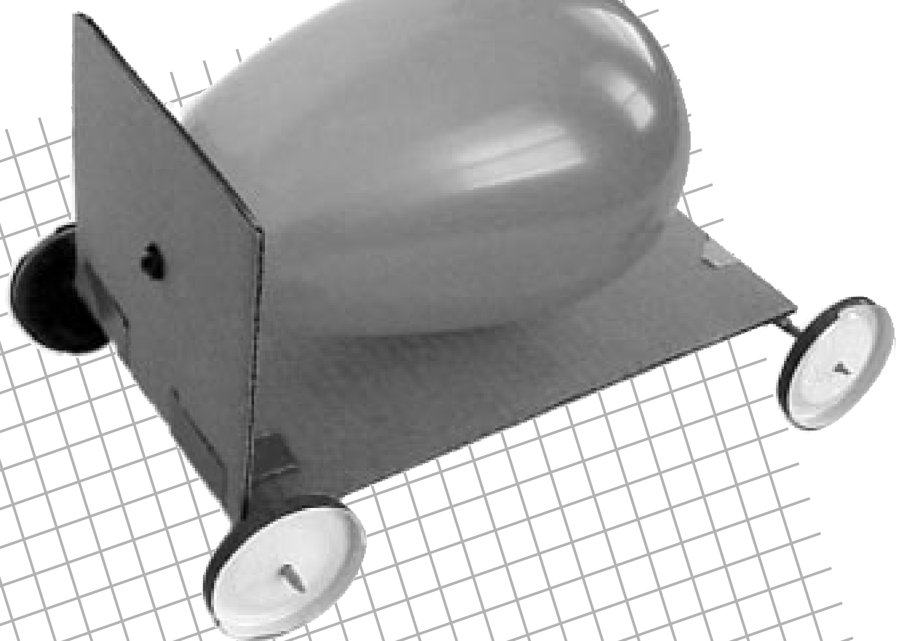

BALLOON-POWERED CARS

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DESIGN IT! ENGINEERING IN AFTER SCHOOL PROGRAMS

Education Development Center, Inc.

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Activity 1: Making and Testing a Model Car

What Materials Do I Have?

- 1 piece of cardboard (6 inches x12 inches)
- 2 dowels (3/8 inch in diameter, 8 inches long)
- 4 bottoms of cups
- *Data Sheet—Activity 1*

The Challenge

Make a model car with the materials provided and see how far it can travel when launched from the ramp.

What Do I Do?

1. Talk with the members of your team about how you will assemble a car with the materials provided.
2. Decide what kind of wheels you will use and how you will attach them to an axle.
3. Decide how you will attach some of the materials to the cardboard so the wheels spin freely.
4. When you think your car is ready, test it by rolling it down the ramp.
5. How far did it go? Write down the results on *Data Sheet—Activity 1*.
6. Make changes to the car or wheels that might make it run more smoothly. Test it and record the results.

SAFETY

Keep pointed dowels away from your face and other peoples' faces.

What to Think About

- What determines whether a car goes straight or not?
- What determines how far a car will travel when launched from the ramp?

Data Sheet—Activity 1

Team Members: ____________________

____

____

Trial	Distance Traveled (feet)	Changes Made to Car
1		
2		
3		
4		
5		
6		
7		
8		
9		

Activity 1: Making and Testing a Model Car

PREPARING AHEAD

1. The least expensive way to make wheels for this project is to use the bottoms of plastic cups:
   - Larger plastic cups usually have thick bottoms, which makes for more rigid wheels and also helps them hold the dowel tightly. Cut out the bottoms of cups before starting the activity. Use a craft knife to cut along the ridge at the bottom of the cup. Try to do this in such a way that you end up with a smooth surface for the wheel.
   - Punch a hole in the middle of the wheel using a push pin. You can find the center by measuring the diameter with a ruler and making the hole at the halfway point. Some cups may have a small raised dot in the middle. Punch the hole there.

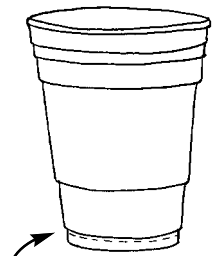

Figure 1.1
Cut along the base.

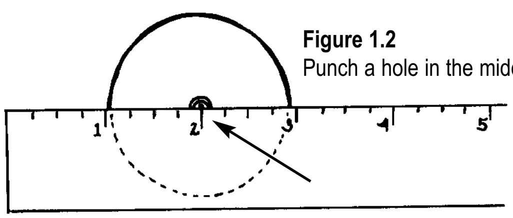

Figure 1.2
Punch a hole in the middle.

You can also supply the children with other kinds of materials that can be used as wheels. For instance, you can have them bring yogurt and other plastic lids from home (such as those from margarine tubs). However, they need to bring *at least two* each of these lids. Stores that sell craft supplies often carry a variety of beads, both wooden and plastic, that can also be used. These same stores may also sell wooden or plastic wheels. (Plastic wheels are available from Kelvin.) However, do not give too many choices to the children. Three different kinds of wheels is sufficient for the first activity.

2. Cut the cardboard into 6-inch x 12-inch pieces. These will be used for the bodies of the cars.

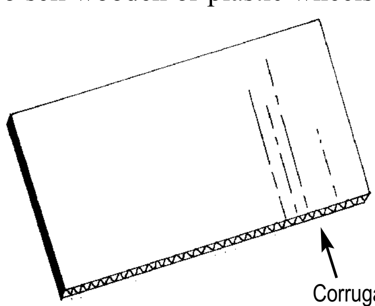

Figure 1.3
You should be able to see the corrugation along the long side of the cardboard piece.

NOTE: Make sure the holes of the corrugation are lined up on the long side of the rectangle (see Figure 1.3).

Materials

FOR EACH TEAM
- 1 piece of cardboard (6 inches x 12 inches)
- 2 dowels (3/8 inch in diameter, 8 inches long)
- 4 bottoms of cups
- *Data Sheet—Activity 1*

Optional
- 4 wood beads (1 inch in diameter)
- wood or plastic wheels, wood beads (3/4-inch)
- other kinds of materials for wheels, such as yogurt or other plastic lids

FOR THE WHOLE GROUP
- drinking straws
- masking tape (1 inch wide)
- scissors
- pieces of cardboard
- pencil sharpener

FOR THE PROGRAM LEADER
- 1 craft knife
- 1 push pin

FOR TESTING
- 1 piece of cardboard (36 inches long and at least 24 inches wide)
- yardstick
- books

3. Make a ramp for testing by placing books under one end of the long piece of cardboard so that it is raised about 6 inches off the floor (see Figure 1.4).

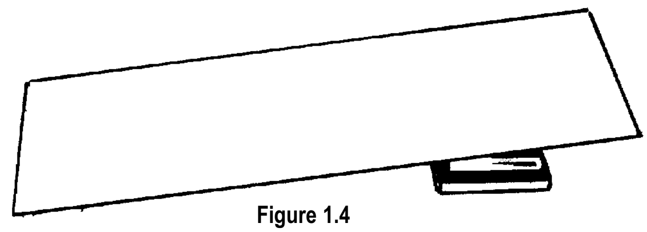

Figure 1.4

4. Find a space in your center to place your ramp to test the cars. Hallways or auditoriums with no carpeting would be best. The space needs to be at least 6 feet wide and 15 feet long. If you can, mark off with tape on the floor 1-foot increments in a line away from the bottom of the ramp before the session. Your room may have linoleum tiles that are exactly 1 foot long. These can also be used to measure distance.
5. Before starting the activity with the children, you should construct a car yourself and test it on the ramp. By experiencing the process of constructing and testing a car, you will be more prepared to help the children with any problems they may encounter.
6. Sharpening the dowels in a pencil sharpener will make it easier for children to push them through the lids. You can sharpen the dowels ahead of time or have the children do it before they begin.
7. Make enough copies of the Challenge Sheet, including *Data Sheet—Activity 1,* for each team.

Introducing the Activity

Explain to the children that they will be building model cars. Point out that model cars are propelled all kinds of ways, such as by electric motors, springs, or rubber bands. In this project, they will be using inflated balloons as the means of propulsion.

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- Do they think that a model car can be propelled by an inflated balloon?
- How far do they think they can get a model car to travel using a balloon?

Show them the materials they will be using. Ask them if they have any ideas of how to assemble these materials into cars. Show them the ramp and describe how they will use this ramp to launch their cars to see how well they travel. They should make adjustments to their cars after each test to try to keep them moving straight and as far as possible.

Divide the children into teams of two or three. Some children may want to attempt to construct cars by themselves, but it is best if they work in teams because there is much to be learned from cooperation with others.

Tell them that in this first session they will just be constructing the cars and trying to make them travel straight and well. Later, they will be given balloons to propel the cars.

SAFETY

Remind children to be careful handling the sharpened dowels and to keep them away from their faces.

THE CHALLENGE

Make a model car with the materials provided and see how far it can travel when launched from the ramp.

LEADING THE ACTIVITY

The main design task is to find a way to attach the wheels to the dowel while allowing the wheels to rotate freely as the car moves. Let the children try out their own ideas even if they are not initially successful.

When testing their cars, children should make adjustments so that the cars will travel farther. During the testing, check with each team to see that they are recording the distance their car traveled on *Data Sheet—Activity 1*.

If some teams have decided to use lids brought in from home, check to see how well they are functioning as wheels. Some of the lids may have to be reinforced with cardboard so they hold onto the dowels better. Suggest to the children that they put pieces of cardboard inside the lids. If they place a lid on a piece of cardboard and draw around the perimeter of the lid, they can then cut the resulting circle out of the cardboard (it doesn't have to be exact) and wedge it into the lid (see Figure 1.5). The dowel now has more support and a tighter grip.

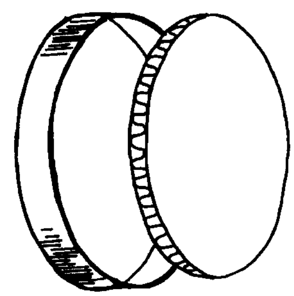

Figure 1.5
Push the cardboard support into the cup bottom to make the wheel sturdier.

Troubleshooting

There are two major problems that the children may encounter:

1. **The car does not travel in a straight line.** They should check the alignment of the dowels. Are they parallel to each other (Figure 1.6)?

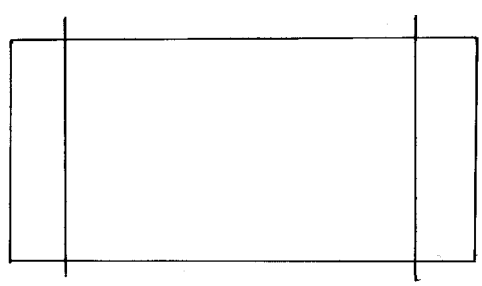

Figure 1.6
Dowels should be parallel to each other.

2. **The wheels wobble.** Are they actually too loose on the axles? Do the wheels need cardboard for support and sturdiness?

Leading the Discussion

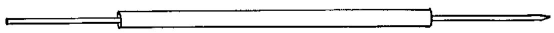

Figure 1.7
A dowel in a straw.

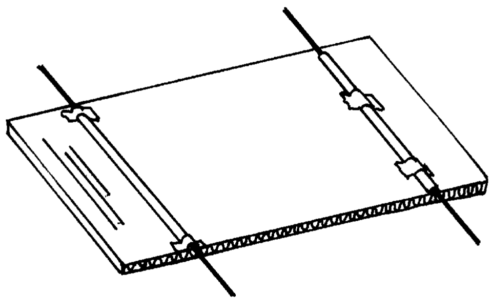

Figure 1.8
A bottom view of the car with the straws housing the dowels.

Ask each team to report on the longest distance that their car traveled. Point out that they all started with the same materials. If the results are different, then something about the design or arrangement of the materials must be the reason for this difference. They can learn from each other by examining (comparing and contrasting) the different designs. Ask the team with the farthest result and the team with the least far result to show their cars. Ask the whole group to examine each and see where they are different and how they are similar. What may account for the different results? Have both teams spin their wheels to see how long they spin. Do the wheels spin freely for both? Sometimes the wheels may be rubbing against the cardboard and slowing the car down.

Ask each team how they used their dowels. The dowels can act as axles in several ways. They can turn inside a drinking straw that has been taped to the cardboard (see Figures 1.7 and 1.8). Wheels are attached to the dowel and both the dowel and wheels turn together.

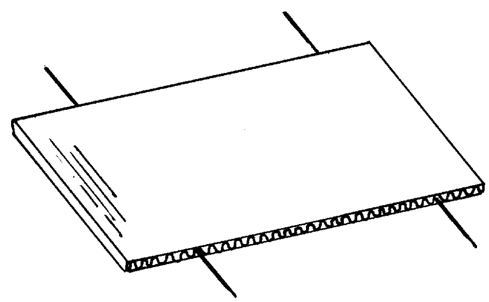

Figure 1.9
Here, the dowels are pushed through the corrugation holes in the cardboard.

They can also be slid into the holes of the cardboard (see Figure 1.9). This results in a fixed axle (the axle will not rotate), meaning the wheels must turn freely on the dowel rather than both the dowel and wheels turning together.

Ask the whole group:

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- What are the relative advantages or disadvantages of each arrangement?
- What other differences in the designs might cause your different results?
- Did your car travel straight? What did you do to make this happen?
- Now that you have tested your cars and seen each other's designs, what do you think makes for a smooth running car?

Activity 1: Making and Testing a Car

Rationale

In this first activity, the focus is on the construction of the car. Although not recommended, you could give to the children all the materials at once so they have access to balloons and pumps. The reason for not introducing the balloons at this point is to help children give their full attention to the functioning of the car. They need to have a car that moves smoothly because the power of the balloon is not that great. And if they're given the balloons, there's no guarantee that they'll concentrate on making the best car possible.

This is also a time when they can try out different kinds of wheels and different arrangements of the axle on the body of the car. If they had balloons at this point, they might jump too quickly to inflating the balloons and trying to get their cars to be propelled by them.

Introducing the Activity

This is the first activity of the project. Try to give the children some sense that this will be an interesting project where they can have fun but also learn something about engineering. It will be hard to avoid having a competitive atmosphere as the project moves along. Tell the children that their challenge will be to see how far they can get the car to travel with the inflated balloon, which will be introduced later. Some teams will be more successful that others. Although special recognition should go to the best teams, the overall idea is that all can learn from each other and arrive at a good functioning design.

Leading the Activity

The materials are limited so the children have limited possibilities of where they are going to place their axles. They can:

- tape straws onto the cardboard using them as the housing for the axle (Figure 1.7 on page 14),
- slide the dowels through the cardboard (Figure 1.8), or
- tape the dowels directly onto the cardboard.

The first arrangement allows the axle to spin freely while the second design tends to create lots of friction, slowing the movement of the wheel and axle. In the third arrangement, the axle does not move at all. The wheels must be free moving. As a result, they may be very wobbly.

Getting the bottom of the cups (wheels) onto the dowels may be a problem for some children. They need to push with a lot of force, but they do not want to enlarge the hole made with the pushpin, which will cause the bottom of the cup to slide or be too loose and wobble.

If you use wood beads for the wheels, they will have a tendency to slide off the dowels. The children will have to use tape or some other means to prevent this from happening, yet they do not want the tape to interfere with the spinning of the beads.

Testing should be the way that children determine whether their cars are functioning or not. Let them struggle with the problems they may have. If a team does seem to be stymied with their design, you can step in and try to help them analyze where they are having their problems.

Leading the Discussion

During the activity the children saw other teams' designs and how they performed, but they probably did not look closely at them. They are likely aware of different results but may not have taken the time to figure out why there may be differences. During the discussions, children should think about the differences between designs in a focused, systematic manner.

In this first activity, it is important that the teams get their cars running consistently. The axles should be moving freely without much friction. They should also travel straight. Use this time to have each team share what they have discovered. During the discussion you can take some cars that are not performing well and have the whole group give suggestions of how they can be improved. Comparing and contrasting different kinds of cars helps focus the children's attention to the most important features of the car. As they make suggestions for each car, make the changes and test it right away. Does the change make a difference in how far the car travels? In this way, you can model for the children how they should be thinking about the design process and how they should troubleshoot.

Potential problems

The wheels wobble.
If the wheels are not securely lined up, they may tend to wobble as the car moves. This can cause it to not travel in a straight line. Children should get in the habit of adjusting the wheels before each test.

The car does not travel in a straight line.
Check the alignment of the straws holding the axle to see that they are lined up properly.

The dowels are pushed through the corrugation of the cardboard.
This arrangement create lots of friction, slowing the movement of the wheel and axle. The better of the two arrangements is to have the dowels spin freely in the drinking straws.

SCIENCE BACKGROUND

Friction and the Concept of Force

Children may already have heard the term *friction*. *Friction* is used to describe such problems as the rubbing of the axle against the inside of the drinking straw or the wheel against the piece of cardboard. It can both help as well as hinder our efforts. For instance, we need friction between our shoes and the ground to move forward. Otherwise, we would slip and slide, such as when we try walking across ice. On the other hand, too much friction, such as the rubbing of the dowel against the drinking straw, can hinder the cars' movement. There needs to be a balance of friction (not too much nor too little) for the car to move most efficiently.

Force is a basic concept in physical science. As children talk about the functioning of the cars, try to get them to be specific about the kind of forces they think are acting on the car. For instance, are there relative advantages to using different kinds of wheels and axles? Do some arrangements spin more freely than others and result in less friction? During this discussion, get the children to speculate what would happen if there were no friction on the axle of the wheels. How far would the car travel? This is a useful exercise to help them think about how objects move.

In later activities, they will also encounter the force of air in an inflated balloon and learn that this force is helpful in making the car move forward.

ASSESSMENT

You should use Activity 1 as a reference point in terms of design thinking, construction techniques, and procedures. In later activities, you can compare the children's thinking and ideas with their thoughts during this activity.

- How do they go about their constructions?
- Do they assemble their cars in a haphazard manner, or do they try to think ahead to what they want to do?
- How do they deal with problems?
- Do they conduct more than one test?
- Do they make adjustments after each test to see if they can improve the performance of the car?