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# Moving Shapes for AutoSTEM

## Pedagogical guidelines and building instructions

This guide includes the following parts:

- How to use the moving shapes to teach STEM content
- How to build a moving shape

## How to use the moving shapes to teach STEM content

### What is the AutoSTEM moving shape?

It is a toy made of cardboard, which uses a linkage mechanism and can transform into different geometric shapes. Depending on how it is built and how it is moved, the shape changes, allowing various narratives and connections with the sciences, in particular geometry.

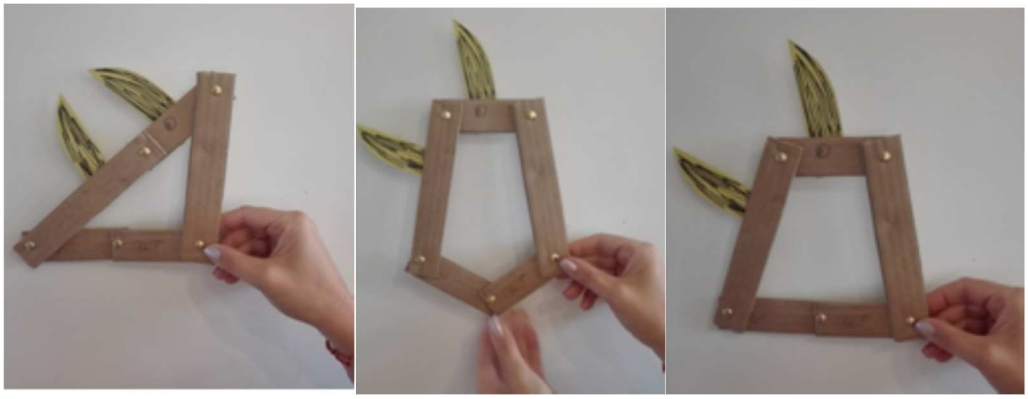

*Figure 1. Examples of different geometric shapes made with the same automaton*

Below are ideas for introducing STEM content while building and using the moving shapes. The teacher can adapt these suggestions to their teaching context and plan their own activities.

### Target group

The shapes we describe here are suitable for children 4 to 7 years of age. Teachers can adapt the ideas for other ages. Based on their knowledge of the children, the teacher can decide whether they should work in groups or individually.

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## Learning objectives

Several learning objectives can be achieved in constructing and using the moving shapes:

- Understanding of the physics and mechanisms, in particular linkages
- Developing engineering skills of analysis and construction
- Learn mathematical concepts in the construction and assembly process, including geometric shapes and numbers
- Other learning objectives such as problem solving and creativity can be included

## How to introduce STEM content while building

The starting point is the automation itself, how it works and how it is built.

### To observe

The first thing the teacher does is show the different shapes. The teacher may ask such things as "Why is it moving?"

### Explore and learn physical principles and mechanisms

When introducing the shapes, the teacher should challenge the children to observe and analyse the movement, especially the change in shape, depending on how it is moved. The teacher can ask the children how they think the shapes change. This can be a first contact with the mechanism, using a playful approach. Teachers can talk about the linkage mechanism very simply.

A linkage is a rigid element (here a piece of cardboard) with a pin at each end to connect it to other elements. Linkages are used to join the elements together and to transfer movement from one point to another.

Figure 2. A simple linkage

### Build moving shapes for learning mathematics, physics and biology

The construction and use of the moving shapes allow for teaching several STEM concepts during the building and assembly process. Children will observe the toy and make comments and ask questions about how it moves. There are good examples of linkages in our body, for example, the elbow and the knee. The teacher talks to the children and asks them questions about the geometric shapes they are using. For example, how many there are and what they measure. We need rectangles that must have the same width but may have different lengths. If the children bring up an animal in the narratives, you can also introduce biology concepts by looking at the chosen animal's characteristics.

## Building the mechanism to develop engineering skills

Once the children have prepared the different parts, it is time to put them together. Children build the mechanism following the method in the section below, “How to build the moving shapes”, and explore how linkages work.

## Variations on the shapes and adding in narratives and scenarios

Here we describe a workshop with teachers from a kindergarten and primary school as an example. A group of participants designed a narrative and scientific path using the moving shapes. The project was called “The pursuit of happiness”. The story, invented by the teachers, tells about a timid child who, every day, sees other children playing with kites on a beach and not having the courage to fit into their game decides to build his own kite, looks for some material on the beach. With what he finds, he begins to develop his kite. Still, before reaching the perfect shape, it passes through several other shapes, including a hexagon, rectangle, triangle, pentagon, until finally reaching the kite. All this is achieved using the same automaton, which, moved in different ways, transforms its geometric shape.

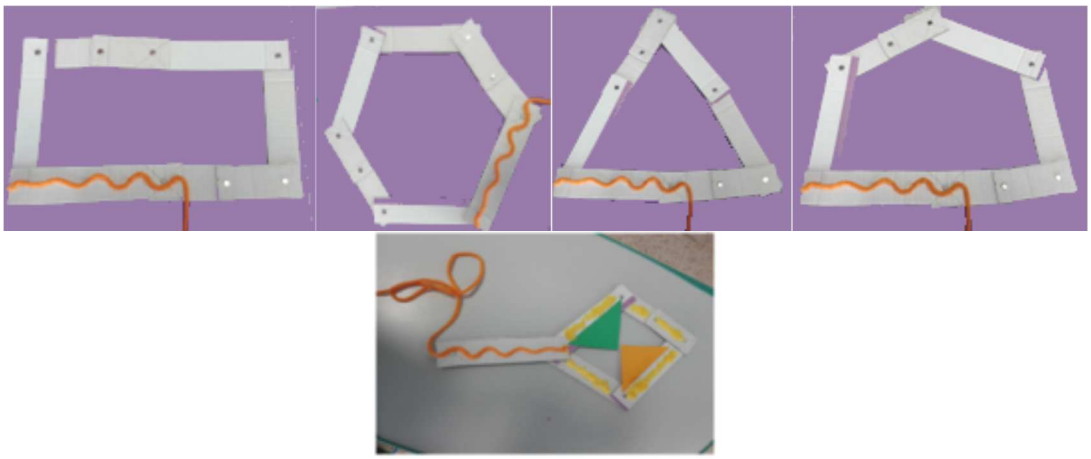

*Figure 3. The transformation from the hexagon to the kite*

In the same workshop, another group of teachers produced a story starting from the fairytale “The Wolf and the Seven Young Goats”. With one automaton moved in different ways, they created a goat and the house, and with another automaton, the clock and the wolf.

*Figure 4. By moving the clock and turning it around, it becomes a wolf*

## How to build the moving shapes

### Material and tools

- Cardboard - to be cut
- Ruler
- Pencil
- Colours - for decorating
- Awl - to make holes in the cardboard
- Scissors
- Split pins

The materials used are very easy to find, recycled items, and can be used to give an added value connected to sustainability.

### Method

You can watch the video at https://youtu.be/U_Eqf0rlNHQ before starting.

- Cut out four rectangles of size 3x15 cm.
- Make holes at the two ends of each rectangle with the awl. (If you don't have an awl, you can use a toothpick or the tip of a pair of scissors.)
- Attach the rectangles to each other, with the split pins, as shown in figure 2 above. Continue until each rectangle is connected to two other rectangles (one on each end) and you have a closed chain.
- At the end of the construction, you can decorate the automaton as you want. You can also attach eyes or beaks, or crests to transform the shape into an animal or a character from a story.
- Finally, have fun observing how many and which shapes can be obtained by moving the moving shapes!

## Additional ideas

It is also possible to make changes and experiment with which types of shapes can be obtained. By cutting one of the rectangles and rejoining the ends with the split pin, you get one more side. Cutting two or three sides of the moving shape will give you more additional sides. You have to bear in mind that for regular polygons (shapes with equal side lengths), a few centimetres more must be allowed for the connections to overlap.

You can observe what happens when moving the parts. The more pieces the automaton has, the more different shapes you can make.

- With four rectangles, you can make triangles and different quadrilaterals.
- With five rectangles, you can make the former shapes and pentagons.
- With six rectangles, you can make the former shapes and hexagons.
- And so on

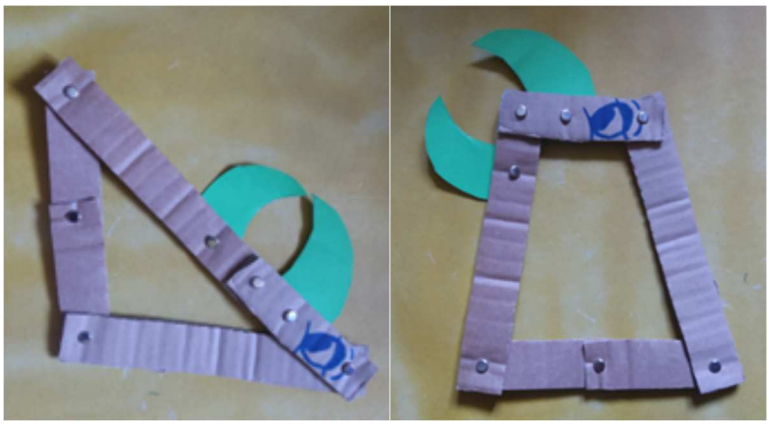

*Figure 5. Other examples of shapes: starting from a triangle and bending one side outwards to make a trapezium*

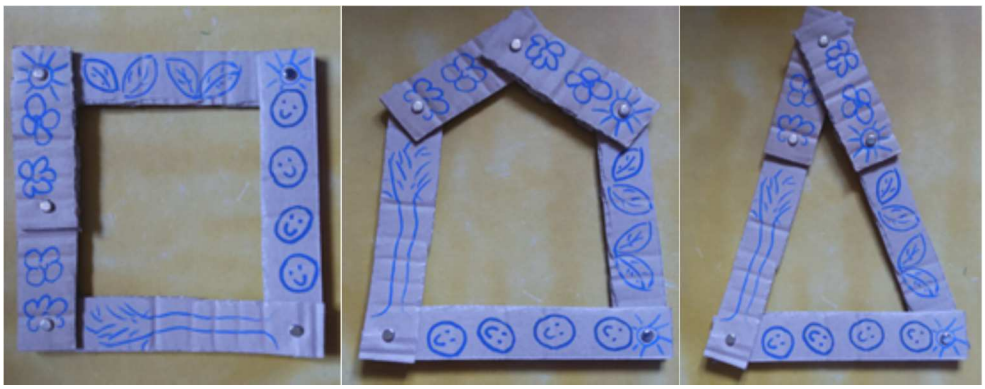

*Figure 6. Starting with a square, bending one side outwards to make a pentagon, and finally straightening two sides to form a triangle*

## Evolution of the two faces

The shape can become an automaton with “two faces”. In the example, we added two beaks. Depending on how the rectangles are oriented, either one beak is open, the other is closed, or both are half-open. We can imagine two birds talking to each other. In this case, we used a rectangle that we built out of six cardboard rectangles.

*Figure 7. Example of shapes that become two faces:*
*starting from a rectangle and bending the two longer sides outwards*