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Mathematics Alive: Environment and Design of Human Habitats

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'...all Arts were begot by Chance and Observation, and nursed by Use and Experience, and improved and perfected by Reason and Study.'

Leone Battista Alberti

How can architectural mathematical concepts be integrated into everyday life applications? What are the basic principles and relationships between mathematics and architectural design? What are the direct and indirect impacts of architectural form and design in our lives? And more importantly, how can these concepts be presented to elementary school students in a meaningful way? These are some of the central questions that this curricular unit begins to answer and attempts to clarify. The inherent concepts will be used to implement this unit of study so that elementary school students can understand the importance they have in our lives.

In order to accomplish this, students will participate in a series of activities focused on direct observation and enquiry based learning allowing them to:

· Compare and contrast different types of structures (at least two neighborhood structures)
· Differentiate between two-dimensional planes and three-dimensional objects
· Study the differences and relationships between design, materials, structures, interiors and exteriors
· Observe how materials can affect the form and function of a structure
· Design and create a structure and compare this to other local structures
· Create a picture dictionary with terms related to the design and building of a structure
· Participate in a neighborhood trivia hunt with buildings around the Fair Haven neighborhood
· Make observations of the design elements and components of the interior and the exterior of a building
· Make visual, written and oral presentations based on observations from a neighborhood building hunt
· Recreate through drawings and models story settings having to do with location or structures in stories
· Describe and create a matrix with the spaces in a building, the functions, and who uses them

Key Concepts

The following is a list of the basic concepts that will be targeted throughout the unit and in the lesson plans.

· A two-dimensional drawing is an abstract representation of a three-dimensional object
· Form follows function and function follows form represent the dual dichotomy of designing a structure
· All buildings have form and enclose functions (human activities)
· All buildings have a structural system (constructed elements which give strength, stability, and definition to the form they enclose)
· All objects have a structure which give the object form and strength and equilibrium
· Humans depend on buildings as shelter from predators and natural forces
· Differentiate between a building as an enclosed space, and a structure as the bones and strength of a building
· Buildings are material dependent
· All objects and structures have a natural tendency to give way due to gravity
· Three aspects of a building are: construction, containers, and envelopes
· A society cannot maintain economic growth and subsist without functional structures
· There are many types of buildings and structural systems according to their intended purpose and design
· Pushes and pulls (forces and moments) in a building structure have a direct relationship to equilibrium
· Weather and environment play a direct role in the type of structures built in a location

Introduction

From the houses we live in, to the temples in which we worship, to the schools where we teach, these buildings do not only offer as a structure but also motivate clear feelings because of their forms. Thus, the duality of form and function are constantly at play in any of the many structures that through the day we come into contact often being unaware of the effects these have in our lives.

As human beings, everything that surrounds us has a structure. All objects have a structure which give the object form and strength and equilibrium. All buildings have a structural system (constructed elements which give strength, stability, and definition to the form they enclose.) Even an organization (such as a school's faculty and staff) has an organizational structure, which gives order and clarity and functional patterns for operation. Our bodies are composed of a set of structures that could be studied independently of each other and that make up who we are. Thus the digestive, circulatory, or breathing systems form independent structures that when working collaboratively allow us to perform and enjoy life.

Everything around us has a structure that allows the human being to perceive it in a three-dimensional manner. The three dimensionality of an object gives it depth and allows the viewer to imagine being inside the object. The two dimensionality of an object or structure is an abstract view. That is, a representation of one plane of the 3D object drawn on paper. This view of the object allows the individual to focus on one plane at a time.

However, when we speak of a structure we refer to the three-dimensional object in the form of a sculpture or a building even though as part of its design and creation, we make use of blueprints that are two-dimensional. The structure is the bones and that which gives strength to the building. With the emergence of faster computer processors, new technologies, and software representation of objects is becoming more common to have architects and engineers design three-dimensional models of the structures from the onset. This offers many advantages to the designer, from a clear picture of what the structure or object will look like, to the management of materials and time needed to make any necessary changes as part of the process.

There is a close relationship between architecture and engineering. Architecture and engineering are integrated as a whole. So, "structure" may mean "building", "architecture", "engineering", or simply "objects". But before we explore these relationships it is important that we begin by defining architecture and engineering. In a few words and in simple terms that even a third grader would understand, I would refer to architecture as the science of designing and building a structure to shelter things, animals, or humans. Engineering, as the science of solving the challenges encountered in the creation of an object or structure for the purpose that which it was intended.

According to Bowland, the goal of the architect is "to enclose space and provide shelter, and in so doing, to create appropriate expressive and perhaps also symbolic relationships of forms". However, the goal is also to create structures that stand and endure the passing of generations. "They must be so proportioned and so build that the natural tendency of most things to give way eventually under the constant action of gravity and the varying assaults of other disruptive agencies is forestalled."(Bowland, 1999)

Therefore, the architect with the assistance of the engineer, and vice versa, have the task and responsibility to design and build stable and safe structures that take into account the laws of physics and mathematics. Tzonis (1999) describes the task so as to "make structures stable and enclosures secure."

Purpose

As in every field of study, the field of education does not escape the waves of innovations and trends. Every year there are either new mandates or a renewed emphasis placed in a specific area of the curriculum, research strategies, or methodology with the goal of improving students' learning outcomes. Through writing curriculum, I analyze, clarify, and synthesize these trends in a meaningful way in order to integrate all areas within the different demands placed on me as a teacher. Thus, the principal objective of this unit, "Mathematics Alive: Environment and Design of Human Habitats" is to create an interdisciplinary unit where I integrate the new district mandates and prepare my students to look at how mathematical concepts affect form and design of the structures that surround us. Throughout this unit, we study basic principles of geometry, functions of numbers, and visual representations.

The following lessons and concepts represent only part of the whole unit and are presented here as sample and suggested activities.This integrated unit will provide the elementary school teacher with a framework that closely matches district wide goals of literacy and numeracy in a Dual Language Program while exploring and studying the concepts of space, form, materials, and structures in architecture while exploring the above mentioned mathematical concepts and principals.

Goals and Objectives

The goals and objectives of this curricular unit are multi modal. First, science is used as a springboard to expand and build upon the third grade unit on rocks and minerals. Second, the multiple new district mandates are integrated in regards to the different components of a balanced literacy program such as shared reading, keys to comprehension, and response to text, among others. Third, my unit is formatted to meet the aligning and balancing the curriculum format that the New Haven Public School District is following using the current framework and curricular standards adopted by the district.

Overview

This unit begins by looking first at the relationship of mathematics and architecture (environment) through the explicit use of the senses. Students must develop their ability to use their senses to perceive everything that surrounds them and to provide them with the needed language to express what they see, feel, hear, smell, and taste. This skill is essential for them to better describe, explore, and pay attention to details. Thus, the students look at an object such as a building, a work of art, or sculptural piece and describe it in terms of color, form and light. Students touch different building materials - coarse to fine textures, sharp to smooth, etc.; or as in vibrations. They will explore and expand their vocabulary and then sense sound by listening to chimes, music compositions, environmental sounds in relation to a structure. Students explore the sense of smell as we study the vent for the cafeteria system. Why is it that smells travel to certain spaces and not others? They will experience smell words such as pungent, penetrating, biting, stimulating, - the rose garden,

the orchard, the highway, or the rain. The sense of taste is explored in the context of foods and then extended to describe objects or structures that cannot be tasted as in bitter to sweet, sharp to mild, inviting or repulsive.

All of these descriptors have some degree of intensity, repetition, fractions, and flow for mathematical assessment yet all can be experienced for their appropriate beauty and placed within a culture or historical period. Therefore, when studying some building materials (e.g. adobe) we look at the cultures and historical period or periods when it was most prominent.

As part of the third grade curriculum in the New Haven Public Schools, students' work through a hands-on unit having to do with rocks and minerals. Students look at the similarities and differences between rocks and minerals. Some of the key concepts that children explore throughout that unit are how different rocks have different properties, how minerals are composed of only one substance, that minerals differ in color, textures, hardness, etc, and how these properties of rocks and minerals determine how they are used.

Through the unit, we expand on the use of rocks and minerals as building materials and, for example, compare the use of building materials and the rational of, design and form of artisans during the Arts and Crafts Movement to Post-Modern architects and crafts. These two periods are chosen specifically because of my interest in those periods and because of the clear differences among them. Given the diverse make up of the cultures represented in the classroom, we explore some cultural similarities and differences in the design and material use of some of the most representative architects and artisans.

The topic at hand will allow for many activities related to the steps of building a structure from the concepts or blueprints to the final building. The parallelism between the writing process and building a structure can be explored and extended to the Writer's Workshop.

Through the different activities we would explore different building materials, their environmental factors that affect form and design, basic mathematical principles involved from the concept stage to the final structure, highlights of the language of architecture, and the how and why of cultural differences in architecture around the world.

Ways of seeing

We live in a society at a point in time where we have to be constantly competing for our children's attention against new media and technologies. Our students live and grow in a culture where multitasking has become the norm and the exception to the rule is to concentrate on a task at a time. As teachers and adults we need to be aware that the way our students process information and interact with others and their environment is widely different. However, we also need to recognize that these same students need to discern what is important from what is not and help them in making choices and in learning to "see the world" around them. This unit attempts to focus the students' attention into other ways of "seeing" and "perceiving" their environment and those structures that surround their environment.

Weismann describes three different kinds of seeing: operational, associational, and pure (Weismann, p.18). In the "operational" way of seeing there are no remembered feelings, ideas concerning the object, and leave the

object unexplored. An example of this type of seeing is crossing the street looking at the cars going by where your eye sees but does not perceive any characteristics related to the object. In the "associational" type of seeing, a chain of reactions is unleashed when the viewer associates the object with a word. To follow the example of the cars going by, the object is related to the word "car" and the viewer in his or her mind might think how once was nearly hit by one and how he heard the breaks screech and later tried calming down by sitting on the curve. In the "pure" mode of seeing we are interested in the "how" the object is; in the specific qualities of the object. This mode of viewing is a learning discovery process through the study of the qualities, characteristics, and attributes of the object. It is this type of seeing, that I want my students to begin to do when they look at a building or a structure.

In order to have students begin to see in this "pure" way, students need to be taught step-by-step the "how". This unit represents a primer on how to begin helping the student to pay closer attention to the environment surrounding them. It is through the exploration of the five senses that we begin that journey, followed by a series of activities that focus the students' eye to take a closer look at specific elements of different structures around their community.

Structures in our environment: Design and considerations

According to Peter Blake (1996), a great building has several lives. In life one, the building or structure is completed and it is judged by whether it serves the intended function for what it was designed. In life two, a generation or two later, it begins to be judged as a work of art, as good bad, or indifferent. Sometimes life three starts many years later, at this point in time, the fact that it is a very old building makes it valuable regardless of the intended function or form.

As we look at the community of Fair Haven and New Haven we can certainly begin to categorize the standing structures following Blake's continuum. There are many of these buildings in each of the three stages. Also as new buildings go up, we should ask ourselves, if the building's function will one day be a landmark and make it to stage two and what purpose will it serve then.

A new beginning

There is a controversial relationship between new and old architecture in historic preservation. This controversy is based on the struggle between the new and the old between the wrecking ball and what has been called "architectural strangulation" (Overby,1980).

An example of this struggle can be seen in Fair Haven, an old neighborhood of New Haven, and more specifically, in the history of Christopher Columbus Elementary School. This year, the Columbus Family Academy (as it is now known), will meet the wrecking ball and a new school raised in the same lot. This dynamic is only the repetition of a previous struggle, where as a community grows, choices need to be made and new structures replace the old. Osmind Overby argues that "there is a bias that new buildings should not imitate the style of old buildings but should find appropriate and harmonious relationships with them through the control of volume, mass, scale, color, materials, and textures." (National Trust, 1980) This could not be farther from the truth in the case of Columbus Family Academy and, as such, has only reached to Blake's stage one.

If you look around Fair Haven you have to notice the diversity there is in its make up of its people and also on the range of architectural styles that make up the neighborhood. From colonial to federalist, from Victorian to neoclassic, to what I am calling the Columbus Family Academy, definitely one of the most modern building samples of architecture of its kind in our community.

In the same lot that the school is built, at the corner of Grand Street and Fillmore St., The Fair Haven & Westville Horse Railroad Company had its large wooden barn (c. 1860) with the horses in a building nearby (Monroe &Clay). The stable housed up to 450 horses. This two-story frame barn was torn down when the company exchanged horse power for electric power in 1893. A new brick structure was raised to house the trolleys that would become the new mass transportation system.

In 1965, Mayor Richard C. Lee, New Haven's Major at the time, initiated the beginning of construction at a groundbreaking ceremony of what is the current building of Columbus Family Academy, where once stood the old horse car barn. And just as Columbus Family Academy replaced three other schools (Cheeber, Woolsey and Lloyd) in Fair Haven, and was raised in the lot of the Fair Haven & Westville Horse Railroad Company, so now will a new building replace the old with something that will serve this community to offer an education to the next generations of students.

Another landmark in this lot where the new school will be located, and that was replaced by the building of the old Columbus Family Academy, was the Nonpareil Laundry at 271 Blatchley Ave. This laundry was said to have been the largest and most thoroughly equipped laundry in New England and founded in 1891 by James B. Moran. The Nonpareil went out of business in 1965 when it met the wrecking ball and was cleared for the new Columbus School. These structures neither made Blake's stage two, nor did they have time to meet Overby's " architectural strangulation."

Functions and Forms: A historical overview

In the inception of many structures, forms had a purely functional origin. Later the forms were so valued they were transferred to other materials. In the beginning form followed function. With those transformations, form came first and function followed.

The domes of famous buildings such as the Pantheon or the Serapeum, Villa Adriana, were conceived as forms and interior spaces and not structures. Thus, they were so valued for their associations such as temples, mausoleum, churches, but rather for their structural merit. When some of those elements are transferred to other materials such as brick or concrete, the form becomes a matter of structural concern and then it becomes a structural invention.

In the last century and a half, the many new technological advances in all of the areas tied to an exponential growth in world population made it possible for new developments in the field or architecture. The need to house such an increasing population tied to the advances with new technologies (mechanical elevator) and materials (steel-framed buildings) made it possible and necessary to begin building vertically in order to house and employ large populations. Mass-production of goods on large assembly lines made it necessary to come up with large building structures that could make this possible. Thus, technology came up with the answer in the form of iron-and-glass structures and reinforced concrete vaults. Because transportation and communication were seen as essential tools for society to growth and development, human ingenuity made possible to come up with structures and buildings such as long-span bridges, roads, harbors, and railroads, canals, for the transportation of these mass produced materials.

Nowhere before 1850 was there a precedent for a skyscraper, the modern factory, school, hospital, recreation center, shopping malls, etc. Most of these structures have been inventions that originated due to influences on population growth and migration, technological advances, industrialization, mass production of goods, and modern societal needs.

The greatest change since has been in the understanding of the characteristics of materials and the ways in which these determine the strengths and stiffness of what we make from them. Part of this understanding has been a new insight into the internal balances of compressions and tensions and into the ways in which these stresses and forces are combined to determine equilibrium.

Lesson plans and strategies in a Dual Language Program

The following lessons are to be representative sample components of many of the elements to take into consideration when implementing this unit in a Dual Language Program. These lessons can be modified to meet the needs of students in a bilingual or ESL program, taking into account their linguistic needs. The two main goals of these lessons are to develop content academic proficiency at the same time that second language acquisition is being targeted. For such a purpose, close attention is placed upon key concepts, outcomes, assessments, appropriateness of language, lessons developed with the second language (L2) learner in mind, and selected vocabulary following many of the SIOP (Sheltered Instruction Observation Protocol) methods and strategies (Echevarria, 2004). For an expanded description of the Dual Language model offered, please read Mendia-Landa (2004)

As part of the concept development strategy, three types of lessons are demonstrated: 1) concept comprehension (presented in L1), 2) integrated group lesson, and 3) second language development.

Introduction

Every child has at least a personal connection to a shelter structure in the form of a home. In order to activate students' prior or background knowledge, of what architecture is and the importance that it has in our lives, the unit will begin with a shared reading of the classic story of *Los tres cerditos* . There are many versions of this traditional *Three Little Pigs* story and the purpose is to center our discussion of structures as secure shelters from predators (the wolf in this case) and to begin exploring some of the concepts previously outlined. The key concepts throughout the unit will be written in a highly visible area as they are introduced and presented. They will serve as the content objectives and as such will anchor the activities that follow. The students will be able to explain in their own words these statements and will be the opening and closing task of each of the succeeding activities.

The importance of this first activity cannot be understated for it represents the methodology to be followed through the unit. Here the students will need to understand the steps to follow and the concepts in their first language before they are introduced to other mixed linguistic integrated activities where the students will be required to perform in their second language. In order to activate prior knowledge and find out how much the students know, the teacher will do a read aloud and pause after each pig builds one of the houses. Individually, each student will draw each house and in groups of four will name and list all the components that they can visualize. The following might be some possible lead on questions.

What does the house that … built have? How many rooms are there? What are the materials that … used to build the house? Is there a roof / basement/ attic/ chimney, etc.?

As children freely respond through drawings and group created lists of structural elements, the teacher takes note of the observations and makes a list of what the children know, and talk about. This exercise informs the teacher on how much prior and background knowledge the students have and when repeated at the completion of the unit as a means to evaluate how much information the students have gathered.

Next, the teacher will show the students two of the key concepts that will direct the discussion prior to a hands-on activity that will follow the whole class mini-lesson on structures and the senses:

· Humans depend on structures as shelter from predators and natural forces
· Structures are material dependent

Components of a shelter or dwelling structure

There are many classic books that can be used as building blocks for this unit. Earlier I suggested using the story of the *Three Little Pigs* because of its universality. There are many such stories that can be used as a means of exploring the concepts of structures as shelters from predators and natural forces as well as how these structures are material dependent on local natural resources and on the type of structures that can be constructed using those local or imported materials.

In order for students to be able to better understand these concepts, they will have to perform a series of tasks. That is to say, that the students will be required to build their own structures in order to manipulate the language and understand the concepts first hand. Here is where the two previously stated goals of language and content development are integrated into a meaningful and significant task that will require the student to do much more that simply select a multiple choice to a question or give a yes or no answer.

After the students have read the two key concepts, the teacher will reread any of the versions of the *Three Little Pigs* . This story will allow the teacher and students to begin exploring the concepts of houses as shelters and how different types of materials affect the structure of the shelters. This exploration can also look into animal shelters. Students will explore shelters and dwellings in other cultures that use straw, wood, bricks, or a combination of the three. Some of the guiding questions could be: Where do people make houses made out of straw/wood/brick? What else is straw/wood/brick used for in a house? What is the function of straw/wood/brick in a cob/hut/ house?

Shelters and their composition: Materials at work

Next, the same story will be read looking at how the materials and shape affect the construction and stability of the structure. As a class we will make a list of the advantages and disadvantages of each of the homes. The students will begin using straw to make a structure and come up with the best shape to the shelter so it is stable. Then, they will list the advantages and disadvantages of each of the shapes and how the material affects the construction.

Through this whole group exercise, we can revisit almost any book, and begin to create a word bank that

gives us the names of the different elements of a house. Thus, this is a way of presenting some of the vocabulary so when observing a real building; the children can use it in context.

Design

Prior to this event, the teacher will have familiarized himself or herself with the different buildings that will be studied through the neighborhood, so as to introduce the needed vocabulary and pick an area that has a wide range of architectural styles and elements.

One of the first lessons needs to be on how to make observations and how to gather data using the senses. Children need to be guided step by step through this process so they can later be independent in making their own observations. Students will be directed to draw pictures of the elements that catch their eye.

Neighborhood observation walk

Due to the importance that observation skills play fieldwork as a step-by-step process to the success of the unit, my sample lessons are concentrated presentations. Here begins the process of helping the students to "read" the environment and what surrounds them by bringing their attention to the structures and their elements.

On the first observation that takes place in our walk through the neighborhood, the students will be directed to use only the sense of sight and gather data in a notebook. The original purpose is to introduce to the students the importance of using the sense of sight, smell, hearing, and at times touch and taste to identify the elements of a structure. However, this will be done in separate lessons so as to introduce the specific vocabulary related to each of the senses as previously stated in the unit.

The students will write an entry in their mathematics and architecture notebook, which will include the date and a drawing of the structure or elements of a structure that are the focus of the neighborhood observation walk. Back in the classroom the children will self-assess their entries and share with the rest of the students those structures or elements that caught their attention. We will begin at this time to create a vocabulary picture dictionary with a visual description and key words attached. This lesson will be repeated with the senses of smell, hearing, and touch. Note the importance that these lessons have to vocabulary development and how important, especially in the case of second language learners, to scaffold the vocabulary through the use of word banks, webs, and organizers.

Once the children are able to make simple observations, create a log entry, and also make use of the basic vocabulary needed to describe some of the basic elements and structures that surround the school and nearby neighborhood, we will take another field trip looking for specific elements in the structures. During these follow up observations walks, there will be a theme or specific focus. Thus, one day we may look at the materials. Other day at elements of student interest (i.e. chimneys, doors, garages.)

Main Functions and related functions of structures

Having structured the way that the observations will take place in the neighborhood, we will begin to look at the functions within the school. Here, the purpose is to demonstrate, that the building, and the spaces within a building, make it possible, and often times are designed with a purpose in mind. Also, to bring students' attention to the fact that building spaces have intentional relationships to one another as service spaces or groupings. i.e. main entrance to office; or kitchen to cafeteria; etc. As a class we will list the names of all the

spaces in the school (hallways, classrooms, bathrooms, gym, etc.), list the function(s) i.e. walk, read, exercise, and who uses them (teachers, principal, kindergarteners, everyone, etc. The teacher will model how to create a matrix with the information and the relationships among the spaces will be listed.

The picture dictionary

Students will create a picture dictionary with drawings and names of the most significant elements of the exterior and interior of the school. Probably this will be one of the most challenging activities for the teacher and the students. Often students share a sense of "learned helplessness" that they are unable to draw. As visual representations the teacher needs to model for the students that it does not have to be perfect but that it has to have some visual accuracy and tell them that they all have undiscovered talents and unique individual abilities to draw and to sketch (or doodle!). At first, the drawings will not be so, but with time and encouragement the students will succeed in representing through pictures what they see.

Visual representations of story settings

There are many architectural references to most children and young adults literature, which can be explored through the students' imagination. From the "Three Little Pigs" to the Hobbit, students can recreate through drawing such edifices, and towns so as to later come up with their own descriptions. The following description from chapter 1 of *The House of the Seven Gables* is an example of the rich descriptive language to help students visualize and recreate through drawing the structure, elements, spaces, and uses.

The Old Pyncheon Family

Halfway down a by-street of one of our New England towns stands a rusty wooden house, with seven acutely peaked gables, facing towards various points of the compass, and a huge, clustered chimney in the midst. The street is Pyncheon Street; the house is the old Pyncheon House; and an elm-tree, of wide circumference, rooted before the door, is familiar to every town-born child by the title of the Pyncheon Elm. On my occasional visits to the town aforesaid, I seldom failed to turn down Pyncheon Street, for the sake of passing through the shadow of these two antiquities, --the great elm-tree and the weather-beaten edifice.

Other stories such as *Harry Potter* offer students and the reader with rich descriptions of characters and settings that can also be used to encourage visualization. However, the teacher needs to be conscious of the vocabulary and language patterns and structures, in order to ensure comprehension.

Concept Comprehension L1

Title: Form versus function

Performance Task I- Designing a structure

The lesson plans will be broken down further into significant tasks and written with the student in mind. The different curricular standards targeted through these tasks are listed in the Appendix and the descriptions give the student a clear understanding of what they are expected to do, how they have to do it, and how they are going to be assessed. The students will receive copies of the assessment by which they will evaluate their

own work.

I don't assume that the students have had much experience with performance tasks learning. Therefore, it is important to model the first few lessons as a class. This will ensure students' success in completing the different steps expected of them. The performance tasks are to be given to the students prior to the beginning of the task. It is the road map that the student, will use to be able to perform what we are asking them to do. As part of the process the students will also be able to preview the assessment tool by which they will be evaluated.

Background: There are many structures around us in our neighborhood that provide us with spaces and that allow us to use them for a purpose.

Task: You will work with your group in creating a structure with at least three different spaces. You have to begin by making a drawing (blueprint) and then creating the structure with any material you choose.

Procedure: Begin by brainstorming with the aid of an organizer the type of structure that you would like to build.

Use the charts and blueprints created in previous lessons to get ideas of the different organizers and of structures, elements, and functions.

Taking turns with your classmates, begin the brainstorm process writing one structure you think your team should build. Go three times around taking turns and each person writing what structures to build.

Before you move on to the next classmate, the student's whose turn it is, will tell to the rest of the team the type of structure they want to build:

· "I think that our team's structure should be a …"

When everyone is done, take your journal; write the title of the lesson "Designing a Structure" and today's date.

Individually write the sentence of the structure you want to build.

Next, discuss with your group which of those structures your team will build. Once you reach consensus, write the following sentence in your journal:

· "After discussing with my team members what structure to build, we decided to build a…"

Repeat the same steps to brainstorm three spaces that the structure should include. Here there are some sentence starters to be added to your journal entry.

· "I think that our structure should have …"
· "We decided that our team's structure should include…"

Finally, using some of the sample blueprints, individually draw the structure with the three spaces that you agreed upon.

Audience: Classmates and teacher

Assessment: Please see Appendix - Performance Task Designing a Structure

Extension: This lesson can be repeated as an integrated lesson, looking at materials, specific elements, or functions. Students will build the structure using any materials they choose. Additionally, they can revisit the brainstorming organizer and each student can sketch or draw their suggestions of structures to build.

Home-School Connection: Students make a blueprint of a part of their house. i.e. bedroom, kitchen, living room, house, apartment, and list the materials that they can observe that are part of the building construction.

Integrated Lesson

Title: Function versus form

There are many structures in our communities that are significant either because of the functions they serve, their design, or both. These buildings and structures are part of the cultural heritage of the community and give a place a sense of history and of character.

Students in groups will create organizers with as many structures as they can think that are unique and part of their community. They will proceed by labeling each of the structures and name the function they serve.

First, we will begin with a shared reading of *Roberto: The Insect Architect* by Laden (2000). We will discuss the different type of buildings that Roberto builds and how the form is related to the function that each of the animals perform in their lives. We will try to figure out why does Roberto become an architect and how does the form relates to the function. Next, we will read the following key concepts and look for examples in our community and the cultures represented in the classroom.

· A society cannot maintain economic growth and subsist without functional structures
· There are many types of structures according to their intended purpose and design
· Weather and environment play a direct role in the type of structures built in a location

Next, students will learn and be able to see, through colorful illustrations, detailed cross-sections of a city, from the Stone Age to the XXth century through shared reading of *A Slice Through A City* (Kent, 1996).

This will be followed by an activity where each group of students selects one of the structures, labels the functions or purpose it serves, and then modifies the building to show what it would look in two hundred years from now and what it might have looked like two hundred years ago.

Second language development

Title: From blueprint to three dimensions

Having performed some fieldwork around the neighborhood and the community, studied the functions of buildings, and some of the elements; now students will embark into the creation of three-dimensional structures to represent their two-dimensional designs.

As always we want to begin with a shared reading experience. For this purpose, the picture book *How a House is Built* (Gibbons, 1990) depicts how to build a house and provides the class with important vocabulary of the many types of workers needed, from surveyors to plumbers. Even more technical and detailed is the must share read *Underground* book by Macaulay (1976). This classic book looks at the buildings underground in a city intersection and explains through pictures the structural underpinnings of skyscrapers and other large building structures. As a class we will create a list of all the workers needed in the construction of a structure and what is needed before we start to build. That is: who is needed and what has to happen from the design to the completion of the structure.

The following key concepts will be the overarching underpinnings of the lessons.

· All buildings have a structural system (constructed elements which give strength, stability, and definition to the form they enclose)

· All objects have a structure which give the object form and strength and equilibrium

· Pushes and pulls (forces and moments) in a structure have a direct relationship to equilibrium

Next, we will talk about how we can gather data by making observations using our senses in the neighborhood walks. As described earlier in the introduction, this will be one of the most important lessons in as much as it will lay down the process and procedures to follow when doing observations. The emphasis will be on gathering data using the senses, how to enter a journal entry, and on presenting the findings to the group and the class.

Performance Task II-Gathering data from neighborhood walks

Background: Every community has buildings and structures that are representative. A community is a group of people who share a geographic location under a local government. Some examples are schools, post-offices, temples, churches, or residencies. Within each structure there are many elements integrated and represented.

Task: You will collect data from around the neighborhood looking at the buildings and make notes and sketches of the functions the buildings serve and how are alike and different from each other.

Purpose: To gather systematic data of everything you observe in the community and to begin discovering the interconnections between structures, functions, and forms.

Procedure: Take your journal and write today's date.

In the next line write the street and the number of the building you are observing.

Next, write the time of the day that you are making the observation.

After, draw all the structures you can observe.

Label all the structures and elements you can name.

Use the rubric *Gathering Neighborhood Data* to assess your work.

Audience: Classmates and teacher

Assessment: See Appendix - Performance Task Gathering Neighborhood Data

Extension: The same activity will be repeated with the sense of hearing, and smell. The students then can gather data by using all the senses at once to create a chart.

Home-School Connection: Students observe their block or other part of the neighborhood and make a list of those structures and elements that they can name.

And then there were more

The following lessons will share the same structure as the previous ones and are listed as extensions here. All of them will begin with a book from the teacher or student bibliography, followed by some of the key concepts listed above. We will then discuss what we learned in the previous lessons and relate what we are about to learn, to our lives. Consequently, the other standards listed in this unit will be targeted during the implementation of these activities.

Language arts: Students will create their own settings for any of the stories read during read-aloud or shared readings. For example, the students will re-write the story of the *Three Little Pigs* in a different country or place. They will also add more descriptive words based on the word sorts and word walls generated during the community walk-through.

Art: Create an imaginary structure to be built in space or in any given environment (i.e. underwater, sea, North Pole, etc.) Choose the materials that would be needed to withstand the environmental factors for each of the settings.

Science: Students will create structures able to withstand weights and forces that are greater or equal to a given amount. Students will look at how materials affect the stability of a building and begin to make connections between environment and how natural resources are used in building structures. Also, will look at how animals use colors and patterns to hide from predators.

Social Studies: Students will look at traditional structures of the nations and peoples represented in the classroom. Students will answer questions related to typical and common building materials, elements, and structures that are representative of those cultures, i.e. "How are doors and windows alike and different?" "What are the most important building materials of each structure?" " How does environment affect building styles and construction?"

Mathematics: There are many mathematical concepts and principles related to numbers, shapes and quantities that can be applied throughout the unit. For example, students can collect data and graph the number of windows and doors per floor or per building, that can be seen from outside versus inside the school.

The field of architecture requires the understanding of signs and symbols necessary to create and read a

blueprint. Students will learn some of the basic symbols for the different types of doors (double, sliding, pocket, interior, etc.), windows, walls, etc.; and simple elements of algebra, calculus, and geometry applied in the construction of simple structures. Students will be involved in estimating and measuring the perimeter and area of different rooms around the school, and creating structures using given scales based on a blueprint.

From the school's backyard to the students' front door

Once the students have made multiple observations and entries in their journals and created some simple structures of their own, students will begin to map some of the building structures they come into contact and see as they go back and forth from home to school. As a result the students will begin to apply the concepts and ideas here presented to other areas of their lives.

The Fair Haven community in New Haven is lucky to have an incredible wealth of historical sites and structures that have survived the passing of time. Students can research some of these sites and comparisons made among the structures. Thus, houses around the Quinnipiac River, part of a once well known oyster culture, can be compared to houses around the main artery to downtown New Haven, Grand Avenue.

Additionally, students can continue exploring how the design of spaces and the environment around, which they are built, are often complementary of each other.

Last Word

All around us we can see evidence of the way that mathematics affects everything we do in our lives. The basic principles and relationships between mathematics and architectural design are a must, in order to understand how mathematics is applied throughout the design and the construction process steps.

In this unit, the architectural mathematical concepts are integrated into daily life applications by helping students observe the environment around them in terms of becoming critical observers, by paying attention to details that can then be quantified, tabulated, measured, graphed, and analyzed, and by allowing students to see the various relationships between the design and application of mathematical concepts of measurement, arithmetic, and geometry in the completion of a structure.

Therefore, students begin to understand that there are direct and indirect impacts of architectural form and design in our lives, which often cannot be understood or clearly observed without having first looked at how design and implementation are connected. This unit's concepts are presented in such a way that it takes into account the environmental and physical factors with the goal of walking students through a discovery journey of their community and building structures.

It is by providing students with many opportunities to come into contact with their environment; helping them make connections between mathematics and architecture in their lives; and becoming critical viewers of the community where they live, that the goals of this unit are accomplished.

As Jim Cummins states, it is not only teaching the children to read the words that is important. More so, it is to help children to read the world and go beyond. It is my hope that through the participation in the activities of

this unit, students become active critical viewers of the many elements that make up their communities, and are able to transmit that way of "seeing" to those around them.

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Harris, C. M. (1983). Illustrated dictionary of historic architecture. New York, Dover Publications.

From Aaron's Rod to zystos, this illustrated dictionary of historic architecture is a great source of detailed information about all the design, decorative, and structural elements of a building. This is a must have for teaching the needed vocabulary. Great black and white illustrations.Contains over 2000 line drawings, and clear, concise definitions for over 5000 important terms.

Haslam, A., D. Glover, et al. (2000). Building. Princeton, Two-Can.

Hands-on experiments introduce such structures as skyscrapers, dams, keystone bridges, igloos, and lock gates and show the materials used, the method of construction, and the source of strength.

Kardon, J. (1993). The Ideal home 1900-1920 : the history of twentieth-century American craft. New York, H.N. Abrams in association

with the American Craft.

There is no better period in the American history that reflects the tension between form versus function. The Arts and crafts movement rebels against the mass production and objects were designed to serve a domestic function. The essays in this book explore these topics and offer the reader great color plates of the most significant crafts of what in history has been called the Progressive Period.

Kent, P. (1996). A slice through a city. Brookfield, Conn., Millbrook Press.

Detailed cross-sections show a city from the Stone Age to the twentieth century, including the structures which are raised and torn down, the people who inhabit the city, and an accumulating underground collection of artifacts.

Macaulay, D. (1976). Underground. Boston, Houghton Mifflin.

A must read book for the beginner reader on what goes into constructing a building. Has a great section on the importance of the foundation and on the different types. Also the text and drawings describe the underground elements of a large modern city.

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Great photographs and drawings make this book a must read in exploring the controversial relationship between new and old architecture in historic preservation.

Student Bibliography

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Uses cheese slices, pretzel sticks, a slice of bread, graph paper, a pencil, and more to introduce various polygons, flat shapes with varying numbers of straight sides.

Barton, B. (1984). Building a house. [New York, NY], Puffin Books.

From surveyors to buyers moving in,this beginner's reader book describes through pictures the steps in building a house.

Bryant-Mole, K. (1996). Los materiales. Parsippany, N.J., Silver Press.

Photographs introduce a variety of materials, such as wool, glass, and paper.

Bryant-Mole, K. (1997). Materials. Parsippany, N.J., Silver Press.

Photographs as well as text introduce a variety of materials such as wool, glass, and paper.

Deedrick, T. (1998). Construction workers. Mankato, Minn., Bridgestone Books.

Different houses, materials, shapes and sizes; this book allows the reader to name all the diverse workers (i.e. contractor, surveyor, septic system crew, heating specialists, landscapers) involved in designing, building, and decorating a new home. A simple shelters

of the past reference allows the reader to compare how homes are alike and different in different cultures and historical times.

Dodds, D. A. and J. Lacome (1994). The shape of things. Cambridge, Mass., Candlewick Press.

A simple book about shapes.

Gibbons, G. (1990). How a house is built. New York, Holiday House.

Describes in very simple terms how the surveyor, heavy machinery operators, carpenter crew, plumbers, and other workers build a house.

Haslam, A., D. Glover, et al. (2000). Building. Princeton, Two-Can.

Hands-on experiments introduce such structures as skyscrapers, dams, keystone bridges, igloos, and lock gates and show the materials used, the method of construction, and the source of strength.

Holm, A. and F. Hald (2001). Anton y los dragones: Un libro sobre Gaudi. Barcelona, Ediciiones Serres, S.L.

A translation from Danish into Spanish of the story of a boy as he discoveres Gaudi's artwork in Barcelona with his father. This children's book is broken down into chapters and would be a great read aloud book when supported with more visual materials such as http://www.greatbuildings.com/buildings/Park_Guell.html.

Kent, P. (1996). A slice through a city. Brookfield, Conn., Millbrook Press.

Detailed cross-sections show a city from the Stone Age to the twentieth century, including the structures which are raised and torn down, the people who inhabit the city, and an accumulating underground collection of artifacts.

Kent, P. (1998). Hidden under the ground : the world beneath your feet. New York Dutton Children's Books,.

If you are interested on learning about what the world beneath your feet is like, then this is the book for you. Divided in two-page sections that explore topics such as the history of going underground, caves and caverns, digging for minerals, homes, the street beneath our feet,etc. It has great colorful illustrations.

Laden, N. (2000). Roberto : the insect architect. San Francisco, Chronicle Books.

A termite moves into the city to build his dream of becoming an architect but nobody wants to hire him. This is a very whimsical and witty story full of colorful and idiomatic expressions.

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This gateway to architecture around the world and across history documents a thousand buildings and hundreds of leading

architects, with 3D models, photographic images and architectural drawings, commentaries, bibliographies, web links, and more, for famous designers and structures of all kinds.

Hardy, M. (2006). I.N.T.B.A.U., International Network for Traditional Building, Architecture, and Urbanism. **4/15/2006** , **2006** http://www.intbau.org/.

Matthews, K. (1995). The great buildings collection a designer's library of architecture on CD-ROM. New York, Van Nostrand Reinhold,.

Multimedia CD-ROM-based designer's library of architecture. Represents more than 750 important buildings from around the world and throughout history. Materials include photographic images, drawings, videos, textual commentary, and interactive 3-D models of the buildings. Possible to search by geographic location, historical period, architectural characteristic, and basic find commands.

Performance Standards

Scientific inquiry

1.1b Students will express interests and opinions using appropriate verbal and non-verbal communication.

Students in groups will observe neighborhood structures. Students in groups will express interest and opinions orally and in writing of structures they will create. They will communicate their findings orally and in writing as they compare two neighborhood structures.

Visual Arts

3.1a Students will construct, with blocks of wood or cardboard boxes, new building structures that demonstrate homes, communities, cities, sports complexes and playgrounds or parks.

5.1a Students will draw, without patterns, all the basic shapes, cut them out, paste them in a pattern, and describe how well they solved the design problem.

Students will build a structure using any media they choose based in an original design integrating different elements. Students will observe the dependence of humans on building structures.

Language Arts

1.3 c Students will demonstrate strategic reading skills *after specific reading tasks* ; they will:

1.3.c1 Construct meaning through initial understanding and interpretation.

1.3.c10 Select and use relevant information from a selection to include in a response to or an extension of it.

Students will read for information at least three books related to the design and construction of a building. They will then demonstrate their understanding orally and through a model of some of the most important elements. Students will compare at least two neighborhood structures focusing in specific elements. i.e. windows, chimneys.

Mathematics

2.2c. Students will measure and create a scale in maps or scale drawings using the idea of constant ratio.

2.3 Students will use models to reason about the relationship between the perimeter and the area of rectangles in simple situations.

Students will create a scale drawing of a simple structure and then build their own. They will make multiple drawings to show the difference between plan, section, and elevation of a structure. They study the relationship between scale measurements, perimeter and area based on original design and structure.

Social Studies

1.1c Students will compare various cultures within a classroom with respect to family life now, over time and between cultures.

1.2a Students will understand the history of their respective neighborhoods.

1.2b Students will understand their city community and its geography.

Through comparing two or three different neighborhood structures the students will make observations of their community.

Evaluation Rubrics

CLASSROOM ASSESSMENT LIST

Designing a Structure - ELEMENTARY SCHOOL

1. Journal entry- My structure

T: I have written a complete sentence of the structure I want to build.
O: I have written part of the sentence of the structure I want to build.
W: I haven not written the structure I want to build.

2. Journal entry- My Team's structure

T: I have written a complete sentence of the structure my team will build.
O: I have written part of the sentence of the structure my team will build.
W: I haven not written the structure my team will build.

3. Journal entry- My structure spaces

T: I have written a complete sentence of the spaces I want my structure to have.
O: I have written part of the sentence of the spaces I want my structure to have.
W: I haven not written the spaces I want my structure to have.

4. Journal entry- My Team's structure spaces

T: I have written a complete sentence of the spaces our team structure will have.
O: I have written part of the sentence of the spaces our team structure will have.
W: I haven not written the spaces our team structure will have.

5. Blueprint of team's structure with the three spaces

T: I have drawn all, the structure and the three spaces.
O: I have drawn most of the structure and the three spaces.
W: I have drawn some of the structure and the spaces.

Did I do my best work?

Terrific OK Needs Work

CLASSROOM ASSESSMENT LIST

Gathering Neighborhood Data - ELEMENTARY SCHOOL

1. Date

T: I have written today's date at the top of the log entry.
O: I have written the date on my log entry.
W: I have not written today's date on the log entry.

2. Location

T: I have written the street at the top of the log entry.
O: I have written the street on my log entry.
W: I have not written the street on the log entry.

3. Structure drawings

T: I have made many different drawings of structures on the street.
O: I have made some drawings of structures on the street.
W: I have not made any drawings structures on the street.

4. Elements drawings

T: I have drawn many different elements of the structures.
O: I have drawn some elements of the structures.
W: I have not drawn any elements of the structures.

5. Labels

T: I have written the names of all of the elements in the structure.
O: I have written the names of many of the elements in the structure.
W: I have not written the names of any of the elements in the structure.

Did I do my best work?

T errific **O** K Needs **W** ork

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