

Discovering the STEM Within Block Building

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PURPOSE OF BLOCK BUILDING



Interviews with successful engineers reveal many had an early exposure to materials such as wooden building blocks, K'nex®, Erector sets®, Tinker Toys®, Lincoln Logs®, and Legos®. Such materials enabled them to investigate the physical properties of the materials and how those properties affected their use in design and construction. An added benefit in building with these materials are challenges to spatial reasoning, a mathematical skill that has huge implications for success in math and science in middle and high school. These construction materials are rarely available to children of all socio-economic levels. Making these materials available in the classroom and providing time for children to engage with them will provide opportunity for ALL children to develop the spatial reasoning necessary for success in later math and science education, and ultimately, in STEM professions.

A building material we recommend for preschool, kindergarten, first, and second grade classrooms is a set of wooden unit blocks. Unit blocks were invented by Caroline Pratt at the start of the 20th century and remain a foundational educational material for early learning. The blocks are machined precisely so that each block is a fraction or multiple of every other block. Children have the opportunity to engage in part-whole relationships as they deconstruct and reconstruct shapes to make other shapes. Because building with

unit blocks rely on balance, friction, and tension to construct stable structures, builders are constantly grappling with force and motion and counteractions of forces to obtain balance. The ability to construct a tower that utilizes the builder's knowledge of balance has been linked to high performance in math and science starting in middle school. Children who work with blocks in the early years outperform their peers in math and science who don't because of all of the mathematical concepts that can be addressed through block play.

MATH CONCEPTS THAT BECOME MEANINGFUL THROUGH BLOCK BUILDING

Counting / Magnitude	Left / Right	Part-Part-Whole Relationships	Taller / Shorter
More / Less	Equivalence	Fractions	Longer / Shorter
Addition / Subtraction	Congruence	Categorizing / Classifying	Estimation
Shapes	Negative Space	Sets	Area and Volume
Graphing	1-to-1 Correspondence	Seriation	Symmetry
Vertical / Horizontal	On/Under/Next-To/Over/In...	Measuring	Pattern

EXAMPLES OF QUESTIONS FOR ADULTS TO ASK AND COMMENTS TO MAKE

- *How many different kinds of triangles can you find? Squares? Rectangles? Circles?*
- *I notice you are using all the same kinds of blocks. Does this help you build a taller tower? What kinds of blocks make the best towers? Which blocks don't make the best towers? Why do you suppose that is?*
- *When you push on this side to make the edge on this side the same, what happens to the edge on the other side?*
- *I see you used one block that is longer than the others.*
- *I notice your blocks make a space in the middle.*
- *All of your blocks except one are touching.*
- *I notice all your blocks are rectangles, but they're not all the same size.*
- *You made the top block balance. I bet that wasn't easy.*
- *Some of your blocks lie down and some stand up.*
- *You have each block touching just at the very tips of the corners.*
- *You used four blocks and they touch on four corners!*
- *You laid these two blocks the long way and these two blocks the short way.*
- *I notice you have made a square with your four rectangle blocks. Do you see it?*
- *What would happen if you turned the blocks on their sides. Could you still make a square?*
- *Is there a way you could make an inside rectangle?*
- *I see you selected all the same kinds of blocks to build this. Would it work with different kinds?*
- *Your blocks are way out at the edges without peeking out. You made the edges flush or even.*
- *If I count the blocks on their sides, I can say your structure is two blocks high. I wonder if it could get even higher.*
- *I see you've begun a pattern of two on their sides, one flat on top. Two on their sides, one flat on top.*
- *It looks like two windows when look through it from the ends. When I look at it from this side, I don't see any windows.*



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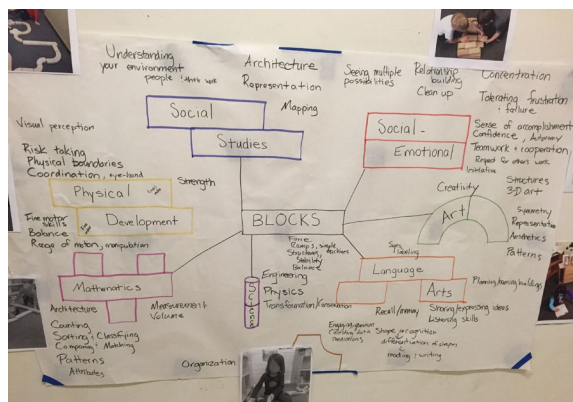
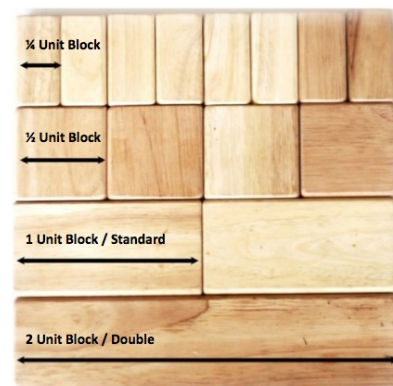
EXAMPLES OF CHALLENGES FOR EXPERIENCED BUILDERS

- How could you build me a fence with walls that are two blocks high and has an arch way.
- Build me a bridge to go over this water, but make sure there are steps so the people can get onto the bridge.
- Is there a way to build me a hotel with two floors? Please make sure there is a fire escape with stairs to get out.
- I wonder if there is a way to get these two structures to connect.

ARRANGING THE ENVIRONMENT TO INCLUDE BLOCK BUILDING


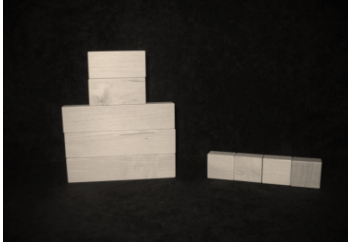
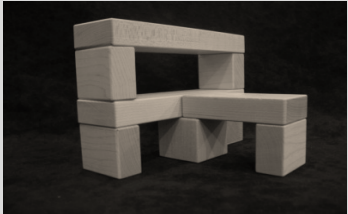
Teachers will have little difficulty enticing young learners to engage in block building. With a little effort, teachers can capitalize on this interest to create an environment that enables the teacher to capture young learners' attitudes in regard to success and failure, logic, and conceptual understanding. Below are guidelines to assist in creating such an environment.

- Block area is in a traffic-free zone and clearly designated for block building.
- Blocks are arranged on shelves in a way to allow children to see attributes of blocks and return them to their rightful place.
- When appropriate, accessories or props are available by the blocks.
- There is sufficient time (a minimum of 45 minutes) allowed in the schedule for children to select block building.
- Sufficient quantities of a variety of types of blocks are available to support spatial reasoning within block building.
- Pictures and books for references are readily available to pull out when needed.
- During field trips, digital pictures are taken, printed off, and displayed in block area to inspire building.
- Adults support mathematical and science concepts in a meaningful manner through conversations with children about their block structures.
- Checklist and questions are available to serve as prompts and suggestions for adults as they learn to interact with children as they build.
- Digital camera is available to photograph works in progress and structures in a completed state.
- A system is in place to take note of who builds and what they build.
- Efforts are made to ensure every child is confident to build and builds regularly.
- Builders are allowed the opportunity and support to develop skills to solve their problems independently.
- Regular class meetings are held (at least every other day) to allow builders to share their insights and questions about building.
- Documentation of children's work is displayed.



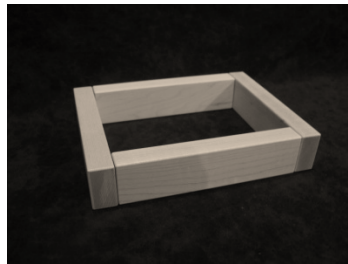
Web on potential of block building created by teachers in the Clarendon Child Care Center

The Progression

Child Behavior		Ideas to support	Questions/Comments/Challenges
<p>Stage 1: Carrying</p> <ul style="list-style-type: none"> • Carries blocks • Can move shapes to a location • Explores with senses • May hit blocks together or against other objects • Can compare to find the same block • Can match shapes of different sizes 		<p>Provide:</p> <ul style="list-style-type: none"> • Wagons for hauling • Buckets/baskets for carrying • Boxes to fill with blocks • Small suitcases or briefcases to pack the blocks 	<ul style="list-style-type: none"> • Will the blocks fit in this box? • How could you make a line with the blocks? • Can you find any more blocks that look just like this one? • Let's put only these kinds of blocks in the bottom of the box. I wonder if they will fit. • How are these blocks different? • Can you find more blocks like this one by the window?
<p>Stage 2: Stacking</p> <ul style="list-style-type: none"> • Stacks blocks either vertically (towers) or horizontally (rows) • May not be selective of what blocks to stack at first, but later understands that stacking similar blocks works better • Begins to build sets of rows and towers • Rows may begin to go in different directions, making corners 		<p>Provide:</p> <ul style="list-style-type: none"> • Pattern cards for children to copy • Cars and road signs • Floor mats or place mats to build on 	<ul style="list-style-type: none"> • I see you are putting the blocks on top of each other. • Tell me why you are using only these kinds of blocks to stack? • I notice you are laying the blocks next to each other. • You made a long road. Let's count how many blocks you used. One, two, three. . . . • How high is your tower? Let's count how many blocks... • You are stacking these the tall way and they fall down. If you stacked them the short way, will it stay standing? • Which row is longer? The four squares or the four rectangles? • I see you used a long double unit on the bottom, and then you put two unit blocks on top to match. They fit just perfectly. • You put the triangle at the very top of the rectangles!
<p>Stage 3: Bridging</p> <ul style="list-style-type: none"> • Bridges the space between two upright blocks with a third block • Often happens at the same time as enclosures • Often begins by holding top piece and placing ends beneath • Eventually doesn't have to think hard to make corners and edges flush 		<p>Provide:</p> <ul style="list-style-type: none"> • Pictures of bridges • Architectural drawings showing bridging concepts • Large pieces of blue cloth to symbolize water • Boats • Columns 	<ul style="list-style-type: none"> • You made the top block balance. I bet that wasn't easy. • Some of your blocks lie down and some stand up. • You could drive a car through this space! • Can you think of another kind of block to make a bridge? • You have some windows in your structure! I can look through them at you! • Last week you were building structures with one level. Now you have three! • Which one of your bridges is tallest? Longest? Can you make it even longer?

Stage 4: Enclosures

- Purposefully places blocks to enclose a space
- Making things fit well becomes more important – the corners begin to match up
- Complex bridges with multiple arches with ramps and stairs with ends appear
- Can eventually anticipate what the shape will look like before building
- Works into building enclosures and bridges several blocks high



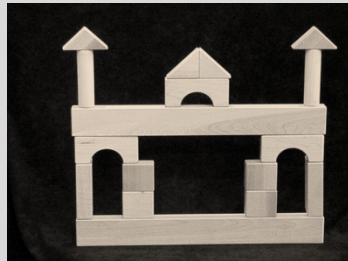
Provide:

- Farm/zoo animals
- Doll house furniture
- Fruits and vegetables to make a fruit or vegetable stand at a farmer's market
- Posters/photographs of buildings that show examples of enclosures

- Look, your blocks make a space in the middle.
- What shape is the open space in the middle? Could you make the open space a square? Is there a way to make an open space a triangle?
- How many blocks do you think it will take to fill up that space?
- That was clever to make both ends of your building match.
- I see you used one block that is longer than the others.
- All of your blocks except one are touching.
- You used five blocks. You made the whole structure with just five blocks.
- You have each block touching just at the very tips of the corners.
- You used five blocks and they touch on five corners. What shape is in the middle?

Stage 5: Patterns and Symmetry

- Builds structures with balance, symmetry, and decorative elements
- Structures may be horizontal structures or vertical



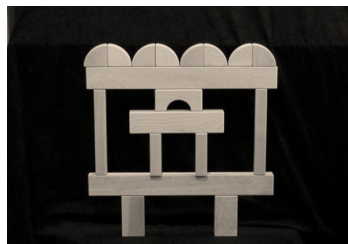
Provide:

- Challenge cards of photographs and/or paintings of buildings
- Challenge cards of symmetrical patterns
- Mirrors
- Blank paper to make signs and labels
- Roofing materials
- Field trips around neighborhood

- How did you decide to put those blocks together?
- If you don't have enough rectangles, what else could you use? What if you run out of squares?
- I notice you put the roof on very gently.
- You make a different kind of triangle when you put those two triangles together!
- It looks like a triangle from here, but if I stand over here, I see a rectangle.
- How many openings do you have?
- Is it taller or wider?
- I notice you have a pattern here. You have the same sized opening on each side, the same triangles on top...

Stage 6: Early Representational

- Incorporates building techniques from stages 1-5
- Begins naming structure during or after construction



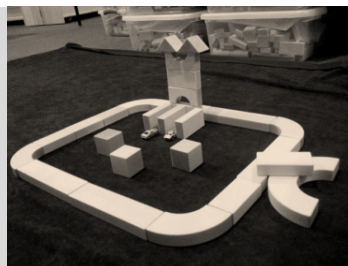
Provide:

- Challenge cards
- Block building books
- House building magazines
- Blueprints
- Field trips around neighborhood

- I see you used all the same kinds of blocks to build this. Would it work with different kinds?
- Did you change anything? What made you decide to change it?
- I notice your top floor fell a few times. How did you get to it stay up?
- How could you add a chimney to it?
- Where could you add a lookout?
- I wonder if you could add a turret to your castle.

Stage 7: Later Representational

- Often announces name of structure before building begins
- Builds familiar settings
- Uses structure and related accessories for dramatic play



Provide:

- Measuring tools
- Photographs of familiar buildings and structures
- Accessories that relate to type of structure

- You built a tall apartment house. How do the people get to their floor?
- Can you tell me what you plan to do to build your house/road/train station?
- Where do people park their cars when they come to visit the shopping center?
- Is there a way to connect your houses to make a mansion?