Co-funded by the Erasmus+ Programme of the European Union

The Eco-car 2 for AutoSTEM

Construction instructions and pedagogical guidelines

This guide includes the following parts:

- How the Eco-car 2 can be used to learn STEM areas
- How to construct the Eco-car 2

How the Eco-car 2 can be used to learn STEM areas

What is the Eco-car 2?

The Eco-car 2 is a moving toy made from wooden sticks, bottle tops and drinking straws. When children use this Eco-car they play with the moving toy. The movement is possible because of the potential energy stored in a drinking straw when it is deformed as a spring.

The energy is transformed into kinetic energy when the spring is released, and the car moves because of the rotational movement in the axel and the wheels of the car.

STEM subjects can be introduced when constructing the Eco-car 2. We present some ideas below. Teachers can adapt these suggestions to their own class and context and plan their own activity.

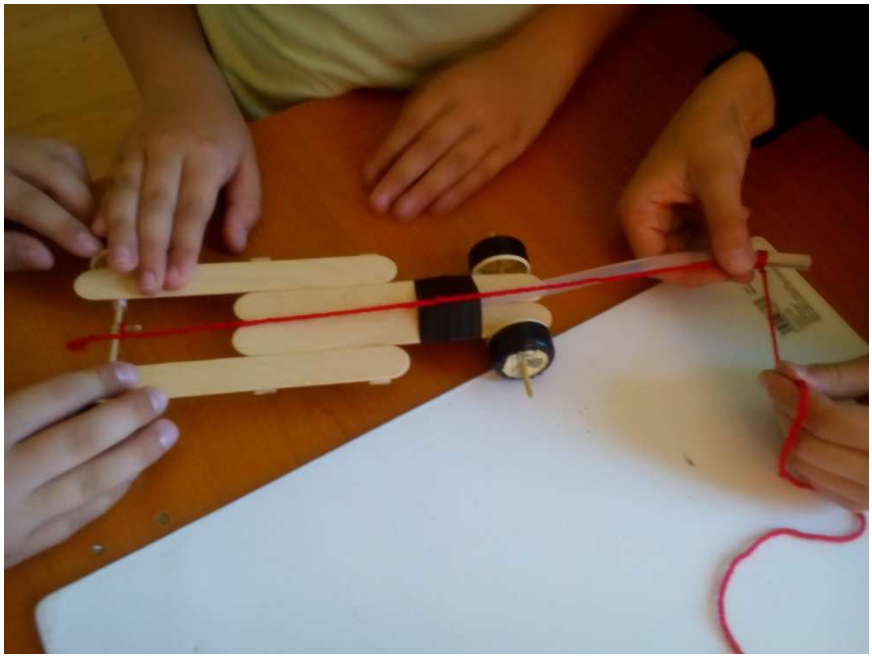

Figure 1: Children building the Eco-car 2

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Target group

The Grabbing Hand example described here is designed for children from 5 to 8 years old. Teachers can adapt the proposal to other ages.

Depending on the children's knowledge, the teacher can decide whether they should work in groups or individually.

Learning goals

When constructing the Eco-car 2, several learning goals can be achieved:

- To learn about physics, storing and transformation of energy, experience potential and kinetic energy, experience the centre of mass of an object
- To develop engineering competencies of analysis and construction
- To learn mathematical concepts within the construction and assembly process, including shapes, design, location, numbers and measuring
- Other soft-learning goals like problem solving and creativity can be included

Guide on how to introduce STEM concepts during construction

The starting point is the Eco-car 2, how it functions, and how to construct it.

Observing

First, the teacher shows an Eco-car 2 model and makes it move. The teacher can ask, 'How and why did it move?' Here is a link to a video that shows the movement: https://youtu.be/mQjEdTuCL-A

Exploring and learning about physics and mechanisms.

Children can observe the Eco-car 2, and make comments and ask questions about how it functions. Maybe the children can make drawings about how and why they think the car is moving?

Teachers can talk about energy in a very simple way. Energy never disappears. It is transferred into other kinds of energy. The children can experience that energy is stored in the straw as potential energy. The straw acts as a spring. The potential energy is stored in the straw (spring) is then transferred into rotational kinetic energy because of the movement in the axel and the wheels. They are rotating. The rotational kinetic energy is transferred into translational kinetic energy – the forward motion of the car.

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For those who want to go into a deeper understanding, the discussion about why the car stops can be started. The reason is the friction caused by the force resisting the motion when the wheels roll on a surface. It is a possibility to discuss the children's different interpretations of this.

Starting to construct the Eco-car 2 and learning mathematics and physics

The *Eco-car 2* allows teachers to speak about aspects of mathematics and physics.

- Mathematics
  - **Counting**: wooden sticks, straws (will be divided into three parts), bottle tops, skewers
  - **Measuring length**: Direct comparison between the width of the four sticks and the lengths of sticks, straws and skewers. Older children might use a ruler; younger children can use the width of a lollipop stick as a unit. Direct comparison to make a hole in the bottle top that is 'just' big enough for the wooden skewer to pass through and still be tight.
  - **Fractions**: ½ the width, ½ the length
  - **Locating**: use spatial concepts like rear, front, under, top, bottom, centre (find the centre of a circle), around, rotation (the motion of the axles and the wheels), translation (the forward motion of the car)
- Physics
  - **Energy**: different types of energy:
    - *work* (The child does work by applying a force to the straw.)
    - *elastic energy*: potential energy due to the deformation of the straw
    - *rotational kinetic energy* (the rotation of the wheels)
    - *translational kinetic energy* (the forward motion of the car)
    - *thermal energy* (heat)
  - **Force**: The child uses force to deform the rubber band.
  - **Rolling friction**: the force resisting the motion when the wheels roll on a surface

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- **Conservation of energy**: Energy can be converted but not destroyed. The child's work is converted into elastic energy (of the straw), elastic energy into rotational energy (of the axles and wheels), rotational energy into translational energy (of the car), translational energy into thermal energy (the wheels and the floor become slightly warmer through friction)
- **Centre of mass**: In order to find the centre of a wheel, the children can balance the bottle top on the tip of a skewer.

Constructing the mechanism to develop engineering competences

Once the different parts are completed, it is time to put them together! Children construct the mechanism following the method described in 'How to construct the Eco-car 2' below and explore how the transformation of energy works.

Variations on the Eco-car 2 and adding scenarios and narratives

Instead of an Eco-car other themes and characters can be used when introducing the same mechanism.

Different scenarios can be developed for the Eco-car. The scenario can be used at the beginning of the activity or the end. For example, a park, a playground or a car race track can be used to contextualise the activity.

How to construct the Eco-car 2

To make the Eco-car 2, you will only need seven necessary parts and tools that are found in every school or preschool. Below we list the materials required and alternatives.

Parts and tools required

- 4 wooden sticks (normally used for throat examination or to name flowers in a garden), width about 20 mm and length about 200 mm
- 2 wooden sticks (normally used for ice lollies), width about 10 mm and length about 115 mm.
- 1 drinking straw
- 1 thick plastic drinking straw (This needs to be a particularly strong straw. The type found in plastic beaker sets or the tube from a hand sanitiser dispenser.)
- 4 plastic bottle tops for wheels (Each set of 2 must be the same size. The larger the wheels, the better it works.)

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- 1 or 2 wooden kitchen skewers
- Hot melt glue gun
- Strong sticky tape, e.g. electric insulating tape
- Thread

Since the materials that can be used are very wide and easy to find, the teacher can ask the children to find objects that might otherwise be thrown away (e.g. straws, bottle tops). In this way, we can add sustainability and recycling into the teaching.

Method

It is best to watch the video https://youtu.be/2YInHwYQ3RM before starting to make your own Eco-car.

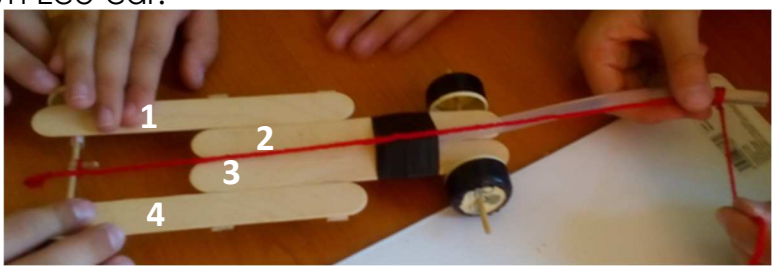

Figure 2: The Eco-car 2 with the four wooden sticks marked

1. Place the 4 wider sticks together flat on the table, and measure that they have the same width. At least 2 and 2 ought to have the same width.
2. Take the 2 thinner sticks and place them perpendicular to the wider lollipop sticks. If they are much longer than the width of the 4 sticks, cut off the excess wood.
3. Place the 4 lollipop sticks in the configuration that you see in Figure 2 and 3. Stick 1 and 4 are on the outside of stick 2 and 3. Stick 2 and 3 ought to be about halfway in on the whole length of stick 1 and 4 and between stick 1 and 4. They should not be more than halfway in between.
4. Use the 2 thinner lollipop sticks to hold together the 4 wider sticks. In the area where all 4 sticks are laying together, place one of the thinner sticks just below the top of stick 2 and 3, perpendicular to stick 2 and 3. The other stick is placed just below the top of stick 1 and 4.

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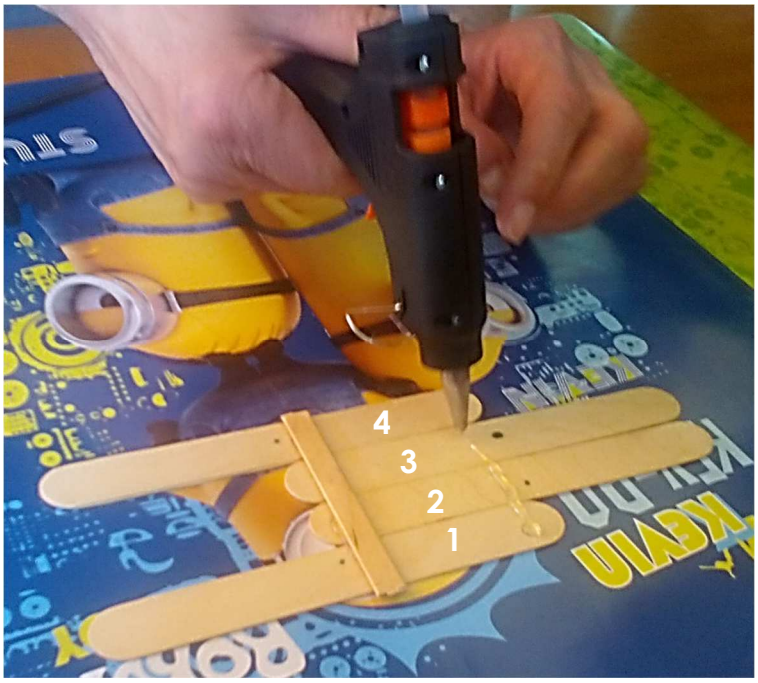

Figure 3: Joining the wooden sticks together

5. Glue the 2 thinner sticks to the 4 parallel sticks (see Figure 3).
6. Cut the normal drinking straw into three parts.
    a. 2 pieces with the same length as the width of the wider sticks (i.e. about 2 cm)
    b. 1 piece with the same length as 2 of the wider sticks (i.e. about 4 cm)

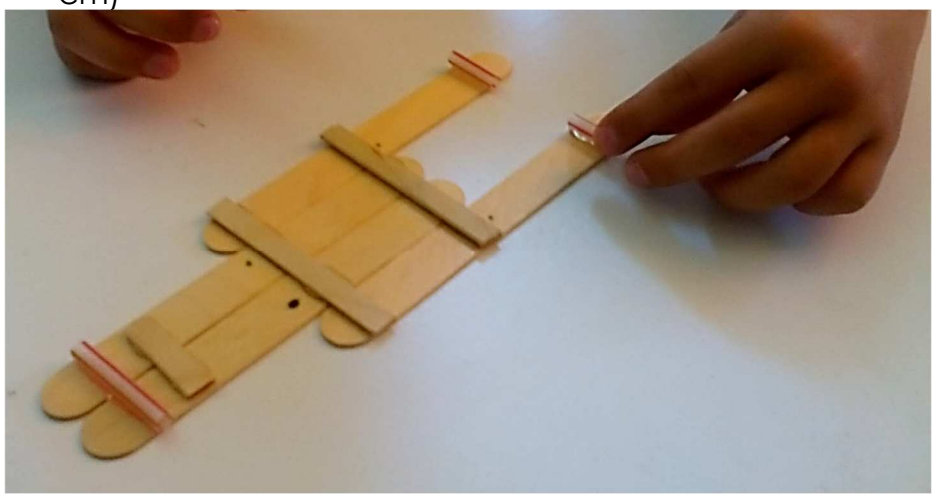
Figure 4: Glueing the straw pieces to the wooden sticks

7. Glue the long piece at stick 2 and 3 on the front of the car.
8. Glue the 2 shorter pieces to sticks 1 and 4 at the rear of the car (see Figure 4).

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9. Make holes in the centre of the 4x bottle top wheels. You might need to work out how to find the centre of each wheel. The holes must be 'Just' big enough for the wooden skewers to pass through and still be tight.
10. Cut one of the skewers so that it has the same length as the width of the whole car. This is axle 1 in the front of the car.
11. Cut the second skewers so that it has the same length as the width of the whole car, adding the width of the wheels and some additional space to attach the wheels to the axle (about 6 cm longer than the width of the car for those using a ruler). This is axle 2 in the back of the car.
12. Wait until the glue has dried before going to the next step.
13. Attach one wheel each to axle 1 and 2.
14. Cut the last piece from one of the skewers about 2 cm long. This is the hook.
15. Push axle 1 through the straw on sticks 2 and 3 in front of the car. Attach the other matching wheel to the empty end of the axle.
16. Push axle 2 through the straws on sticks 1 and 4 in the back of the car. Attach the other matching wheel to the empty end of the axle.
17. Find the centre of axle 1, and mark it with a pen.
18. Use the glue gun to glue the hook to the centre point of axle 1.
19. Take the thick plastic straw and place it exactly between sticks 2 and 3, running parallel with them. Let the end of the straw almost reach the point where all 4 sticks are parallel.
20. Take the strong tape and wrap it around the straw and sticks 2 and 3 so that the straw is very tightly fastened at its end (see Figure 5).
21. Cut a thread that is about one and a half the length of the car, including the length of the strong straw.
22. Tie one end of the string securely around axle 2 and the hook. Then tie the other end securely to the loose front end of the straw. Look at Figure 2. The red thread is rather straightened out there.
23. Bend the straw by coiling the thread around axle 2 by rotating axle 2 backwards (against the later forward motion when the car is driving).

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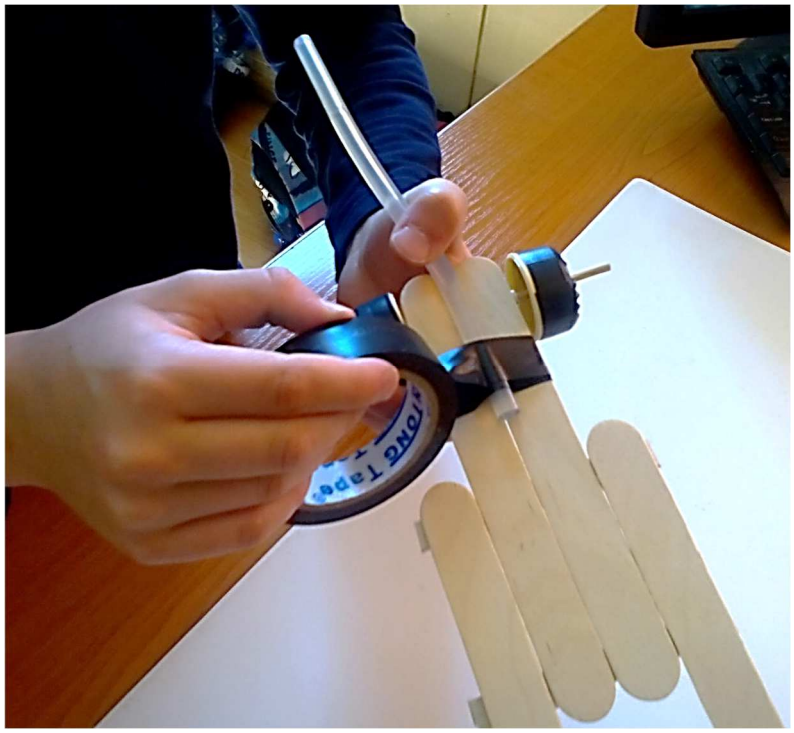

Figure 5: Attaching the strong straw to the car

When the straw has bent, place Eco-car 2 on to a hard floor and let it go quickly. The car will move across the floor on its own. Well done.
If you find that the hook comes unstuck, take the electrical insulating tape and wrap it around the join of axle 2 and the hook to add strength. If you find that the straw comes unstuck, add some more turns of the tape to add strength.
The larger the wheels, the better works the eco-car 2. You may replace the bottle tops with the tops of plastic honey jars about 10cm in diameter (see Figure 6).

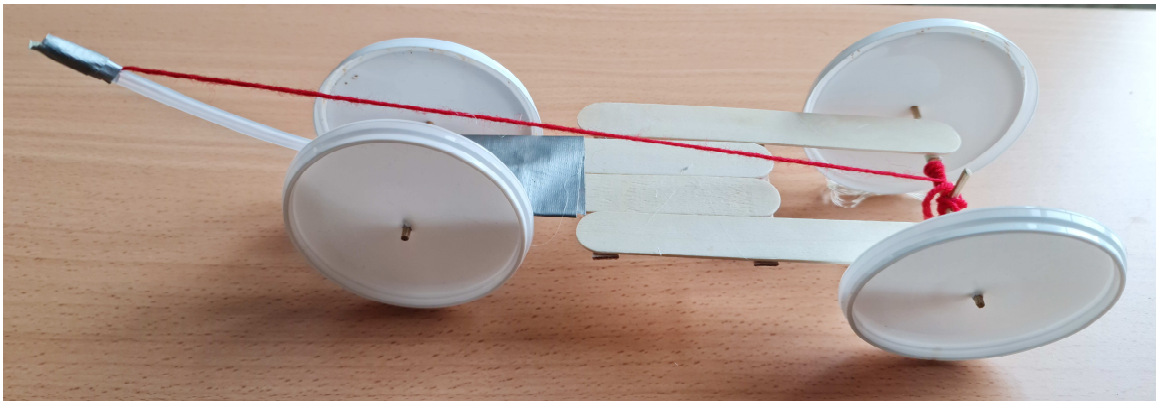

Figure 6: An Eco-car 2 with larger wheels

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