Changing the Equation:
After-School Math Curriculum

THE BUILT ENVIRONMENT MATH

Based on *After-School Math PLUS*
from the Educational Equity Center at
Academy for Educational Development

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KIT: BUILT ENVIRONMENT

This After-School Math Kit includes engaging activities that are fun for both students and after-school staff. Students learn math while working in cooperative, supportive groups facilitated by staff members. Even better, after-school staff don't need to be math experts!

Through these activities, students and staff hone math skills, gain confidence in math, and increase their enjoyment of math.

THIS KIT INCLUDES

■ **Instructions to facilitate 4 activities.** These activities are simplified summaries and extensions of the "After-School Math PLUS: Built Environment" curriculum created by the Educational Equity Center at Academy for Educational Development (AED).
The 4 activities are:
Part 1. According to Height
Part 2. Planning the Ideal Community
Part 3. Mapping Your Community

■ **Scientist Spotlight** Ask your students "who is a scientist?" and you'll typically get answers that include white lab coats, microscopes, and bubbling beakers. All of these images reflect some aspect of science and STEM (Science, Technology, Engineering, Math), but they don't provide a full picture. We include stories of two STEM professionals that work at Sandia National Laboratories. Read these with your students, and together list some of the activities, skills, and experiences from the stories. What surprises your students? What was unexpected? Does this change how they think of scientists and engineers?

TIPS FOR LEADING ACTIVITIES

- Give students opportunities to share their ideas with you and with each other.
- Make sure to introduce each activity. Learning happens best when learners know what's coming up and why it matters to them.
- Ask open-ended questions, rather than those that have a "yes" or "no" answer.
- Ask questions that inspire the learner to thoughtfully analyze a situation and consider consequences, such as, "What do you think will happen if you do this?"
- Give the learner time to answer the question. Ask the question, then wait. A while. Trust us: thoughtful answers take time.
- When a learner tells you what they think, respond by repeating and paraphrasing what they have said without criticism.
- Don't give too much praise or reject ideas. Telling a learner they are right or wrong can discourage them from generating additional ideas or pursuing deeper exploration.

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Part 1 - According to Height **Main Idea**: Did you know that you are about as tall as your outstretched arms? Students will explore scale, ratio, and proportion, then use graph paper and measuring tapes to create a scale picture of themselves.

INTRODUCTION

Scale is the ratio between the actual size of an object and a representation of it. A ***ratio*** compares one part of an object to a different part – how does the size of your head compare to the length of your arm? ***Proportion*** compares one part to the whole – your head is about 1/8 of your height. These are important concepts for creating accurate representations. Scale and proportion are important to artists, engineers, and many other professionals.

MATERIALS

- Graph paper (2 sheets per student)
- Colored pencils (several per group)
- Measuring tape (1 per group)
- *Body Proportion Activity Sheet* (1 per student, found on pages BE 5 - BE 6)

ACTIVITY: ACCORDING TO HEIGHT

STEP 1: DRAW YOURSELF (15 MINUTES)

Have students draw a horizontal line across their paper, four boxes up from the bottom of their graph paper. Then, starting at the line, ask them to draw a picture of themselves from head to feet, with the bottoms of their feet touching the line. A stick figure is fine, but have them include the shoulders, elbows, hands, pelvis, knees, and feet.

Collect the drawings and hang them on the wall, arranged by height using the line at the bottom of the pages to align the pictures. Then, ask students to physically line up according to height. Are they in the same order as the drawings?

Discussion: Why or why not? Ask students for ideas about how they could draw pictures of themselves that would accurately represent their height. Explain that these would be "drawn to scale."

STEP 2: MEASURE YOURSELF (30 MINUTES)

Have students work in small groups of three. Group members will take turns measuring each other and recording their results on the *Body Proportion Activity Sheet*. Then, group members will work together to answer the questions.

STEP 3: DRAW YOURSELF TO SCALE (15 MINUTES)

Using the new information on the *Body Proportion Activity Sheet,* have students use their measurements to draw a picture of themselves to scale on the graph paper. As a group, agree on the scale to use. For example, each square on the graph paper can represent 10 cm.

Discussion: Which body proportion is the most surprising? Have students describe in their own words what "scale" and "proportion" mean and what purpose they served in their drawings. Was it easier or harder to create their drawings the second time? Why?

Connect: Where else is scale used? Ideas might include maps and models (cars, planes, trains). Discuss how scale is used in each idea.

Many artists use standard human figure proportions, included in this activity. For example, the height of a person is the same as the measurement of their outstretched arms (a 1:1 ratio). And the length of a person's head is typically about one-eighth (1/8) of their overall height (a 1:8 ratio). Did you know that the width of your shoulders is about a quarter (1/4) of your height?

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Body Proportion Activity Sheet

	Your Measurement (in inches)	Human Figure Proportions for artists
Total height (measure from the bottom of your feet to the top of your head)		8 heads
Head height (bottom of your chin to the top of your head)		1/8 of total height
Hip height (measure from your feet to your hip)		1/2 of total height
Arm Span (with arms raised parallel to the ground at shoulder height out to your sides, measure left hand fingertip to right hand fingertip)		Same as total height
Elbow to fingertip		1/4 of total height
Elbow to armpit		1/8 of total height
Wrist to fingertip		1/10 of total height
Width of shoulders (measure between the points of your shoulders)		1/4 of total height
From the bottom of the foot to the bottom of the knee		1/4 of total height

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QUESTIONS:

1. Write down the ratio of your head height to your total height. How does your own ratio compare with that used by many artists?

2. What is the ratio of your total height to your hip height? How does it compare with the proportions for artists?

3. What is the ratio of your total height to your arm span? Is it 1:1? If not, which one is larger?

4. Find three other ratios and see how they compare with the proportions for artists.

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Part 2 - Planning the Ideal Community **Main Idea:** What would your ideal community look like? Students will work in small groups to design a community. Each group will be given a budget and will choose components that they want included in their community (such as parks, transportation systems, services, and recreation).

INTRODUCTION

This "simulation" style activity challenges students to apply what they know about community to create a model community for a fictitious group of 20 households. The imposed budget and cost list will force groups to make choices. While there will be no absolute "right" or "wrong" choices, your role will be to challenge students to justify their choices and to ensure students are being thoughtful. Giving specific praise—"I really like how you planned this to minimize the walking distance between the houses here and the park"—as well as specific challenges— "If you locate the landfill here, don't you think the smell will impact the houses right next to it?"—will work wonders in motivating teams to make careful decisions.

MATERIALS

- Graph paper (6 sheets per group)
- Colored pencils (several per group)
- Ruler (1 per group)
- *Community Structures and Features Cost Sheet* (1 per group, found on page BE 11)

ACTIVITY: PLANNING THE IDEAL COMMUNITY

STEP 1: DISCUSS (15 MINUTES)

Discussion: Challenge the students to write what community means to them in one or two sentences. Ask students to volunteer to share their definitions. Responses might include a group of people who all have something in common or ideas around people coming together to help each other and others in need. Use chart paper to categorize responses. Category headings might include: Place, Interdependency, Belonging, Common Interests, Culture, Family, Support, Common Good, etc.

STEP 2: SMALL GROUPS (15 MINUTES)

Divide students into small groups of three or four. Have each group develop a list of features and structures they associate with their community.

Discussion: Help them with their list by prompting them: What brings people together? How are community members supported? What do families need? How do communities provide support, including food, water, shelter, and medical care? How do people move around?

Connections: Have each group share their list. Compare these lists with the categories from the original discussion. What is missing? What can you add to your community to promote a sense of belonging, support, culture, safety, comfort? Tell the students that they will now be given the role of "Community Planning Team" tasked with creating a community for 20 families.

STEP 3: TEAM PLANNING (30 MINUTES)

Each small Community Planning Team will be given a budget of $10,000 that they can spend on a list of potential structures and features as listed in the handout: *Community Structures and Features Cost List*. Each team should spend their budget to obtain the features they think should be included in their "ideal community."

Discussion: Challenge each group to compare their final list with the group's definition of community. What is missing? Have each team share their list and justify the choices they made. What features will provide a feeling of belonging? What features will help promote culture and common interests? Are there enough trees and other green spaces included? Why are these important? What are their favorite aspects of community, and why?

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Part 3 - Mapping Your Community **Main Idea**: What would your ideal community look like? Each team will use measurement, scale, and proportion to create a blueprint drawing of their ideal community.

INTRODUCTION

This "simulation" style activity challenges students to apply what they know about community to create a model community for a fictitious group of 20 households. The group will have to agree upon the scale that they will use for their model, and think about how to draw the community structures and features to match that scale.

MATERIALS

- Graph paper (6 sheets per group)
- Colored pencils (several per group)
- Ruler (1 per group)
- *Community Structures and Features Cost Sheet* (1 per group, found on page BE 11)
- *Proposed Size and Scale for Community Structures Sheet* (1 per group, found on page BE 12)

ACTIVITY: MAPPING YOUR COMMUNITY

STEP 1: PLANNING TEAM REVIEW (10 MINUTES)

Have each Community Planning Team review their *Community Structures and Features Cost Sheet*. They should have spent $10,000 to provide structures, features, and services to their community of 20 houses. Have them give their community a name.

Next, ask each group to think about the arrangement of the features in their new community. Should the school be located next to the landfill? Should the hospital be located next to the outdoor theater where loud music is played?

STEP 2: ARRANGING A SCALE MODEL (20 MINUTES)

Have each team take a piece of graph paper and cut out shapes to represent each feature and structure that they purchased for their community. Each shape should be made to scale. Give the students the *Proposed Size and Scale for Community Structures Sheet*. They can use the ideas listed on the sheet, or choose to make their own scale. Emphasize that the structures should be in proportion to each other.

Next, each team should tape together four sheets of graph paper. This will be the space in which their community will be located. Then, each team should arrange their features on their community space.

Discussion: Have each team justify their choices by asking questions as they try different ideas. Challenge the teams to think about the relationship among the features. Is it easy to get from one place to another? How would a child get from their house to the playground? To school? How easy is it for the police department or fire department to respond? If there are no roads, how will someone carry their groceries and other shopping bags from the store to their house?

STEP 3: BUILD THE COMMUNITY (20 MINUTES)

Now that each team has an idea of how they would like their community to be arranged, they should transfer their ideas onto their community space (the four pieces of graph paper taped together) using colored pencils and the ruler. Have the students use words and symbols to label all structures and other features. They should also indicate the scale that they used; for example, 1 square = 10 feet.

Reflection: Ask each team to share their blueprint. Ask the other teams to share two things they like about the plan. Follow with one or two questions about why that team chose to do something in a specific way. Ask the presenting team: Are you satisfied with the plan? What trade-offs did you have to make? Would you make different choices if you had more money? What if you had less money?

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COMMUNITY STRUCTURES AND FEATURES COST SHEET

CATEGORY	FEATURE DESCRIPTION	COST	Included in your community? List cost here
Environment	Trees	$10 each	
	Pond	$250	
	Desert ecosystem - desert scrub, grasses, and animals	$5 per 10 square feet	
	Grassy Area	$10 per 10 square feet	
Services	Hospital	$3,000	
	Doctor's Office	$500	
	Water Tower	$250	
	Fire Department	$500	
	Garage collection and sewage treatment	$350	
	Landfill	$250	
	Grocery Store	$500	
	School	$500	
	Police Station	$500	
	Community Center / Cultural Center	$500	
	Shopping Mall	$2,500	
	Small Store	$350 each	
Transportation	Airport	$5,000	
	Roads for Cars	$500 per mile	
	Train Tracks	$2,000 per mile	
	Bicycle Lanes	$250 per mile	
	Sidewalks / Walking Paths	$150 per mile	
Recreation	Playground - small (slides, teeter totter, merry-go-round, monkey bars, and tether ball)	$300	
	Playground - Medium (everything listed above + climbing structures, basketball court, and features for toddlers)	$600	
	Playground - Large (everything listed above + zip lines, large tree house, musical area)	$1,000	
	Mountain Bike Park	$250	
	Skateboard Park	$250	
	Amusement Park (like Cliff's)	$4,000	
	Swimming Pool	$500	
	Water Park	$1,000	
	Outdoor Theater for Concerts, Plays	$2,500	
			Total Cost:

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PROPOSED SIZE AND SCALE FOR COMMUNITY STRUCTURES SHEET

FEATURE	SUGGESTED SCALE	OR CREATE YOUR OWN SCALE
Each square on the graph paper	10 ft by 10 ft	
Each house (20 houses total)	10 ft by 10 ft	
Pond	20 ft by 30 ft	
Desert ecosystem - desert scrub, grasses, and animals	per 10 square feet	
Grassy area	per 10 square feet	
Hospital	100 ft by 100 ft	
Doctor's office	20 ft by 20 ft	
Water tower	10 ft by 10 ft	
Fire department	20 ft by 20 ft	
Garbage collection and sewage treatment	50 ft by 50 ft	
Landfill	100 ft by 100 ft	
Grocery store	100 ft by 100 ft	
School	100 ft by 100 ft	
Police Station	20 ft by 20 ft	
Community center / Cultural center	20 ft by 20 ft	
Shopping mall	100 ft by 100 ft	
Small store	10 ft by 10 ft	
Airport	100 ft by 100 ft + runways	
Playground - small (slides, teeter-totter, merry-go-round, monkey bars, and tether ball)	20 ft by 20 ft	
Playground - medium	30 ft by 30 ft	
Playground - large	50 ft by 50 ft	
Mountain bike park	Your choice	
Skateboard park	20 ft by 20 ft	
Amusement park (like Cliff's)	100 ft by 100 ft	
Swimming pool	50 ft by 50 ft	
Water park	50 ft by 50 ft	
Outdoor theater for converts, plays	50 ft by 50 ft	

Funding provided by Sandia National Laboratories

I review the work conducted at Sandia National Laboratories for potential emissions that pollute the air and contribute to climate change and ozone depletion. I like my job, because I'm helping to keep people and the environment safe now and into the future! It's important that big companies like Sandia Labs follow the rules to protect the environment, just like everyone else. In school, I took math classes every year and built up a solid foundation that helped me in my engineering and science classes once I got to college. I still use math all the time, especially showing my work and converting between different units—like from inches to centimeters. Math skills have helped me learn to think analytically and ask questions, two skills that have helped me in all the different parts of my life. Remember that different people learn in different ways, so if you don't understand what your math teacher says, ask questions and keep trying—it will be worth it!

ELIZABETH QUINLEY
Air Quality Compliance Engineer

I am a geophysicist at Sandia National Laboratories who plans experiments using maps and information about an area's geology (rock formations). The data from these experiments helps me determine what is underground without having to dig a big, expensive hole. People need to know what is underground so they can build buildings, run plumbing and utility lines, and find oil, gas, and other resources. My job takes me all over the world; I've even done experiments in Antarctica! I use math in my experiments to predict wave speeds, amounts of energy, and directions to make sure my experiments run smoothly and the data is accurate. It took me a long time to learn all of the math I needed and to get good at it, but practice helped. Everything can be hard when you are first learning, but if you ask for help when you need it and keep practicing, it will get easier!

NEDRA BONAL
Geophysicist