

## Designing like a Spider- Facilitator's Guide

This activity will introduce participants to hidden aspects of geometry in nature. They will learn how geometric shapes play a large role in the beauty of nature; in things like seashells, honeycombs and especially in the creation of spider webs. Mathematicians use their knowledge of geometric reasoning to understand natural phenomenon and to understand how the world around them works. Participants will use their mathematical knowledge and engineering expertise to create and understand a spider web.

A **mathematician** uses an extensive knowledge of mathematics in their work, typically to solve mathematical problems. Mathematics is concerned with numbers, data, quantity, structure, space, models, and change.

More information on this field can be found at resources such as:

<https://en.wikipedia.org/wiki/Mathematician>

<https://www.bls.gov/ooh/math/mathematicians-and-statisticians.htm>

Participants will be designing spider webs to catch three ping-pong balls covered in Velcro, or “insects”. The efficiency of their design is judged by how much yarn they use.

### **Facilitator Pre-work – Cut cardboard into strips**

In advance of the activity, cardboard needs to be cut into strips. A large discarded box can be used or a poster board or even a foam board. Using a yardstick, measure and draw one-inch strips of 24 inches in length. Cutting with a box cutter/utility knife is faster than a scissors and will avoid compressing the corrugated cardboard. Two of these 24-inch strips are required.

### **Materials:**

Two 24-inch strips of one-inch wide corrugated cardboard

Yarn – each participant should measure and start with one yard

Duct tape (~12 inches per team required)

One-yard stick

Hot glue gun and glue

Index card or card stock (to reinforce corners)

Scissors

3 ping-pong balls

Velcro patches or strips

Googly eyes (optional but fun!)

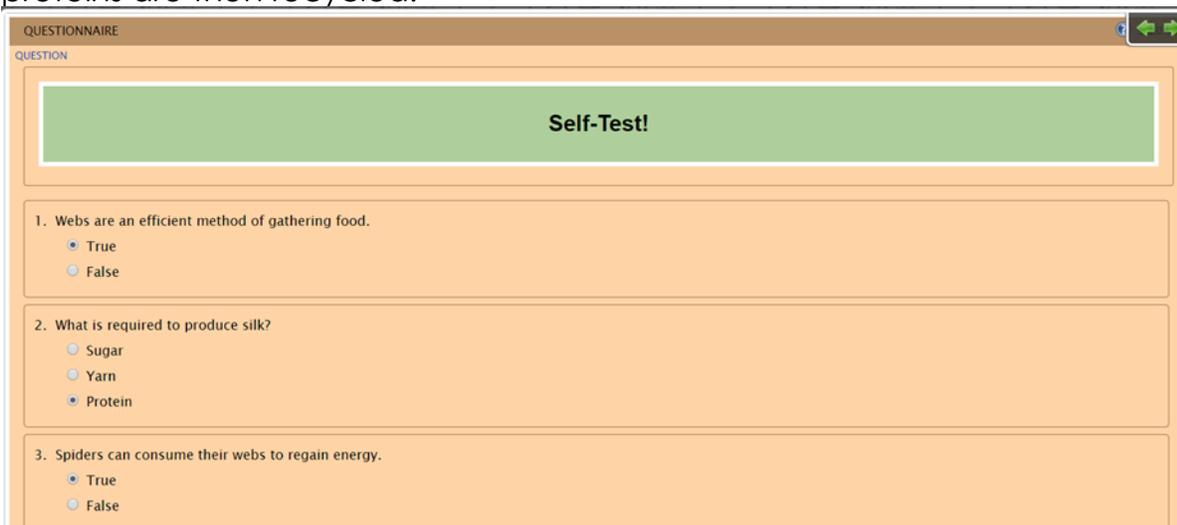
## **Safety Notes**

Use caution when cutting corrugated strips, especially if using a box cutter and also if using a glue gun.

## **Knowledge and Skill Builder 1 - How Spiders Create a Web**

Spiders are legendary as builders of the animal kingdom. They can produce as many as seven different kinds of silk. To begin a web, some spiders anchor a strand of dragline silk—three times stronger than the Kevlar in bulletproof vests—and waits for a breeze to blow it to a second attachment point. The spider then completes the outer ring and spokes, and finally builds the spiral. A spider will create sticky and non-sticky threads. Sticky threads are used around the outer spiral to catch prey.

Webs allow a spider to catch prey without having to expend energy by chasing and catching the prey. Thus, it is an efficient method of gathering food. However, constructing the web requires a large amount of energy to produce the protein used to make the silk. After a time, the silk will lose its stickiness and become inefficient at capturing prey. In which case, it is common for spiders to eat their own web to recoup some of the energy used in spinning. The silk proteins are then recycled.



The image shows a screenshot of a web-based questionnaire interface. At the top, it says "QUESTIONNAIRE" with a small icon of a person and a refresh button. Below that, the word "QUESTION" is visible. A large green box in the center contains the text "Self-Test!". Below this, there are three questions, each with radio button options:

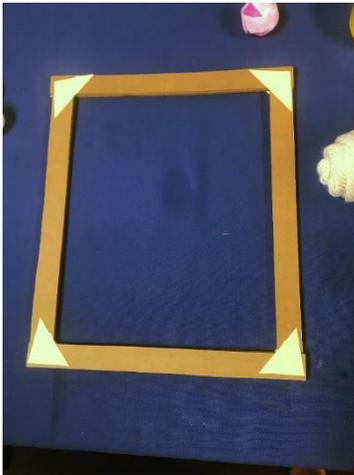
1. Webs are an efficient method of gathering food.
  - True
  - False
2. What is required to produce silk?
  - Sugar
  - Yarn
  - Protein
3. Spiders can consume their webs to regain energy.
  - True
  - False

## **Procedural Notes**

Participants should draft a design for the web before starting. They should consider if they want a square, a rectangle, a trapezoid etc. and how they will arrange and connect the strands. They can be as creative as they like but they should consider how big the ping-pong ball is when designing their web.

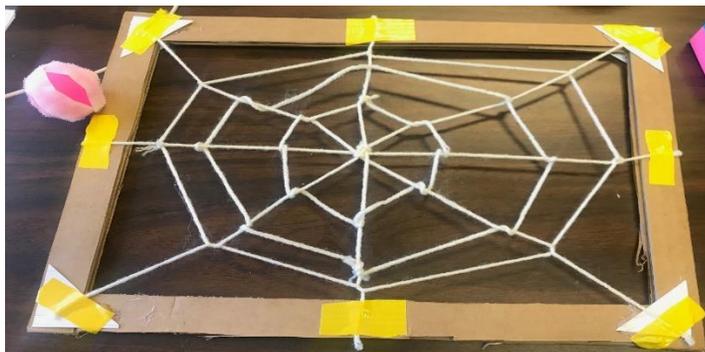
There is a cost to using more yarn and they need to act like spiders and be efficient! For participants who need more guidance a potential process is outlined below.

Creating the Frame- Participants will cut their two 24-inch corrugated cardboard strips to make the shape they have designed. The corrugated cardboard should be glued together at all ends, and at points of connection between the other cut lengths. To stabilize the frame, cut out triangular sections of an index card (or cardstock) and glue it to both sides of the corners.



Creating the web- Once the frame is together and stable, the web building begins. The yarn should be secured with duct tape or knotted to other strands.

Ping Pong Ball Insect Construction- If using the Velcro tape, wrap it once around the ball, top to bottom; and once around the mid-point. If using Velcro dots, attach eight dots equally spaced around the ball. Participants may use the ping-pong ball when building and can decorate the "insect" after Velcro is attached.



### **The Design Criteria:**

Make sure the definitions are clear before starting. Perhaps draw an example of a web and discuss how it would be scored using the design criteria.

One decision is how much yarn to use in the final design. This will be the only item that has a cost. They need to think about their budget when they decide how much yarn they use. They should keep in mind they will get points for staying under 40 cents.

## Design Criteria

Your final product should deliver on the design criteria outlined below.

Criteria	One	Two	Three
Cost of Yarn, 10 cents per yard	More than 60 Cents	Between 40 and 60 Cents	Less than 40 Cents
Ping Pong Balls Captured	None	One or two	Three

### **Testing Your Design:**

Participants need to stabilize their frame horizontally between two chairs and then drop all three ping-pong ball “insects” from a 3 feet height above the frame. To be successful, webs should be able to capture and hold three Velcro “insects”. Turn the webs vertical and see how many insects remain stuck to the web.

If there is time to have some fun, lean the web vertically against the wall and toss the ping pong balls into the web. How far back did they stand? How many did their web catch now??

Once participants test their designs, have them reflect on their designs and discuss how they could be optimized.