From the Author

Welcome to this hands-on, bodies-on science learning experience!

The journey through this material evolved over many years and through multiple interactions with children, classroom, music and dance teachers, and science educators. In the hands of others, I hope these ideas will continue to grow in new ways.

Creative movement and dance are natural vehicles for exploring science. Both dance and science address the big idea of process over time. Movement is the embodiment of science fundamentals such as force, gravity, and momentum. When we combine moving with speaking, singing, looking, and listening, holistic learning takes place. As an added benefit, many of the movement activities involve weight sharing with one or more people that help foster trust and build community.

I developed these lessons with third graders. The ideas and activities in this book can be adapted for both younger and older students. You know the capabilities of your learners and I encourage you to find ways to make this material your own.

As part of a Teaching Artist residency, I deliver the content in five, one-hour lessons, during a concentrated week of instruction. This immersion approach challenges students to build on their learning from one day to the next and to sustain focus. It would be an ideal way to present the work.

Collaboration between teachers—classroom, music, dance, or physical education—could be a wonderful way to teach the material. One could also extract select elements for specific science study without covering all the content in this book.

Novelty is stressful. Any time we teach a new lesson, we start from a degree of unfamiliarity and hesitation. The expression "Fake it until you make it" seems completely appropriate in this context. Trust that the content and the delivery system are valid, time-tested, and worthwhile. Just as students start to feel more comfortable after a few days, so you too will come to own these strategies and methodologies. If you have physical limitations, work within your range of motion and have student demonstrators model the bigger range. Ultimately, your enthusiasm will be your greatest asset for engendering student buy-in to this experiential learning approach.

At the other end of the spectrum, once you've become comfortable with this material, you may be inspired to explore other pedagogical strategies for content delivery. For example, once your students have learned the material, divide them into groups and have them create an interactive "museum" in which the students prepare materials and activities to teach peers or younger students.

I'm so happy to share these diverse teaching strategies with you. Enjoy this playful and serious exploration!

—Kate Kuper

Contents

About the CD

The CD included in this product is enhanced and contains both audio tracks and digital files to assist you in presenting these activities to your students.

The CD will play audio files like any regular CD in your CD player. To access the digital files, you will need a PDF reader, such as Adobe Reader, which you can download for free at https://get.adobe.com/reader/. Once you have installed a PDF reader, simply insert your CD into your computer's CD drive. When prompted, click on **View Files** to see all of the amazing resources available to you.

Digital Files include:

- Concept Posters
- Reproducible Images
- Lyrics and Actions for Songs
- Journal Pages

About This Resource

All of the activities presented in this book were developed for third grade students. They have been organized sequentially, as I taught them in five-day arts residencies. While I only had five contact hours in which to deliver this content, you are not under that time constraint. Feel free to expand upon the time frame, perhaps selecting from among the content to teach in a different sequence and at different times of the year, or even divide the content delivery among more than one teacher.

Each lesson includes CD track information, DVD Options and relevant images of posters, objects, and children in action. Reproducible lyric pages and the actions that accompany the songs are available as data files on the CD.

In addition to what I would consider the core activities, I've included some ideas for "Going Further" which are not necessary and often require students who work well together. Incorporate these activities as you wish.

Throughout the lessons, I've also built in time for reflection within the activities and at the end of each lesson. This reflection time is critical to assess student understanding and the effectiveness of the instruction. It also provides a nice transition as students prepare to leave my room and get on with the rest of their day. The reflection activities make use of the Student Journal pages which you will find on the CD. These student pages are optional, however the content is a good jumping-off point for closure and reflection after each lesson. Even if you decide not to have each student complete a journal, you should use these prompts in a discussion format. The journals may also become portfolio assessment pieces in both science and language arts.

To even further enrich this resource, we've added Science Corner and Kate Says features. The Science Corner text was developed by my knowledgeable colleague Troy Vogel. This feature provides deeper scientific information based on the activities, so that you can answer higher-level questions and conduct reflection and discussion moments with confidence.

The Kate Says features provide phrases and tips and tricks that I use in my instruction. May these words and strategies assist you as you teach.

The DVD is designed for instructional purposes, featuring activities and demonstrations best learned through watching. Additional step-by-step instructions, scripts, and valuable science content are found in this book. The two components are designed to support each other. The DVD will help you practice the script and sequence before teaching your students. The modeling on the DVD is authentic; featuring recently graduated third-grade students. All but one had already learned this material during a one-week residency.

In some cases, it might be beneficial to show your students clips from the DVD, but for the most part it is designed solely for the instructor's eyes. Warm-ups are an exception; you can play these segments for your students as you prepare together for the movement activities ahead. Each lesson has its own menu so you can select the parts that you would like to review.

Be sure to check out the Appendix in this resource and the Tips and Tricks section on the DVD in which I model classroom management strategies. You will see these tips embedded in activities, and can review them individually. You'll also find these tips useful in other contexts that require space, time, and behavior management, such as during transitions.

Lesson 1

Part 1: Force, Load & Gravity

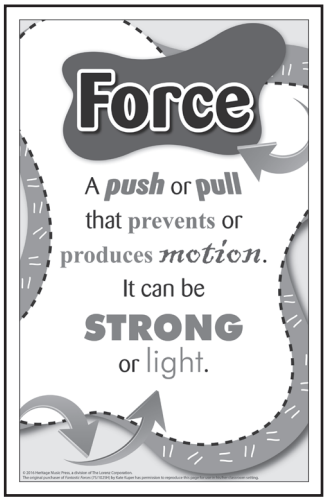
Objectives

To introduce:

- The movement/dance concept of weight (strong, light, active, passive)
- Push and pull forces (strong and light)
- Loads (heavy and light, big and small, active and passive)
- The Earth's gravity pulls us down, and we push back up from the ground. When forces are balanced, loads don't move.

Warm-Ups and Introduce Force and Load

1. Lead the Weight Warm Up. See p. 45 for concept connection and the DVD for the demonstration of the warm-up and the entire lesson.
2. Review/Discuss the following Weight Concepts: strong, light, active, and passive. Display the Force and Load Posters. With students sitting in Ready Position, review these concepts as you read the text together. Use the See, Hear, Say, Do strategy as modeled on the DVD. Add movements and gestures to exemplify the emphasized words. Ask the students for input in creating the movements.

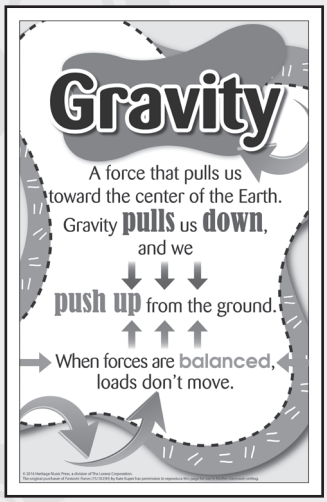


Science Corner

Science Corner: Weight is not used in this context as a scientific term. Instead, it is a general term to mean "an object or a force." A load is something to which we want to apply a force. This can be anything. Weight is also used as a movement/dance term to mean how strongly or lightly we use our muscles. We engage our muscles to make them move with strong force, and relax them to move with light force.

Gravity Introduction and Activities

1. Display the Gravity Poster. Read the text together, and add gestures to exemplify the text.



Audio Tracks

Warm Ups

1. Seafaring Man

DVD Options

- Weight Warm-Up
- Weight Demonstration: heavy, light, passive and active
- Force Poster Demonstration
- Load Poster Demonstration
- Gravity Poster Demonstration
- Activity: Connect active and passive weight to gravity

Visual Supports

Force Poster
Load Poster
Gravity Poster

Science Corner: Gravity is one of the fundamental forces. It is an "attractive" (pulling together) force between all objects which have mass. The Earth pulls us down with a very strong force because the Earth has a very large mass, about 6 septillion kilograms; that is 6 with 24 zeroes after it! We also pull the Earth up, but with a much, much smaller force because we have a much smaller mass. We cannot feel our mass pulling on the Earth.

Weight and mass are two different things. Mass is the amount of stuff/ matter of which something is made. Weight is what we feel from the Earth's gravity acting upon us. If we travel to the moon, we will have the same mass, but our weight will be different due to the decreased mass of the moon, and thus decreased gravitational force.

2. Instruct students to Stand Tall One and All.
3. Have students jump. Ask them the following questions:
   - Why did you come back to the ground? (Gravity pulls us down.)
   - What stopped your fall? (The ground.)
   - Why does it stop you? (It's hard.)
4. Explain how if you jumped into spaghetti or Jello ™, you would fall right through. It's not hard enough to hold you up. The ground holds you up by pressing on your feet with the same force as gravity is pulling you down. Remember, when forces are balanced, loads don't move.
5. Instruct the students to sit in Ready Position.
6. Use the See, Hear, Say and Do Strategy to engage the students in exploring active weight by asking the students to repeat after you, "active weight." Then demonstrate and have them reach up with strength, resisting gravity's pull.
7. Ask the students to mirror you again. This time lightly float your arms up. Have the students say "light, active weight" in a light voice.
8. Now, lead the class in exploring passive weight. Demonstrate how to drop, release and give in to gravity, allowing for unbalanced forces. Then lead the class as they repeat the actions while saying "passive weight." Encourage them to allow the jaw to be passive when saying "passive weight."
9. Ask students to mirror you again. This time drop and release more strongly to emphasize heavy weight. Have students say "heavy, passive weight."
10. Hold up an object and ask students to predict what will happen when you release it. Release it. Ask why it fell. Lead the class to discover that the forces between the object and gravity were not balanced. The object couldn't push back up against the pull of gravity.

Keep in mind that a load, such as a person, can choose to have active weight. But an inanimate object, like an eraser, cannot choose. Its weight is always passive. This will be important to remember when we make balanced load structures and I ask you to let your weight be passive.

Lesson 1

Part 2: Compression, Tension & Structures

Objectives

To review:

- The movement/dance concept of weight (strong, light, active, passive)
- Push and pull forces (strong and light)
- Loads (heavy and light, big and small, active and passive)
- The concept of gravity

To introduce:

- Compression is the force of push
- Tension is the force of pull
- Compression and tension work with gravity. When forces are balanced, loads don't move.

Warm-Ups and Introduce Compression

1. Begin with the Weight Warm-Up (assuming you are teaching Lesson 1, Part 2 on a separate day).
2. Review Weight Concepts: strong, light, active, and passive. See the DVD for demonstration. Review the concepts of Force, Load, and Gravity. Read the posters aloud together, using gestures and movement.
3. Consider using this script to introduce the lesson component: Now we are going to learn to use the forces of push and pull to support loads. In doing so, we will build structures with our bodies. We will resist gravity, using active weight, and let gravity work for us, using passive weight.
4. Have students get a prop (book or shoe), place it on the floor in front of them, and sit in Ready Position. I suggest using a "1,2,3 Transition" for this process. See the Transition Strategies on p. 51 or the DVD option.
5. Display, and read the Compression part of the Compression and Tension Poster.
6. Have the students place the book or shoe between both hands in front of themselves at breastbone level, with fingers pointing up. Ask them to keep the hands centered at the midline and to push evenly with both hands.
7. Ask, "Does the object move? Why?" Explain how the object is held in place by equal forces. When forces are balanced, loads don't move. You can also say the object is stable.

Audio Tracks

Warm Ups

2 Rio Loco

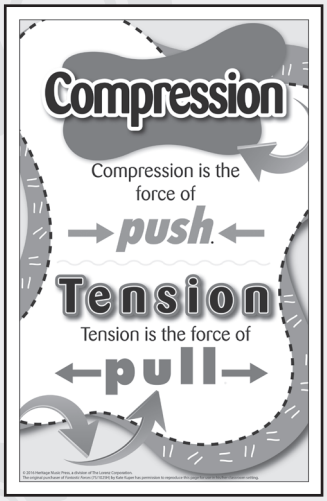
DVD Options

- Structures Introduction
- 1, 2, 3 Transition
- Introduce Compression Structures
- Activity 1: Compression with two hands
- Activity 2: Compression with one hand
- Activity 3: Compression back to back
- Activity 3a: Compression with bent knees
- Activity 4: Flying Buttress

- Introduce Tension
- Activity 1: Suspension bridge in pairs
- Activity 2: Cantilever
- Cantilever variations
- Group of 3: Suspension bridge cables & tower
- Group of 6: Dome

Visual Supports

Force Poster
Load Poster
Gravity Poster
Compression and Tension Poster
Reproducible Images Set 1



Science Corner: The force of gravity is pulling the object down. In order for the object not to fall, the downward gravitational force must be countered by an equal and opposite upward force. But how can this be? You are pushing your hands towards the center, but not upwards. Where is the upward force? In this case, the upward force is a frictional force between your hand and the object. For more about friction, see the Science Corner in Lesson 4, page 37.

8. Ask the students what happens when they push harder with their left hands and then right. Allow the students to explore these ideas and then discuss, explaining how the object moves because unequal forces cause motion. You can also say the object is unstable.
9. Have the students put their props away, and sit in Ready Position.

Activity #1: Compression with two hands
(See the DVD for demonstration.)

1. Choose a student demonstrator to help you model. See the Teaching Strategies on p. 46 for choosing a student demonstrator.
2. With the student volunteer, model the following:
   - Face your partner. Shake hands and say hello.
   - Reach two hands across and press, palms flat, fingers pointing up, using active weight.
   - "Listen" with your muscles to match the amount of push with your partner's.
   - Step your feet back a little when you feel you can trust your partner with your weight. Keep your legs parallel.
   - Your feet should be further back than your shoulders. Each of you should be like one side of a triangle (or trapezoid). To make the sides diagonal, make your body straight from shoulders to feet, without bending at the hips.
   - Adjust the push force so your legs can be passive weight. Breathe.
   - Continue to match the push force with your partner so that your hands stay in the middle, just as we did when we pushed the object between our hands individually.
   - Keep your hands at shoulder height. You should feel that you are supporting your partner and being supported at the same time. Look at your partner and smile!
   - To come out of the shape, both walk your feet forward at the same time, to support your own weight.
   - Thank your partner.

Just as we adjust hot and cold water to get the temperature just right, adjust the amount of push to match your partner so the forces are balanced. Listen with your muscles. Keep shoulders over hips; don't let your behind get behind.

3. Instruct the students to pair up. (See Teaching Strategies on p. 49 for ways to choose a partner and good characteristics of a partner.) Repeat the instructions and process outlined in step 2 as students work. If partner work fails, have those students press against a wall with their arms, keeping their legs parallel, using active weight. This allows students to feel the firmness of the wall. The force that you exert is equal to the force the wall exerts, which is why the wall doesn't move.
4. Have students sit in Ready Position. Display the pictures of the stone arch, sloping roof, and barn-roof (see Reproducible Images Set 1). Complete the following with the class:
    - Identify the shape each pair made.
    - Identify a compatible structure from the structure images and guide them as necessary to identify the arch and roof.
    - Identify who or what was the load in their paired structures. (Both people are the load!)
    - Explain why they were stable. (Equal forces in opposite directions stabilize you.)

Activity #2: Compression with one hand (See the DVD for demonstration)

This activity is slightly more complex than Activity #1 because you touch your partner's torso and only use one hand. It takes more trust and sensitivity as well. Use the "adjusting the temperature" and "listening with your muscles" devices during modeling.

1. Choose a new student demonstrator to help you model the following process:
    - Once again, face your partner. Shake hands and say hello.
    - Explain how this time, you're going to use only your right hands and press on your partners' right shoulders. You'll reach diagonally across to press on your partner's right shoulder.
    - Touch the lower part of your palm. Have everyone do this and say "heel of hand."
    - Touch the soft place where your shoulder meets your chest. Have everyone do this and say "small of shoulder."
    - Place the heel of your hand on the small of your partner's shoulder.
    - Next, while applying a push force, step your feet away. Keep your body aligned, from shoulders to feet, with no bend at the hips. Once again, your bodies are two sides of a triangle.
    - Observe how the equal force holds your shape.
    - To come out of this position, walk forward at the same time, to support your own weight.
    - Thank your partner.
2. Instruct the students to pair up. Repeat the instructions and process outlined above as students work with their partners. Remind students to use the same hand as they shook hands with, so they will be reaching across diagonally. Remember "no behind behind" and walk forward to support your own weight at the end.

Science/Geometry Corner: This is a more stable structure because the top of the trapezoid has a smaller length than in Activity #1. This structure continues to get stronger as the top length decreases. Eventually that length will be 0 and produce a true triangle, one of the stronger shapes used for building. Students with a high interactive ability can form this true triangle structure by facing forward and leaning shoulder to shoulder, hands by their sides.

3. Point to the image of the stone arch. Ask students if they can see how equal and opposite forces hold the archway in place. You may want to mention that this point of equalization is the fulcrum.

Activity #3: Compression back to back (See the DVD for demonstration.)

1. Have the students sit in Ready Position for the introduction and modeling. Explain how you will explore making a stable structure, back to back with a partner, using balanced force and equal push.
2. Choose a student demonstrator to help you model the following process:
    - Start back to back, in contact from shoulder blades to tailbone. Make sure your shoulders, spines, and tailbones remain in contact, as though measuring to see who's taller.
    - Step your feet away. You should be as comfortable as if you were leaning against a wall. Your legs are like forward ramps. Your arms hang by your sides, with passive weight. Remember to equalize the force of push in your whole spine, with active weight, so you do not move.
    - Point out the negative (empty) space under the legs and ask students to identify the triangular shape.
    - To come out of the structure, walk your feet back in to support your own weight.
    - Thank your partner.
3. Repeat the instructions as students work. If partner work fails, have those students press against a wall with their whole backs, from shoulder blades to tailbone, keeping their legs parallel, using active weight. This activity allows students to feel the firmness of the wall. The force that you exert is equal to the force the wall exerts, which is why the wall doesn't move.

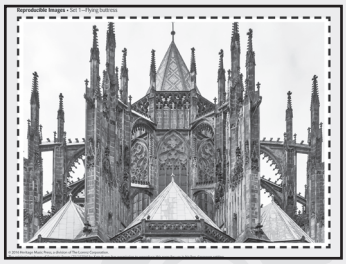
Going Further: Activity 3a: Compression with bent knees (See the DVD for demonstration.)

1. Select a pair of students who are working well together to model this idea. Have the rest of the class sit in Ready Position and watch.
2. Tell the class, "If you can press back to back successfully, try to bend your knees while maintaining the push force."
3. Have the student demonstrators start in the previous shape (from Activity #3), and bend their knees.

4. Point out the negative (empty) space under their legs. Ask the students to compare it to the shape of a barn roof. Explain how a barn roof is designed to allow for greater storage. Point out how the amount of negative space is increased when the children bend their knees.
5. If you wish, have all students try this variation.

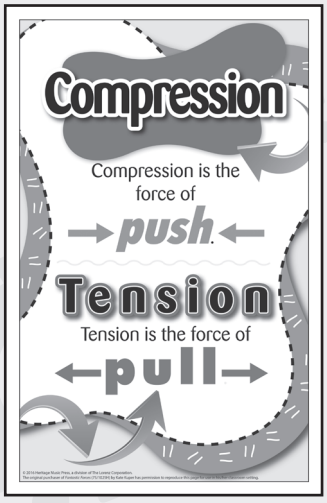
Going Further: Activity #4: Flying Buttress (See the DVD for demonstration.)

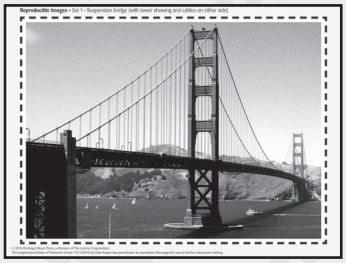
1. Display the picture of the flying buttress. You can provide some background on the history of the flying buttress as an architectural feature of European cathedrals of the Middle Ages, and the role they played in creating light, airy and tall buildings with lots of space for stained glass windows.
2. Select three students to demonstrate while others sit in Ready Position. See the DVD demonstration for instruction.
3. Ask for a student to explain how compression keeps the center of the structure stable.
4. Have the center student, playing the "cathedral," rise up on his toes to demonstrate being tall and airy, yet supported by the buttresses.



Tension: Introduction and Activities

1. Have the students sit in Ready Position. Say, "Let's learn about pull force and tension."
2. Display and read the Tension part of the Compression and Tension Poster.
3. Demonstrate and instruct the students to hook their fingers at breastbone level, point their elbows to right and left, and pull in opposite directions as they feel the muscular tension in their arms and backs. Have them pull evenly and observe that their hands stay in front, not moving.
4. Ask students to pull with more force on one side. Observe how their arms move because the force is unequal.





Activity 1: Suspension Bridge in pairs
(See DVD Option for demonstration.)

Science Corner: Within a suspension bridge, you see cables attached to the deck (road bed) of the bridge. These cables experience a tension force, a pulling force. The deck is held up by these tension cables.

1. Choose a student demonstrator to help you model the activity. Prepare your partner (and the class) by explaining how you will make a stable structure by using balanced force and equal pull.
2. Make sure sleeves are rolled up and you are not wearing a watch or bracelets. Model the following process:
    - Face your partner. Shake hands and say hello.
    - With right hands (the same hands you shook with) do a wrist connect with your partner.
    - Lean back, keeping arms straight. Your feet don't have to move at all.
    - Your shoulders will be further away than your feet.
    - Make a plank from shoulders to feet; don't bend at the hips.
    - Keep your eyes and your torso pointing toward your partner.
    - Equal pull forces should make this feel comfortable and supported.
    - If you feel secure, walk feet closer to your partner and lean back more.
    - Ask students to notice the shape that you make with your partner is an inverted triangle (or trapezoid).
    - To come out of the shape, use your arms with active weight and pull force to bring you back to vertical, supporting your own weight. Pull with your arms and let your elbows bend.
    - Stand on your own two feet. Thank your partner.
3. Repeat the instructions as students work.

This transition is an opportunity for students to work with a new partner, and for you to help some students find a more suitable partner. Move among the pairs, offering suggestions and corrections. Stand near spirited pairs as necessary.

Activity #2: Balanced Pull Force Using Active and Passive Weight (Cantilever)

Science Corner: A cantilever functions very much like a suspension bridge. One type of cantilever uses a diagonal compression support, called a leg, to help stabilize the load. Within this cantilever, there is a tension force applied to the load by the arms of the students. The load has its own leg (human legs in this example) that is held up by the compression force. The combination of two forces (tension and compression) acts to form a stable cantilever.

This activity takes trust, cooperation and following the "no goofball rule." (See Appendix p. 49 for this teaching strategy)

1. Choose a student demonstrator to help you model the activity.
2. Explain the activity objective: In this activity, one person pulls in one direction with active weight while the other leans in the opposite direction with passive weight. Both people will have active tension force in the arms. The person who leans away keeps both legs on the ground to act as a compression force. To be successful, you must both keep the opposite tension pull within the same plane, as though between two panes of glass.
3. Model the following process:
    - Decide who will be the active weight "support," and who will be the passive weight "cantilever."
    - Position the support behind the cantilever (both facing in the same direction). Instruct the support to stand strong, with legs braced and create a wrist connect with the cantilever.
    - Instruct the cantilever to extend both arms directly backwards and parallel, supported by partner at the wrist connect. The cantilever should tilt away from counterbalancing support, so as to look like the carving on the prow of a ship. Legs stay in place. Chest is the farthest point out, hips are forward of feet. Keep the head up.
    - Point out how the weight of the passive tension partner is increased by allowing the hips to go forward, while keeping the chest and head lifted.
    - To come out of the position, it is the support's job to carefully bring the cantilever up to a vertical position, bearing his own weight, before both step apart.
    - Thank your partner and trade roles.
4. Repeat the instructions as students work.

Science Corner: This cantilever example uses counter weights. One student's extension is enabled by the large counterweight of the other student. A common example of this would be a crane or a boom.