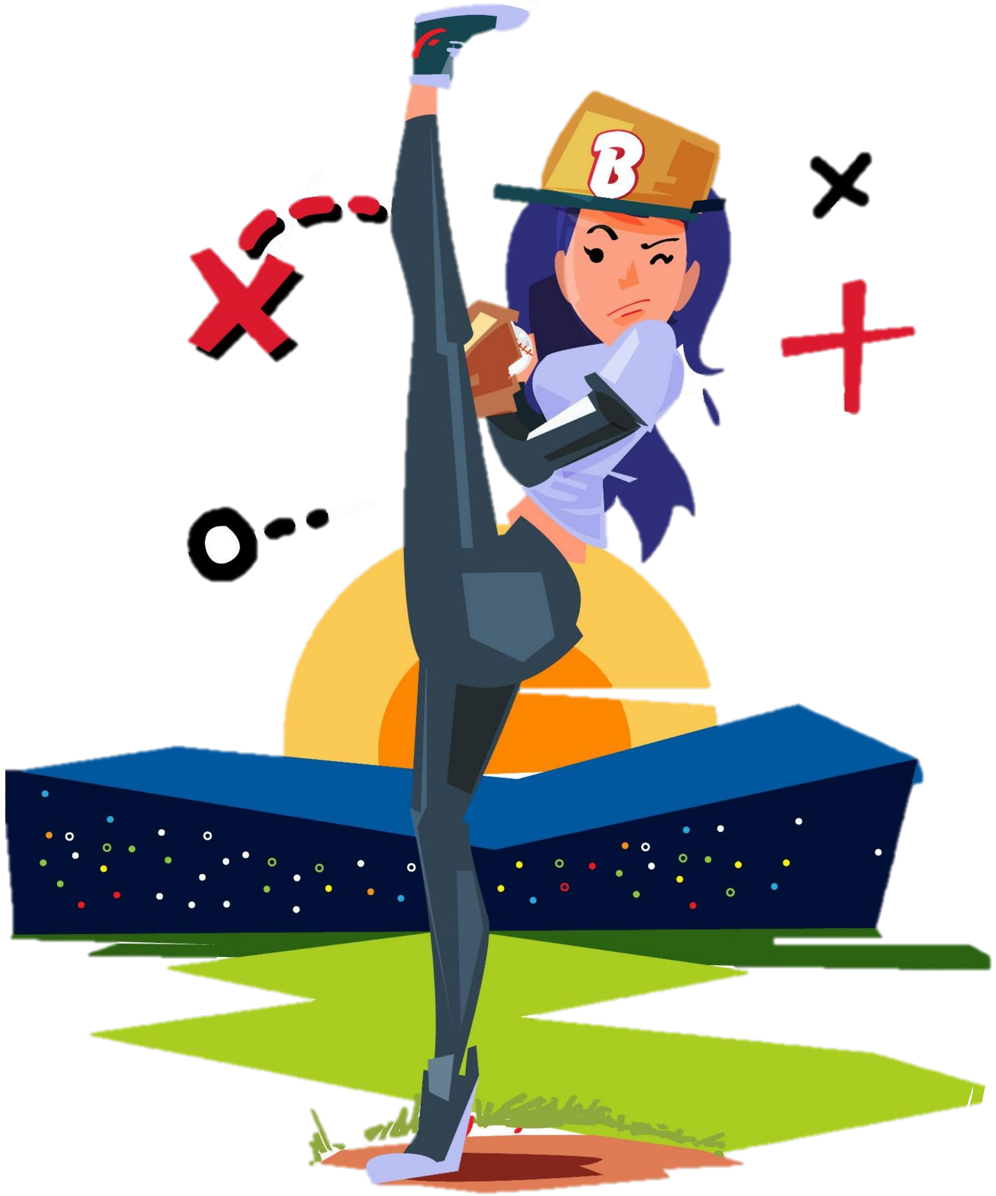


# Math: Catch the Vision

# Seeing the Connection

Studies examining the relationship between spatial skills and mathematics achievement find that the two are significantly correlated for students at **all** educational levels.


Students with dyslexia are often good at problem solving and "seeing the big picture". They show creativity in solving all kinds of problems and are good at seeing how things fit together.

# What is spatial reasoning?

Spatial thinking is the ability to visualize or picture things in your mind's eye and to mentally move, rotate, stretch, bend, or fold objects and shapes in space.


# Visual Info

It involves locations of objects, their shapes, their relations to each other, and the paths they take as they move.

# Better Together

"Spatial thinking is not an add-on to an already crowded school curriculum, but rather a missing link across that curriculum. Integration and infusion of spatial thinking can help to achieve existing curricular objectives."

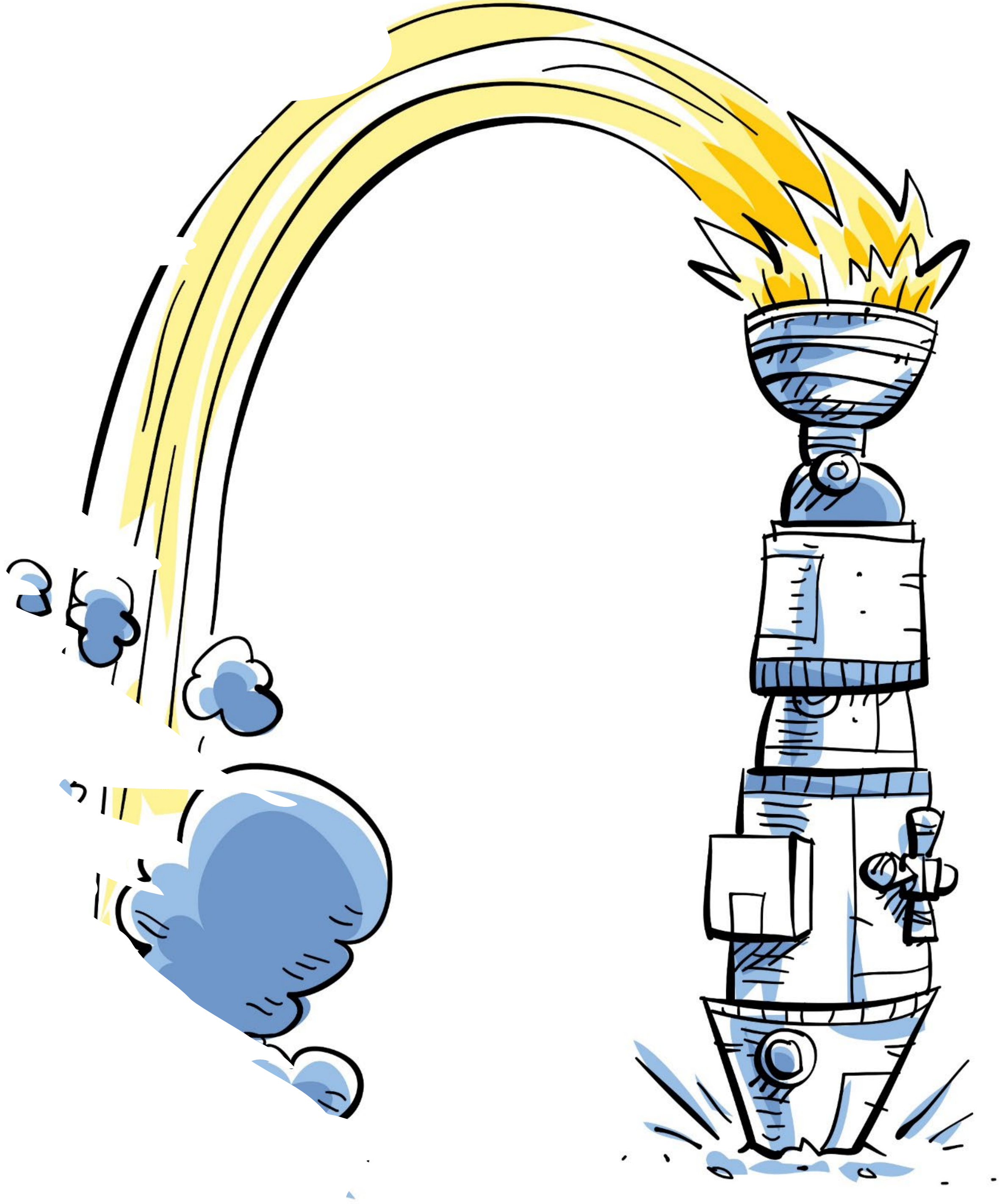
(National Research Council, 2006, p. 7)

# I'm just not good at…

There is a widespread belief that spatial thinking skills are fixed – either you are a spatial thinker or you are not. This is a misconception.

# You are what you think

When students attribute their successes to ability, they tend to succeed; when they attribute their failures to lack of ability, they tend to fail.



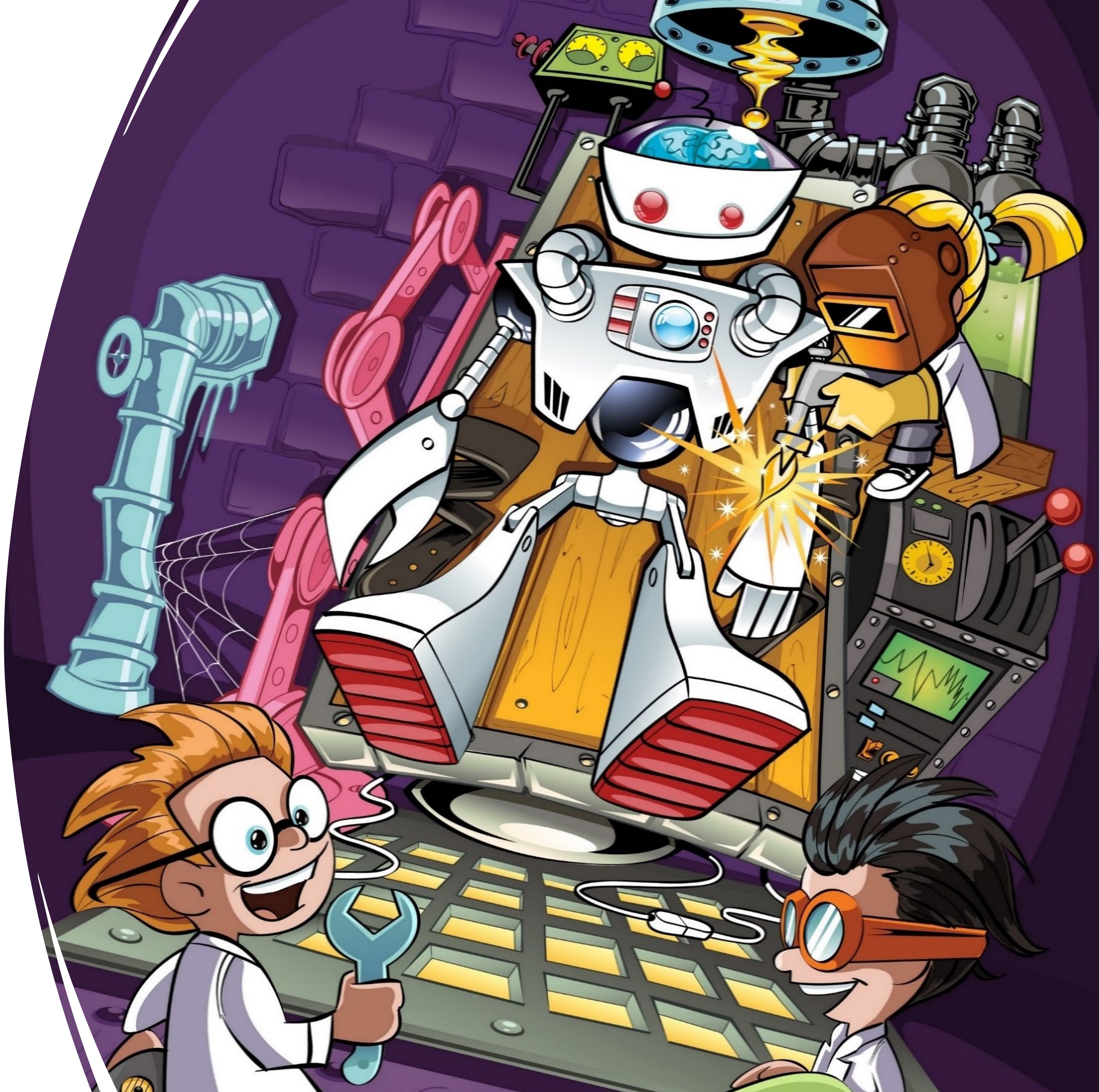
"Most individual differences [in math ability] are probably due to the lack of opportunity."

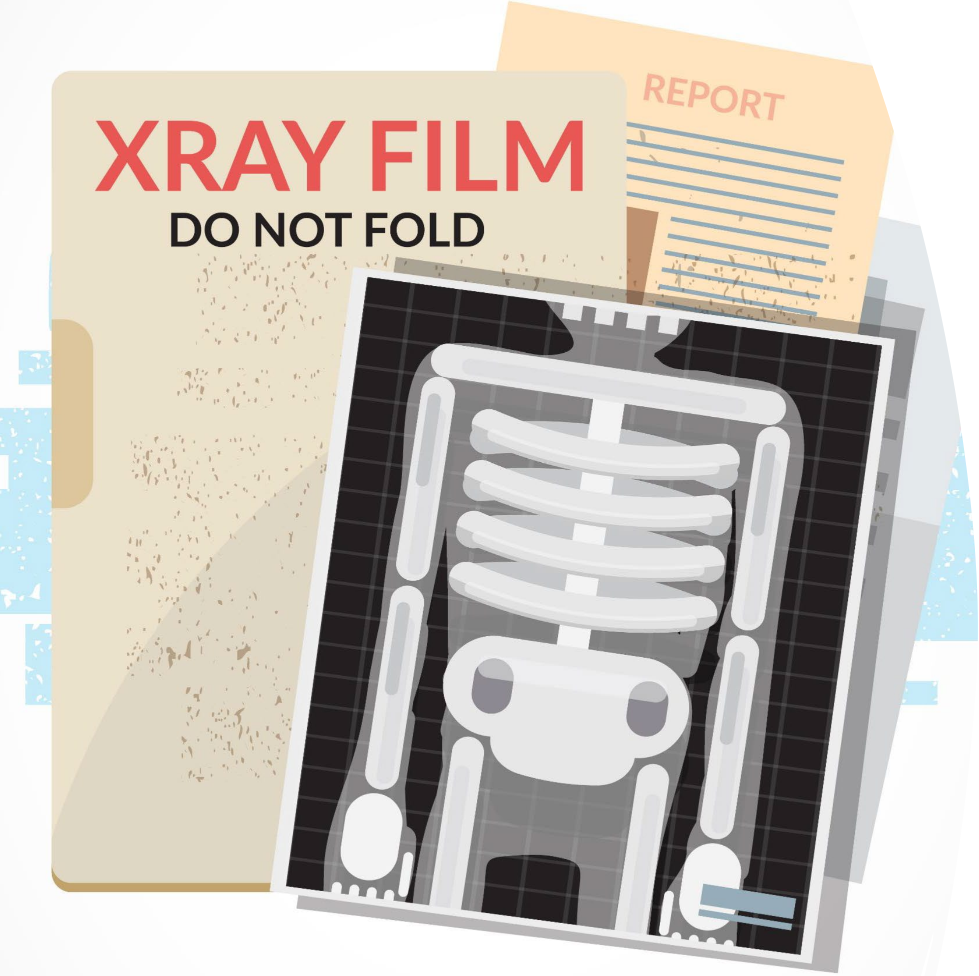
--Baroody, Lai, and Mix (2006)

# Who needs to think spatially?

Besides the fact that we all need to navigate our way around in a three-dimensional physical world, careers in the sciences, technology, engineering and mathematics (STEM) require strong spatial skills.

Research has shown that spatial ability is a predictor of success in these areas.






# Not Only Them

Spatial thinking is also critical to many of the arts. Architecture, graphic design, computer sciences, biology, physics, chemistry, geology, geography and even medicine (consider the spatial reasoning required to understand various ways of mapping the body, such as x-rays and MRIs) all require strong spatial skills.

We saw how it can affect athletes. Ex. Simone Biles got ‘the twisties’ and "literally [could] not tell up from down.” What about other sports?

“Early experiences talking about, organizing, moving through, drawing, and modelling space provide a critical conceptual base for the mathematical study that will turn them into engineers, architects, scientists, taxi cab drivers, and other adults who competently make their way from here to there” (Erikson Institute, 2014, p. 132).

# The Art & Math of Design

## Dominic-The shoe Surgeon

[How to Make a 10k Pair of Shoes from Scratch]

## Tinker Hatfield:

Tinker Hatfield's background in architecture and athletics sparked his game-changing shoe designs for Nike, including the iconic Air Jordan series.

# Did You know?

- "London cabbies have remarkable brains," -- Hugo Spiers, a professor of cognitive neuroscience
- London taxi drivers must pass one of the hardest tests in the world. It's called "The Knowledge."
- It takes most people 3-4 years of prep before they attempt it. Only 50% pass.
- Memorizing 25k streets literally changes their brain. The hey have a larger hippocampus (in charge of spatial intelligence & memory.)

# Six Processes to Pay attention to

These are crucial aspects of spatial reasoning ability, and they all help with other aspects of mathematical ability as well. *Keep them in mind as we explore activity ideas.*

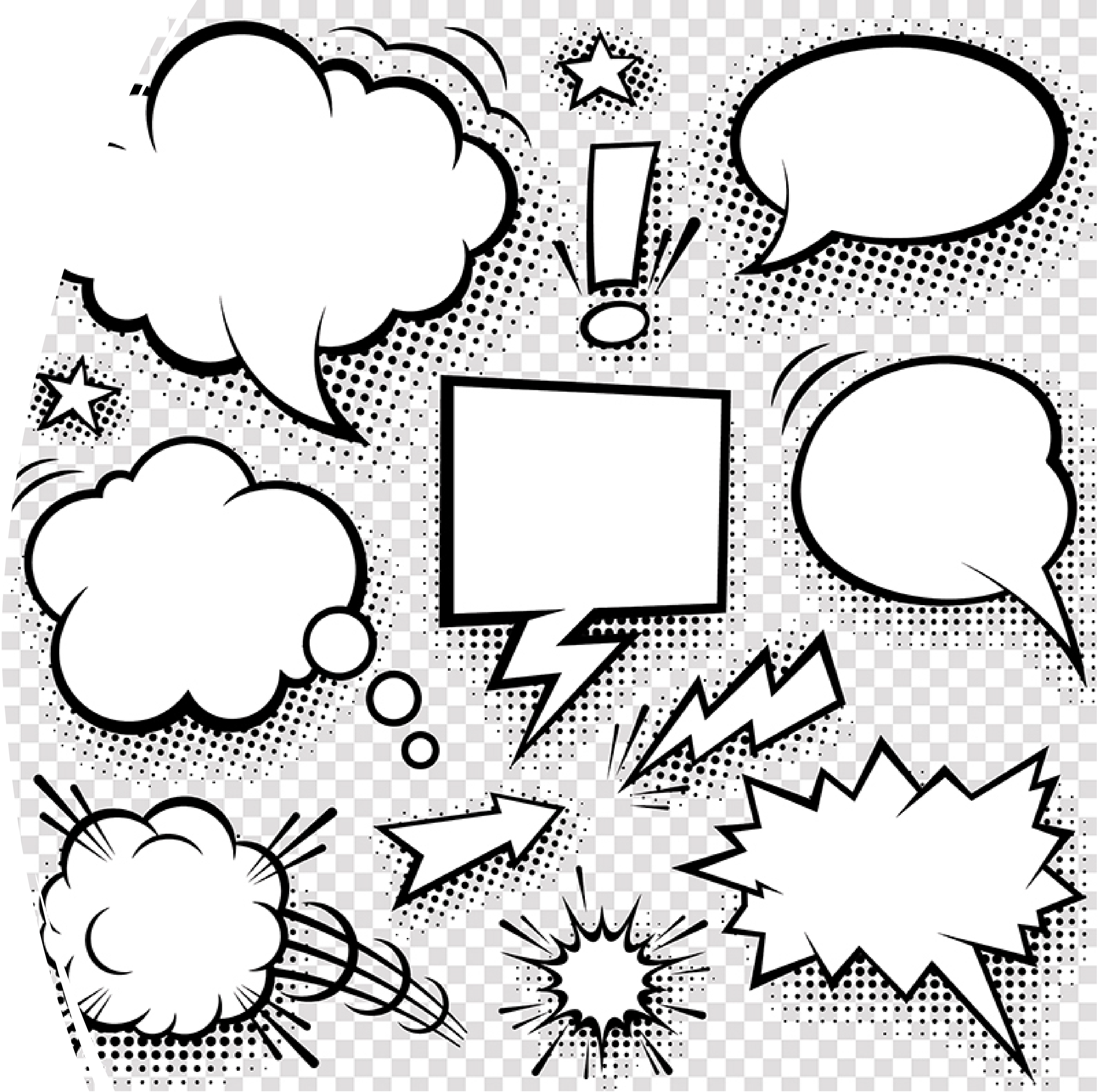
- Visualization – Seeing it in your mind
- Mental rotation – Moving it
- Visual-spatial working memory – Remembering it
- Information processing – Analyzing it
- Spatial Language – Talking about it/describing it
- Gestures – Illustrating it

# The Three Vs

Encourage students to do the following:

- **Visualize!** Create a picture in your mind. It may help to close your eyes.
- **Verbalize!** Describe or explain what you see.
- **Verify!** Solve the problem—do the activity. How does it compare with what you saw in your mind's eye? What do you see now?

*Tip: It can be helpful to put a poster on the wall for students to reference and to remind them. Even very young children can learn these words and what they mean.*



# Talk about it: Visualization Questions and Prompts

To have students articulate the visual imagery they are using when problem solving, try asking students, “What are you seeing in your mind?” or “What did you see or visualize that helped you to solve the problem?”

These kinds of questions get descriptions from students that clearly show their understanding while encouraging them to think about what they’re doing inside their own heads aka ‘their visualization strategies.’

## Visual-Spatial Working Memory aka mental doodles

Visual-spatial working memory is, in some ways, like a mental blackboard on which you bring images into focus, using your mind's eye, and manipulate them. It's your brain's white board or sketch pad.

# Fun & easy or personal nightmare?

Have you ever tried to cut out a paper snowflake and utterly and completely failed?

Or, are you really good at them?

# *How did you do that?*

Things like snowflakes and paper doll chains are great examples of ‘simple’ tasks that need spatial skills.

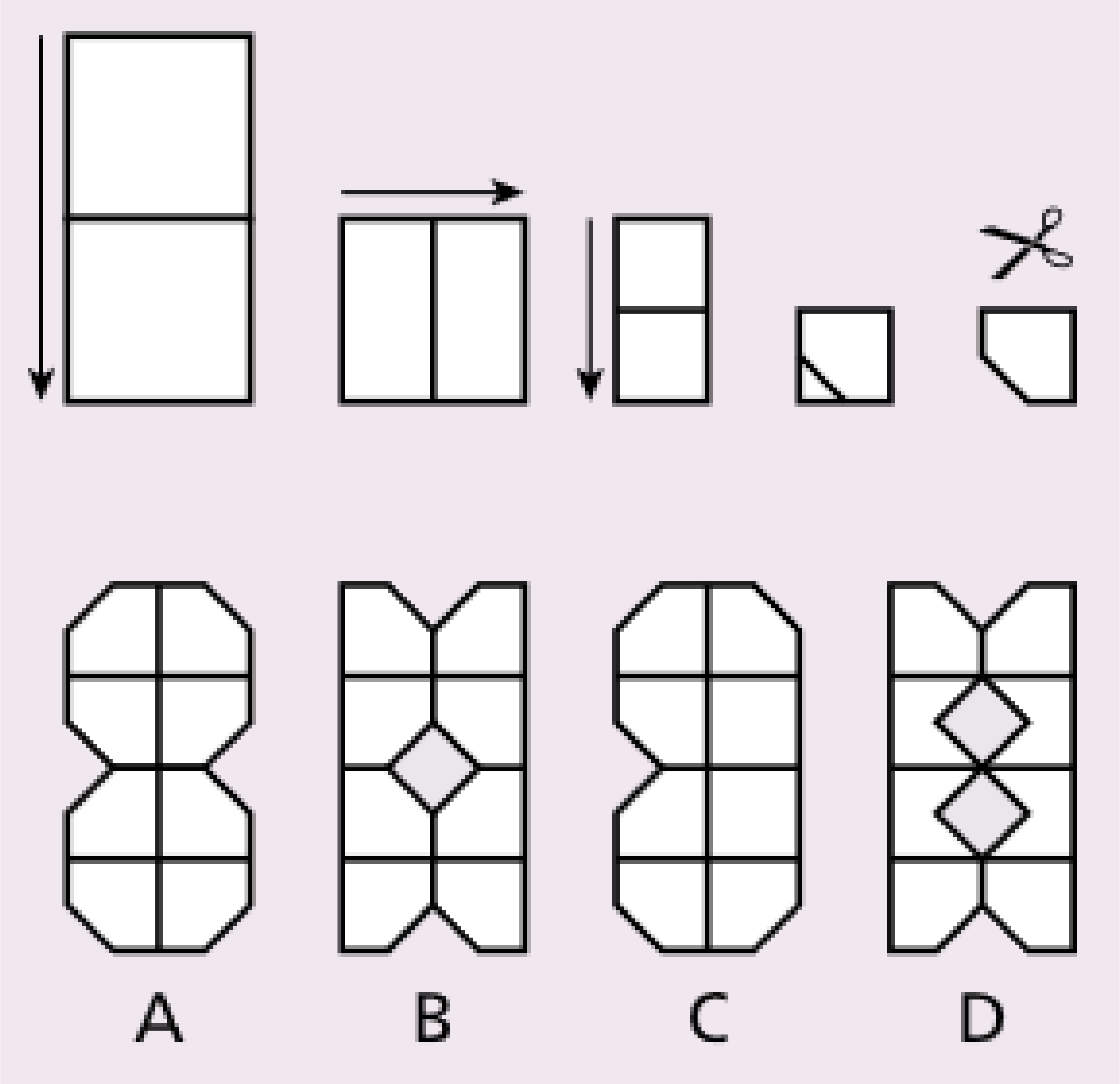
*How many of the six do you think they include?*

# Not Just Child's Play

Actually, a common student test of visual-spatial skills involves paper folding. Answer the following question.

What piece of paper accurately represents the finished result?

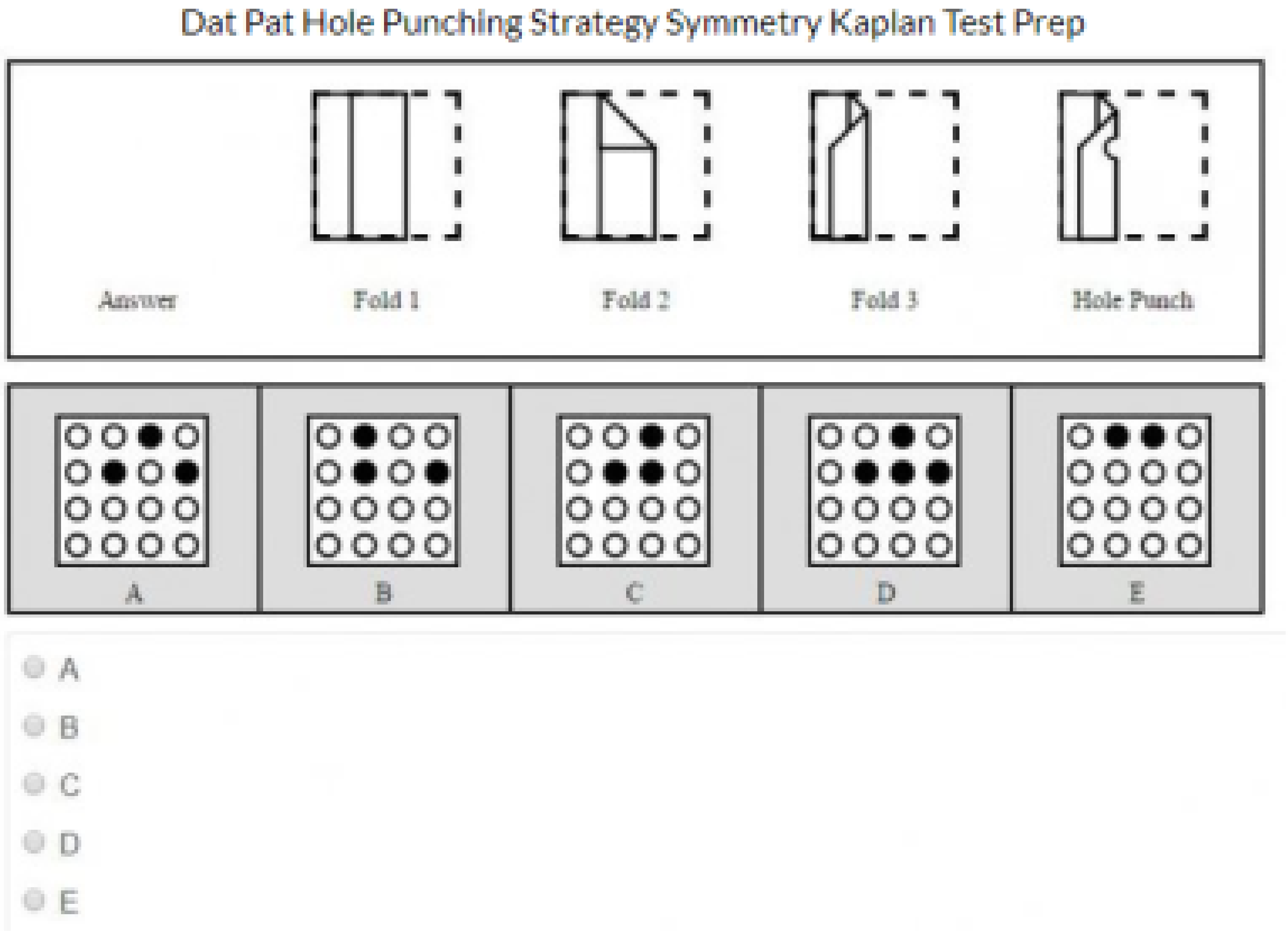
Note: The arrows indicate the direction of the fold, and the scissor icon represents a cut along the designated line.



# Sample test

Here is another example of one of these cognitive test questions.

Students are asked to mentally fold a piece of paper and then punch 1 hole through the folds, then imagine what the paper would look like once opened.



# Get their hands on it!

Instead of trying to measure our students' abilities by giving sample problems like this, it is far more productive to offer experiences where our students can learn to think spatially.

Ex. With proper scaffolding making paper snowflakes can help with hand eye coordination, bilateral hand use, develop sequencing *skills*, and *spatial* and visual perception.

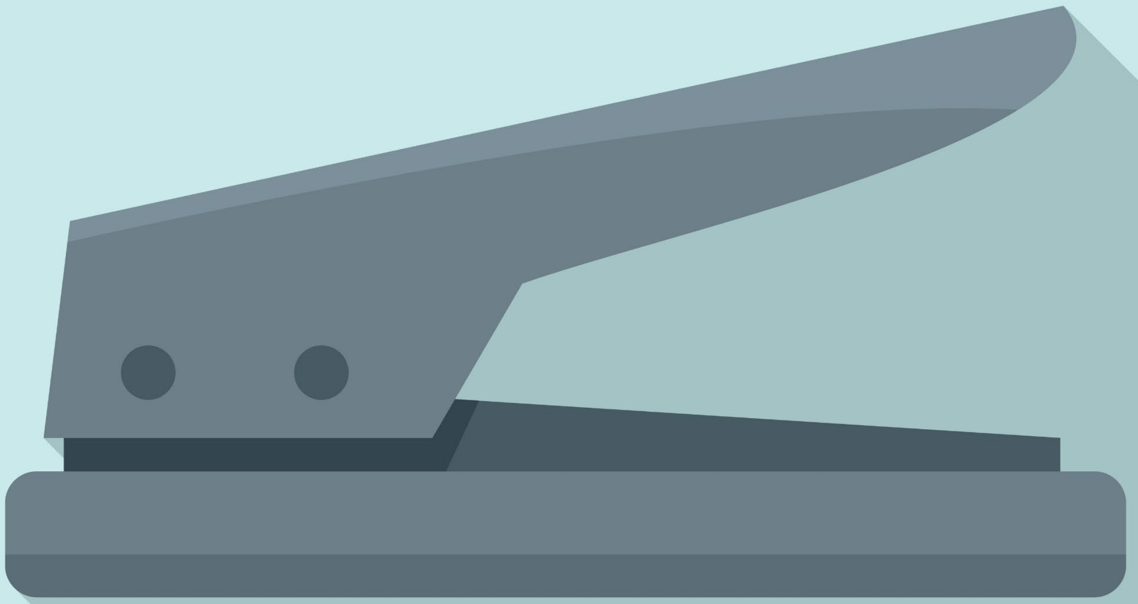
# The One Two Punch

Students use their imagination to anticipate how paper that has been folded and hole-punched will look when it is unfolded.

“These are One-Hole Punch puzzles.  To complete a puzzle, take a square of paper, fold it using as many folds as needed so that if you punch one hole and unfold it, you will match one of the puzzles.  Complete the following puzzles in any order.  Be prepared to discuss your strategies with others.”

These puzzles are tricky because **only 1 hole** can be punched to create several holes.

https://buildingmathematicians.wordpress.com/2019/11/24/one-hole-punch-puzzle-templates/

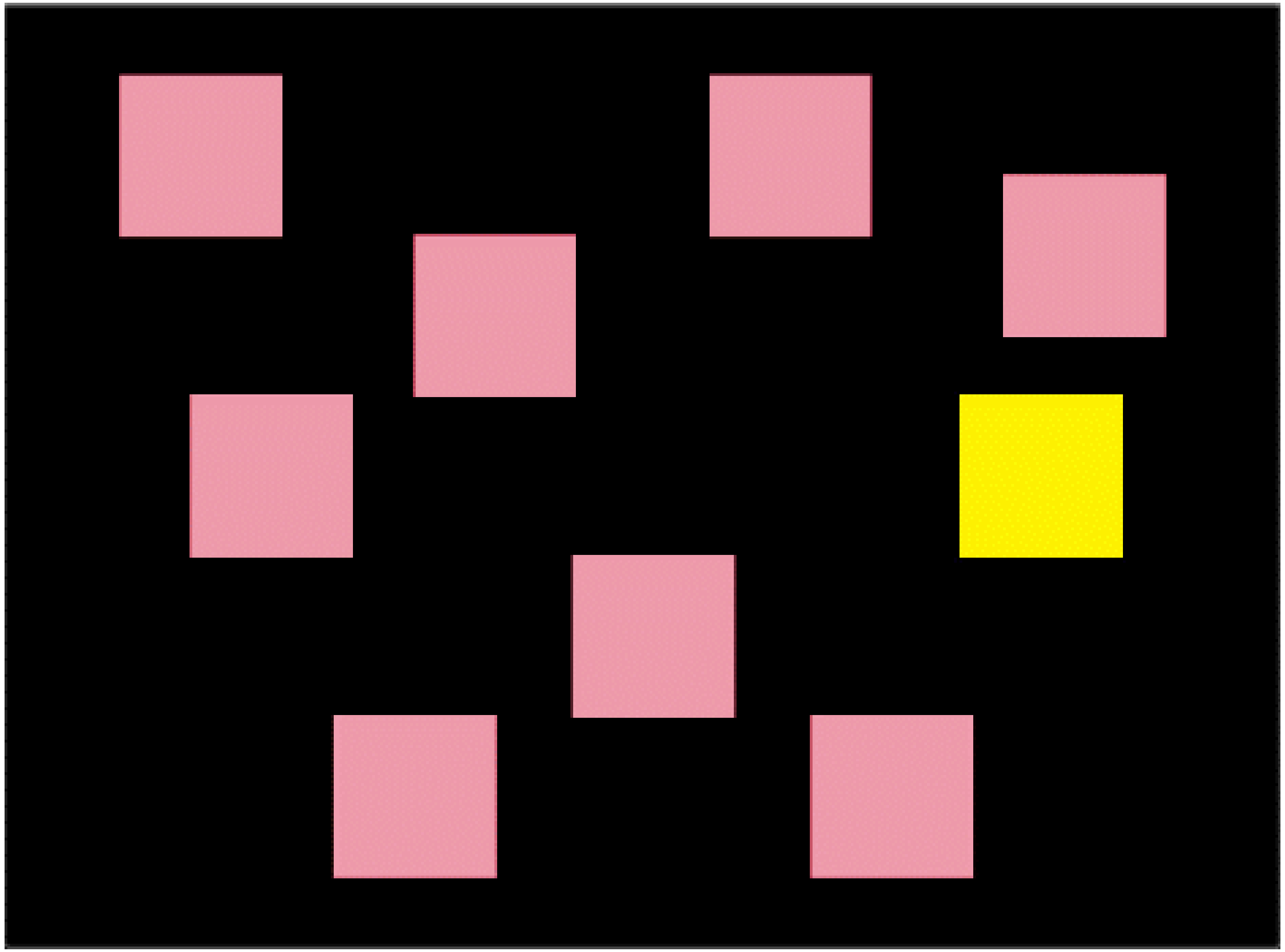


# Do You Remember?

Visual-spatial working memory is often tested by having participants recall a sequence of randomly presented locations. All variations of these tests share the requirement to “hold onto” and keep track of precise spatial locations in a sequence.

It will start off with two or three items, gradually increasing the number of items until the person can’t remember the order correctly.

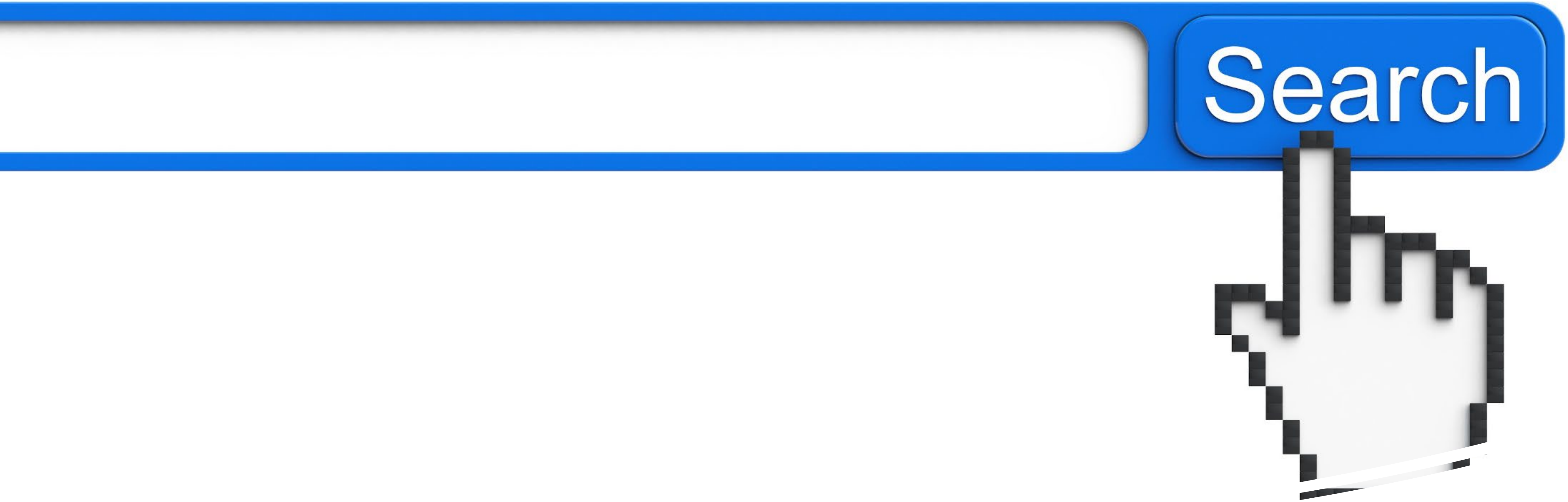
How many can you remember?
https://www.psytoolkit.org/experiment-library/experiment_corsi.html



# Information Processing

Taking in information as input and responding in the form of an output. This can be taking in one piece at a time, in sequence (sequential), or in chunks or groups (simultaneous).

When it's integrating you can possibly relate it to other familiar objects.



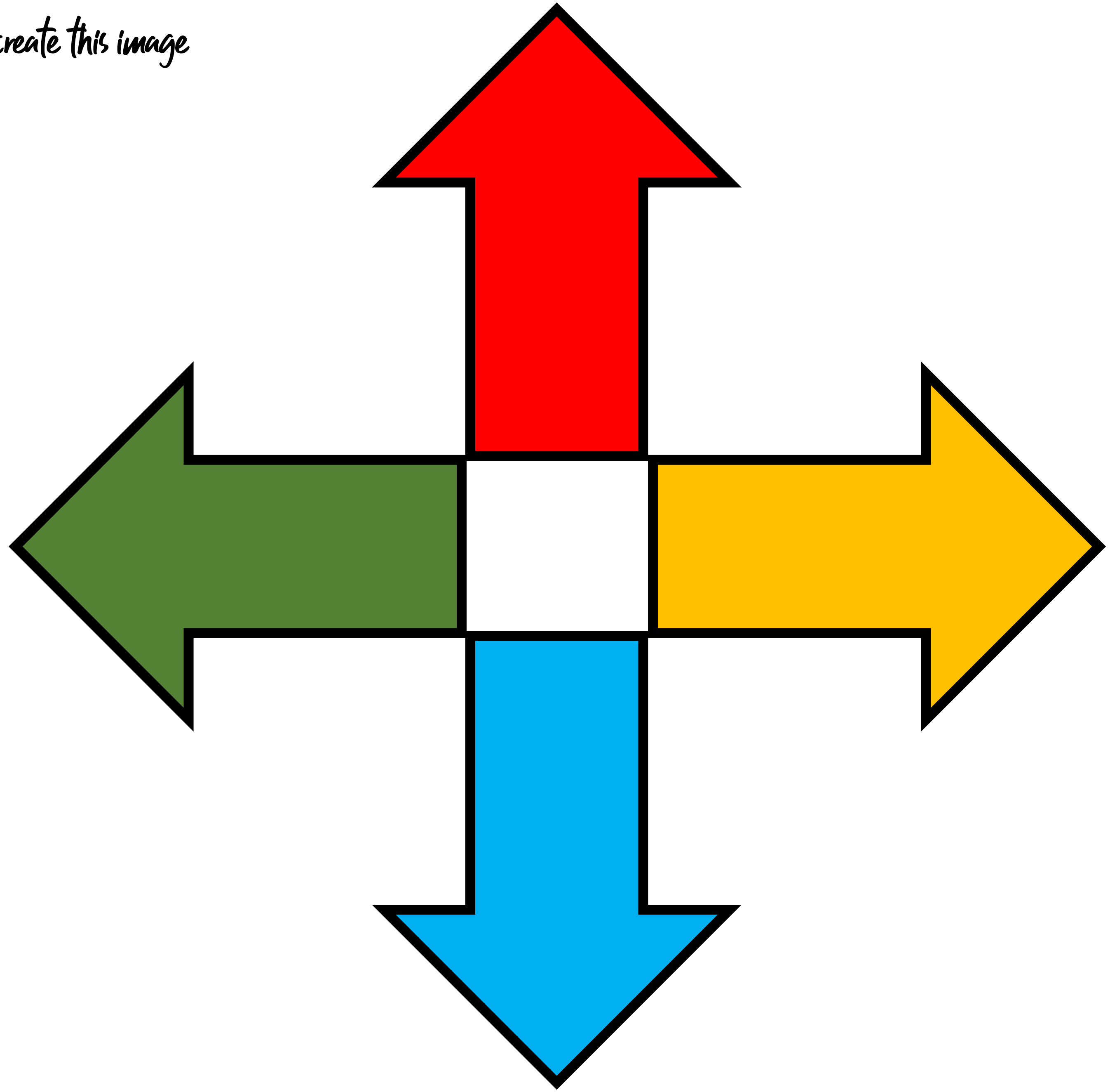

# Sequential vs simultaneous

Let’s say a child is trying to recreate a pattern with pattern blocks. If they use sequential, they may look at one piece at a time. Back and forth they search between the pattern and their work. They may miss or forget elements and make mistakes without noticing.

# Simultaneous

Simultaneous means they take in the image as a whole. They may relate it to another familiar pattern, shape or object. These connections may help them more easily relate to, remember, and recreate the pattern.

Getting Sketchy: Could you recreate this image after a few seconds?



What techniques would you use?

# Speak Outside & Inside the Box!

The more children are exposed to spatial language, the more likely they are to use it themselves.

Children engage in more spatial language during block play that includes guidance, ex. a goal or a problem to solve, than in free play with blocks.

# Finding the balance: Integrating Play & Instruction

The sweet spot is a combination of direct instruction and guided play. A balance of freedom and structure is critical to children's learning at any age. This allows students to "play with" precise, and often complex, mathematical ideas.

# Play alone is not enough. Kids need YOU!

To be clear, **play alone does not guarantee that mathematical learning will take place.**

Research has repeatedly shown: Children *can* learn from play, including free play, but they learn MUCH more with artful guidance and challenging activities provided by their teachers.

# Lego Challenges: Build Your Own Adventures

Numerous studies have shown that kids (and adults) show improvement on spatial reasoning tests after spending time with LEGO Bricks and other kinds of construction play.

Tip: Set up "Inspiration Stations"

This is where students can get inspired by adding to existing LEGO cities and making them their own by building and adding in their own custom creations.

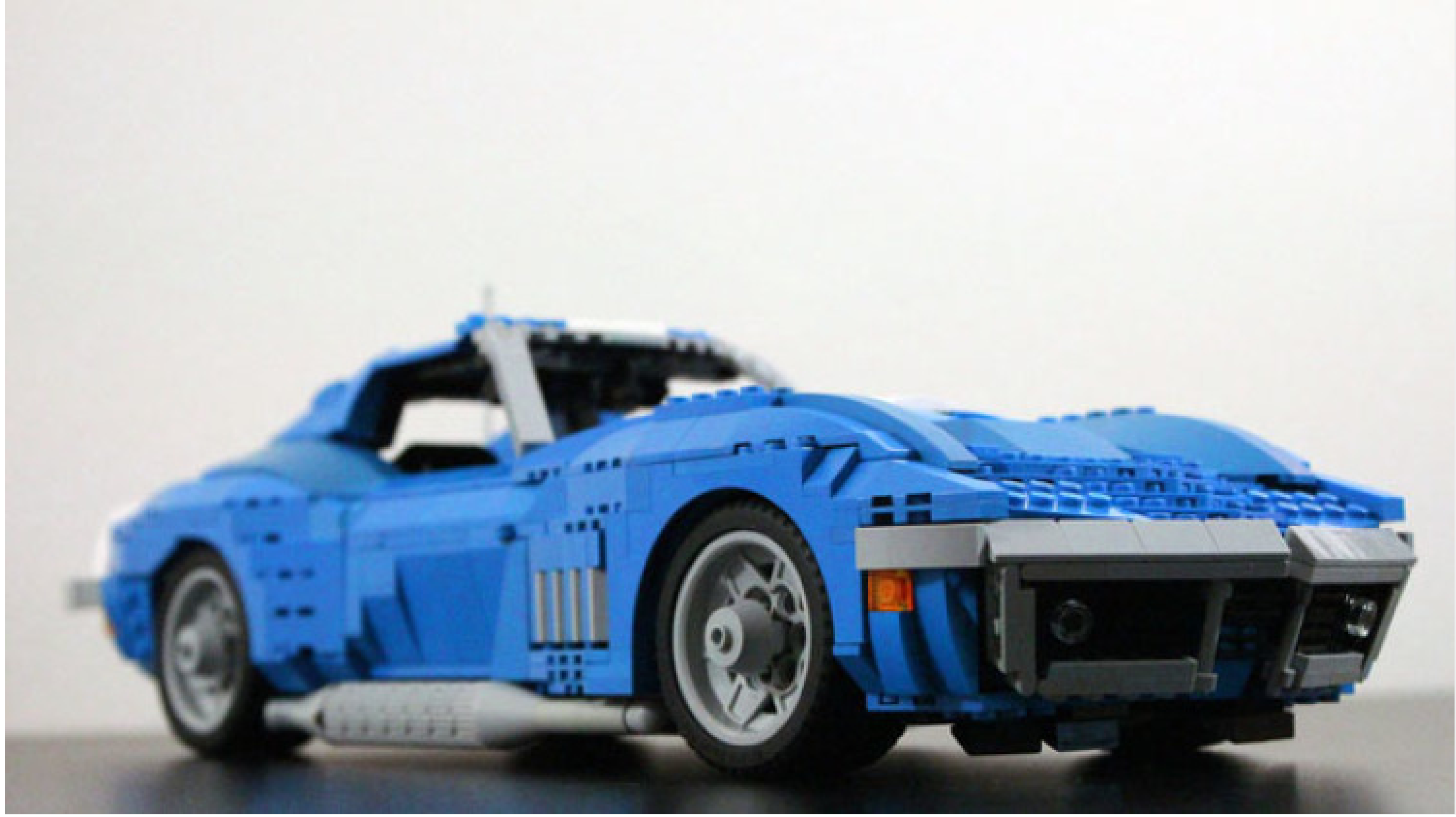
# Not sure where to start? There's a book for that

# Give them Challenges to Succeed


**PUT YOUR NOTIONS IN MOTION:**

Students are challenged to Design a Vehicle
The car can be a replica of a real car, a fantasy car (like GeekPerson's Flying Car), a mini car, or a floating car… if you don't have wheels. Of course, transportation design is not just limited to cars. There are also motorcycles, marine craft, airplanes, commercial transport such as semi-trucks, small personal mobility vehicles, and public transit like buses and trains. The horizon's the limit!

Not only is their goal to make it look awesome, but also add  cool features and details that add even more playability. Ex. Include landing gears, a landing pad, and even a power cell behind the seat in the cockpit:

## What's Your Vision?

- How could you modify this challenge for grade levels?

# Challenge Idea: Rubber Bands & Rocket cars

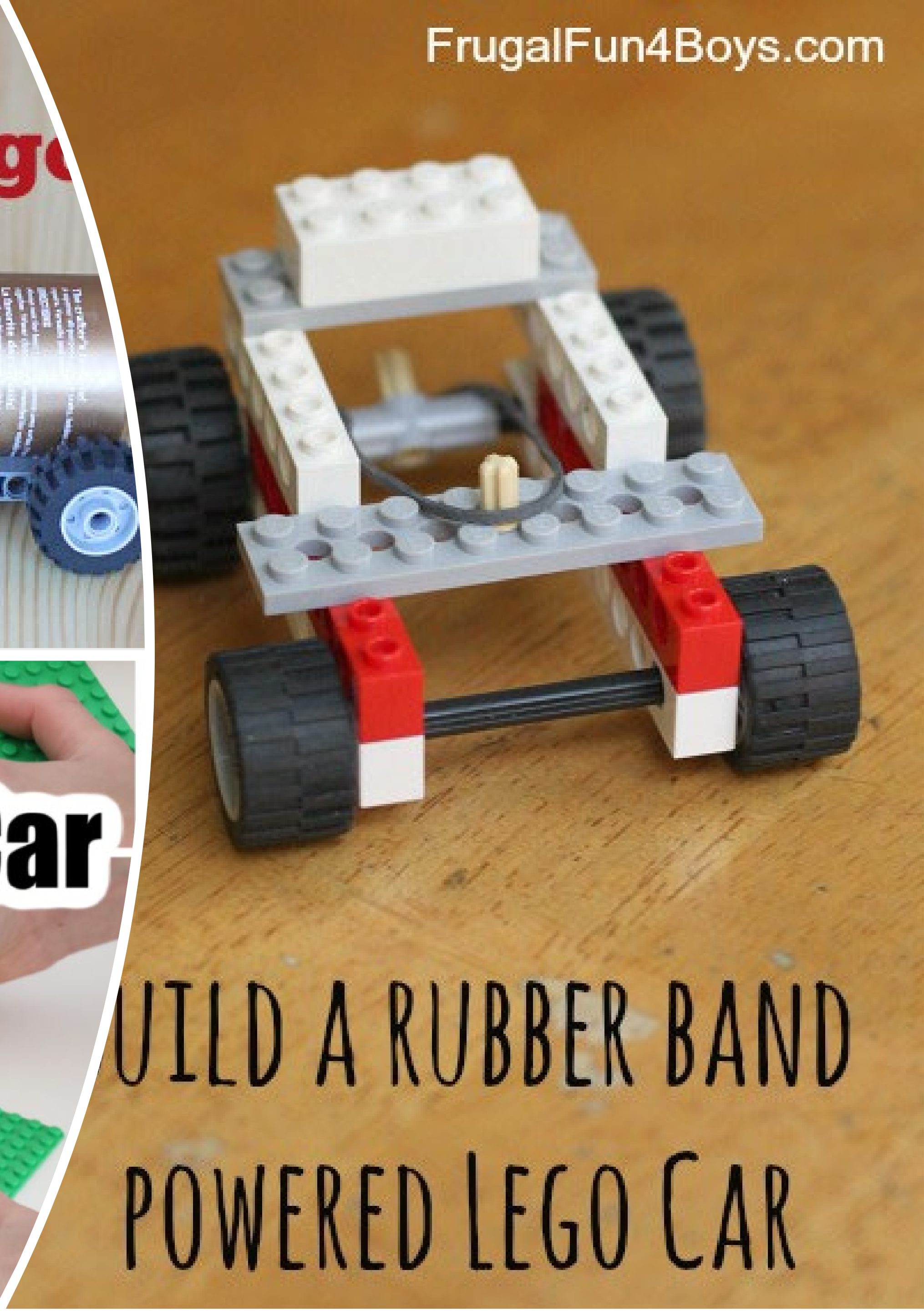
Students are challenged to construct LEGO cars that race across the room.

There are so many variations you can do. Make a cool rubber band powered car, a slingshot car, a rocket car, or try their hand at the motors and see what they can make.

Next Challenge? Challenge the students by having them design a ramp for racing their cars. They'll need to build race lanes out of Legos and find a way to release all the cars at once!

Tip: Check out STEM Inventions for a cool non-LEGO popsicle stick version of this project.



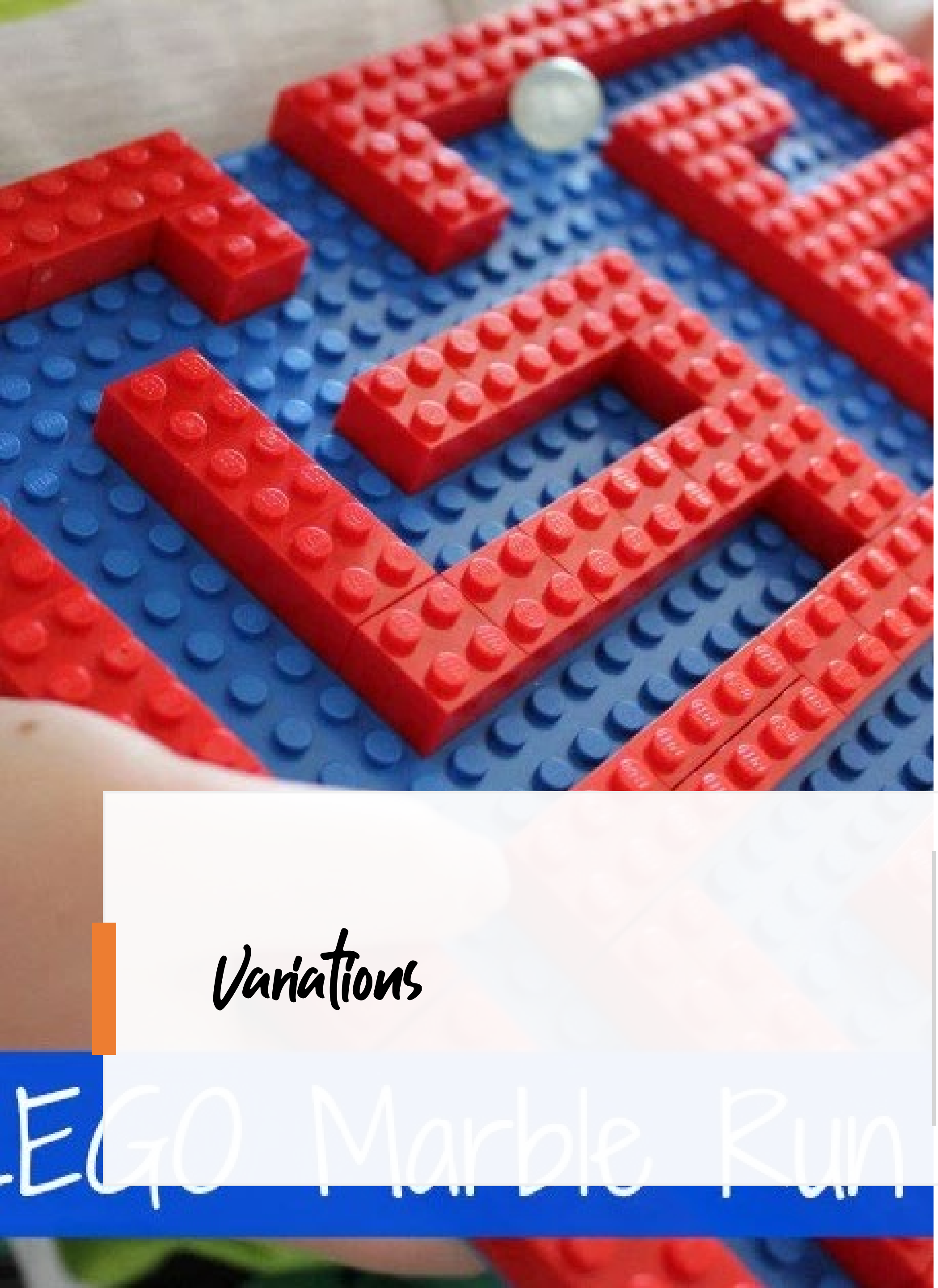


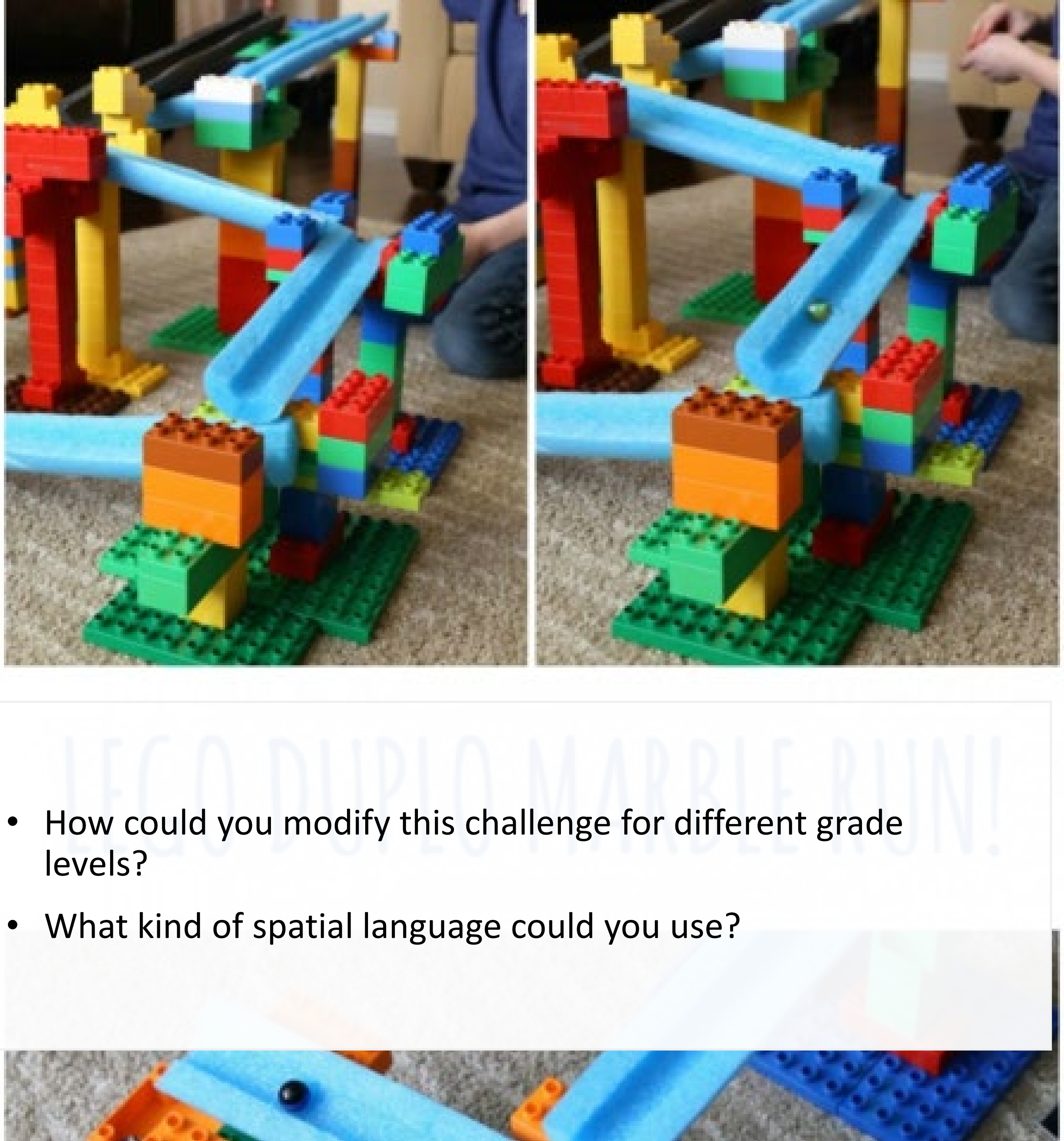
# Amazing Mazes! Escape the Minotaur

Our LEGO heroes are facing off against the dreaded Monster of the Maze…the Minotaur! Can they find their way through the tricky maze or will they face the Minotaur's Gaze?!

Challenge students to create a maze that a marble can run through including turns, tunnels, and dead ends to make the maze difficult to navigate. Them, time how long it takes to get the marble through the maze without helping it (only tilting the large base piece).

- Then time other students using the same maze and see who wins! The players will need luck, skill, and wit to be the first to escape! It’s a race to the finish line with a monster hot on your heels!
- Challenge students to build it so that it will last at least 30 seconds. The longer the better!
- As always with LEGOs: Build it, play it, and then make it better!




# Variations

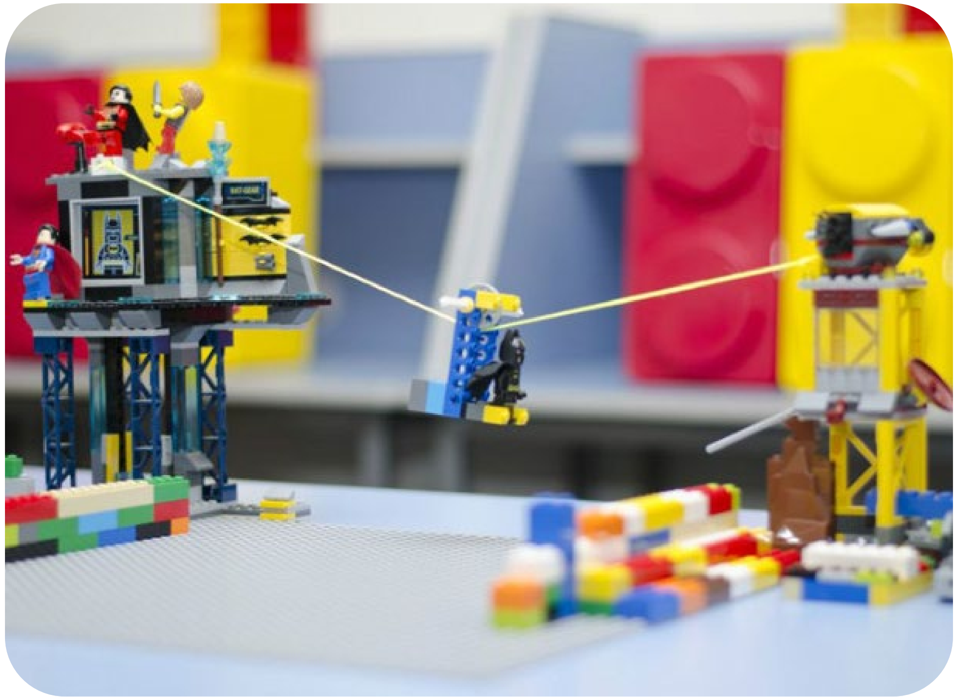
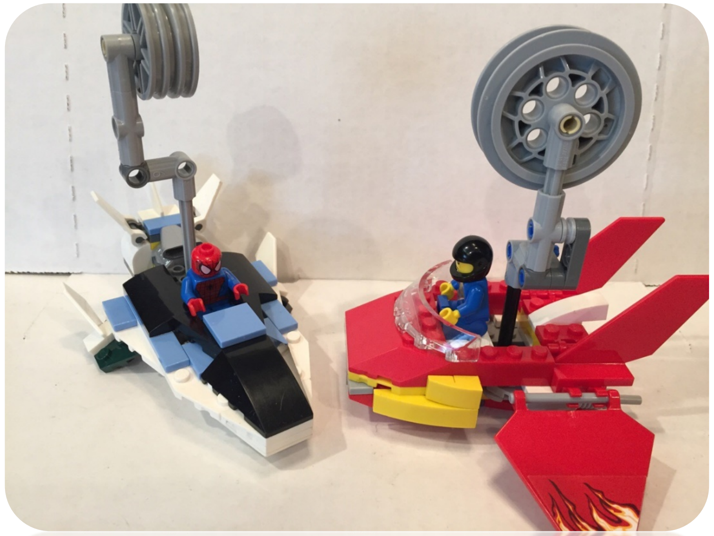
- How could you modify this challenge for different grade levels?
- What kind of spatial language could you use?

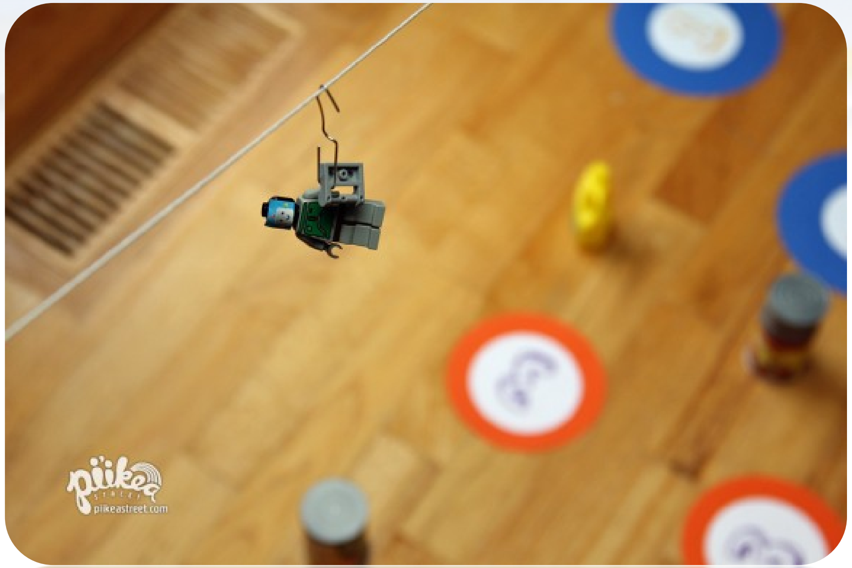
# Challenge: Ride the Line!

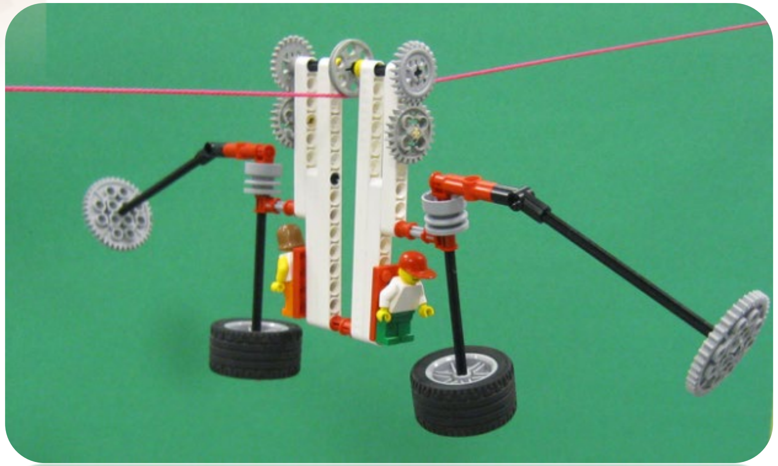
Our heroes need a way to make their great escape from their latest adventure. Perhaps your idea is to build something for your LEGO hero to sit in as he zips down the line. This is a great opportunity to test out those master builder skills!

To build a machine to travel on the string, you might (or might not!) need at least one wheel and some technic pieces to add weight so that the vehicle balances (you will need that for sure). It can take several experiments to get the balance right. If you string is over a hard floor, the vehicles can crash in pretty dramatic fashion too.

Additional Challenge: Target Acquired! Let’s zipline our heroes into a field of targets!





# Challenge: Musical Monsters

This Brickfest challenge involves combining ideas to create an elaborate monster! To do this every young engineer starts by building their own monster while music plays in the background. Then when the music stops everyone must pass their monster to the left. When the music begins again, kids add onto a fellow Brickfest member's design. At the end every monster will be unique because of the variety of ideas!

A fun book to go along with this activity for your young builders is the *LEGO® NEXO KNIGHTS™ - Book of Monsters*

Tip: With some hot glue,  googly eyes, or some stickers (ex. Inanimate Office Supply Stickers), you can upgrade your Duplo Legos into a fun monster building set that can be used over and over again!


# And so many more…

- A secret lair up in the air: Construct the tallest LEGO skyscraper that you can while maintaining stability.  Their tower must be able to withstand the heroes' attack (a shake test)

- Build Bridges: Challenge students to build a bridge that is strong and sturdy enough that no LEGO people fall into the ocean (or sink).

- Craft Amusement Park Rides that really move


# Create a "Brain Building" Tub

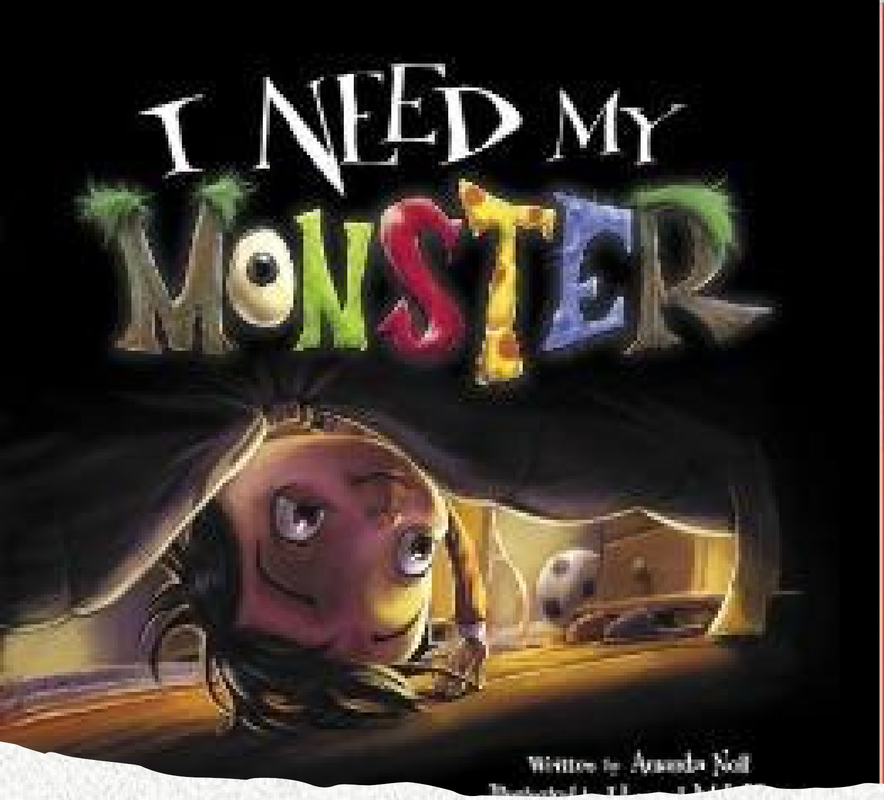
KEVA planks are a great equalizer in the classroom.

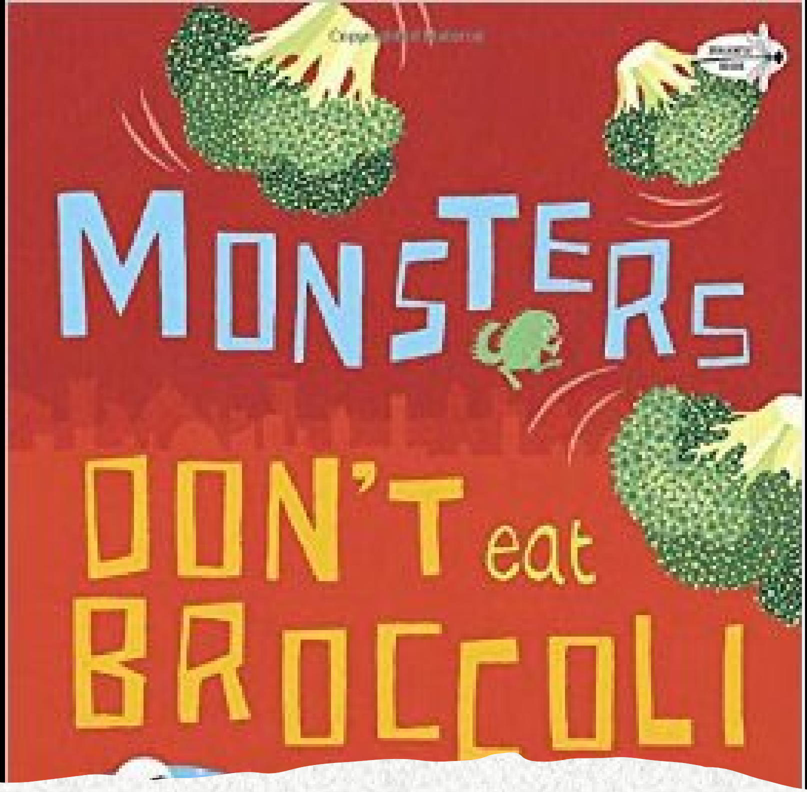
Keep it simple. Have a tub or spot with everything students need to use these building blocks. Inside keep the KEVA Planks, a red ball that comes with the kit, and challenge cards.

Keep these cards inside the tub so students always have guided objectives to follow when they are designing and building their own creation.

Students who use the challenge cards usually end up blending the written challenge with their own creative thinking.

Sample Educators Guide, Challenge Ideas, & Lesson Plans





# Tip: Build Connections with a great book

Making connections is a critical part of learning and retaining information in any subject. The more connections we can make with what students of any age already know, the better.

Plus, a great book is memorable and a fun way to introduce a lesson/activity in any subject.

# Composers

There are lots of ways to compose 3D objects: 2D shapes can be combined to create patterns that form 3D objects when folded and 3D objects can be combined to form new 3D objects. Ex. Blocks, clay, KEVA planks, and LEGO bricks are often used to create 3D structures.



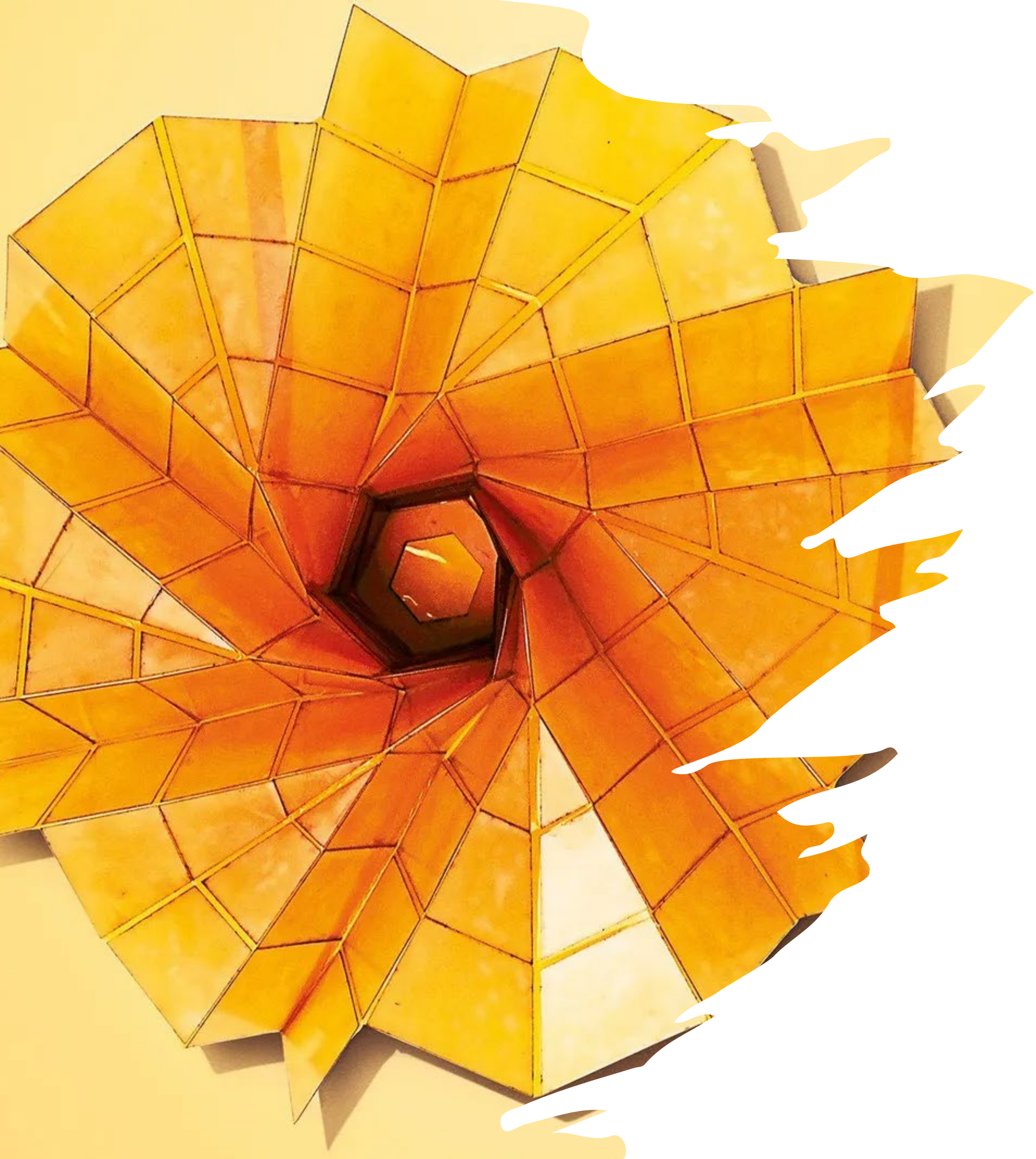

# Origami

This type of exercise not only encourages the use and development of *spatial* reasoning but also trains deductive skills and creative thinking.

The process of doing origami—in particular, the need to understand the processes that should be followed in order to fold the figure into shape—is an effective way of understanding and developing spatial reasoning with everyone from Kinder to adult students.

# Cost-effective!

One of the best things about origami is that it's relatively simple to use to develop spatial reasoning. It's accessible to almost all people and the tools required cost very little.



# Origami in Outer Space?

This isn't a skill just for odd 'spare moments' in the classroom. In space engineering, origami mathematics is applied as a method of organizing luggage for space travel, increasing flexibility of spatial structures, improving the accuracy of robotic motion, and more.

Got to love when math, art, and science work together to expand our knowledge of the universe.

- How NASA Engineers Use Origami To Design Future Spacecraft
- Origami in Space Engineering: Rediscovering the Meaning of Discovery

# Representational Gestures


These kinds of gestures are much more than a waved hello or goodbye style gesture. They communicate information.

What could these simple gestures express to you in a mathematics setting?

- Bringing hands towards each other
- Throwing one hand to the side
- Moving a finger in a line

# Ways to communicate

Research shows that children learn more when teachers gesture along with their instructions.

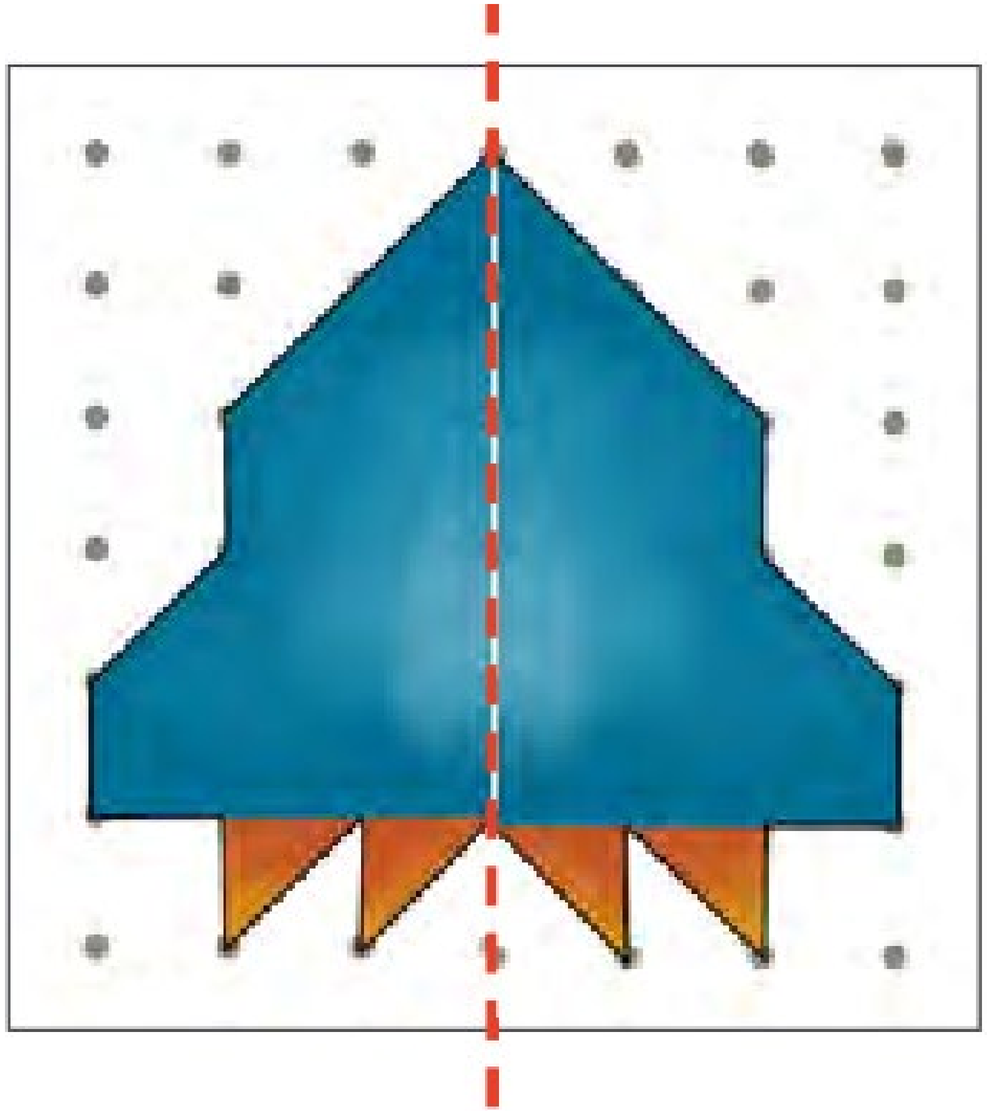
Gestures communicate important information to the learner that is not present in the verbal instructions.

# Symmetry

Some objects have multiple lines of symmetry. Some objects are asymmetric, meaning they have no symmetry.

# Activity ideas:

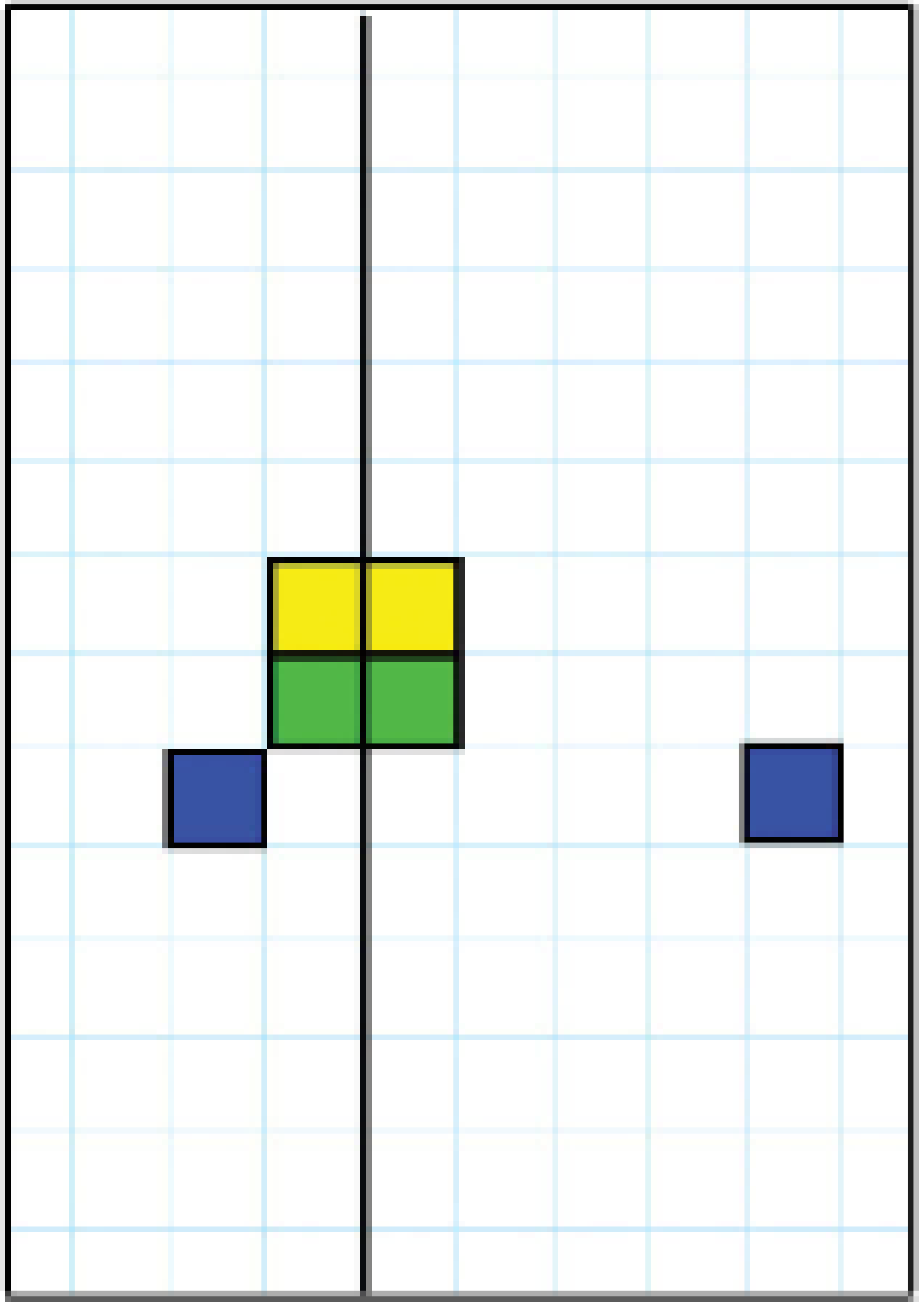
- **Drawing a blank:** Introduce reflection symmetry and the line of symmetry through folded drawings, art projects, and mirror-image halves.
- **Pattern block Puzzles:** Use pattern blocks to create symmetric designs. Children are provided with half-finished block designs on one side of a line of symmetry, ex. A line of tape on a cookie sheet. They're challenged to create a symmetric design by correctly placing matching blocks on the other side. Extend the challenge by using a horizontal line of symmetry, a diagonal line, and/or double lines of symmetry.
- **Symmetry Detectives:** As a quick-challenge for older students or longer activity for younger- Students look at pre-made symmetry patterns on cookie sheets and decide which are correct and which have errors.



# Pentomino Symmetry Games

Children challenge each other to complete symmetrical puzzles/designs across a line of symmetry using pentominoes. First round: a taped line of symmetry. Second round: Use a game board with a 12x11 grid. The game ends when the board is so filled no more pentominoes can be placed without going over the outer boundary.

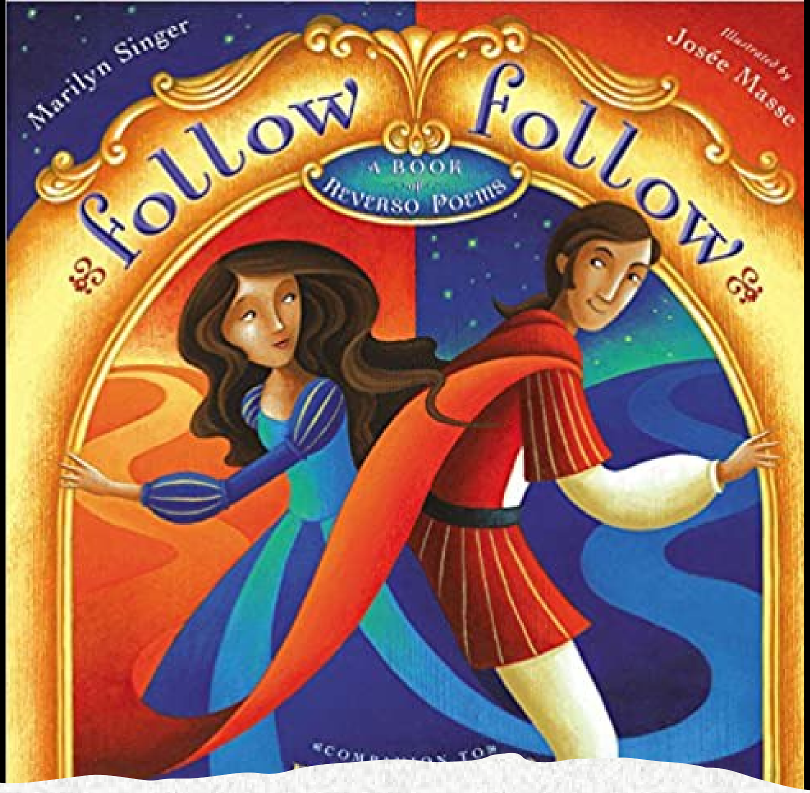
- Variations: Instead of placing a single pentomino, players can place 2 or 3 on each turn. Or, one partner can place all 12 at once and challenging the other player to find all the corresponding matches.
- The games are more challenging if the player who has to match the leader is not allowed to watch their partner place the challenge pentomino. This can be incorporated as a rule.
- Increase the challenge by changing the orientation of the line of symmetry.

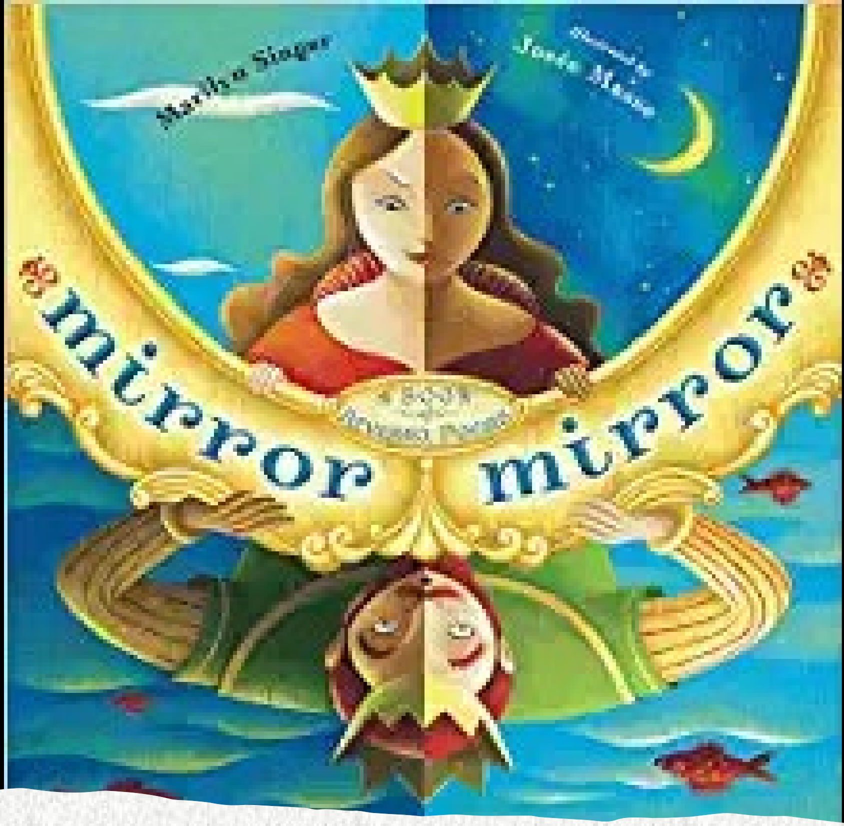


# More ideas

- **Symmetry on Grids:** Students learn to recognize and create symmetrical patterns on a grid. Then challenge each other to find symmetrical matches to configurations of squares on one side of a grid.
  - Notice the strategies students use. Many students find it hard to verbalize precise instructions for moving an incorrectly placed square to make a symmetrical match. One effective strategy to encourage precise language is to follow instructions to the extreme. Ex. If a student says, “Move the square up,” you can move it to the top of the grid, etc. Encourage students to count the squares on the grid as a scaffold.
  - Increase the challenge by placing a greater number of squares each turn.
  - Variation: Create a symmetric pattern on both sides of the line of symmetry using 5 tiles on each side. Have them ‘take a picture’ in their mind and then have them close their eyes. Switch 1 or more squares from either side of the board. Invite them to open their eyes and ask them to figure out what changed.

**Make it a game! Students can challenge each other. (eyes open or closed)**


# Tip: Build connections with a good book

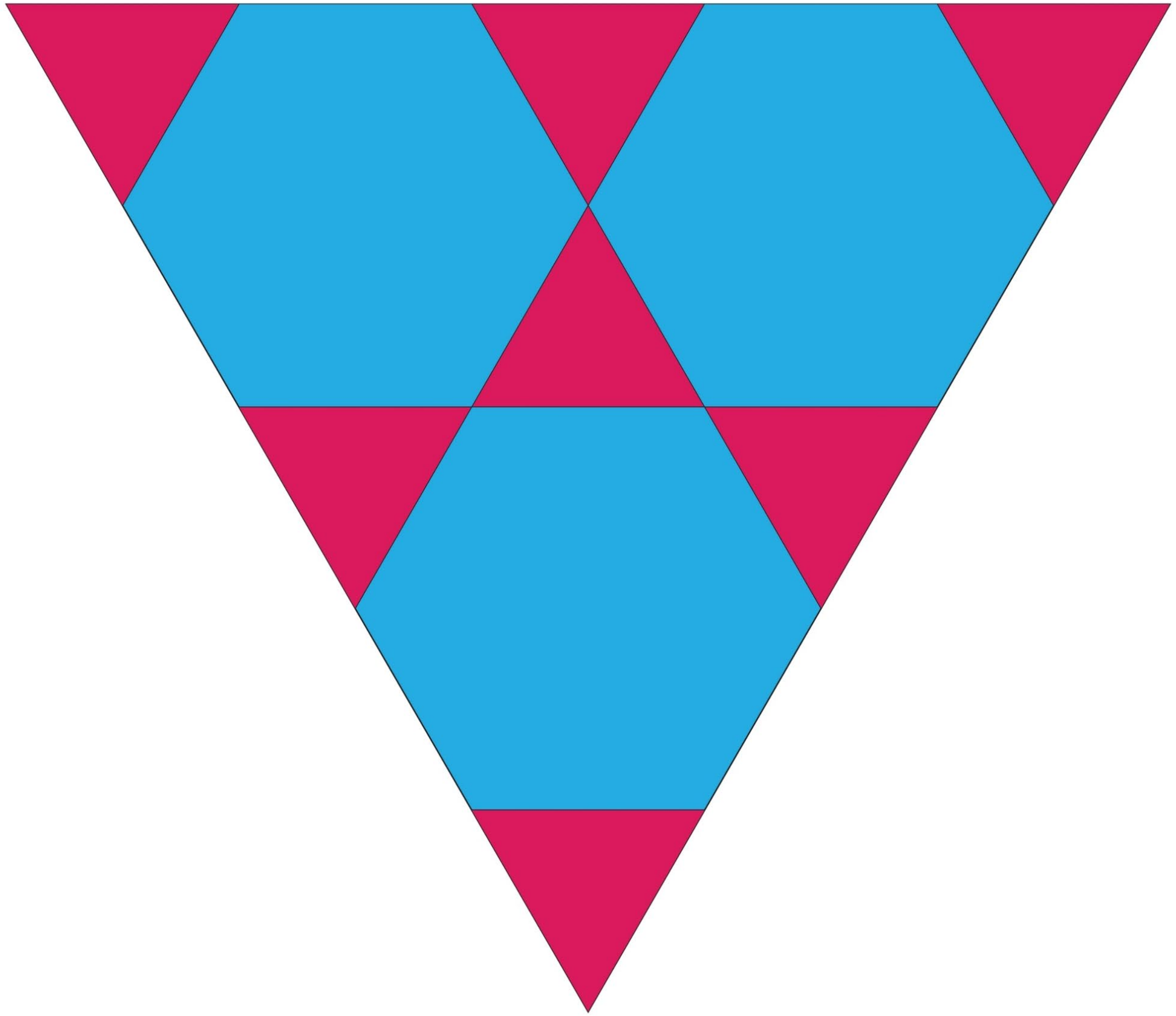
Activating Prior Knowledge basically means figuring out what students already know and helping them connect it to new ideas. When we can connect something "old" to something new it helps us better understand the new.

*What happens when you hold up a mirror to poems about Greek myths or fairy tales? You get a brand-new perspective on the classics!*

# Missing Pieces

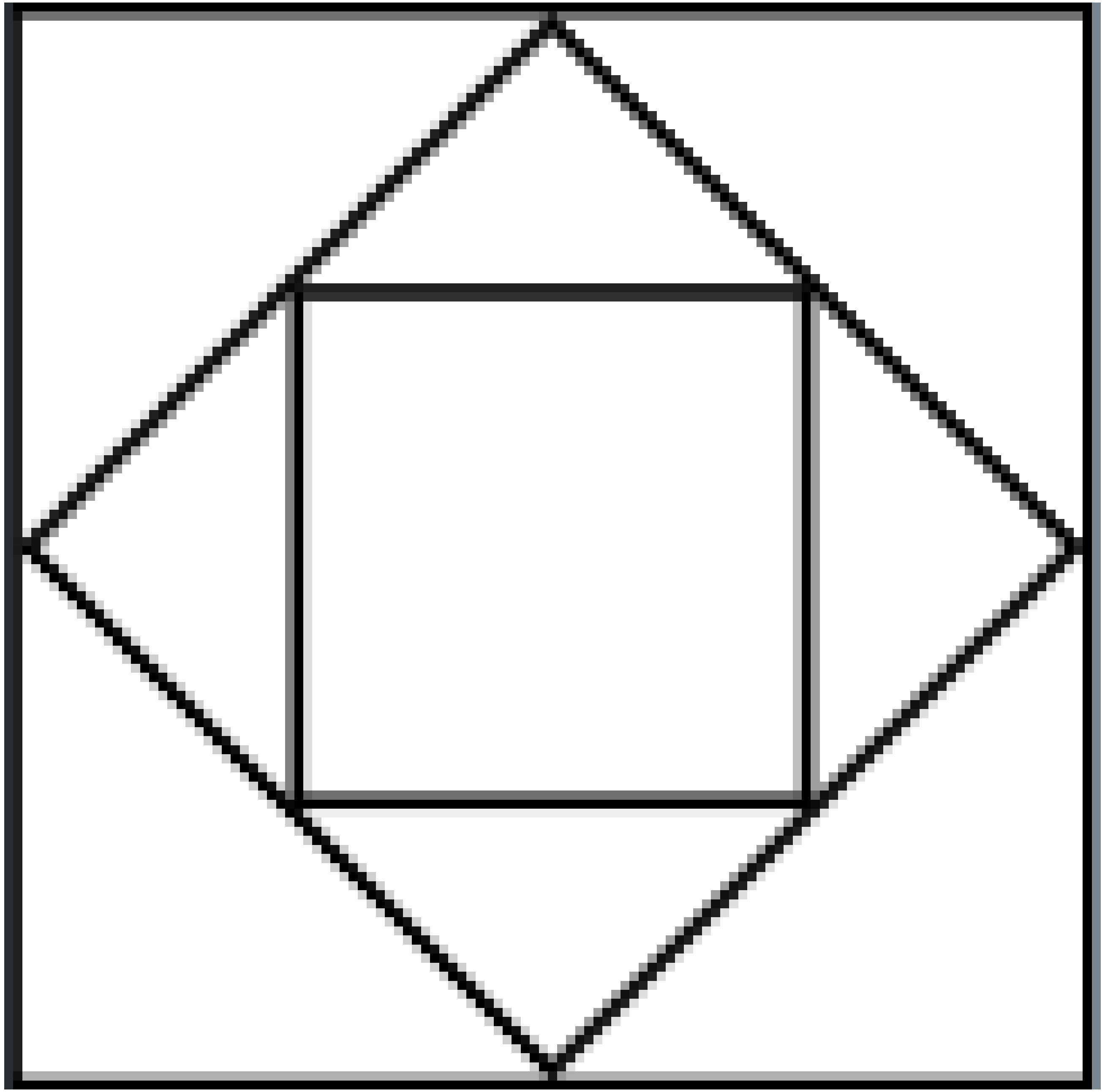
Just as experiences composing and decomposing numbers are important for the development of number sense (ex., 10 is made up of 2 and 8, but also 5 and 5, and 6 and 4), it is important for children's understanding in geometry that they experience decomposing shapes into smaller parts and recomposing them into a whole.

It is the beginning of a strong foundation for future success in geometry.



# Take a Look

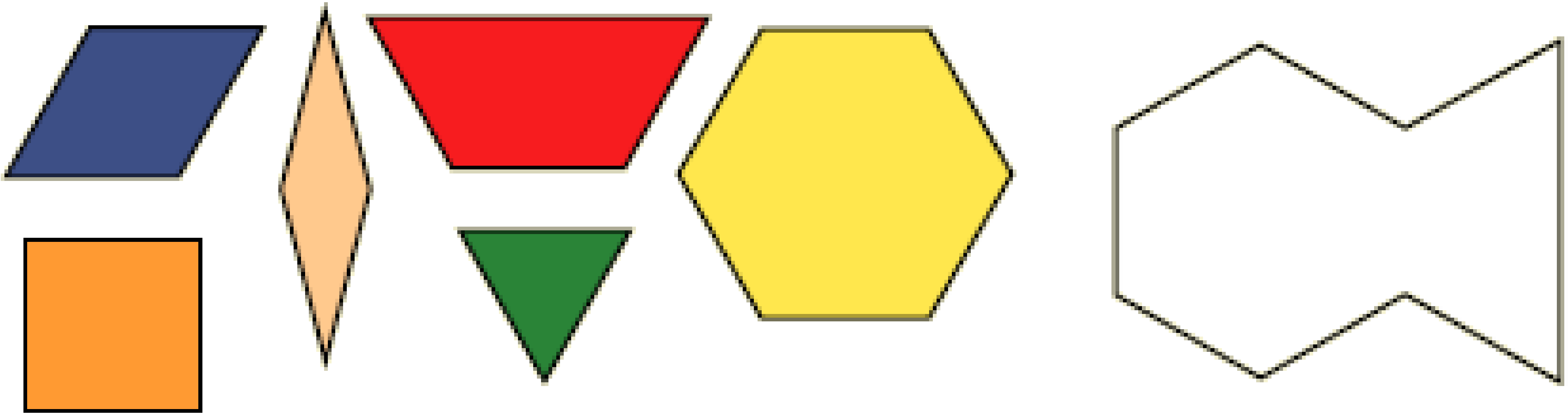
You have 5 seconds to study this. You should not be drawing yet.



# Do you remember?

Do your best to sketch the image from memory on a scrap of paper.

# Composition and Decomposition Tasks



- Using any combination of the pattern blocks above, and your visualization skills, determine the fewest number of blocks needed to fill the figure at the right.
- What is the greatest number of blocks needed to fill the figure?
- Composing and decomposing activities are full of opportunities to visualize possible solutions before actually carrying out the task with manipulatives.

# Activity Ideas

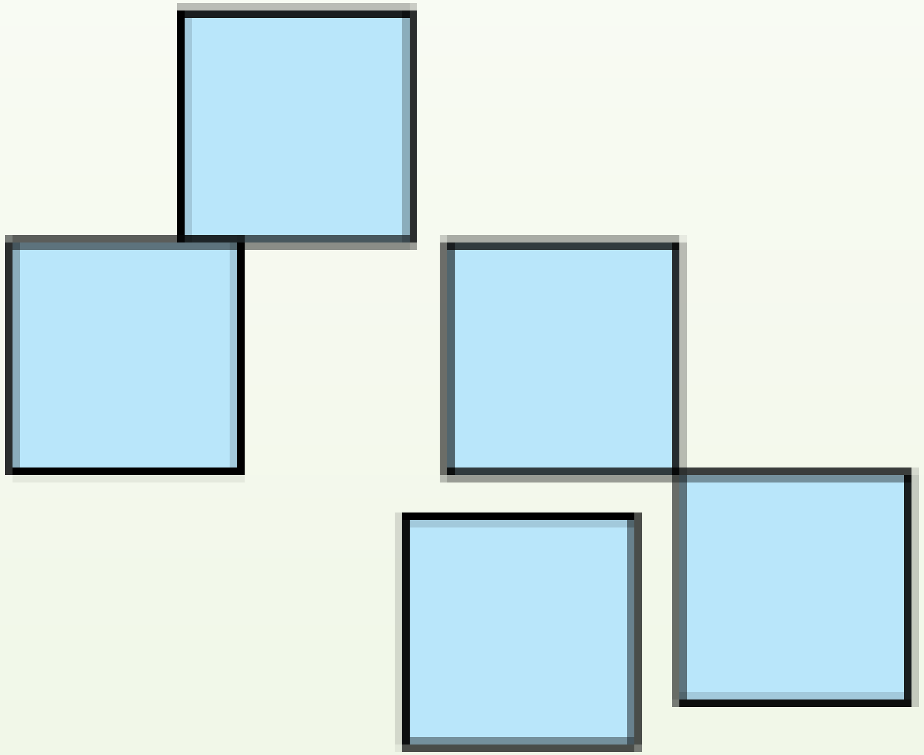
- **See it, Build It, Check It—Pattern Blocks:** Students are presented with an image made of 2D shapes created with pattern blocks. They're challenged to recreate the image on their own sheets. First round: Original is visible. Second Round: Original is hidden from view.
- **It's a Cover Up!** – Students are shown an outline of a shape on an interactive whiteboard or paper. They are asked to name the shape and cover it using pattern blocks. Start with simpler shapes and gradually get more complex as students gain experience. Note: Children are more successful if you say *cover* the shape instead of fill it in.
- **Square Mover** – Students are shown a shape made of squares glued on paper or square magnet tiles on a tray. They copy the shape using their materials. Have students close their eyes after you say the 'Square Mover' is going to try and trick them. The teacher then shows a second shape using the same number of squares. Students are challenged to transform their shape into this target shape using **as few moves as possible.**

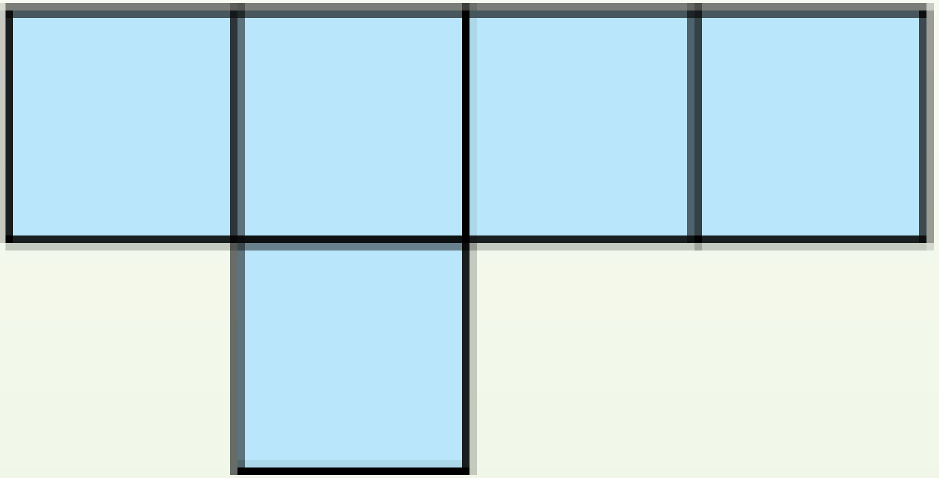
# Activity: "Find the Magic (Pentomino) Keys"

There is a palpable excitement in the Kindergarten classroom. The children sit in a large circle in rapt attention as their teacher tells the story of a princess, a prince, and a scary troll. "Oh no, the troll has locked the prince in the dungeon, and the only way to release him is to unlock the 6 doors in the long tunnel. Our challenge is to make 6 magic keys for the 6 doors. Can you help me? Each key needs to be made with 5 square tiles, but with a special rule—the squares have to line up edge to edge, not corner to corner. And, each key has to be different. Are we ready to make the 6 keys?" The children lean into the circle and exclaim: "Yes!"

# Using sets of five square tiles, how many unique pentomino configurations can you make?

Note: A pentomino
is a geometric figure formed by joining five equal squares edge to edge



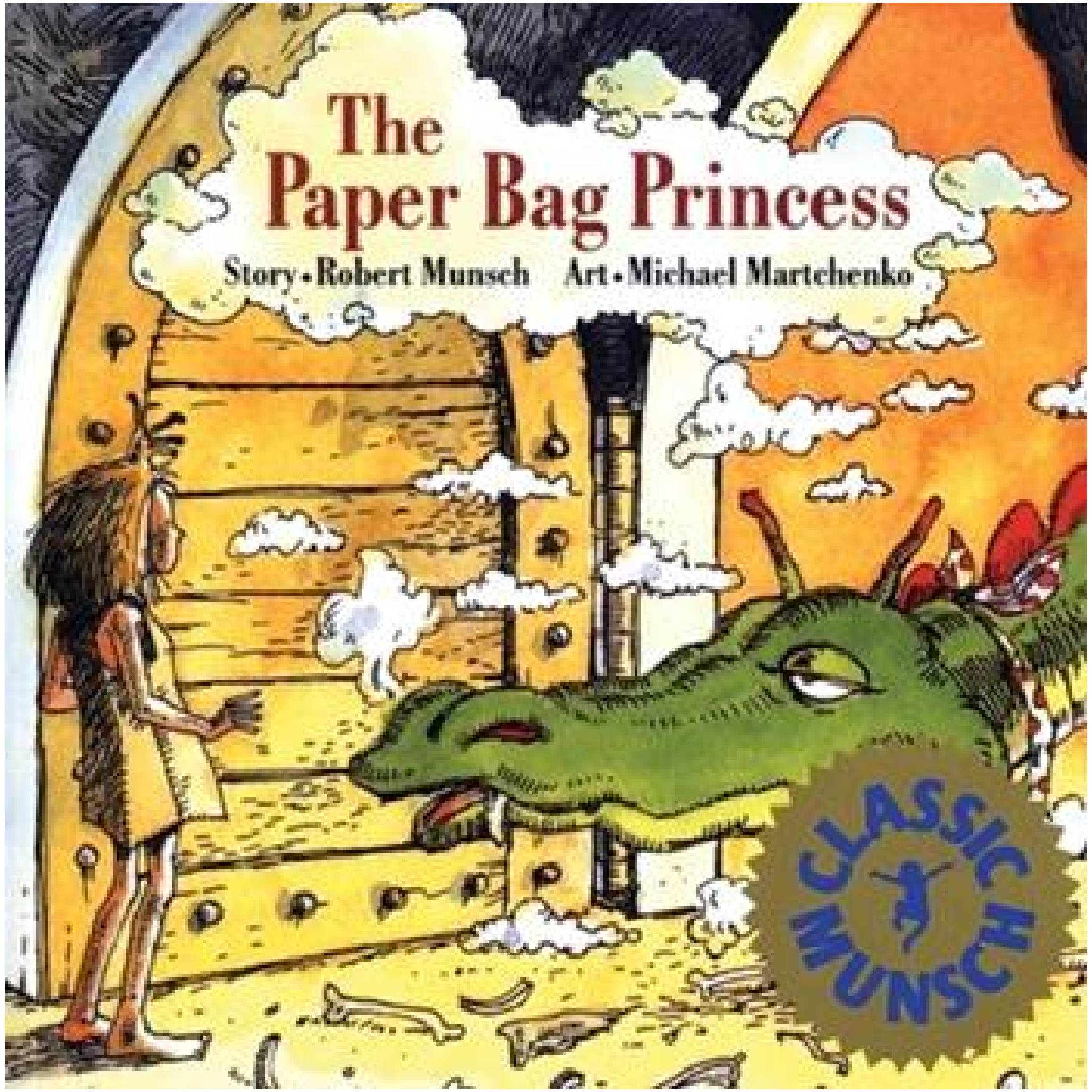


# Unlock Learning

The students work with square tiles to create as many configurations using five squares as possible, while making sure that each square is connected to at least one other by one side.

For younger students only challenge them to find 6 keys. This starts as a whole group challenge and then you can split students into pairs/teams.

**Variation**: Use a book like *The Paper Bag Princess* by Robert Munsch. Stop the story partway through and change the words of the story so that the dragon challenges the princess (Elizabeth) to create 12 magic keys to save Prince Ronald. *There are 12 different locks so we have to make 12 different keys. We have to use 5 square tiles to make each key*.



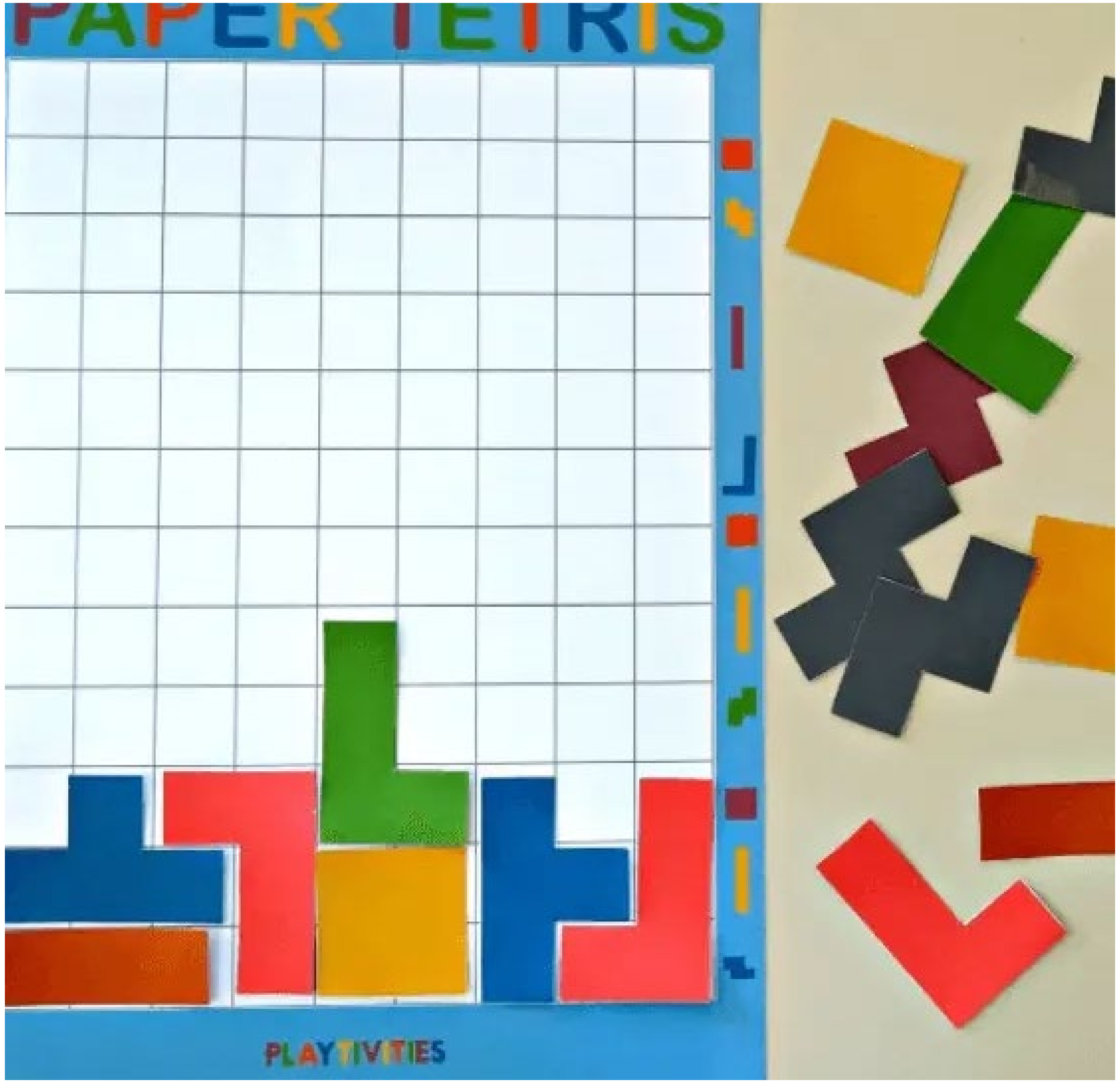
# Unlock Learning

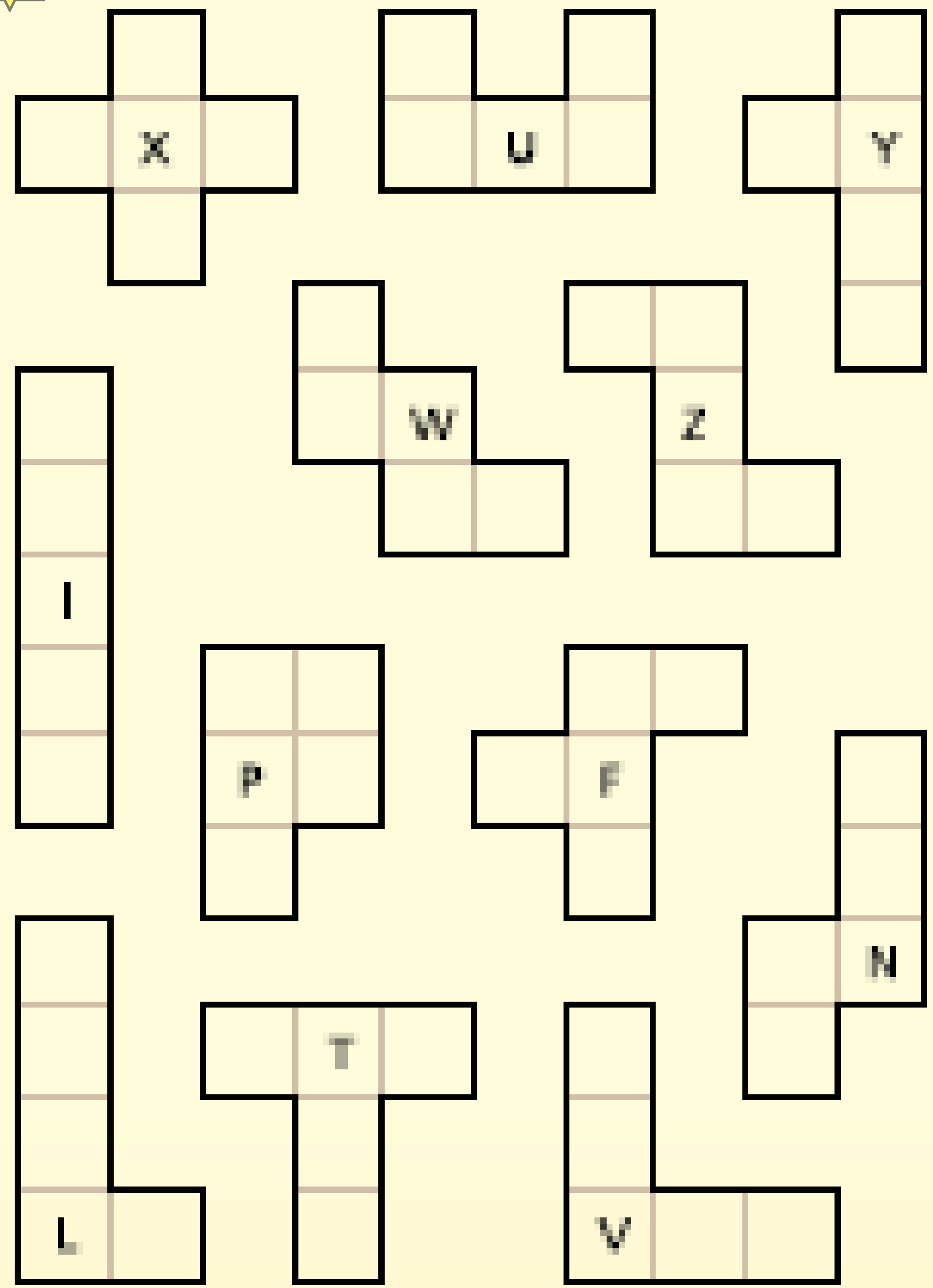
This task, and the larger task of finding all 12 pentominoes (some can be mirrored for 18 total shapes) is something that older students and even many adults find challenging to solve.

Yet in the classrooms that were part of the project, the children's level of interest, persistence, and ultimately success at finding the "keys" was impressive.

# Extensions and Variations

- Place large grid paper at the front of the room or use an interactive whiteboard. Invite students to give you instructions for drawing each key. Number each new pentomino on paper for easy reference.
- Older students can create pentominoes by arranging square tiles on grid paper with 1-inch squares. This allows them to trace the outlines of each key/pentomino they create.
- Introduce students to Tetris: this uses tetrominoes (geometric shapes made of 4 squares.)
- Invite students to use 6 squares to create unique hexominoes. There are 35 possible.






# Box or Not?

Show students all 12 pentominoes. Which pentomino shapes can be folded to form a box (i.e., open-topped cube)? They visualize and then test their predictions using physical materials.

**Extensions & Variations:**

Invite students to discover all the possible hexominoes (6-sq) that can be folded to make cubes. Since there are 35 possible ways, with this have students start with a cube in hand and work backwards. Work to discover all the ways a cube can be decomposed into a 2D hexomino and then refolded.

Try other polyhedra, ex. Square-based pyramids.

*https://www.scholastic.com/content/dam/teachers/lesson-plans/migrated-files-in-body/pentominoes.pdf*

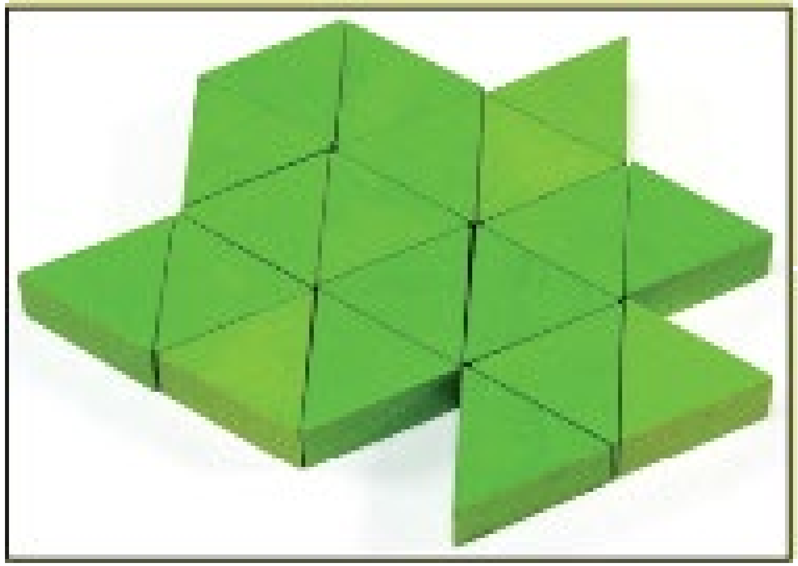
# Finding the Pattern

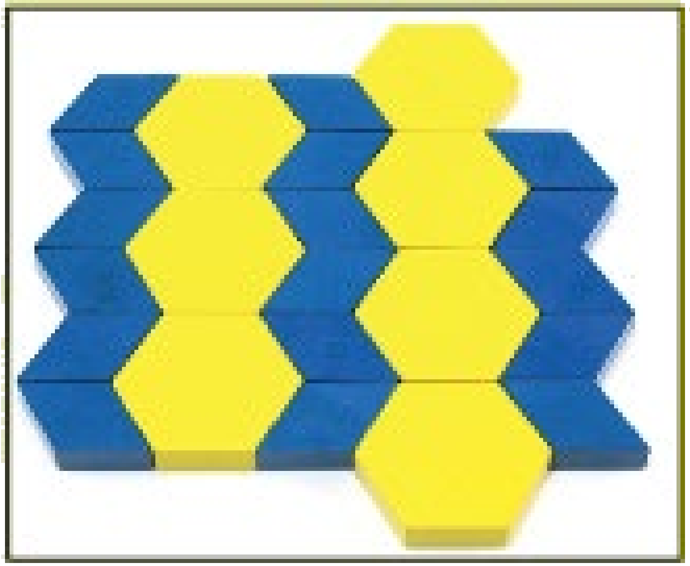
As with puzzles, tasks that involve composing, decomposing, and transforming 2D and 3D shapes also call on mental rotation skills.

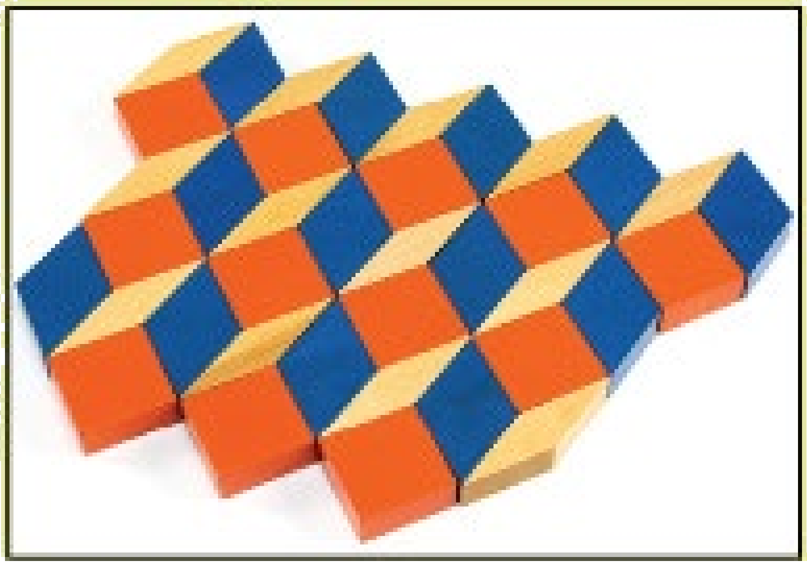
Ex. With pattern blocks, tangrams, etc., children must recognize which blocks can be rotated and placed in various positions to complete the image.

# Tesselating Tiles

Examples of tessellating designs, like Islamic tile art, created with pattern blocks. These can be simple one-block designs or more complex patterns.







# Puzzle it out

Puzzle play provides powerful opportunities to develop spatial thinking skills.

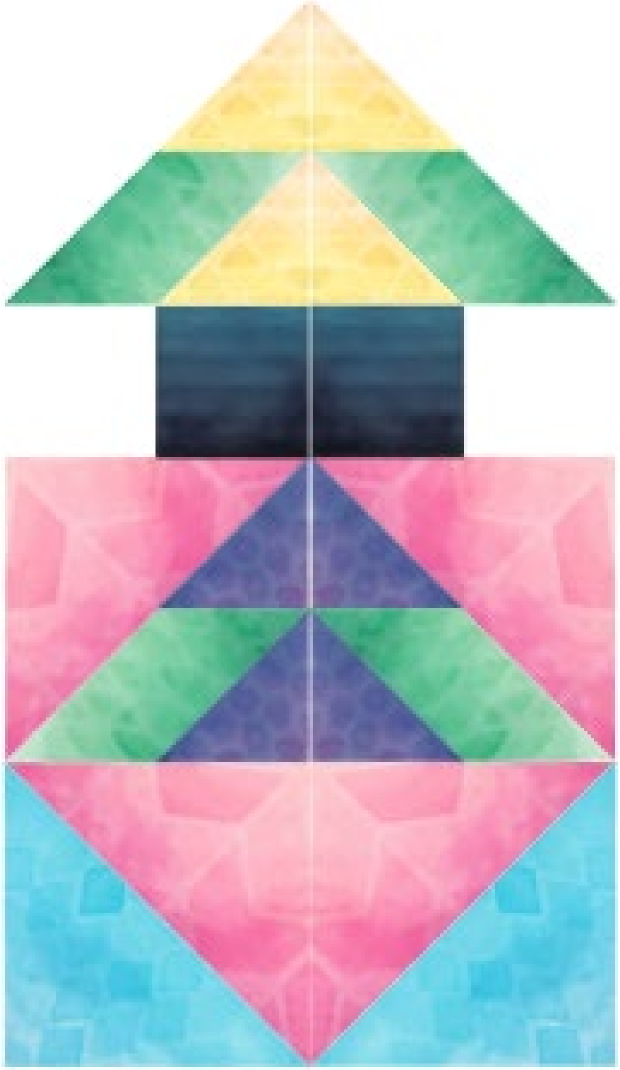
# Tangrams

The Tangram is a deceptively simple set of seven geometric shapes made up of five triangles (two small triangles, one medium triangle, and two large triangles), a square, and a parallelogram.

When the pieces are arranged together, they suggest an amazing variety of forms, embodying many numerical and geometric concepts.

https://www.hand2mind.com/glossary-of-hands-on-manipulatives/tangrams

https://www.commonsense.org/education/lesson-plans/tangram-fun



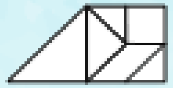
# Hand to Mind!

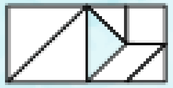
Tangrams are great tools for practicing geometry, area, perimeter, and fractions.

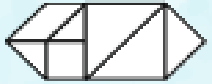
Give your students short frequent challenges.

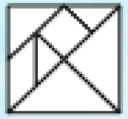
"You all have the same 7 pieces. You have 30 seconds to make a bird."

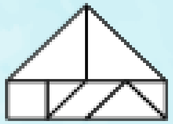
# Growing in complexity

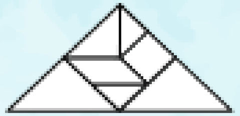

CARD 44

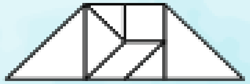

CARD 45

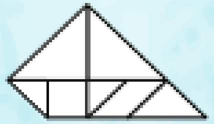

CARD 46

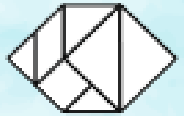

CARD 47

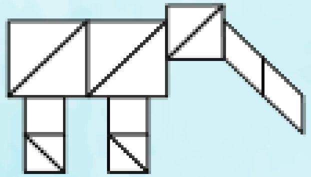

CARD 48

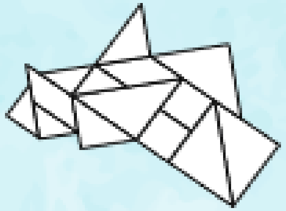

CARD 49

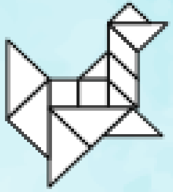

CARD 50

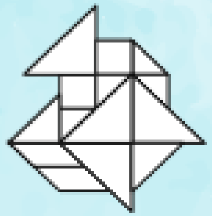

CARD 51


CARD 52


CARD 57


CARD 58


CARD 59


CARD 60

# Addressing Decomposition

Decomposition involves taking objects apart.

While students are often observed or explicitly asked to build or compose 3D structures, they’re rarely required to deconstruct objects in any sort of systematic manner. Though they’re naturally good at knocking them down!

# Activity Ideas: Build It in Your Mind

Students listen to instructions describing a 3D structure build from cubes and use their imaginations to build it. They are then shown (a photo of) four structures (the correct one and three others) and are asked to identify the structure they built in their minds. With more experience the descriptions get less explicit in detail. This is meant to be a short activity with only one or two challenges given at a session.

# Flash! See It, Build It, Check It

Students are briefly presented with a 3D structure. They must then recreate the structure from memory. This activity can be easily adapted by changing the complexity of the structure. In general, the more parts and directions the parts go in, the more difficult it is to remember.

Tips: Depending on complexity and student experience you may show it more than once. Encourage chunking strategies and tell students to relate the object or parts of it to familiar objects.

This can also be done with pattern blocks for 2D structures.

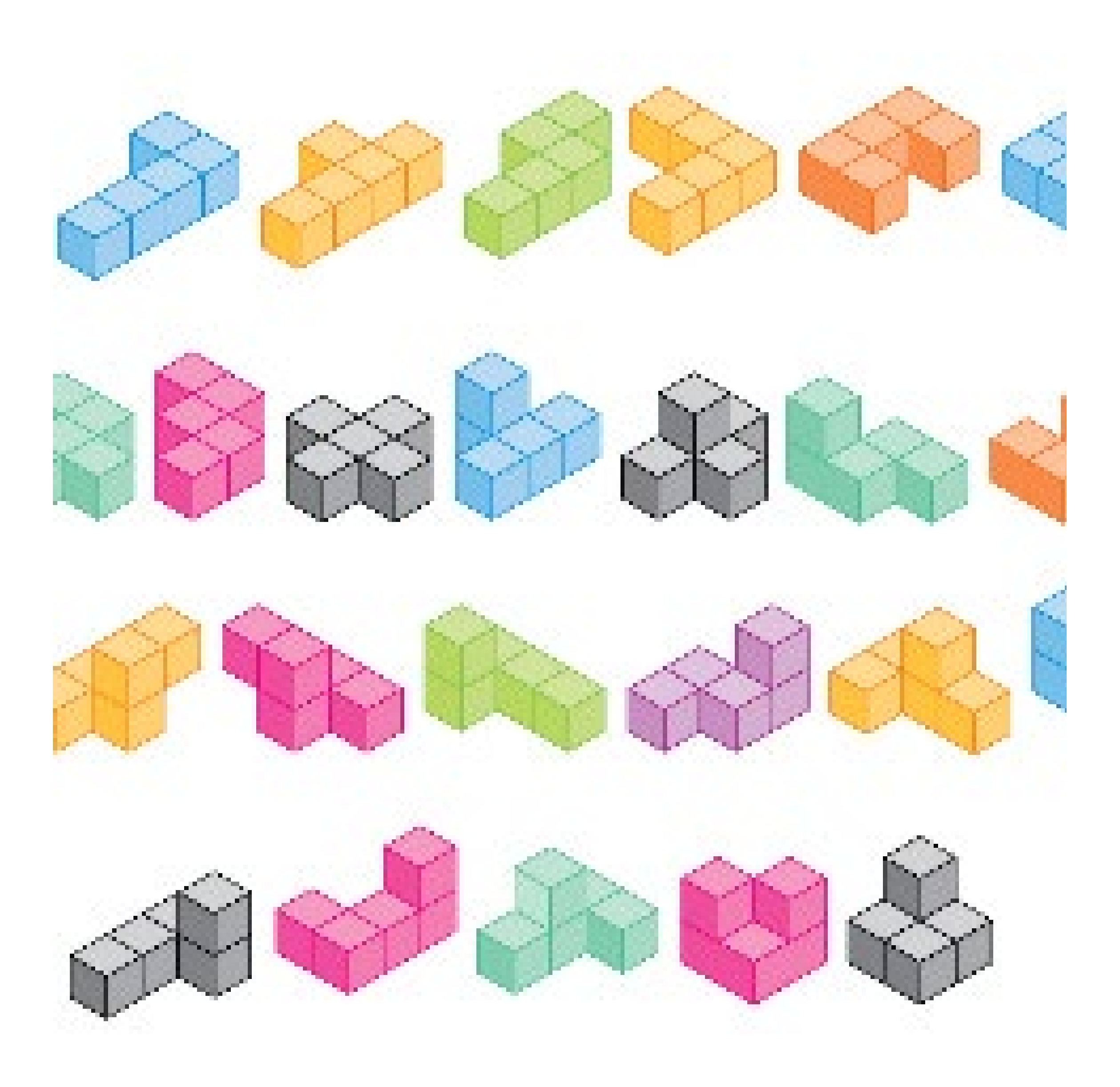
# The Cube Challenge

Students build and compare structures to create as many unique structures as possible with 3 (max number is 2), 4 (max number of possible structures is 8), 5, (max number of unique combinations is 29) interlocking cubes.

Note: One 'rule' is that each cube must line up with adjacent cubes, so all edges are flush. They can't be twisted at an angle. Do not tell students the number of possible solutions at the outset.

**Extension:** Have students try to find all 29 solutions to the five-cube challenge. You may wish to provide the solutions and then they can identify (based on 2D representations), which ones they have and are missing. Then they can build the missing ones.

https://www.cutoutfoldup.com/patterns/1204_us.pdf



# It's all relative

Students need to understand the idea of relative location, namely, that any location can only be described in relation to them or something or someone else.

They also need the means to communicate about and represent space and describe where objects are, ex. Maps, gestures, words, grids, models.

# Map Mania

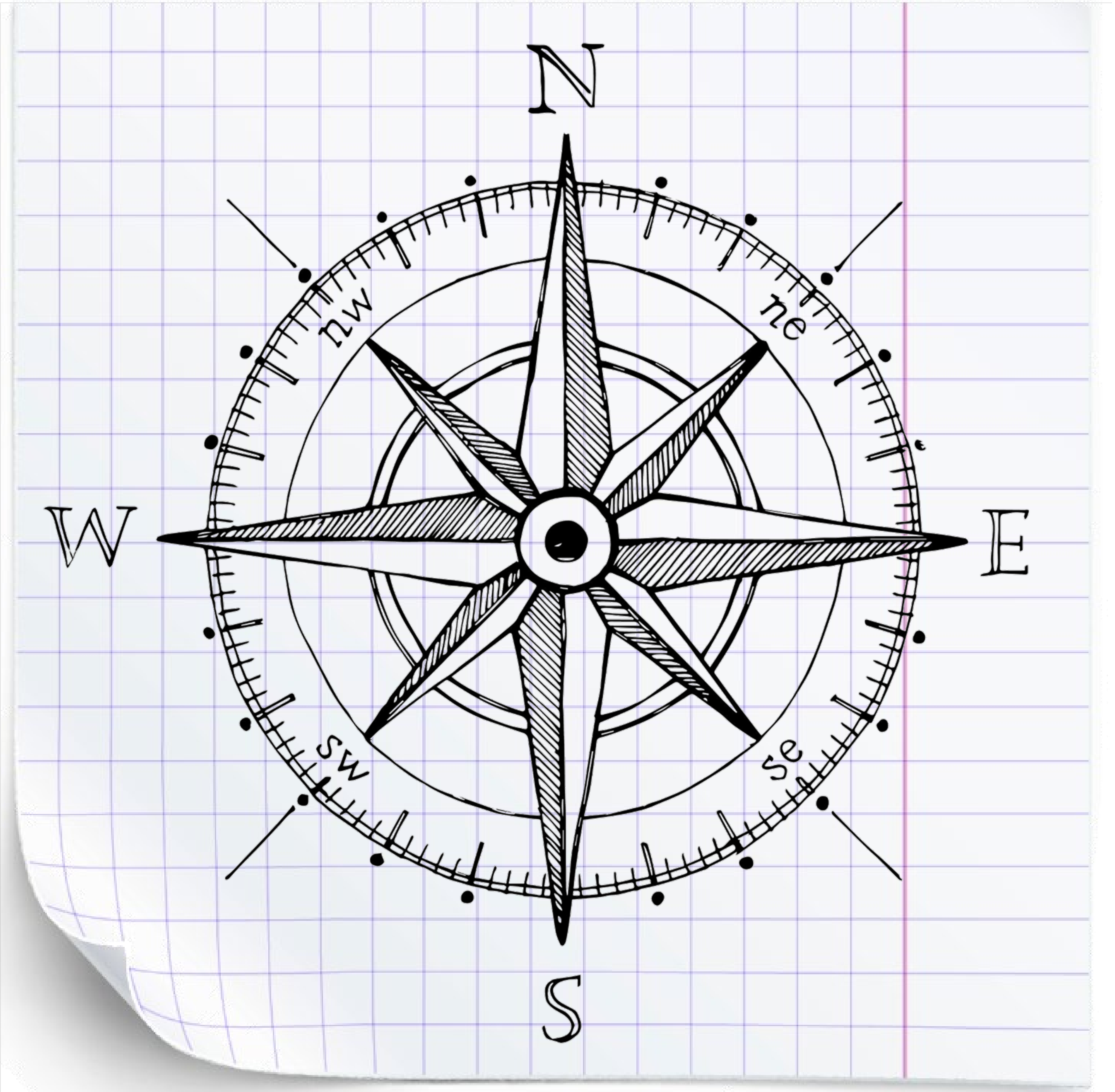
Kids love maps and mapping things, but these topics seem to be an afterthought in most geometry curricula.

Mapping and location tie to later mathematics when students are asked to consider Cartesian coordinate systems and all forms of graphing.

# Map Out Your Imagination!

Once students have seen and discussed multiple examples of imaginary maps in books from the library or from online [a large image gallery of fantasy maps is available [here] work together to create a story and/or cartographic story map.

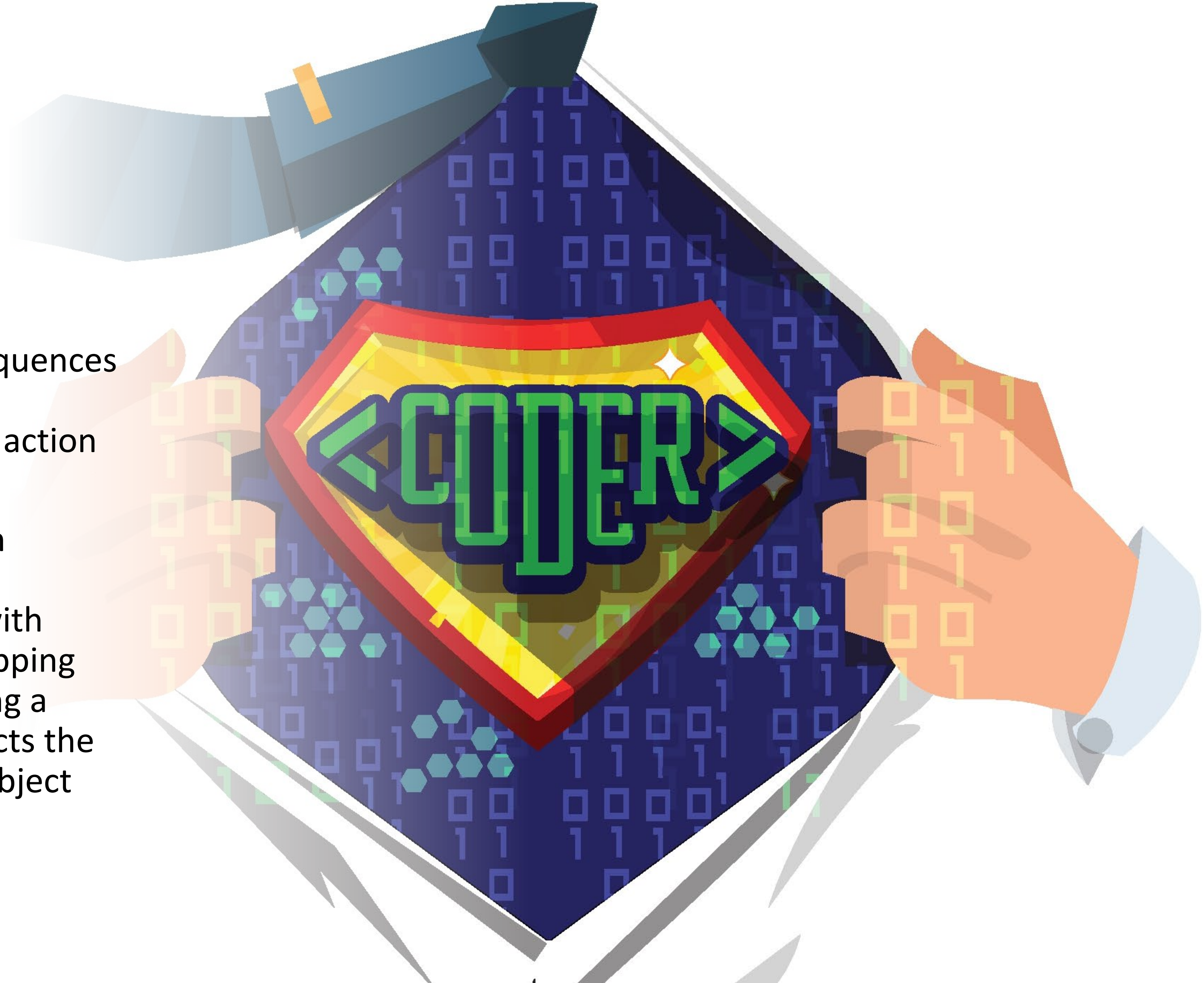
Ex. Students make a literal story map of the path taken to get to the witch's candy cottage, and then show the path Hansel & Gretel take out of the forest including a compass rose. *What kind of spatial language can you practice?*



# Coding

Coding involves building sequences of numbers and symbols to efficiently communicate an action or instruction.

While often associated with computer commands and programming: Coding fits with locating, orienting, and mapping because it involves designing a code or algorithm that directs the movement of a person or object along a pathway.



# Encoded messages

- In some ways all math involves coding of some kind: encoding ideas and actions into abstract symbols.
- A very simplistic example: 104 – 4 = represents taking a collection of 4 items from a larger collection of 104 items.
- Much like a good song, good code and good equations are all about how the individual pieces fit together.

# Maps Matter

- In mapping, locating, and orienting activities, directional words and positional words are foundational for many math ideas because they inherently identify relationships between objects and space.
- Much of math involves understanding relationships and this helps lay the foundation for more sophisticated math later on.

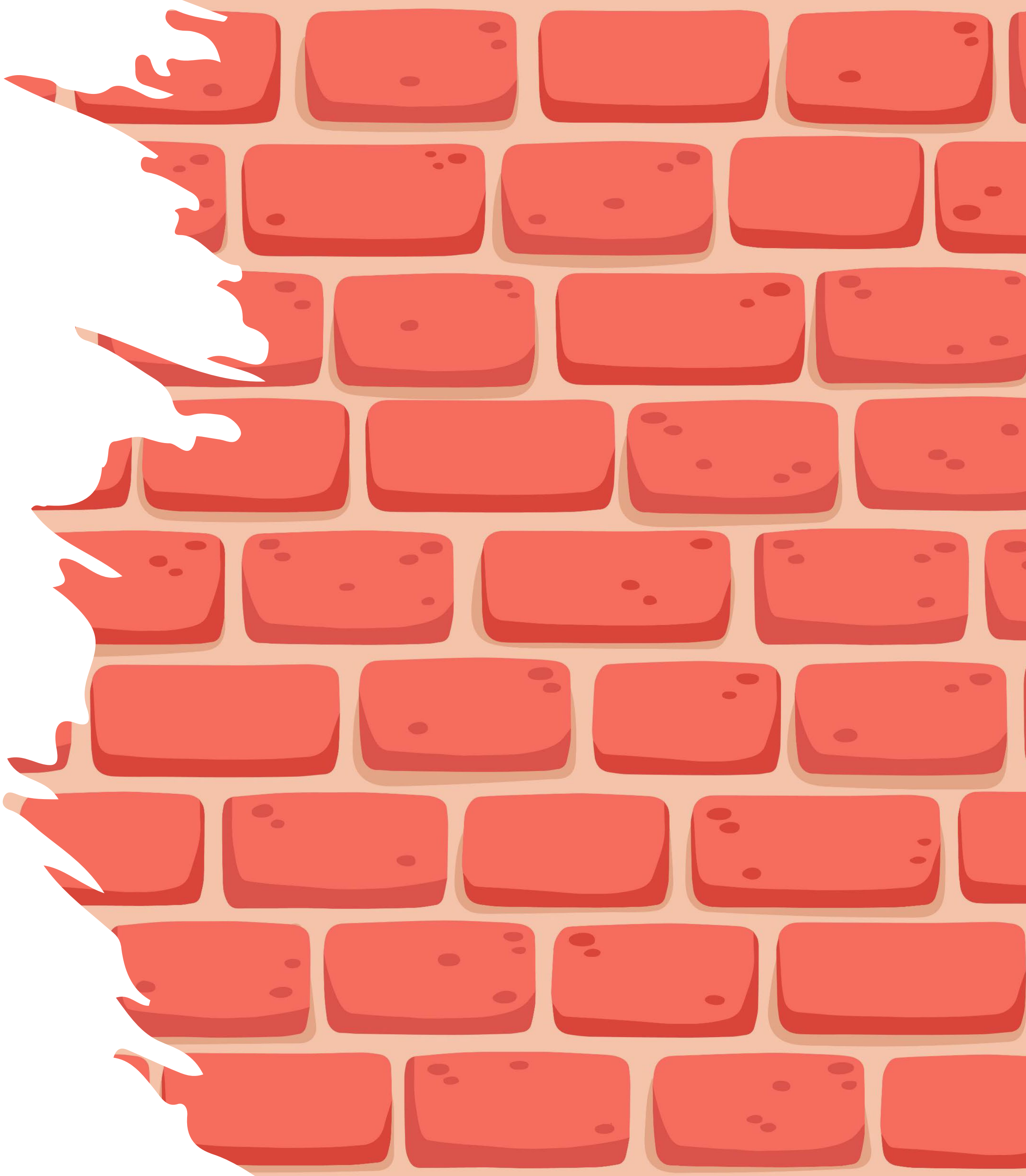
# Activity Ideas

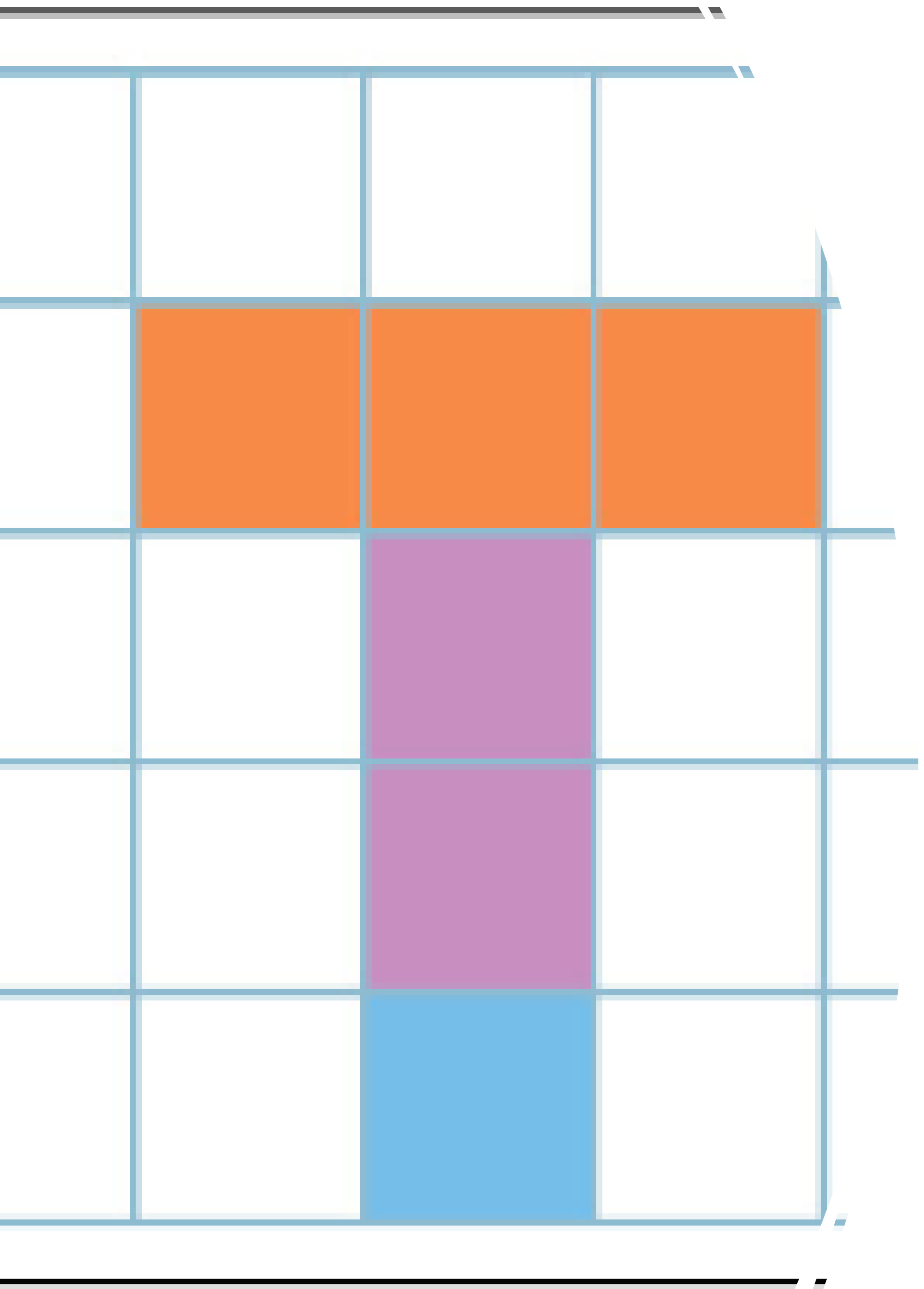
**Introductory Barrier Games** – Students play a game where one student (the designer) makes a design (with a limited number of single-color square tiles) that is hidden from their partner who is sitting by their side.

The other student (the builder) has the same materials and recreates that design based on the designer's verbal description. They then compare results.

Many variations can be made by adjusting the materials.

- Pattern blocks provide an easier version because they have more attributes for descriptions.
- Tangrams make it more challenging and draw on students' knowledge of geometric shapes.
- Adding additional colors of tiles makes it much easier to describe.

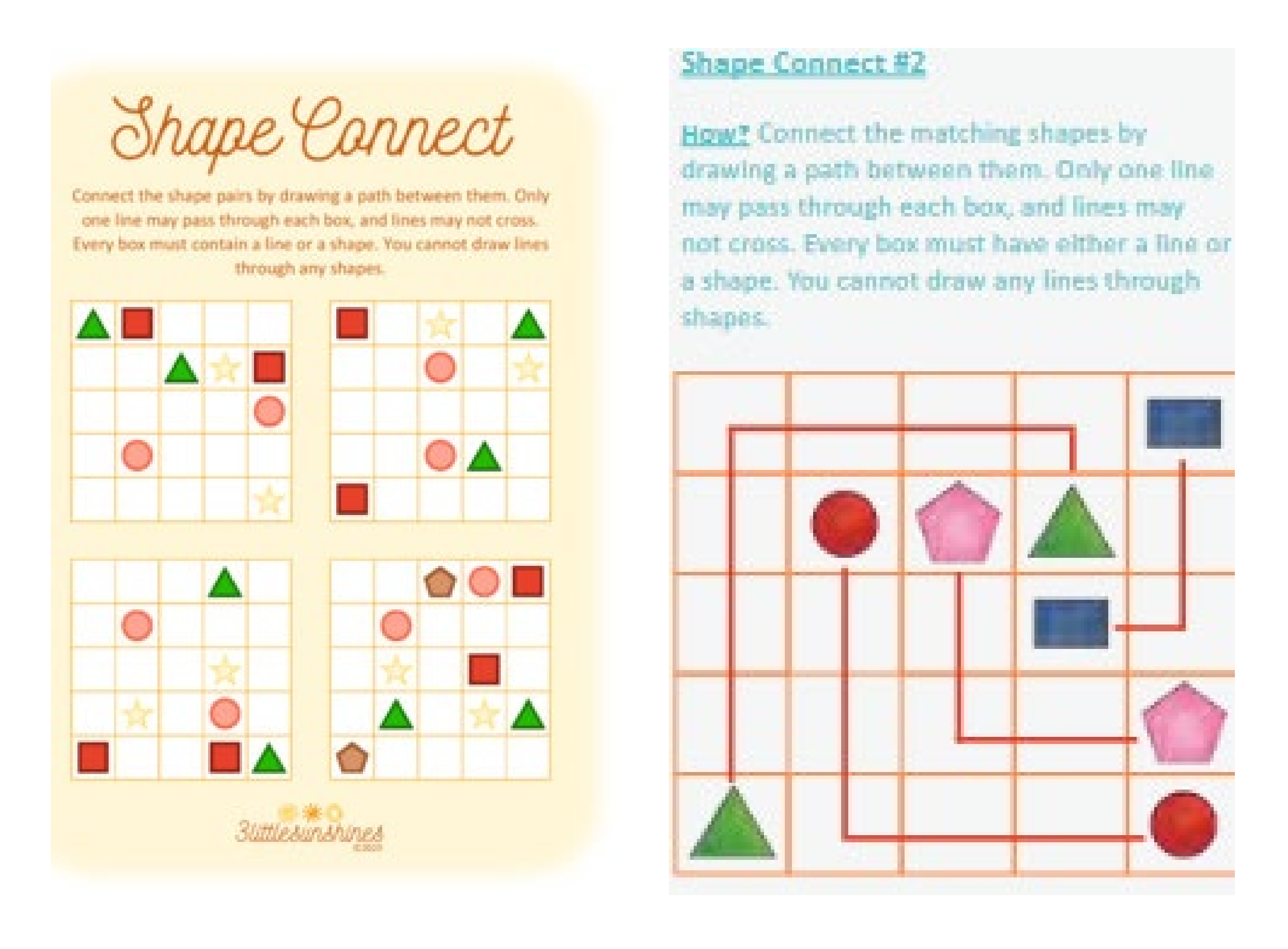




# Activities

- **Secret Shape Code:** Using a barrier, one student (the designer) places shapes on a grid to make a secret shape code. The designer gives instructions to another student (the builder) to recreate the code. They then switch roles. Varying the shapes and/or increasing the size of the grid increases the complexity of the task.
- **What did you make?** The teacher describes a design made from colored squares in a grid (ex. 5x5) that is hidden from students' view. The students follow the description, placing squares in their own grid to try and recreate the design from instructions alone.
    - Modifying for older students: Label the grid and use coordinates. E.g., Place a blue square in C1.

# Pick the Path



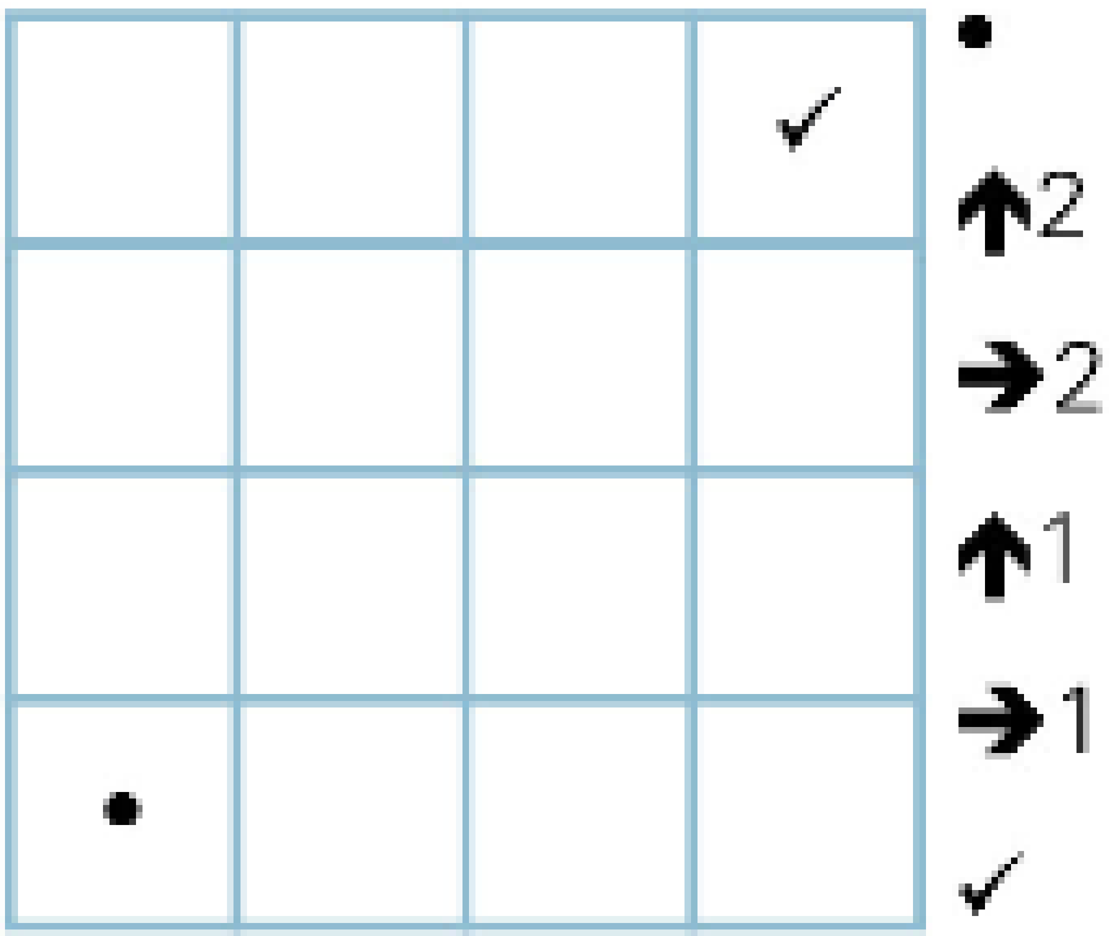
# Activities: In Control

- **Pathway Moves:** One student helps another student (or an adult) get from a starting point to an ending point on a (ten-frame) grid marked on the floor by giving the person directions for a pathway. How many different pathways can they come up with?
- **Paper Pathways (2D):** One student gives instructions to another student for a starting point (.) to an ending point (√) on a 4x4 grid. Partners switch roles and repeat, making a different pathway.
  - Add in obstacles.
  - Change the goal to move an arrow from start to finish & incorporate orientation.
  - Does facing each other increase the challenge?
  - Use a hundreds chart as the grid.

  *Note: Remember to help students realize that their first move counts as "1," not the starting square. Otherwise, there will be missteps in creating/following codes.*

# Secret Code Game

Students follow codes that indicate the moves they need to visualize as they imagine a pathway on a grid. They then trace out the pathway from a starting point to an ending point. Each step in the code includes a number (indicating the number of squares to move) and a direction arrow (indicating the direction of motion). The codes are read vertically from top to bottom. For more challenge include obstacles on the grids.



# Go Aaar! Then walk the plank…"

Students work in pairs as a coder and a code checker. One student is "Captain Coder" who has a secret treasure map with a path that ends at a treasure chest.

The Captain/coder makes a pathway to move a marker from a starting point to an ending point on a grid and then uses number and arrow cards (laying them in a row from L to R) to create a code describing the pathway they took.

Add obstacles (islands, monsters, traps) and use larger grids to increase the challenge.

*Tip*: It's helpful for coders to record their path on a grid for comparison. This should stay hidden until after the code checker has followed the code.

# The Code is more like guidelines"

The captain gives directions (the code) for the route to another student, the "pirate." The code checker/pirate tries to follow the code to recreate the Captain's path and draws the route on the grid.

If the pirate correctly follows the code to the end, he/she discovers the treasure.

Option: Add coins drawn on some squares along the route on the secret map.

# The Jolly Dodger

At the end, the pirate must try to find a faster route back to his/her ship at the starting point. Students can then compare codes from the initial route with the most direct path route.

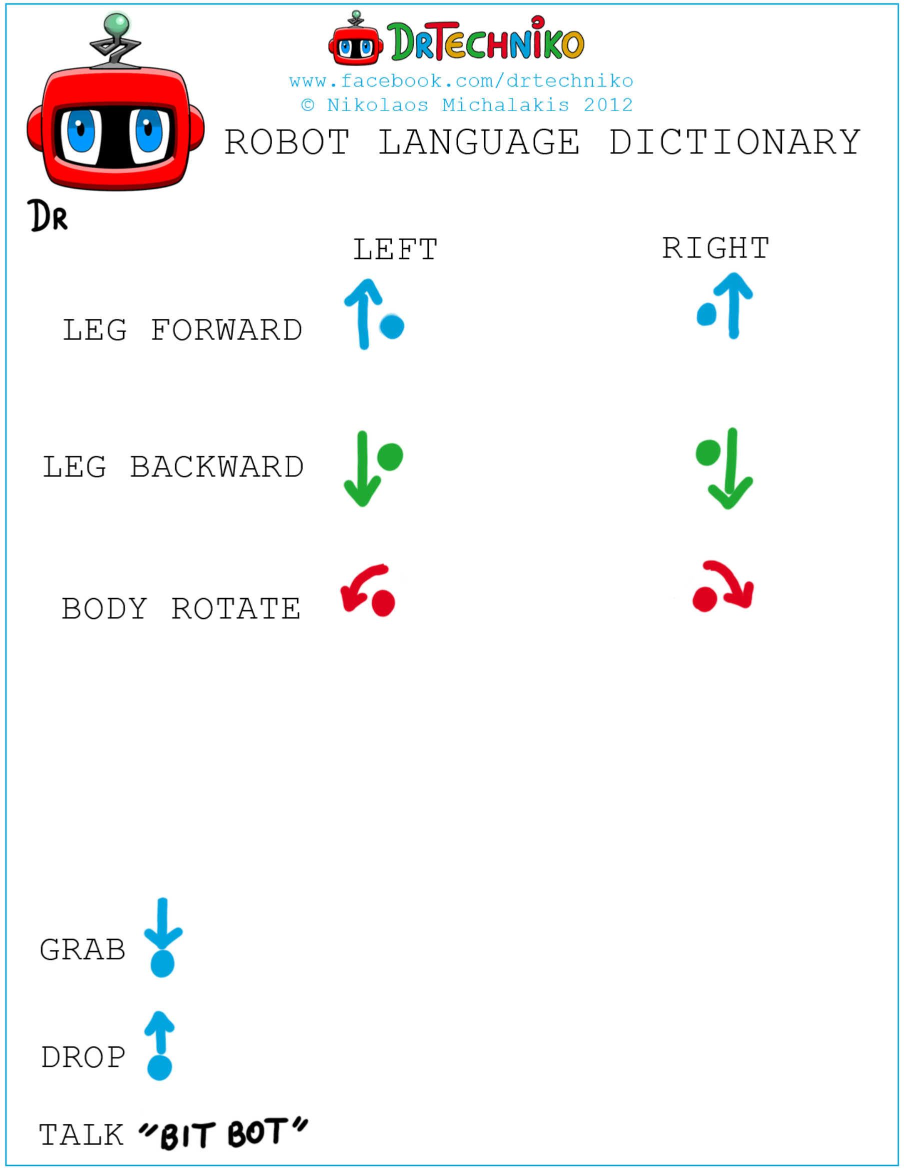
# How to Train Your Robot!

The goal of this game is for the ‘robots’ to go through an obstacle course, pick up a ball and bring it back. The kids have to write a program that will tell the robot how to do all that. Every time they write a program, they hand it to their robot and the robot executes it. To do that, give each kid a pen and paper where they copy symbols from the dictionary to write their programs and off their robots go!

The fun part begins when each robot retrieves the ball. After the initial run [aka test program] let kids invent their own moves and symbols that they add to their dictionary and then teach their robots. There is no limit to what the kids come up with.

# Principles of computer programming this activity teaches

- Programming languages are just another way to communicate to an entity (via programs).
- Programs are recipes for automating stuff.



# If/Then Coding aka Conditionals

- This activity introduces children to the **conditional statements** (If/Then Statements). A conditional statement tells the computer to execute a set of action depending on a specific event.
- The objective of the game is to follow the programmer's instructions and perform a particular task .

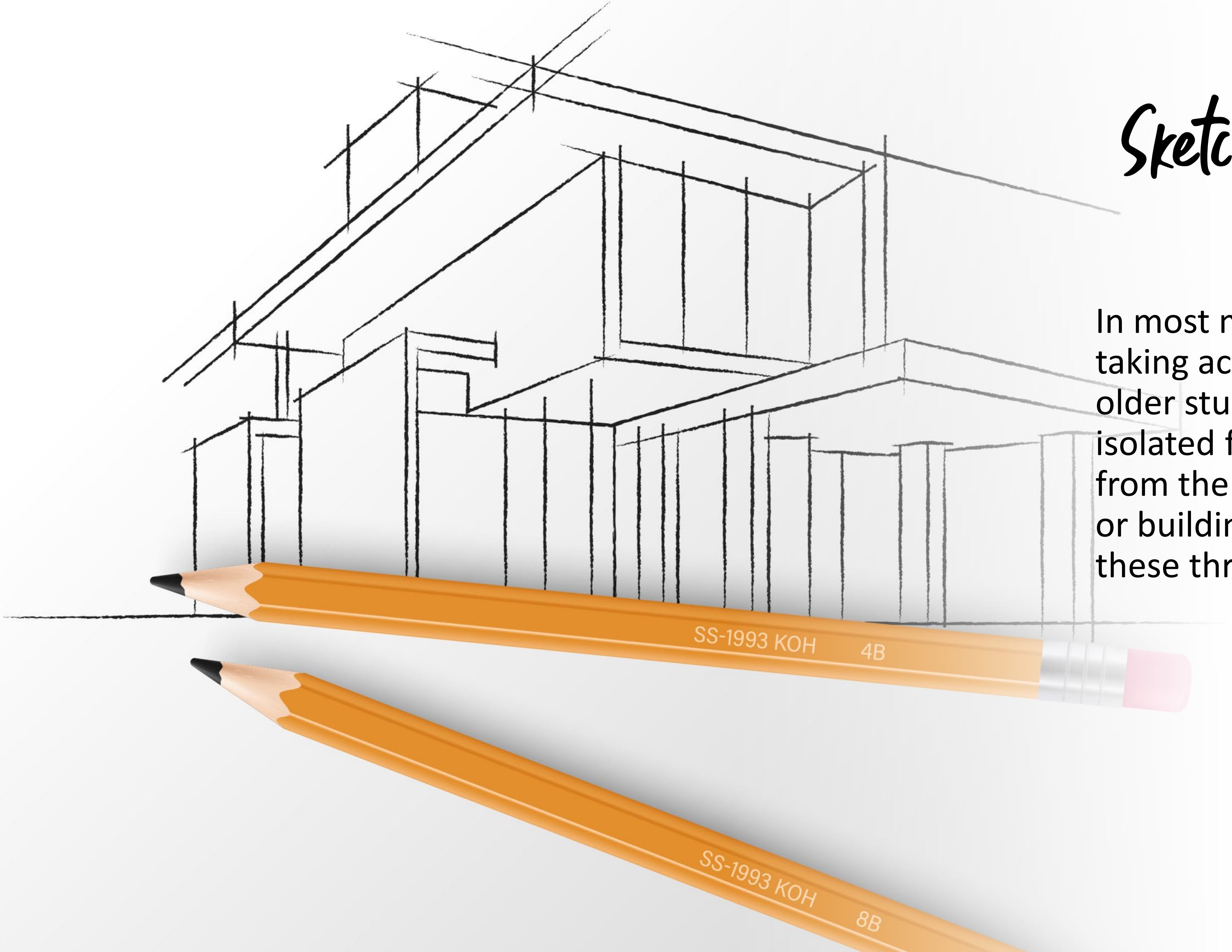
For every round, one child is the Programmer and everyone else are the Computers. The Programmer stands in front of the Computers and gives them commands: "**If** I ____ (fill in the blank), **Then** you _____ (fill in the blank)." For example, the Programmer gave the command "**If** I turn in a circle, **Then** you turn in a circle." Or he can give challenging instructions like "**If** I touch my nose, **Then** you touch your legs."

Variation for older students:
[https://studio.code.org/unplugged/unplug6.pdf](https://studio.code.org/unplugged/unplug6.pdf)

## Other important programming elements students often quickly figure out

- **Program Parametrization:** Instead of putting a forward step ten times,  put a 10 in front of the “step” symbol.
- **Composition:** Grouping of a set of moves (“move left leg forward, then move right leg forward and do this combo 10 times”)
- **Abstraction:** “Run in a circle, then say “I’m dizzy!” , then call this the “Run Dizzy” program and do it 100 times. (For some reason, kids love making their partners repeat stuff 100 times over.)
- **Unit testing:** Write a test program to get the partner moving a few steps, have their partner run it, then fix it and run it again, and then add a few more steps until they reach the goal.

# Sketchy Projects



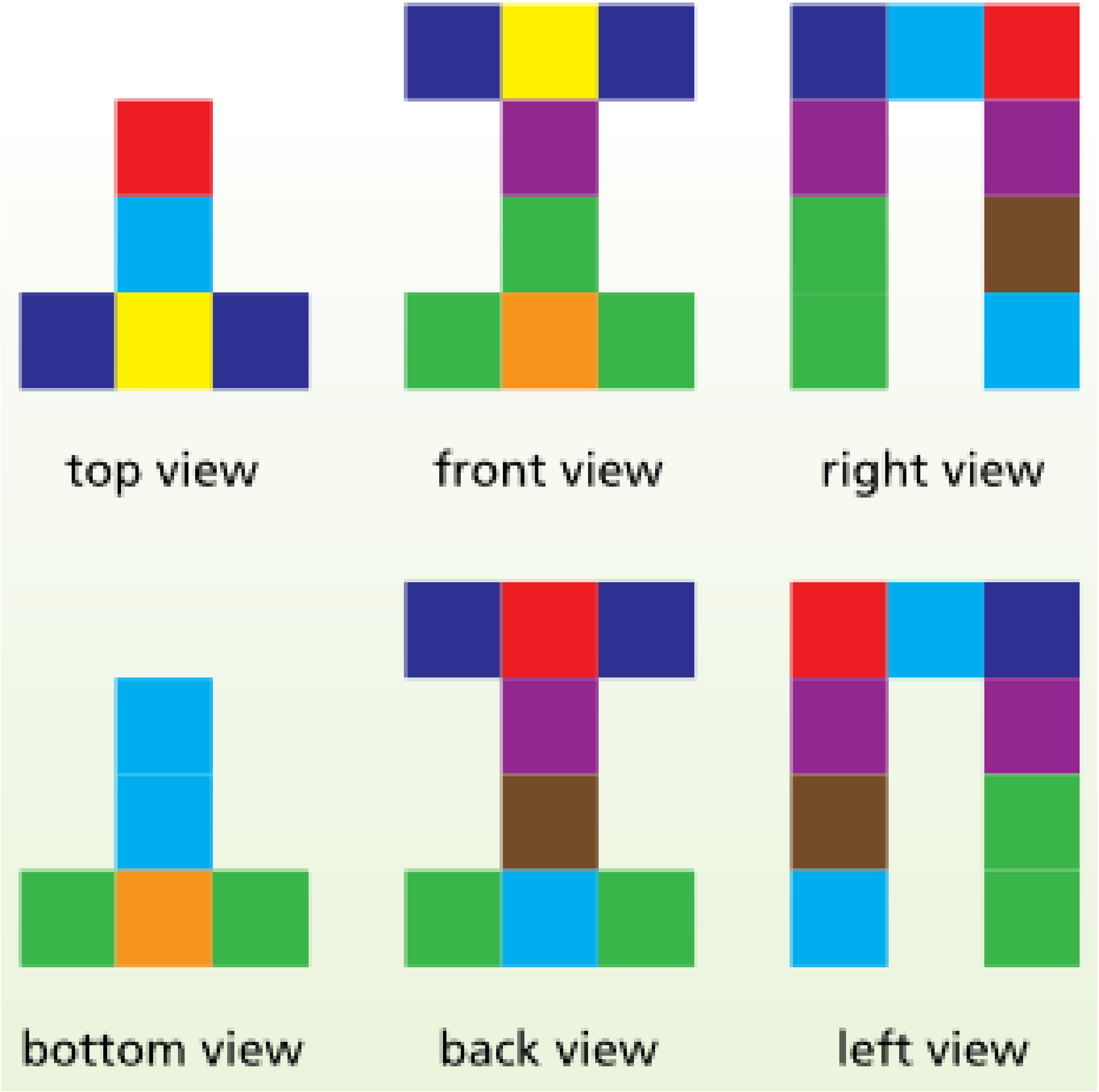

In most math curricula perspective taking activities are usually having older students sketch  or replicate isolated faces of 3D structures from the top, front, and side views, or building models when given these three views.

# Ex. Using Perspective to Build a Three-Dimensional Structure

Students need to visualize how each of the perspectives on the following slide would combine to create a single three-dimensional figure. They need to view the figure from multiple sides and consider rotations of the image to match it with the figure they are envisioning.

# Create the three-dimensional structure with the following views.

What do you envision?

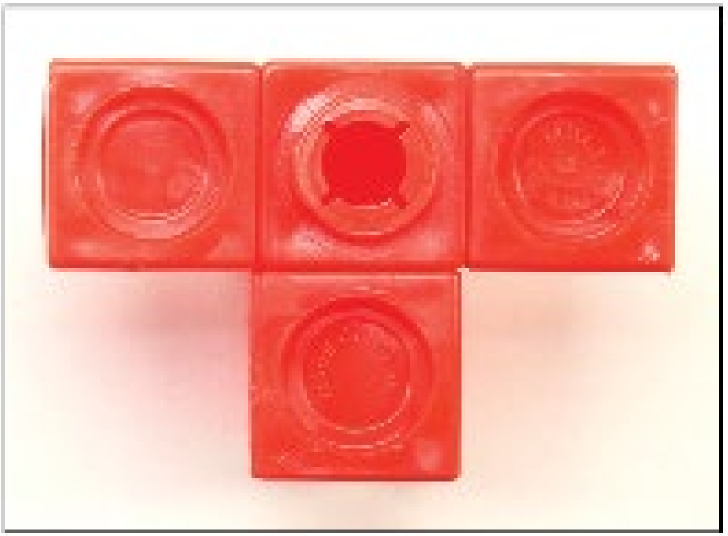



# A daily life skill

- Perspective taking is important to daily human activity, such as giving directions to another person (using your imagination to 'see' where that person is located and is going to), assembling furniture and toys, and almost everything involving maps.
- It also is used in chemistry careers, geography, engineering, design work, architecture, the arts, and medicine. Ex. X-rays and imaging.

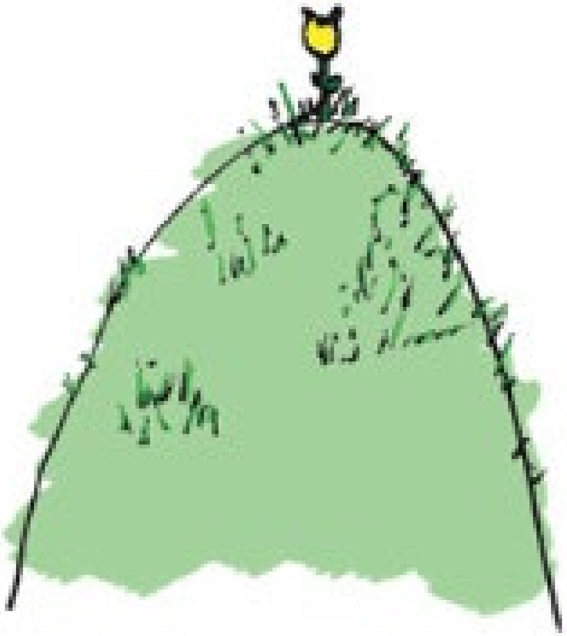
# Activity Ideas

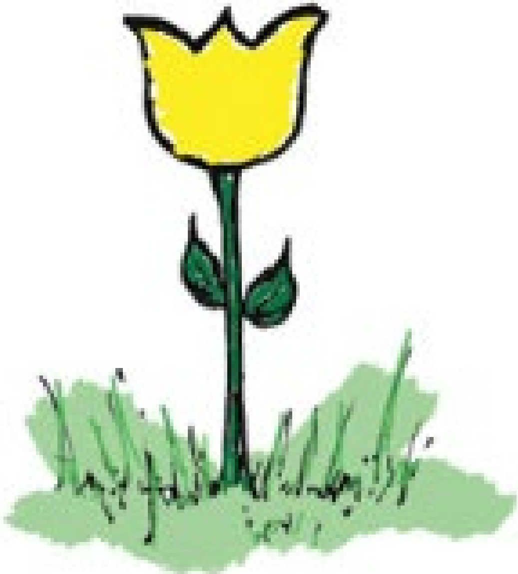
- Mama Bird Finds a Sculpture: Students are introduced to the idea of a "top view" with a story about a mama bird who flies over a sculpture. Students work in pairs to create an object from interlocking cubes based on information about its top view. (Images and verbal clues) The class compares the sculptures they've created. *There can be many different structures that have the same top view.*
  - Option: Read a book such as *As the Crow Flies: A First book of Maps* by Gail Hartman.
  - Increase the challenge and keep adding details as you have the 'mother bird' fly back to the sculpture and get additional perspectives. Ex. She got a side view: It was four cubes tall. She flew and counted: There were 18 cubes total. *All while maintaining the same top view.*



# More ideas

- **What do you see?** Students are asked to imagine what an object would look like when viewed from a particular perspective and then pick from a selection the drawing that best represents that perspective. Extension: Try making up some of your own items. Take pictures of a classroom item from a variety of perspectives and tell a story of a little mouse running by the side of it. Which view would the mouse see? Have students make up stories from the perspective of a character and then make a drawing or painting of that character's perspective.
- **Secret Brick Buildings** Quick Challenge: Students build a LEGO sculpture from memory after viewing it for 5 to 10 seconds.  Students must pay attention to several attributes: color, number, length & width of bricks, organization, orientation, and height.





# Provide Playful Opportunities

Many playful activities require spatial thinking. A solid body of research has established connections between these kinds of playful activities and spatial reasoning, and also mathematics performance.

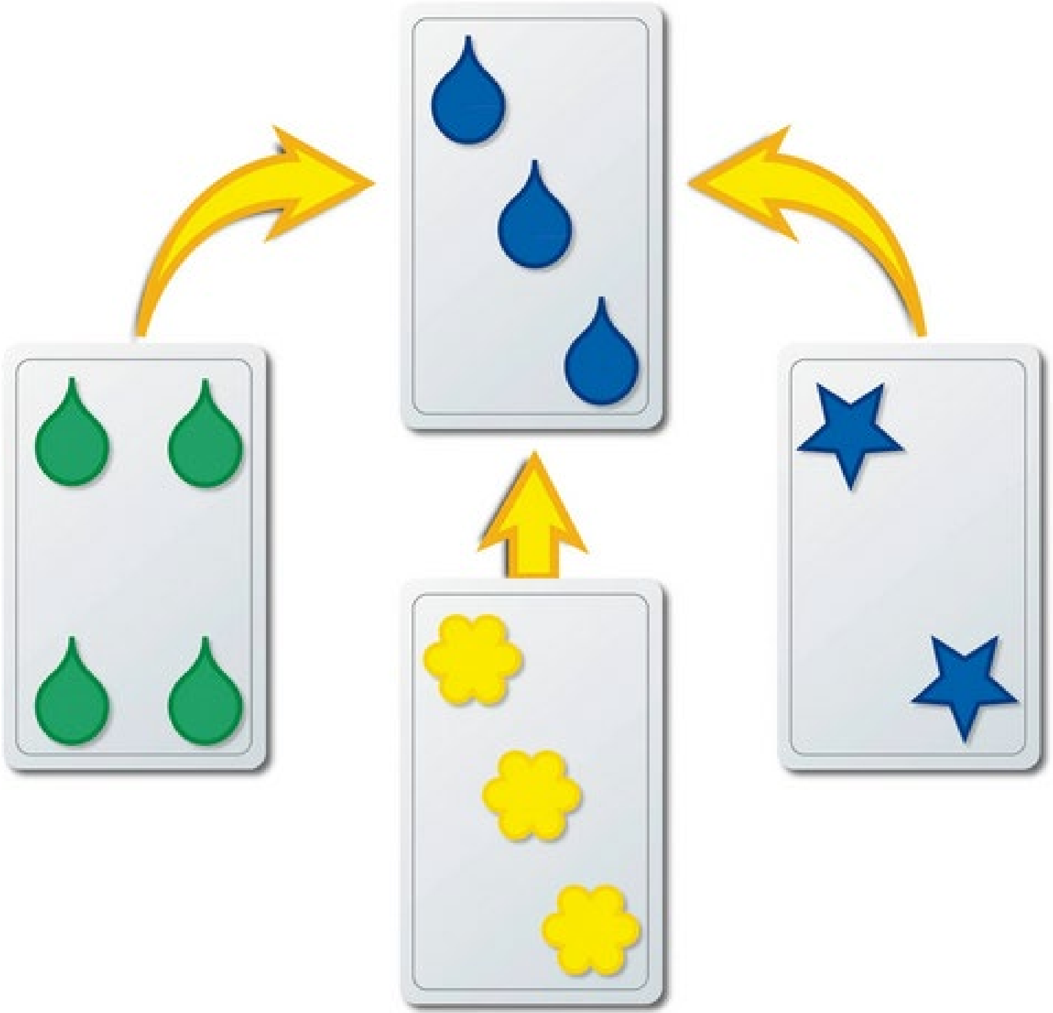
Much of this research affirms that time spent in this kind of play is time well spent when it comes to spatial reasoning for all grade levels.

# More Spatial Reasoning Tools






From the Makers of UNO
mattel GAMES
Reinhard Staupe's
BLINK
The World's Fastest Game!
Ages 7+
Players 2
Family




Q·bitz™
VISUAL DEXTERITY. CUBED.
2 TO 4 PLAYERS
AGES 8 AND UP
MindWare


AGES 3+
1 to 4 PLAYERS
Q·bitz Jr.™
VISUAL PLAY. LEARNING FUN.
INCLUDES 4 GAME BOARDS
MindWare


Q·bitz


PLAY MONSTER
6-99
20 MINS
1+
SET
CELEBRATING 30 YEARS
THE FAMILY GAME OF VISUAL PERCEPTION


ACUITY
THE GAME OF SHARP VISION & KEEN THOUGHT


DOUBLE SIDED
THE KORNER'D CHALLENGE
A PERPLEXING GAME OF PERCEPTION

# Questions? Ideas?

Contact us:

Nora Fry

sparkinginnovations@gmail.com