units (there will be some minor differences if all the boxes are not identical). Will these dimensions fit on their paper? What is the area (in feet) of their unit? Will scale affect the number rooms that will fit in their unit, or the size of the furniture they are to build? Will the box represent a 50 foot-long room with 20-foot ceilings? What will happen to their blueprint if they choose a one centimeter = 2 feet scale, or a 2 cm = 1 foot scale? Which scale is easiest to use when determining what furniture will fit on the blueprint and for designing wall and floor coverings? Will all units have the same number of windows? Will the windows be all the same size? How will the exterior look? How can the individual unit be made to look like a part of the whole structure? Will the exteriors all be the same material (e.g. brick contact paper) or painted the same color? The students will all use the same scale and will need to reach a consensus on the other issues, unless the teacher mandates certain features through the use of the Building Code.

Asking the students to supply their own shoebox 11.5 inches long, by 6.5 inches wide, and 4.5 inches high and using a 1 cm = 1 ft scale will represent an approximate 16 x 31 foot space, which could reasonably represent a bedroom, a living room, or an approximately 500-square foot efficiency apartment (in NY or Toronto). The interior should reflect the student's choice of options.

The teacher will show them a sample unit (make ahead) including plastic windows, lights, and items made from "found materials." Give each student a copy of the Building Code to serve as a checklist and grading rubric. All students will need plastic for windows and a scale drawing on cm graph paper of façade showing the placement of the windows. (Teacher and /or adult helpers use these as a pattern for cutting out the windows with a utility knife) Students write their names on the bottom, and LEAVE the BOXES at SCHOOL.

Lofty Living Building Code

- Builder/Architect must submit a plan prior to construction
- Scale: 1 cm = 1 ft
- Battery holder and switch to be located at the rear of unit
- All units will operate on one D-cell battery
- Mini holiday lights may be included in the circuit
- Floor and/or wall coverings are to be original designs of the builder/architect
- "Found materials" may be incorporated into the design
- All furniture is to be handmade and built to scale
- No doll house furniture or manufactured toys are to be used
- Neatness and creativity count

Lesson Five—Homework: Lofty Living Blueprints

Students will now be ready to create the "working blueprint" of their unit. The next day, the students will need to submit this floor plan of their unit for approval. The teacher will check the scale and make suitable suggestions. Students should finish any details not completed in class for homework. They will need to make a scale drawing of how they want the façade (front) of their unit to look, showing the number and size of windows. (You may want to discourage round windows.) Remind the students to leave enough space at the top, bottom, sides, and between the windows to ensure stability. (Tape their blueprint onto the box and cut through their pattern and box to create the windows.)

Lesson Six—Using Nets to Create Furniture

The objective of this lesson is to have the students apply their prior knowledge of making 3-D shapes from nets to the creation of furnishings for their loft units. The important concept is to maintain the 1cm = 1 ft scale.

Materials

Centimeter graph paper
Paint chips
Assorted paper
Assorted "found objects"
Pencils
Scissors
Markers
Magazines
Wallpaper samples
Packaging materials
Glue
Rulers
Poster paint

Method
The students can use centimeter graph paper to make nets for furniture. The graph paper makes it easy to determine the length, width, and height of beds, dressers, desks, and tables, all of which are forms of rectangular prisms. The nets can be used as is and painted or covered with cloth or paper. The graph paper nets could also be used as patterns to create furnishings out of other materials such as Styrofoam sheets, card stock, paint chips, etc.

The students will submit their Lofty Living blueprint for approval by the building inspector (teacher), who will check the scale and make suitable suggestions. Boxes can be painted or covered today and windows cut, if not done before.

Lesson Seven—Electrical Circuits

The purpose of this lesson is to review and assess the students' knowledge of electrical circuits.

Materials
Wire strippers and cutters
Masking tape
Electrical tape
Extra batteries and bulbs
"Battery testers" (made by cutting apart an old string of mini holiday lights)
Permanent markers

For each unit:
One Ziploc bag
One Battery holder
Two battery clips
One switch
One bulb and bulb holder
Approx. three feet of 22-gauge wire
Two or three mini-lights with attached wires

Method
Depending on your students, each student can cut and strip the ends of their 3-foot piece of wire, or they can be cut and stripped ahead of time. They will need to know how to use the wire cutter and stripper to cut the three-foot piece once or twice to suit their needs. The students will pick up their supplies from a distribution table, write their names on each item, and keep these supplies in the zip lock bag (their name should be on this also) until they are ready to be installed. Have the students build a simple circuit, using the switch and one light, and check all their electrical components (a grade could be given for this accomplishment). They can test parallel and series circuits. The teacher will check to see that all students are able to build a circuit and that all their materials are in working order.

I intend to have each of the completed buildings sitting on a long table, with each "story" sitting on a 12-inch wide fiberboard sheet or shelf. This width provides space upon which the battery holder and switch can rest, and gives the students access to the back of their units. However, they can use masking tape to secure the battery, battery holder, and switch to the back of their units, provided that these items do not interfere with closing the lids.

The students may be allowed to complete the units at home once they have demonstrated an understanding of the key components of building a model to scale. This is especially important with regard to the wall and floor coverings and the furniture.

Everything will go home in working order; therefore, everything must come back in working order. I feel that if they wear out the battery or bulb from overuse prior to receiving a grade, they will need to replace it on their own.

The students are now prepared to take the units home for completion, if this the option the teacher has chosen.

In the event that a classroom teacher would prefer the work to be completed at school, he or she might be able to work with ancillary teachers such as the art or science lab teachers. If this is possible, then the students could create their wall and floor coverings in art class (symmetry and design) and the electrical circuits in science lab (electrical circuitry), thereby giving the students enough time to complete their projects in school and making it possible for all the teachers involved to be able to record a grade if necessary.

Lesson Eight—-Final Assembly

Each student will take home (or will have completed or on-hand):
1. Their unit (with windows in place and exterior finished as planned)
2. The bag of electrical materials
3. A copy of the Building Code
4. Their geometric pattern samples for the floors and walls
5. Their furniture “nets” designed on centimeter paper to assure correct scale
6. A grading rubric with DUE DATE and well-defined penalties for late work

Summary Statement

In an attempt to merely continue a former teacher’s popular “Electricity Project,” I have actually completed this project twice. I deviated from her focus, which concentrated on the electrical circuit, to include mathematics.   Last year’s project emphasized area and perimeter, and this year’s project focused more on the “geometry” involved. Last year, the students did much of the work at home. This year, the students used their own designs for the floor or wall coverings, built more of their own furniture, and did more of the work in class.

In writing this unit I have included ideas that I have not yet put into practice such as the portfolio of work samples and the pictionary of terms. I realized that a portfolio of work would come in handy when my students asked if they could use their laminated tessellation patterns in their loft units, either as floor coverings or wallpaper. They were proud of their patterns as well as the effort expended, and seemed eager to put them to good use. I have used pictionaries in social studies (land forms) and science (water, carbon, and nitrogen cycles) before, but not, surprisingly, in math. I did create a building code for this year's project, and it proved to be very helpful.

I intend to begin next year's project by introducing geometry and measurement lessons early in the year and requiring the students to keep portfolios. If I can collect shoeboxes throughout the summer, I should have enough of the "same size" boxes for each student.

This year, the art teacher allowed us to paint our boxes in her spacious and well-equipped art room. The down side was that the poster paint stayed on some shoeboxes, but flaked off of the shiny ones. Additionally, the paint did not cover some of the name brands printed on the boxes.

Next term, I plan to begin early and experiment with different options, such as using spray paint or contact paper for the exterior. Having samples to examine should make it easier for the students to decide on how they want the exterior of their "Lofty Living Units" to appear.

This year, I created a bulletin board using real blueprints (actually black on white paper), floor plans from the home section of the newspaper, and photographs of some our colorful and uniquely designed local high-rise lofts and condominiums. This year's Lofty Living Units sit on two 5-foot long tables in front of the bulletin board just outside of our classroom, which gives the other students in the school a chance to see our project.

We began the unit in late April and almost ran out of time. It is a good year-end project, to be done when the textbooks have been collected and the weeks are interrupted due to rehearsals, year-end trips, and schedule changes. I found that the project held the students' attention practically up to the last day of class; however, you will want them finished in time to assign grades and have them reflect on their work.

Does this project fulfill the requirements of an "inquiry-centered science module"? According to the authors of *Science for All Children* (64), the three key questions to ask are: "1) Do the materials address the important goals of elementary science teaching and learning? 2) Are inquiry and activity the basis of learning experiences? 3) Are the instructional approaches consonant with the goals of the program?" I believe that, for this project, these three questions can all be answered in the affirmative.

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This book is designed to help educators improve the quality of "teaching, learning, and assessment through the use of inquiry" It is the result of a collaborative effort of the National Academy of Sciences and National Research Council to develop an addendum to the National Science Education Standards with regard to 'Scientific Inquiry' (discovery science, or hands-on investigations). Case studies and sample inquiry lessons are included.

Forty, Sandra. *M. C. Escher*. Cobham, Surrey, UK: Taj Books, 2003.

A large, $35cm^2$ ($14\ in^2$) art book, with colored plates and a history of the artist. Included is Escher's Mobius Strip I and Strip II with ants, a great follow up to a lesson on Mobius strips. My students loved looking at this book, always discovering new impossibilities.

Science for All Children: A Guide to Improving Elementary School Education in Your School District. Washington, D.C.: CSMEE, National Academy Press, 1996.

This book is described as a "guide to improving elementary science in your school district." It is a convenient handbook on implementing an inquiry-centered curriculum in your classroom or school. There are suggestions for choosing new science textbook adoptions, assessment strategies, materials lists, as well as lists of organizations and services of help to science eductors.

Serra, Michael. *Discovering Geometry: An Investigative Approach*. Emeryville, CA: Key Curriculum Press, 2003.

This is a "discovering geometry" high school textbook that was especially helpful for learning about how perimeter, area, transformations, etc are introduced to high school students. For me, it serves as a roadmap of where students are expected to go.

Vantassel-Baska, Joyce. *Comprehensive Curriculum for Gifted Learners*. Boston, MA: Allyn and Bacon, 1994.

In this book, the author aims to allow teachers to differentiate the methods and lessons they use with typical learners from those used with gifted learners.

Supplemental Resources

Bentley, W.A. and W.J. Humphreys. *Snow Crystals*. McGraw Hill, 1931.
The original book of photographs of snowflakes, predecessor to many other great collections of pictures.

Classroom Assessment and the National Science Education Standards. Ed. Atkin, J. Myron, et al. Washington, DC: National Academy Press, 2001.
This book discusses research based formative and summative assessment in the science classroom, derived from the National Science Education Standards. Student work samples, scoring guides, and further references are included.

Briggs Martin, Jacqueline. *Snowflake Bentley*. Boston, MA: Houghton Mifflin, 1998.
This lovely book for children tells the story of Mr. Bentley's life's ambition of photographing snowflakes. By adapting a microscope to a bellows camera, and years of trial and error, he became the first person to photograph a single snow crystal in 1885.

Burrows, Roger. *Images: The Ultimate Coloring Experience*. Philadelphia, PA: Running Press, 1992.

_____. *Images 2: The Ultimate Coloring Experience*. Philadelphia, PA: Running Press, 1992.
I would certainly encourage my students to get one of these "coloring" books. The black on white background, close packing patterns challenge students to discover their "own" patterns within these drawings, and to express the "hidden" patterns through their color renditions. The drawings are a sort of "do-it-yourself Escher paint by number design," without the numbers. Great and fascinating fun. Wonderful teaching aid to tessellations. (I found these at our local Health and Medical Science Museum.)

Carin, Arthur A. and Robert B. Sund. *Teaching Science Through Discovery*. Columbus, OH: Merrill, 1989.
This is the textbook used in my 1991 Science Methods Class. It strongly supports "hands-on/minds-on activity-based science teaching and learning (iii)" or the inquiry approach. The textbook serves as a resource of appropriate activities for a wide variety of students. Carin and Sund address: meeting the needs of all students; diverse learning styles, science teaching theories, technology and cross-curricular activities.

Danielson, C., and P. Hansen. *A Collection of Performance Tasks and Rubrics: Primary School Mathematics*. Larchmont, NY: Eye on Education, 1999.
This book contains 20 performance tasks with accompanying rubrics, designed for the field of mathematics. It is a very helpful source for guidance when

"grades" are needed for performance tasks. Also available in upper elementary, middle school and high school editions.

Escher, M. C. *M. C. Escher: The Graphic Work*. Koln, Germany: Taschen, 2001.
Escher introduces and explains his passion for graphic craftsmanship techniques. This book includes 76 black and white examples of his work and comments. A seminal work of transformations and tessellations that is suitable for both the student and teacher.

Froman, Robert. *Science, Art and Visual Illusions*. New York, NY: Simon and Schuster, Children's Book Division, 1970.
This book is a fascinating collection of ingenious and delicious visual illusions created by both scientists and artists. Many of the illusions can be attempted by the students, or used by the teacher to illustrate a concept. There are paintings of Picasso, Mondraian, Vollard and Dali, which could influence the students to further research.

Goodman, Jan, et al. *The GEMS Kit Builder's Handbook*. Berkeley: U of California P, 1997.
This teacher guide helps teachers visualize how materials can be assembled for 42 different science guides. The lessons are not included. This guide would be particularly helpful for science lab teacher, and can be adapted for creating science or math kits teachers could use with their own units or lessons. Based on the hands-on discovery approach to learning science.

Hart, George W. and Henri Picciotto. *Zome Geometry: Hands-on learning with Zome TM Models*. Emeryville, CA: Key Curriculum Press, 2001.
This is the handbook that comes with the 968-piece *Zometool* geometry construction kit, a unique hands-on way of allowing your students to build polyhedrons. Check out the website for a visual look at the models which can be built.

NSTA Pathways to the Science Standards. Ed. Lawrence F. Lowery. Elementary School Ed. Arlington, VA: National Science Teachers Association, 1998.
A NSTA publication that emphasizes the need for students to engage in hands-on, inquiry-based learning in order to enable them to construct their own knowledge. This book describes the National Standards of Science Education, and gives examples of how the standards can be implemented in the classroom in a diverse selection of settings. One can easily match these standards to those that city and state school systems have implemented.

Robinson, Marlene M. *Crystals: What They Are and How to Grow Them*. Philadelphia: Running Press, 1993.

The title describes what this small but informative book is all about. It includes nets and photographs, Moh's scale of hardness, and where to find, as well as how to grow crystals. The book was part of a 'grow your own crystals kit'. A history of crystals from stone-age tools to Silicon chips in included, and some interesting ways to create "gumdrop" models. This book is useful both for geometric models in nature and earth science lessons.

Washburn, Dorothy K. and Donald W. Crowe. *Symmetries of Culture: Theory and Practice of Plane Pattern Analysis*. Seattle, WA: University of Washington Press, 1998.
This book provides examples of transformations, patterns, and symmetry across cultures and time. The book serves as a reference for both my students and myself when looking for suitable examples of patterns for the floor and wall coverings of our Loft units.

Youngs, Michelle and Tamsen Lomeli. *Paper Square Geometry: The Mathematics of Origami*. Fresno, CA: AIMS Educational Foundation, 1999.
This book gives a brief history of origami and includes a packet of colored origami paper, the nets, directions, student exploration quizzes, a glossary of geometric terms, teacher guidelines as well as NCTM standards. The activities are suitable for grades 5-12.

Web Sources

Libbrecht, Kenneth G. *Snow Crystal Photographs*. SnowCrystals.com. 15 May 2004. <http://www.its.caltech.edu/~atomic/snowcrystals/photos/photos.htm>.
From this site, one can navigate to photographs of snowflakes taken by various well-known photographers.

Original Wilson Bentley Images. Jericho Historical Society. 15 May 2004. <http://snowflakebentley.com/snowflakes.htm>
Wilson Bentley's hometown, Jericho, Vermont maintains a website dedicated to him.

Hart, George W. *Virtual Polyhedra: The Encyclopedia of Polyhedra*. 1996-2000. George W. Hart. <http://www.georgehart.com/virtual-polyhedra/vp.html>.
A great website of thousands of virtual reality polyhedra, models, nets, and geometric sculptures by George Hart. This is the website that led my 5th grade students to create some really fascinating models.

Piet Mondrian, Jr. (1872-1944) Sources

A Dutch abstract painter of spare, precise, geometric art, mostly in primary colors. The following web sites provide information about the artist and his work as well as interactive activities for your students to explore.

Enchanted Learning. 1996-2004. Enchanted Learning Software. 6 Mar. 2004. <http://www.enchantedlearning.com/Home/html>.
Enchanted Learning is a great resource for teachers, worth the $25.00 per year contribution. They have a wonderful selection of topics that I often access for science- and math-related selections.

Mondrian Art Generator. 1999-2004. YourPediatrician.com, Inc. 6 Mar. 2004. <http://www.yourpediatrician.com/CoolThings/Mondrian.htm>.
A great site that allows you to create your own Mondrian-esque art.

The "Mondrian Machine" at ptank.com. 2001-2003. PeoplesTank. 6 Mar. 2004. <http://www.ptank.com/mondrian/>.
Piet Mondrian, Alexander Calder, Joan Miro and Pablo Picasso are some of the artists included at this web address. Look under Art, Dutch Artists.

Teacher's Bundle. 2004. Zometool, Inc. 16 Feb. 2004. <http://store.yahoo.com/zome-tool/teachersbundle.html>.
The Teacher's bundle includes a 968-piece creator kit and lesson plans, all for approximately $150.00. The Zometool kits are based on the 31-zone structural system. The tiny connecting ball is ingeniously designed to allow only certain colored coded rods to fit according to the shapes located at the tips of the rods and in the tiny connecting ball. The size and shape of the polyhedrons that students can create are limited only by the number of pieces and the students' imagination.