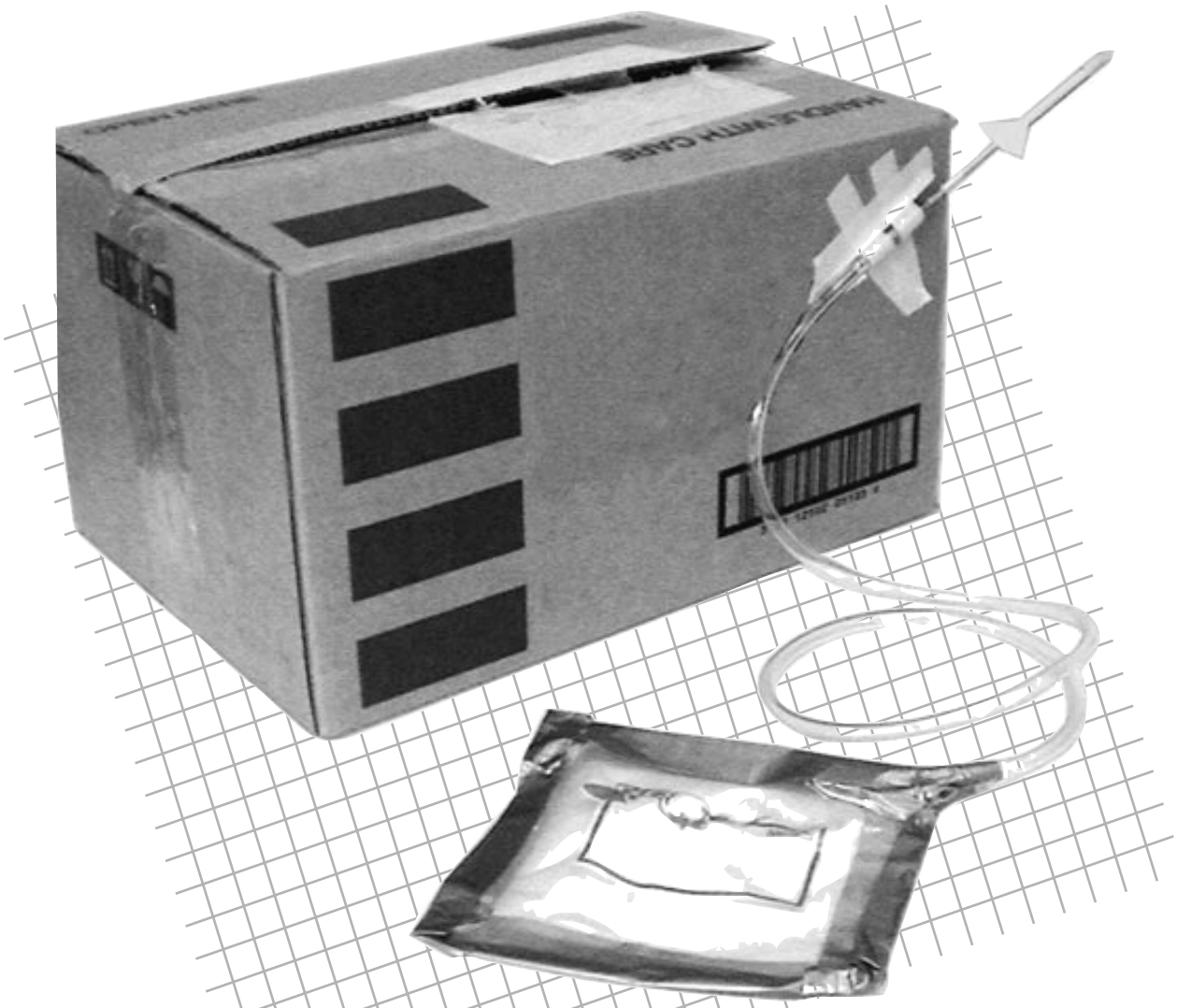


# STRAW ROCKETS

KELVIN® Stock #651816

DESIGN IT! ENGINEERING IN AFTER SCHOOL PROGRAMS

Education Development Center, Inc.

# Table of Contents

# Overview

Rockets have fascinated generations of people. From the firework rockets that the Chinese created centuries ago, to the first rocket to land on the moon, to our latest Mars explorers, we have invested a lot of energy into designing more and more sophisticated rockets. Though we find new ways of powering and building rockets, the basic principles of what they do is the same. In this *Design It!* project, children have the opportunity to design their own launchers and straw rockets while experiencing these basic principles.

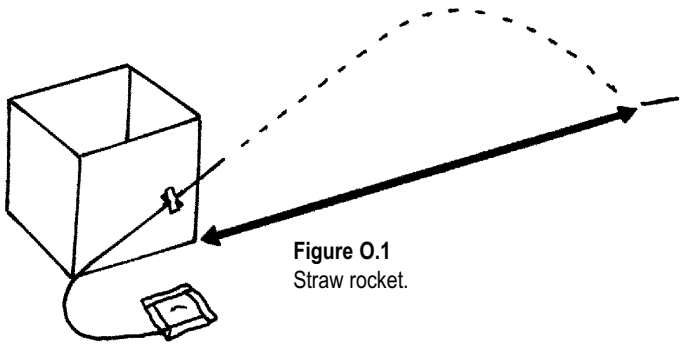


**Figure O.1**
Straw rocket.

Made from drinking straws, the simple rockets of these activities can captivate children for hours. With just a push of air, the rockets are propelled into "space." The children will work together, troubleshooting and problem solving, until they create the optimum rocket and launching system. Their learning and designs are tested when the children play a rocket game.

As the children work through the challenges in this project, they will learn about experimenting, testing, making observations, asking questions, and explaining what they have done and why they did it—the essential elements of critical thinking and the inquiry approach to engineering and science.

## MATERIALS

The materials recommended for this project have been tested by children ages 8–12 years. Most of the materials are generic in type, so virtually any brand will work as well as another. Generally, you should not give alternative materials to the children until you have tested them yourself.

Below is the master list of the materials children will need to complete all of the activities in this project. Each particular activity contains a list with amounts specific for that activity. Items marked with a [*] are available directly from Kelvin (see order form on page 99).

### *For each team*

- 1–2 books (hardcover, 8 x 9 inches or larger, weighing around 2 pounds)
  *or* 5 magazines and 2 pieces of 8 x 11-inch cardboard
- 2 rubber bands
- 1 cardboard box (11 x 11 x 12 inches or larger)
- 9 jumbo (wide) straws
- 1 marker (permanent, dark colored)
- 1 pair of scissors
- several pieces of copy paper
- 2 launching assemblies made from:
  - 1 resealable (slider) plastic freezer bag (quart-size)
  - 1 yard of duct tape
  - 1 yard of plastic tubing
  - 1 regular drinking straw
- 1 roll of masking tape (1-inch wide)
- 1 measuring tape or yardstick (optional)
- 1 pad of self-adhesive notes, such as Post-its (1-1/2 x 2 inches)
- cellophane tape
- index cards (5 x 7 inches)

## For the whole group

- colored markers
- extra straws
- pencils and pens
- extra resealable (with slider) plastic freezer bags (quart-size)
- protractors (optional)
- protective eyewear

## For the program leader

- rocket images (page 90)
- angle template (page 91)
- planet targets (page 92)
- duct tape
- chart paper
- graph paper, yardsticks, paper bags (optional)

### BOOKS

Choose hardcover books or collect magazines and place them between two pieces of rigid cardboard and secure them with rubber bands. Make sure that whatever you use is not heavier than three pounds. It is important that the children do not easily pop the resealable bags.

### CHART PAPER

You will use chart paper throughout the project to create lists and group data sheets during discussions for all children to see. It is not listed in each activity's materials list. Chart paper can be purchased at office supply stores.

### MEASURING TAPE

A measuring tape is only one option for measuring the length of the rockets' flights. As an alternative, you may create homemade measuring string on which you have marked each increment of a foot. You can also use yardsticks or count floor tiles.

### RESEALABLE PLASTIC FREEZER BAGS

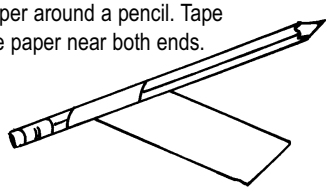
Choose resealable bags with a safety lock—also known as "slider bags" (see Figure O.2)—because they are easier for children to close than regular resealable bags. To help with the problem of bag breakage, it is best to choose a sturdy brand of freezer bags.

**Figure O.2**
Resealable plastic freezer bag.

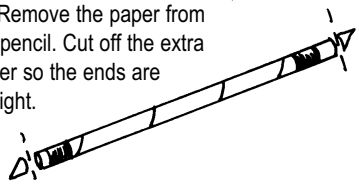
### STRAWS

Both regular and jumbo straws are needed for this activity. Jumbo straws are the type used for thick drinks, such as frappes and milkshakes. Movie theaters, coffee houses, and ice cream servers often have them. If you cannot find jumbo straws, use thin straws with regular straws or try making your rocket by tightly rolling a rectangular strip of paper around a pencil. Secure the paper with tape (Figure O.3). Check for and repair air leaks with additional tape.

**Figure O.3**
(1) Wrap a thin piece of paper around a pencil. Tape the paper near both ends.



(2) Remove the paper from the pencil. Cut off the extra paper so the ends are straight.



### TUBING

Clear, flexible vinyl tubing is available in a variety of diameters, both inner and outer. Make sure that the straws you use for the launchers fit snugly into the tubing you purchase.

The standard inner diameter (ID) of regular straws is 1/4 inch. Therefore, if you buy tubing with an ID of 1/4–5/16 inch, you should have no problems fitting them together. The outer diameter (OD) of the tubing does not matter for this activity. Tubing is available at most hardware stores in the plumbing supply section.

# TEAMWORK

It is recommended that you divide the children into teams of two to four children who will work together as a team for a number of weeks. Try to make sure that the natural skills and energy of your whole group are shared evenly among these teams. If you allow teams of children who are already good friends, be aware that some children may, thereby, be shut out of participation in the project. If practical, mix girls and boys and older and younger children. Be flexible and open to re-teaming the children from time to time if the first groupings are not working well, or simply to ensure that the children experience new working partners that they might not have chosen on their own.

## *Defining roles*

Within the teams, it is recommended that you assign one or more specific role(s) to each child for the design work. Assigning roles can have a number of beneficial effects:

- Each child knows exactly what is expected of him or her and learns how to share the fun and responsibility of the work fairly with others.
- More introverted or timid children get equal access to the materials along with more assertive children.
- Children who might otherwise disengage are given important tasks that demand their involvement.
- Tasks that might normally fall by the wayside are remembered and accounted for.

Here are some roles you might use:

BUILDER: Connects the pieces of the launcher and rocket together. All team members are builders all the time, unless they are actively fulfilling another role.

CHIEF ENGINEER: Directs the team effort. Settles disputes between other team members. Measures the length of each shot and keeps records. Responsible for ensuring that all materials are used safely.

Other roles that should be shared among all the team members are listed below. Remember that each child may have more than one role.

BOX HOLDER: Holds the box in position while the rocket is being launched.

BAG BLOWER-UPPER: Blows up the plastic bag prior to launching.

**NOTE:** So that germs are not spread, the bag blower-upper must continue in this role until a new launching straw is put into the tube.

BOOK DROPPER: Drops the book onto the plastic bag for launching.

ROCKET POSITIONER AND RETRIEVER: Places the rocket in position for launching and retrieves it after it has been launched.

MATERIALS COORDINATOR: Collects initial materials for the project from the program leader. Checks all materials to ensure they are working properly. Searches for additional materials that can solve problems as they come up.

AMBASSADOR: Collects ideas from other teams by watching what they are doing and talking with them about their designs.

PRESENTER: Presents the experience and the findings of the team to the whole group. Responsible for knowing what each team member thought or contributed to the design and construction process.

Watch out for children who dominate their team and exclude others from the process, as well as for children who disengage. To help ensure that everyone remains engaged and has a fair chance to participate, restate the job descriptions at the beginning of each session and be sure the children know who is officially assigned to each role for that period of time. Roles should be switched at least at the beginning of each session, and possibly in the middle as well.

# MANAGEMENT OF THE ACTIVITIES

## *Pacing*

The activities in this project are broken into manageable challenges so the children are able to have success without getting frustrated. As they proceed through one activity after another, they will be able to make the rockets fly farther and more accurately. This gradual improvement keeps children motivated to test and problem solve. Try to keep the children from going ahead or they may burn out quickly or get over stimulated and start to experience problems. The goal is for the children to methodically work through the steps of problem solving and to pay attention to the lessons learned from "unsuccessful" experiments.

## *Competition*

Although competition can be highly motivating for children, it can also alienate some—usually those who are "losing" and, perhaps, those who are already most in danger of disengaging. Monitor the children's language and behavior constantly to ensure that they are not making others feel uncomfortable, and if you decide to have formal competitions in this project, watch out that "winning" does not take over from all the other valuable aspects of this process. Explain that although scientists and engineers do compete, they more often work together to find the answer to a problem. The goal here is for the whole group to learn from each other about what works and what doesn't when designing and constructing rockets and launching systems.

## *Optimization*

In the real world, there are always cost constraints and physical limits to the performance of any device being designed. The solution design engineers look for is called the optimum arrangement—the arrangement that does the best job possible given the limitations of cost, space, or the nature of the materials available. After extensive testing, engineers choose the type and quantity of materials that come closest to fulfilling the requirements of the project. Another way of putting this is to say that there are seldom perfect solutions to an engineering problem.

Using a set group and amount of materials, children will need to manipulate straw weight and length, fin design, and launching force and angle to create the optimum rocket system that will land a rocket on a chosen target. Use your own judgment about whether you introduce the term and the concept of optimization explicitly with the children. What is most important is that they learn to make the kinds of judgments and compromises mentioned and that they notice that the "best" amount of some factor is not always the largest amount possible.

# TROUBLESHOOTING

Children usually do not have much trouble assembling the suggested materials into a working rocket and launcher, but if they perform poorly, their first impulse may be to blame the materials or to blame themselves. Many children are convinced that they are just "no good at making things" or "no good at engineering." Your task is to encourage them to search out the cause of the problems in the device itself, looking carefully at the specific ways that the materials are combined. Blaming oneself never helps, but it may take repeated reassurances and successes before some children buy into the idea that it really is about the materials and not about some quality that they, themselves, do not possess.

Isolating where (in the materials) the problem is and either adjusting the materials or coming up with alternatives is much of what engineers and designers do. So, the tendency to blame the materials is constructive as long as it leads the children to look more closely at the device itself to locate the problem.

In some situations, the solution to solving a problem may not be readily apparent. Try not to offer hints or solutions until the children have made some attempts to experiment with their designs. Three (kinds of) questions may help you stimulate their thinking and energy:

- What have you tried (and what happened)?
- What works (and what doesn't)?
- What has worked for other teams? (Has the ambassador been looking at what other teams have been doing?)

After repeated attempts, children may be ready to give up. If this point arrives, offer a hint or clue that will get the children over the hump and allow them to resume being successful with the device. The Guiding the Activity section of many activities offers suggested solutions to common construction and design problems.

# DISCUSSION

The guidelines for each *Design It!* activity suggest that you hold a formal discussion with the children at some point during each session of hands-on work. It is recommended that you create a Discussion Circle, where children are away from their materials, sitting in a circle or group, to talk about what they have achieved or noticed so far. If you or the children are new to this format, this discussion time need not be very long, but it should become a regular part of your *Design It!* routine from the very beginning.

## *The importance of "talk"*

When children talk about what they are doing they discover much more about the project than if they only do the hands-on portions. When they talk, children have to reflect not only on what they did, but also on how they did it. They have to think about their actions and about their thinking.

Talking openly about how they solved (or didn't solve) a problem serves several useful functions for children. It allows them to:

- share and celebrate what they know and what they have succeeded in doing,
- acknowledge what they don't know and what they cannot succeed in doing,
- hear what other people thought or did in a similar situation, and
- piece together their thinking (about engineering solutions or decisions) in a way that they are not yet experienced enough to do for themselves.

It is very important that these discussions be a positive experience for the children, a chance for them to share, think out loud, and feel good about their contributions. Avoid calling only on the articulate children or the first to respond. Try also to make time for the less verbal children to say what they can about their experiences. Avoid telling a child that he or she is either "right" or "wrong" about something; it closes the door for other ideas and approaches from that child or other children. Thank and praise children for contributing in a respectful and thoughtful way. Sharing ideas should be its own reward—it is not a way to show who is right and who is not.

Specific questions are often suggested to help you lead your discussions. A question mark icon, as shown here, will help you identify where these questions are located in the text.

### *The importance of "non-talk"*

Discussions during this project will strengthen the children's language skills. However, there are other ways to communicate and explain that do not use words. Throughout the discussions, encourage children to use hand signs, drawings, made-up words, and other creative strategies to get their points across.

## ASSESSMENT

The most direct assessment of the children's work in this project is their ability to make rockets and launchers that work. If they are careful in their technique of assembling parts and launching, and if they think through problems deliberately, they should be successful.

It is important to observe each team over the series of sessions and note how they proceed with the more difficult challenges. As you observe, ask yourself whether you see a gradual increase in the children's ability (or willingness) to:

- think through their designs and deal with problems in a skillful manner,
- work cooperatively (i.e., share their work and listen to each other's ideas and suggestions),
- describe to you and to each other how they did whatever they did and why it worked, and
- focus on what they actually see happening rather than what they think should happen.

Specifically, look for increases in these behaviors:

- Taking turns and sharing the hands-on work.
- Asking each other for help before asking you.
- Listening when their peers are sharing ideas.
- Responding constructively to ideas from peers or adults.
- Making deliberate changes to their designs to improve how they work.
- Making these changes to only one factor at a time.
- Keeping accurate and clear data and records.

Where appropriate, more specific suggestions for carrying out assessment are given in the Background section of the activities (Activity 7 offers assessment suggestions in Guiding the Activity).

# Space

## *Work space*

For these activities, each team needs a launch area (runway) at least 18 feet long and 3 feet wide. Teams may share a runway, but each team must have sole use of the runway when they are launching. Push furniture to the side if needed. If space is limited, you might consider adjusting the activity. Have the teams aim at targets that are within the distance that you have available. You can also measure the vertical distance (how high the rockets hit on a wall) rather than the horizontal distance that they travel.

## *Storage*

You will need a place to store the launch boxes (which are also used to hold the children's materials).

# Safety

With clear expectations and rules communicated to children, followed with normal supervision, there is no reason Straw Rockets cannot be used safely by your children. Work with the children to establish safety rules that include the following:

- Only launch rockets away from people.
- Wait until your runway is clear of people to launch your rocket.
- Wear protective eyewear.
- Use materials only in the manner they are meant to be used in the activity.


Safety messages appear throughout the activities when necessary. You will be able to find them easily by looking for the safety icon at left.

# Implementation Guide

The above issues and procedures are developed in more detail in a separate publication called *The Implementation Guide for Design It! Projects.* It is strongly recommended that you purchase this guide and consult it before carrying out any *Design It!* project with your children.

# Activity 1: The Basic Straw Rocket

## What Materials Do I Have?

- 2 regular straws
- 2 lengths of jumbo straws (4-inches long)
- masking tape
- pencil
- paper clips
- measuring tape (optional)
- *Data Sheet*

### THE CHALLENGE

Use your breath and a straw to launch a straw rocket 6 feet or more.

## What Do I Do?

1. Using the available materials, create a rocket out of a straw.
2. Figure out a way to launch the rocket using your breath and the materials that you have. How far can you make the rocket travel?
3. Be sure to write your name on your straw rocket and your launching straw.

## What to Think About

- What will make the rocket fly farther?
- What can you change to make the rocket fly differently?

**SAFETY:**

- Only launch rockets away from people. Wait until the floor is clear before you launch your rocket.
- When you pick up your launched rocket, make sure that no one else is launching in your direction.

# Activity 1: The Basic Straw Rocket

## Preparing Ahead

- Read through the complete guide so you know the goals of each challenge.
- Decide who will be in each team of two.

**NOTE:** In later activities, you may combine teams of two to create teams of four.

- Decide where you want each team to stand when they launch their rockets. Mark those spots with tape. From there, if the children do not have floor tiles or another way of keeping a record of how far the rockets travel, use tape to mark off one-foot increments on the floor in the direction that you want the children to launch their rockets. (Alternatively, the children may do their own measuring.)
- Gather the materials that each team will need. Be sure to have enough straws so that each child can make and launch his or her own rocket. Have extra straws available.
- Make and test a rocket yourself. (During this activity, the children are challenged to design a rocket and launching procedure as outlined below. Let them figure out an arrangement by themselves as much as possible before giving them any directions.)

1. Using tape, close one end of one of the wide, short straws (Figure 1.1).
2. Place the short straw over the thin long straw (Figure 1.2).
3. Blow into the long straw. The short straw will launch into the air (Figure 1.3).
4. Turn over 1/2 inch of the end of another short straw (Figure 1.4). Tape the bent end in place. Test this rocket.

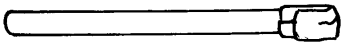


**Figure 1.1**
Straw rocket with taped end.

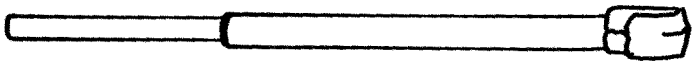


**Figure 1.2**
Straws placed together to launch.

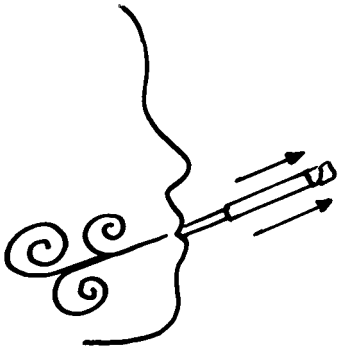


**Figure 1.3**
Launching the straw.

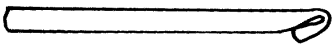


**Figure 1.4**
Bent straw rocket.

## Materials

**FOR EACH TEAM**

- 2 regular straws
- 4 lengths of jumbo straws (4-inches long)
- masking tape
- pencil
- paper clips
- measuring tape (optional)
- *Data Sheet*

**FOR THE WHOLE GROUP**

- extra straws

- Make one copy of the Challenge Sheet and the *Data Sheet* (page 93) for each team.
- Copy the *Letter to Families* (page 97) and send one home with each child.

## Introducing the Activity

Gather the children together and tell them that they will design, construct, and test straw rockets and launchers during this project. At the end of the project, they will play a game during which they can apply all that they have learned while launching their rockets at targets.

Ask the children:

- How many of you have made rockets before. What do you know about rockets from this experience?
- How many have seen a real rocket launch from earth? What did you notice?
- How are rockets different from planes?
- Have you ever built paper airplanes?

## The Challenge

Use your breath and a straw to launch a straw rocket 6 feet or more.

Explain the first challenge and introduce the materials available. Each child should begin with two straws (one thin, long straw and one wide, short straw) and tape.

- What do you think you need to do to create a rocket and launcher out of these materials?
- How will you launch the rocket with your mouths?

Have children brainstorm ideas to answer these questions.

Let the children know that you will assign them to teams of two. Team members will share ideas, help each other test their rockets and record results, alternately launch rockets, and complete one *Data Sheet* as a team. Their goal together, not individually, is to successfully meet the challenge; however, each child will use his or her own launch straw.

Show the group the *Data Sheet* and discuss what information they need to record and how to record it. Each time one of the team members launches a rocket, the other member of the team should measure the distance that the rocket traveled (measuring from the tip of the launcher's feet to the point where the nose of the rocket first touched the ground) and record that measurement under the heading "Distance Rocket Traveled." After a rocket

has been launched and the data recorded, the team members should switch roles. Now the other person launches their rocket and their teammate measures and records the distance it traveled. Describe to the children the different ways they can measure distance from where they launch to where the rocket lands.

Discuss the safety guidelines:

- To ensure that germs are not spread through the children's saliva, each team member should touch only his straw with his mouth. Make sure they put their names on their rockets ahead of time.
- Children should only launch rockets away from people, and must wait until the floor is clear before they launch a rocket.
- When measuring the distance that a rocket has traveled and/or picking up a launched rocket, children must make sure that no one else is launching in their direction.

SAFETY

Let the children know that you will gather them together after they have worked for a while to demonstrate their rocket flying and to discuss what they did and what they noticed.

Just before starting the activity, give the children a specific amount of time to launch their rockets before coming together for discussion, put the teams together, pass out the Challenge Sheets and *Data Sheets*, and set the children to work.

## Leading the Activity

How will the children make and launch the straw rocket? If they put the wide straw onto the narrow straw and blow, they will notice that the wide straw does not move (Figure 1.5). They must figure out that the end of the wide straw must be closed for the rocket to perform.

If they close one end of the wide straw and then place it on the narrow straw, the increased air pressure will propel the rocket forward (Figure 1.6).

If the children start to become frustrated, walk around to teams with the wrapper of a straw opened on one side but still covering the straw. Blow into the open end of the straw. The wrapper should shoot off the straw (Figure 1.7). (If it does not, you may need to tear away a bit more of the wrapper from the end.)

**Figure 1.5**
Straw doesn't move if end is open.

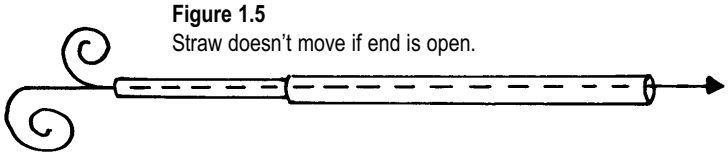


**Figure 1.6**
Closed end enables air pressure to move straw.

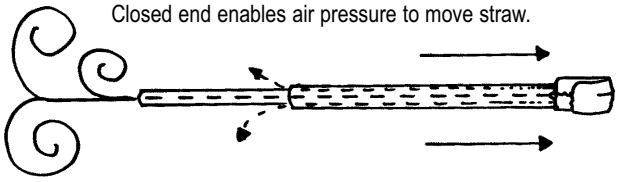
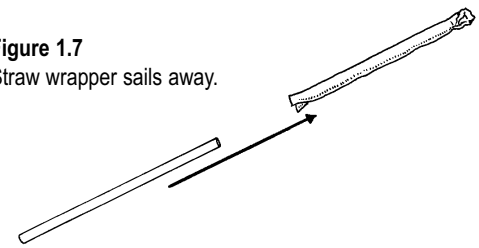


**Figure 1.7**
Straw wrapper sails away.



## Guiding the Activity

Without saying anything, see if the children can translate what they have observed about the straw wrapper demonstration into bettering the performance of their own rockets. Carry extra straws with wrappers so that you can repeat the demonstration as needed. If the children still do not catch on, ask them what they notice about the wrapper.

If they do not point out that one end is closed, open that end and then blow. When it does not move, ask them what happened. Then have them think about how they can apply what they just saw to their own rockets. If you have many straws with wrappers, you can give them to the children to do the experiment themselves rather than showing them.

The straw wrapper demonstration should give the children a hint about how to launch the rocket, since the wrapper fits over the straw in the same way that the jumbo straw fits over the regular sized straw. Perhaps some children have tried holding the rocket directly in their mouths (i.e., without using the long straw as a launcher) and blowing through it while releasing their grip on it. This method does not work very well. Ask them how they can use their breath without directly holding the straw rocket in their mouth. Sliding the wide straw over the narrow straw and blowing into the open end of the narrow straw works well. They can see this from your demonstration.

As you walk around the room, make sure that each team is using the materials safely and taking turns. Encourage them to notice differences between each rocket flight. When they notice a change, ask them what was different in the rocket, the environment, or in their launching procedure that could have caused the difference. Encourage the teams to try and make their rockets hit a target.

Check that teams are recording the measurements of the flight of their rockets on the *Data Sheet*. Children should be measuring from the tips of their shoes to the spot where the rocket first touches the ground. Teams can use a measuring tape, the strips of tape you've put on the floor, or floor tiles, if you have them. Counting floor tiles does not give a perfectly accurate measurement, but it may be easier for children who cannot easily use and read a measuring tape.

When teams use tape or a paper clip on their rockets, weight is added. Ask the children if the weight makes a difference in the flight of the rocket. Does the placement of the weight make a difference? Challenge the children to test their rockets with extra weight so that they can answer this question.

When every child has experimented launching a rocket with varying amounts of breath, launch angle, and weight, stop them from working. Ask the children, one at a time, to demonstrate for everyone how their rockets fly. As the rockets fly, ask the whole group to notice how each demonstrator launches the rocket, how the rocket travels, and where it lands.

Before coming together for a Discussion Circle, have the children store their rockets in an area designated by you. Make sure they have marked their names on their rockets.

## Leading the Discussion

Ask the children what they noticed during the demonstrations and their testing:

- What distances did your rockets fly?
- Did your rockets fly straight?
- Were you able to hit the same target several times?
- What could have made the rockets fly differently each time?
- Were any of the rockets designed differently?
- Did you close the end of your rocket in the same way?
- Did you use tape or bend the end of the straw over?
- How much tape did you use?
- What difference might these variations make in the flight of the rocket?
- What difference did the paper clip make in the flight of the rocket?
- Did the rocket fly straighter or farther with the paper clip in a certain spot?

If the group comes to an agreement that a weight at the front tip of the rocket is best, show them the trick of bending over 1/2 inch of the end of the straw. In any case, let the teams keep their rockets as they designed them, if they prefer, for the next activity.

If during this discussion children do not mention the amount of air blown into the straw by the launcher, the rate at which the air was blown (e.g., a gentle puff or a strong burst), the height of the launcher, or the angle at which they launched the rocket, then bring up these ideas as questions.

- Do these factors make a difference?
- How can you find out?
- How can you know which things make a difference and which do not?

During the next activity, the children will design rocket launchers that will enable them to change just one thing at a time so they can test what makes a difference in the rocket's flight. When the children use their breath to launch the rockets, there is no way to control all of the factors mentioned, even if only one child launches each time, and height and angle are controlled.

Wrap up the conversation by trying to summarize the children's findings and establishing what the optimum straw-rocket design and launching procedure are up to this point.

# Activity 1: The Basic Straw Rocket

## Rationale

During this activity, the children use their bodies to gain an intuitive sense of what goes on when their straw rockets are launched. They use simple materials to focus on what is needed to turn the straw into a projectile that will launch with a blow of air. By the end of the activity, they will notice variations in the flight of the rockets, caused by many things: (1) lack of a consistent source of power children cannot control the exact amount of breath they use each time they launch their rockets), (2) the height of launch (children launch from different heights based on how tall they are), (3) and the angles of launch. In the next activity, the children have the opportunity to design a launching system that provides a consistent launch.

The short straw rockets fly erratically. Long straw rockets do not wobble nearly as much. The tendency of the short rocket to wobble will give rise for the need to add fins, which the children will do in Activity 5. However, during this activity, the children have the opportunity to add weight to their rockets, so they have a rocket that travels well enough to keep them interested in continuing onto the next activity.

## Introducing the Activity

Brainstorming ideas about rockets gives the children some common information with which to start their design thinking. Get the children to think about their own experience with rockets and to predict how the straw rockets may behave. Ask them if they have ever played with or made a model rocket. Have they seen the exhaust come out the back? Have they made paper airplanes? How do they think that a rocket is similar to a paper airplane? Have they noticed that planes are somewhat fat and have big wings and rockets are thin and have tiny fins? If a majority of the children have had experience with rockets, take more time to find out if they have had experience from which they learned about thrust, launch angle, and fins. Their previous experience may or may not be relevant to the learning that they will do during these activities.

Although children do not usually need extra motivation to start this project, you may want to describe the game they will play at the end of the project. Let them know that the time they spend now will help them to develop a rocket and launching system for use in the game.

You can set up the series of activities in such a way as to help guide and pace your progress. For instance, if you ask the children to create a rocket design that is cost-effective (for these activities, this may mean using as few

materials as possible) and that will accurately reach a target, you can lead the children to use less paper for the fins and focus on accuracy rather than distance for a flight goal.

It is important to establish expectations for the children's behavior at the outset of the activity. Children should have fun, but while having fun, they should remember to do the following:

- Be responsible for completing the tasks of their roles.
- Contribute, share, negotiate, help, and problem solve with their teammates.
- Monitor their noise level and make sure it stays within the levels that you establish.
- Use materials in a safe manner and in a way that contributes to their effort to reach the project goal.

It will help the children if you discuss your expectations for drawings on the *Data Sheet*. Some children may be anxious about their drawing skills. The drawings of their rockets and the rockets' flight paths are supposed to remind the children of what they did and saw during previous work. They are informational recordings and a visual cue to jog memory. A simple line drawing is all that is needed for these purposes.

Be aware of the children's limitations for discussion prior to starting the activity. Allow them to spend enough time on their initial rocket designs so they have some common experience to discuss.

## Leading the Activity

At this point in the project, it is more important for the children to gain general experience using the materials than to systematically identify factors that may affect the rocket's flight. While playing with the rockets, the children have fun (which will motivate them to continue) and gain intuitive knowledge about how the rockets function and the factors that affect flight. Later they can explicitly identify these factors and go on to formally test them. During this activity, it is important to point out the unpredictability and differences of each flight. Doing this will give the children a reason to create a launcher in the next activity.

The children may not want to stop working with their rockets in order to record data. Insist that they have this information to share with the group during discussion. The routine of launching, measuring, and recording should slow down the pace enough to facilitate safety and careful observation.

## Leading the Discussion

The discussion sessions have their own requirements for children's behavior, and it is helpful to establish your expectations at the beginning of the first

discussion. You are also the model for the kind of participation you want. To create the best atmosphere for productive discussions, you should:

- provide constructive feedback,
- call on every child at some point
- redirect comments and questions to other group members so that children begin to speak to each other directly and maintain a discussion, and
- wait a few minutes before calling for a response so that children have time to think and no one is able to dominate the discussion.

Establish a routine of demonstration followed by discussion of design features, launching procedures, and the corresponding flights of the rockets. Incorporate bodily demonstrations and drawings of what the rockets did so that the children can synthesize their experience in multiple ways. Elicit the children's ideas about what might make the rockets fly better. Many of their ideas can be tested.

It is important to refer to the data the teams recorded. In this way, you support their efforts to keep accurate data and help them to focus all conclusions on evidence.

Perhaps, most importantly, summarize the children's accomplishments during the discussion.

## ASSESSMENT

During this activity, assess the children's basic involvement. Are they taking turns, keeping data, and focused on meeting the challenge?