CHAPTER 11

Moving with Giant Tangrams

Making geometric shapes dance in space

Grades:	3–12
Time:	20–60 minutes
Math Concepts:	Shape, angle, area
Dance Concepts:	Dance with props, spatial relations
Group size:	4-7
Space:	Requires clear floor
Materials:	One large tangram set per group (see instructions on page 109). Optional: pencil and paper, small tangram sets, ruler
Prerequisites:	None
Related Activities:	Chapter 11 *Moving with Giant Tangrams* (follow-on activity) Chapter 10 *Stick Figures* (also involves moving with large props)

Tangrams, a geometric puzzle invented in China over 200 years ago, is played by millions of people all over the world, making it one of the most popular puzzles of all time. The goal of tangrams is to arrange seven simple shapes — a square, parallelogram and five triangles — to make silhouettes of animals, people, and other familiar figures. In the early 1800s a woman in China named Shu Fen Shih wrote a book containing over 1700 different figures. In the 1900s the great American puzzle inventor Sam Loyd created a gallery of 300 tangram faces, many of which are recognizable as particular people. Nowadays tangrams are a common classroom manipulative in elementary schools for teaching geometry and art.

In this chapter you will read about movement games with giant tangram pieces a foot or two in size, starting with solo exercises and working toward group exercises. By moving tangrams in space students develop their spatial visualization abilities and become acutely aware of geometric relationships. The activities in this chapter can be used on their own, or as preparation for the next chapter, *Storytelling with Giant Tangrams*.

Although a few of these activities are similar to exercises with conventional small tangrams, giant tangrams have several unique advantages. Giant tangrams require cooperation since one person cannot hold all the pieces. Because pieces can be seen across the room they lead naturally to performance and storytelling. The spatial visualization challenges are harder since you cannot see the shape you are making. Finally forming shapes with a group requires working out complex logistics among several people.

Many forms of dance from around the world use props, from Russian sword dances to Native American hoop dances. Acrobatic groups like Cirque du Soleil use props like giant balls as part of precarious balancing acts. Modern dance groups like the Alwin Nikolais Dance Theater create dances of brightly colored shapes by hiding the performers in black costumes against a black background.

11–1 Moving Individually (5-10 minutes)

Before beginning, make several sets of giant tangrams. At a minimum make enough so each student has one piece. For instructions, see section 11-9.

In this activity, students learn to move giant tangram pieces that are a foot or two in size. It is not necessary to do every exercise, just enough so students feel comfortable with the prop.

- Clear the space by pushing desks to the side of your classroom. Or move the class to a gym or other large space. Give each person one tangram piece. Have students stand in two lines facing each other, so they can see each other's shapes more clearly.
- For each of the following directions, have half the class move while the other half watches, then switch, so everyone gets to move and watch. After each exercise ask students to talk about what they saw that did or did not work well. For instance, slow controlled motion is usually clearer than fast careless motion. Seeing what works when other people move is a good way to improve your own movement — see the note on critiquing movement below.
- Explore the space. "Hold your shape in one hand, move it around slowly without moving your feet. Raise it as high as you can, as low as you can, in front of your neighbor to the left, and to the right."
- Change the angle. "Twirl your shape by the handle. Turn it so it is as narrow as possible from left to right. Turn it so it as wide as possible."
- Explore different movement qualities. "Move it slowly and smoothly. Move it staccatto, in sudden movements with long pauses in between. Move the piece as if it were heavy and hard to move. Move it as if it were light as a feather."
- Keep it flat. "Try moving it so the front face stays flat in a plane, as if you were washing a big window, with the handle side toward you. This is how you usually want to hold the tangrams when you are performing for an audience, because the shapes are clearest."
- Keep it still. "Try keeping the shape still in space as if were glued to a pole while you move around, under and over it. How still can you hold the shape?"
- "Use your voice to add sound effects as you move your tangram pieces. What sounds work best with what movements?" W often encourage students to add sound effects to all the tangram exercises in this chapter. In the next chapter students add narration to their tangram movements.

Dance Note: Critique

Learning to look at dance is a big part of learning to move. When one is performing a dance, it is difficult to really see it, so it is important to get other people to say what they see. Encouraging students to talk about their responses helps them become aware of their reactions, learn from each other, and develop an eye for dance. Critiquing the work is a part of all the arts — visual art, music, writing — but is especially important in dance and theater where the performers are part of the art itself.

What sorts of comments do we want students to give? We are not interested in whether a particular movement conforms to a particular performance technique like an arabesque in ballet or a step-ball-change in jazz. All ways of moving are welcome.

Instead, we are interested in which movements work best for the students as they watch the dances. Ask the students: "What ways of moving seem interesting? What catches your attention? What surprises you? What do you find distracting? What new ideas do you see that you might want to add to your own dances?" Avoid personal remarks; comment on movement, not people. Sometimes it is fine to ask students to say what they liked, other times it is better to ask them to say what worked for them.

Of course students may have different opinions about what is interesting. That is okay. The overall goal of critiquing dance should be for the class as a whole to build up a collective understanding of what types of movement work best.

As a teacher, also look for whether students move with clarity and authority. Whatever they are doing, are they doing it fully, with complete commitment? Often it is better not to suggest ways to fix problems, but merely to point them out. For more about critiquing dance, see chapter 14, *Assessment*.

11–2 Moving in Pairs (5–10 minutes)

Try this exercise with half of each group moving and half watching. The "movers" do the following:

- "Find a partner and stand side by side. Hold your pieces in front of you facing the audience, keeping them completely still."
- "One of you slowly move your piece until it joins the other person's piece to make a shape. Now the first person holds their piece still, while the second person slowly moves their piece until it joins to make a different shape. Take turns moving the pieces to make different shapes. Only one person should move at a time."
- "Now try moving your pieces at the same time, always keeping them in contact with each other. Move slowly so you don't lose contact."
- Optional: "Join with another pair of people to make a group of four. See if you can move all four pieces at the same time, always keeping pieces in contact with each other."

After the movers have finished moving, the "watchers" critique the motions by considering some the following questions. There are no right and wrong answers to these questions, but the act of answering these questions will help everyone see what is going on.

- "What did you notice when the other group moved?"
- "For each type of movement, what worked? What did not work?"
- "What are the different ways you saw that people moved from one shape to another?"
- "What did you like or not like about the way pieces came into contact?"
- "How could you do it better? How could you do it differently?"
- "What feelings or images did different types of movement call to mind?"
- "What type of music would be appropriate for each type of movement?"
- "What other things move that way?"

11–3 Moving in Groups (5–10 minutes)

Divide students into groups of seven, each group holding a complete tangram set. If there are too few people in a group, some people can hold more than one piece. For children ages eight and under, use fewer pieces and smaller groups.

- "Make a shape with all pieces in your group. Try not to stand in front of your tangrams, so the audience can see the shapes."
- "Make the widest shape you can. The tallest. The most compact."
- "Make a shape with a hole in it."
- "Make a square using some or all the pieces."
- "Can you bring all your shapes together at a point so they completely fill 360° around the point, with leaving any gaps?"
- "Make a shape. Now make the mirror image of the shape. Does the parallelogram get in the way? How"

11–4 Shape-Shift (5–10 minutes)

This group improvisation often generates wonderful and unusual tangram forms. Have half the class perform while the other half sits and watches, then do the opposite, so everyone gets a chance to watch. Forms usually look best if shapes all face the audience with handles in back and everyone behind the tangrams, though sometimes the handles should be in front or the pieces might be at a different angle.

- One person in each group holds up a piece, keeping it still.
- A second person joins a piece to touch the first piece, and so on, until all the pieces are part of one big shape.
- Now everyone holds their pieces still, except the first person, who moves a piece to join the other pieces at a different place.
- Then the second person moves a piece to a new place, and so on.

11–5 Coordinated Movements (5–10 minutes)

This movement activity develops a sense of ensemble.

- Work in pairs. Each person holds one piece.
- Explore how the two pieces can move in relation to each other. Hold one piece still while the other moves. Try moving both at the same time. Have both pieces move with the same movement quality or different movement qualities. Move pieces in unison or in opposition. Have one piece bump into the other, causing it to move. Pretend both pieces are part of a larger machine.
- Choose three of these coordinated motions and perform them in sequence.
- Try the same activity with groups of three people.

11-6. Reflections and Assessment

The Dance

The essential movement problem in this chapter is the same as in puppetry: to breathe life into an inanimate object. Here are ways to develop the dance aspects of moving with tangrams.

- **Slow down**. The most important thing to know about moving with tangrams is that slow, controlled movements generally work better than fast, chaotic motions, because slow movements draw the eye to the props. Of course quicker movements are still useful as punctuation.
- **Space hold**. To create the illusion that tangram pieces are floating in space, have students practice a "space hold." divide students into groups of three. Each group works with just one tangram piece. First one person holds the piece still in space while the other two people move around it. Then a second person takes over holding the piece still in space while the other two people move around it. Then the third person takes over holding the piece. Continue taking turns having one person hold the piece while the other two move around it, making sure the piece never moves. Beware of moving the piece during handoffs, or when the person holding the piece moves.
- **Turning**. Turn a piece so it appears to rotate around one of its corners, not around the handle. Stop moving, then resume turning, this time around another corner. It takes concentration to do this well.
- **No fidgeting**. Encourage students to eliminate extraneous movements and fidgeting that draw attention away from the shapes — unless they are using their bodies as parts of the shapes. A good way to have students refine the way they move is to have them perform a tangram dance in pantomime without the pieces. This requires good spatial memory.

- **Qualities of motion**. A single shape can convey many different moods depending on how it moves. Choose three adverbs such as happily, slyly, and confusedly, and have students move their pieces in each of these ways. Be sure to consider fast and slow, standing still or moving through space, high and low. Put the three moods in sequence and perform them for the rest of the group.
- **Movies**. Since the invention of film, animators have created movies that are pure dances of shapes in space. View sequences from Walt Disney's Fantasia, the films of Norman McLaren, or the films of Oskar Fischinger. What can be used from these movies in the tangram dances?
- **Beginning and end**. Any of the activities in this chapter can be developed further into a complete dance by asking the questions: How does it begin? How does it develop? How does it end?

The Mathematics

There are many books of mathematical activities with small tangrams. Here are some mathematical group activities that work particularly well with giant tangrams. These activities work best if each group has a complete set of seven tangram pieces. If there are fewer than seven people in a group, one person can hold more than one piece. Younger students may want to work in smaller groups with fewer pieces, since younger children are more comfortable performing for the one or two other people in their group than for an entire audience.

- **Noticing shapes**. "Look at all the shapes in your group. Which pieces have the same shape? Which pieces have the same shape, but are different sizes? What is each shape called? How many sides does each piece have? What is the smallest angle on your shape? The biggest angle? The shortest side? The longest side? Which piece has the biggest angle?"
- **Lengths**. Divide students into groups of 4 to 7. "Some tangram pieces have edges that are exactly the same length. Move your piece so it joins someone else's piece along two edges that exactly match. Can you join all the pieces in your group into one big shape so pieces meet only along edges that exactly match? Can you find another way to do it?"
- **Angles**. Divide students into groups of 4 to 7. "Split your group into two groups. One group bring your pieces together at a point to make an angle. The other group see if you can bring your pieces together at a point to make the same angle. Then trade which group makes the angle and which group copies it. How many different angles can you make using any number of pieces in your group? Can you bring pieces together at a point so they completely fill up 360° without leaving a gap? What is the fewest number of pieces that can do this?"
- **Areas**. Divide students into groups of 4 to 7. "Which shapes can be made of other shapes? How many of the smallest triangle would you need to make each of the other shapes? Make two shapes that are identical."
- **Drawing**. "Record shapes you held in the air. You can draw on paper or work with small tangram pieces. Plan shapes small on paper, then see if you can make them big in the air." Like Chapter 4, *Spatial Paths*, this activity exercises spatial visualization skills, translating between small and large, the difference between horizontal and vertical, and solo and group work.

11-7. Further Activities

Here are further movement activities that use tangrams and other large shapes.

Shapes in the Room. Everyone holds one tangram piece. "Position your piece in relation to a shape you see in the room, such as a corner of a chair, an edge of a table, or a pattern on the floor. Move your piece so it reinforces the shapes you see. Feel free to interact with other tangram pieces, as well as shapes in the room."

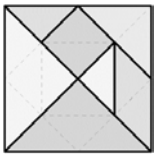
Machine. This is a variation of a popular theatrical improvisation exercise. Divide students into groups of 4 to 7, with one piece per person. One person in each group starts moving a piece in a motion that repeats after about two or three seconds. Vocal sound effects should be encouraged. For instance the piece might suddenly move to the right, then slowly move back to the left. After a few repetitions a second person joins the machine by adding a second moving piece that interacts with the first piece in a repeating motion. One

by one all the people in the group join the machine, making a complex repeating motion. Once everyone has joined the machine, gradually speed up the machine until it falls apart. Build several machines and have them all interact.

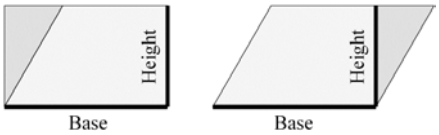
Animation. Another way to make shapes dance in space is to animate them. Get a digital video camera that can record one frame at a time, mount it on a tripod, and point it down at a table. Arrange tangram pieces on the table, record one frame, move the pieces a little, record another frame, and so on. Another way to make an animated movie is to use an animation program such as Flash. Draw the seven tangram pieces in Flash, assigning each piece to a different layer. Arrange the pieces in a shape on one key frame, then arrange the shapes differently on a second key frame. Animate the pieces by using "inbetweening" to make them move smoothly from one key frame to the next.

Math note: Dissection

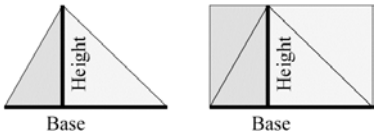
The seven tangram pieces can be cut out of a square. Mathematicians call cutting a shape into smaller shapes "dissection." Note that every tangram piece can be dissected into one, two or four identical isosceles right triangles:



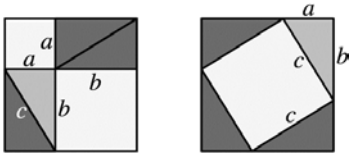
Dissection is useful for showing that two shapes have the same area. For instance, we can use dissection to show that a parallelogram and a rectangle with the same base and height have equal areas, as shown below.



Similarly, we can dissect a triangle to show it has half the area of a rectangle with the same base and height.



We can prove the Pythagorean theorem by dissecting the large square below in two different ways. Notice that the two white squares on the sides of the gray right triangle in the diagram on the left must have the same area as the larger white square on the hypotenuse of the same gray triangle in the diagram on the right. This method is based on an ancient Chinese proof of the Pythagorean theorem prior to the sixth century BC – that predates Pythagoras! (Note: the theorem says that $a^2 + b^2 = c^2$.)



Mathematicians have proved that any two shapes with the same area bounded by straight edges can be dissected into one another. The key is to realize that any polygonal shape can be cut into triangles, and any triangle can be dissected into a rectangle.

11-8. Resources

Tangram Kit. By ETA/Cuisenare. Mathematical classroom activities using tangrams, including two sets of plastic tangram pieces and 20 activity cards.

Tangoes. By Rex Games. Commonly sold in toy stores. Includes figure cards, and two sets of pieces so two people can play at the same time.

Large Tangram. By Educational Design. Includes 70 design cards.

Shape by Shape. By Nob Yoshigahara. A toy published by Binary Arts. An interesting variation on tangrams with two colors of shapes that make both the positive and negative space of a picture. Includes 40 challenge cards.

Sam Loyd's Book of Tangram Puzzles (The 8th Book of Tan Part I), Sam Loyd, Dover Publications, 1968. Hundreds of figures by the great American puzzle inventor.

Tangrams, 330 Puzzles, Donald Read, Dover Publications, 1965. Good source of tangram figures.

Geometry and Fractions with Tangrams, Barbara Bando Irvin. Learning Resources 1995. Over forty K-6 activities.

Tangramath, Dale Seymour, Creative Publications Inc., 1971. Reproducible activities that reinforce math concepts such as size, shape, congruence, similarity, properties of polygons, symmetry, and area. Solutions and supplemental open-ended activities are provided. Tangrams are required. Grades 1-10.

Tangram software by S. T. Han. http://hometown.aol.com/sth777/page0.html. An excellent tangram program popular in schools. For Macintosh or Windows.

More on Tangrams. By Martin Gardner. Article originally published in Scientific American, Sep 1974, anthologized in Time Travel and Other Mathematical Bewilderments by Martin Gardner, W. H. Freeman and Company, 1988. Discusses more advanced mathematical problems like forming "snug" or convex figures.

Dissections: Plane & Fancy. By Greg N. Frederickson. Cambridge University Press, 1997. The best book on the mathematics of dissections. Fascinating, sophisticated yet accessible, with many pictures.

Proofs without Words: Exercises in Visual Thinking. By Roger B. Nelsen. The Mathematical Association of America, 1993. Marvelous visual proofs of theorems in geometry and number theory. In many cases a single diagram is the whole argument. Suitable for algebra and geometry students. Includes several dissection proofs of the Pythagorean theorem.

Fantasia 2000. 75-minute film from Walt Disney Pictures. A collection of short animations in diverse visual styles set to works of classical music. The original Fantasia includes a purely abstract sequence of shapes moving to Bach's Toccata and Fugue in D Minor.

Iota Center. http://www.iotacenter.org. Nonprofit organization promoting abstract animated films. Includes traveling exhibitions, information on purchasing videos, and links to movies on the web. Look here for information on such abstract filmmakers as Norman McLaren and Oskar Fischinger.

11-9. How to make Giant Tangrams

Here is a method for making a set of giant tangrams out of furniture foam. We have also seen tangram sets made of cardboard, styrofoam, foam core, spongy foam hot-glued to cardboard. Whatever method you use, keep in mind that the pieces will work best if they are made:

- Lightweight. If they drop, they will not hurt anyone.
- Thick edges. It is easier to have the edges meet if those edges are at least 2 inches thick.
- Centered handles. Centered handles make pieces easier to handle. It's better if the handles have knobs.
- Bright colors. Colors attract the eye, and help pieces stand out from the background.
- Big enough to see. For younger children, make the pieces smaller.

Shapes. Our favorite material is 2-inch thick poly foam, which is light, rigid, and soft enough that students will not hurt each other. 3-inch poly foam holds its shape better, but is heavier. Stores that sell furniture foam will often cut them for a nominal charge. Have them follow the plan shown on the next page. The assembled square is 32 inches on a side. A complete set costs about $20, including materials and labor. We do not recommend that readers cut pieces themselves, since stores do a better job than most people can do at home. Alternatively, use corrugated cardboard or foam core (available at art stores) instead of foam. Be sure edges are at least 2 inches thick, so it is easy to bring pieces together at an edge without missing.

Handles. Attaching handles is a bit tricky. Ask for help at a hardware store if not sure what to do. To get anything to stick to foam requires a lot of surface area, so we make our handles in two pieces: one to stick to the foam and one to hold with your hand. Cut out a 6-inch by 6-inch square of 1/8-inch thick masonite. Glue or screw a handle to the middle of the masonite square. Make handles out of a spool, a used 35mm film canister, a piece of dowel (1 inch diameter by 2 inches long), or a pop-up garden sprinkler head (a short section of plastic pipe can be screwed on and off the sprinkler head for compact storage). Handles work better if there is a knob at the end that prevents the hand from slipping off. Epoxy and/or screw a disk to the end of the dowel to make a knob.

Glue. Use spray adhesive to glue the masonite square with handle to the middle of each foam piece. Use epoxy glue to attach the handle to the masonite. Be sure to attach the handles at the center of gravity of each piece, so they balance or spin easily. Find the center of gravity of a tangram by finding the point where it can balance on one finger.

Decoration. Foam can be spray-painted, but be sure to use a series of light coats, letting each coat dry before applying the next coat. If foam is spray-painted all at once it may end up a soggy piece of foam that will never dry! Another method we like better is to cut a piece of felt a few inches larger than each foam piece, fold back the edges of each cloth piece to make a straight seam, then spray glue the cloth to the foam. Spray glue is unhealthy to breathe, so be sure to have good ventilation or work outside.