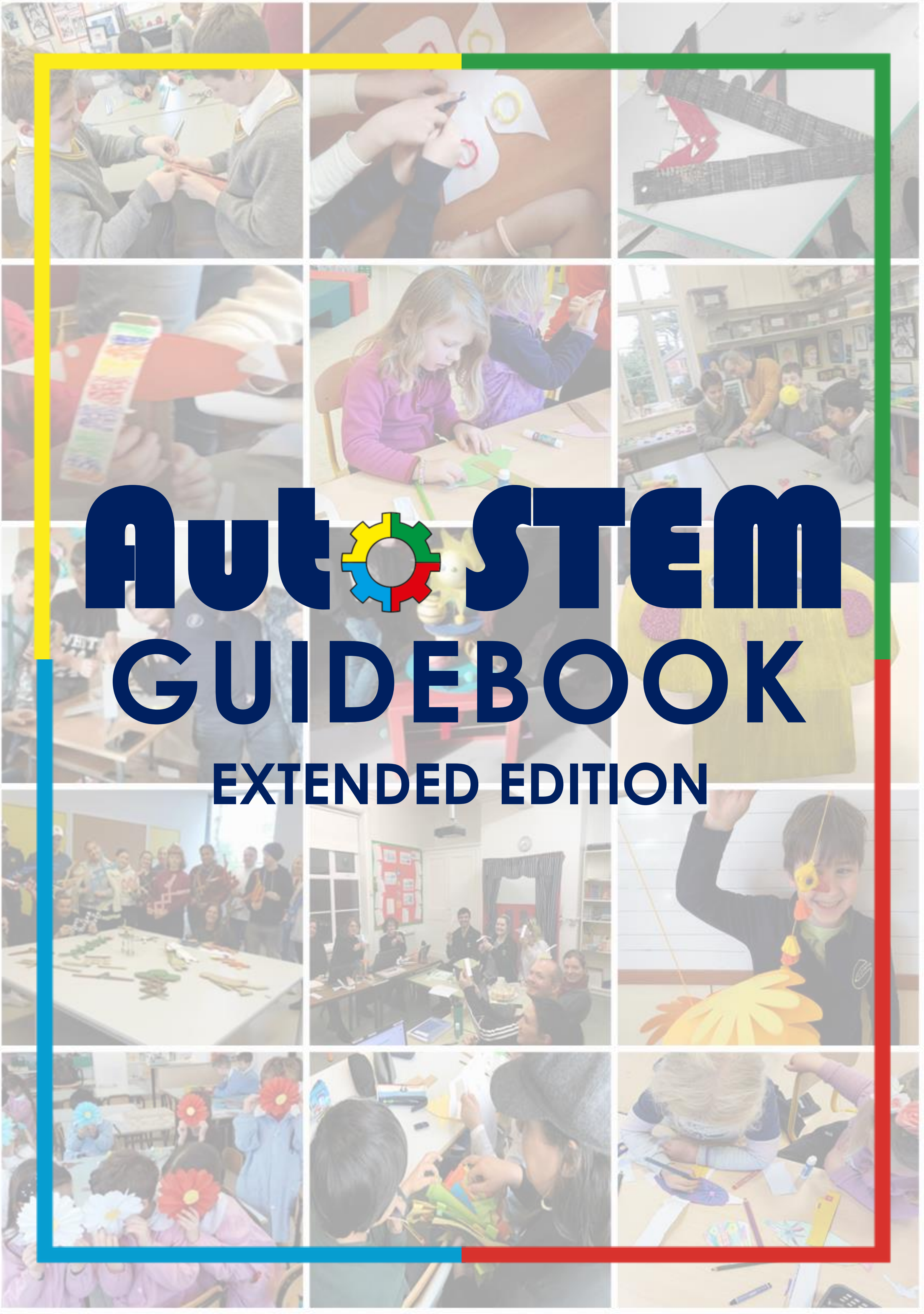

AutoSTEM GUIDEBOOK

EXTENDED EDITION

AutoSTEM

GUIDEBOOK

EXTENDED EDITION

CREDITS

Title

AutoSTEM Guidebook – Extended Edition

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Welcome to AutoSTEM Guidebook!

AutoSTEM is an Erasmus+ project that aims at building automata to promote motivation for STEM education and the development of transversal skills in children, proposing a set of resources to be used preferably by early childhood education and care teachers and primary school teachers.

Automata are fascinating mechanical toys, small sculptures of Kinetic Art. Automata consist of two main parts, a toy with a narrative, and a mechanism that makes the toy move. They can be seen as "mechanical storytelling objects" or as a combination of engineering, cultural awareness, and artistic expression.

This guide is a document in which you can find the whole conceptual framework, pedagogical resources, and examples of how the AutoSTEM Project has been implemented in schools in Europe. It is intended to be a "Pedagogical Guide", a manual for teachers and educators on how to use the resources that have been created within the project, from a pedagogical point of view. There is also a short version with access to all the resources through QR codes.

This guide is divided into five chapters. Chapter 1, the Toolbox, integrates several documents that can support practice. Chapter 2, Automata, includes the Pedagogical Guidelines & Construction Instructions (PG & Ci) of the automata. Chapter 3, Events & Workshops, presents some of the activities developed. Chapter 4 refers to the Case Studies, based on the research on the activities carried out within the project. Chapter 5 presents the Online Course available in the respective website.

This guide includes documents produced within the project already published on the website. Regarding the automata scripts, the numbering of the figures considered in the documents is maintained independently. The appendixes of each script are included for easier consultation.

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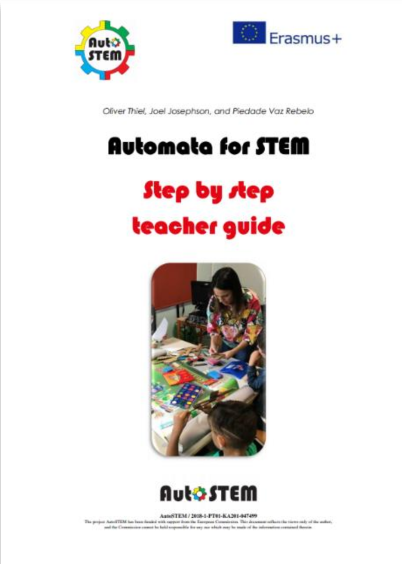
AutoSTEM across Europe

01

Toolbox

Step by Step Teacher Guide



The **Step by Step Teacher Guide** is a document that compiles information about automata and the STEM areas, the theoretical framework and pedagogical concept and the STEM content that you can teach with our automata. Some key concepts for building the automata are also presented in this document.
This guide should serve as a basis for the teacher's practice in implementing the activities of the AutoSTEM project.

In the Step by Step teacher Guide you can find topics has:

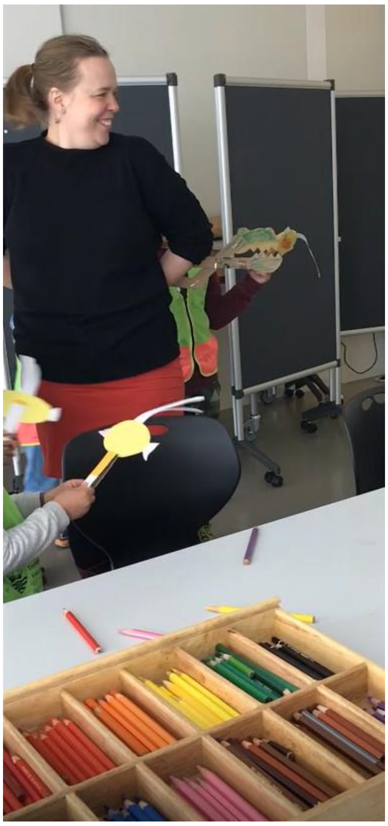
- Play Based learning & Guided Play
- Interdisciplinary, STEM & Transversal Competences
- Mechanisms
- Teacher's and Student's Roles

To find more information you can consult the full Step by Step Teacher Guide at

Play Based Learning & Guided Play

The pedagogical approach developed in the scope of AutoSTEM project is framed in a play-based pedagogy, considering in particularly a guided play approach, as well as how they can be considered in children automata construction workshops.

Play has been considered an essential activity for children cognitive, social, emotional development. Pedagogues, educators, educational psychologists have been stressing the importance of play in children development, e. g. Friedrich Fröbel (1887, p. 57) or' Lev Vygotsky (1978, p. 102), Piaget (1969) or Bruner (1960).



Nowadays the benefits of playing in learning are already known, although these two principles are still often presented dichotomously. To respond to this opposition, the guided-play concept emerges as a middle term between both principles. The guided-play concerns "learning experiences that combine the child-directed nature of free play with a focus on learning outcomes and adult mentorship" (Weisberg, Hirsh-Pasek, Golinkoff, Kittredge & Klahr, 2016, p.177). It has been shown that guided play helps children to a better understanding of academic concepts than direct instruction (Han et al., 2010; Stipek et al., 1995) or free play alone (Chien et al., 2010; Honomichl & Chen, 2012).

In the online course you can find this topic developed and explored.

You can also watch the video available in the course to learn more about Guided play.

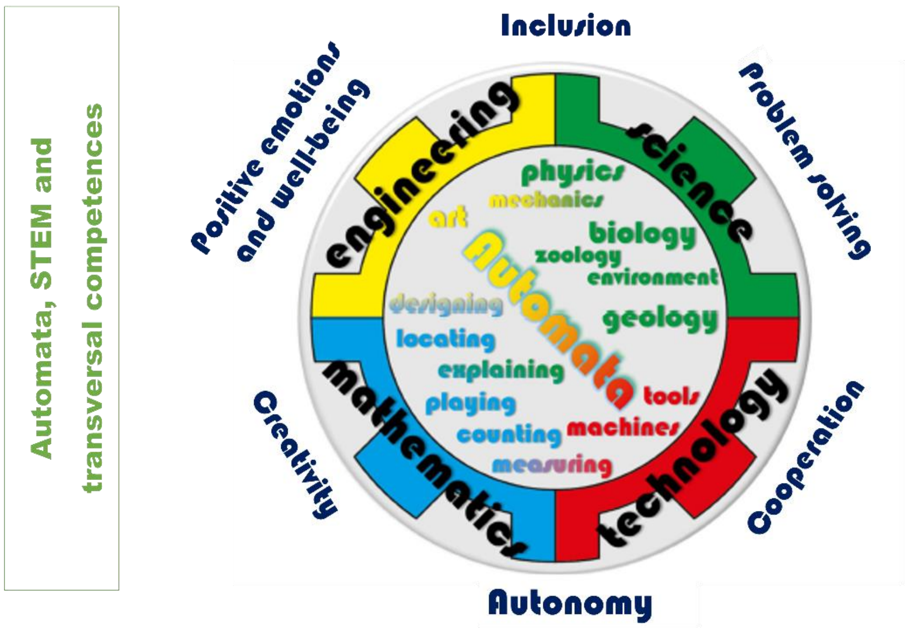
Interdisciplinary, STEM & Transversal Competences

The AutoSTEM project is distinguished by its potential to approach different disciplines, besides STEM, it also promotes the development of transversal skills such as problem solving, creativity and spontaneous cooperation.

To find out more about these competences and others you can refer to the case studies, presented below, which report on research into the implementation of this project.

You can also consult some articles and papers carried out in various congresses and conferences, which analyse this interdisciplinarity and the transversal competences that can be developed through the implementation of these activities. You can access these articles and participation in conferences on the project website.

In the following image you can find a graphic representation of what is the AutoSTEM project at the level of disciplines and skills. While on the one hand there is the interdisciplinarity associated with the various contents of STEM education, there are also a number of important transversal competences that can be enhanced through these activities.



One of the main features of this project is its ability to enhance children's **motivation and engagement** for STEM learning, to learn more about this you can watch the video available also in the online course.

Another feature of this project is the ability to increase **creativity and the feeling of well-being** in the children who participate in it. A clear example of this is the diversity of the products produced by the children, both the automata and their narratives.

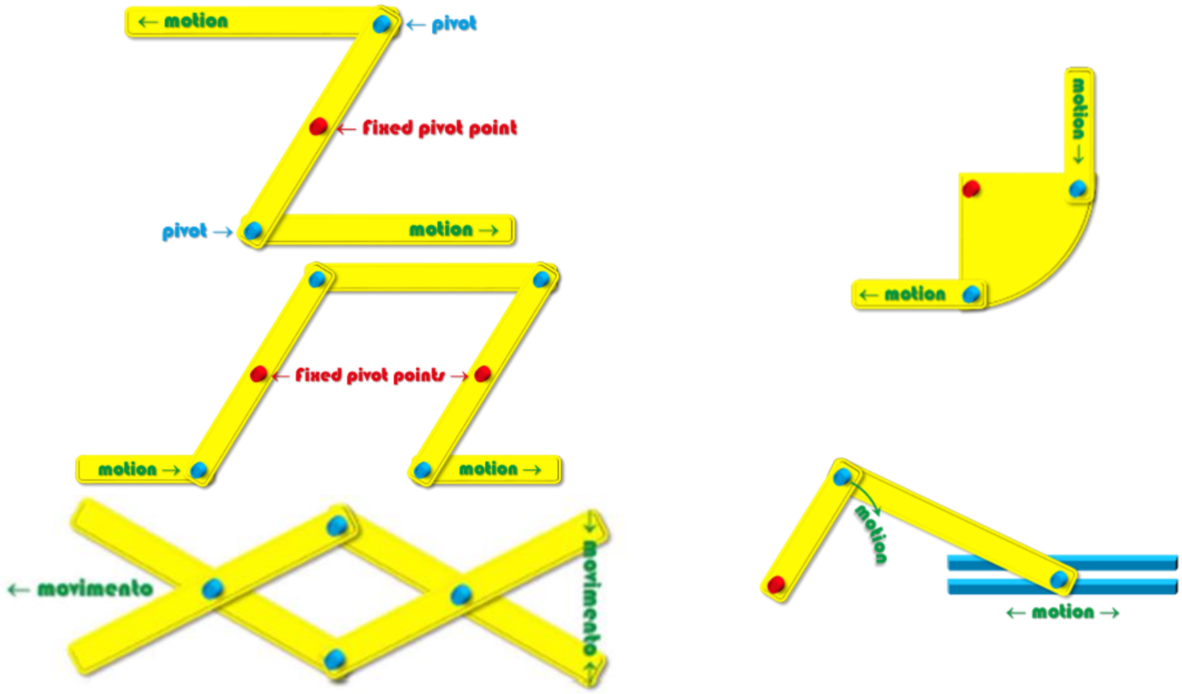
Another transversal competence is the **spontaneous cooperation** emerging in the various AutoSTEM activities. To learn more about this topic you can not only consult the online course but also this video.

Another concern of the project has to do with **inclusion**, so work is being developed to make activities adapted for people who are blind or have low vision. To learn more about this subject, you can consult the case studies, where the work around this adaptation is presented.

Mechanisms & Motion

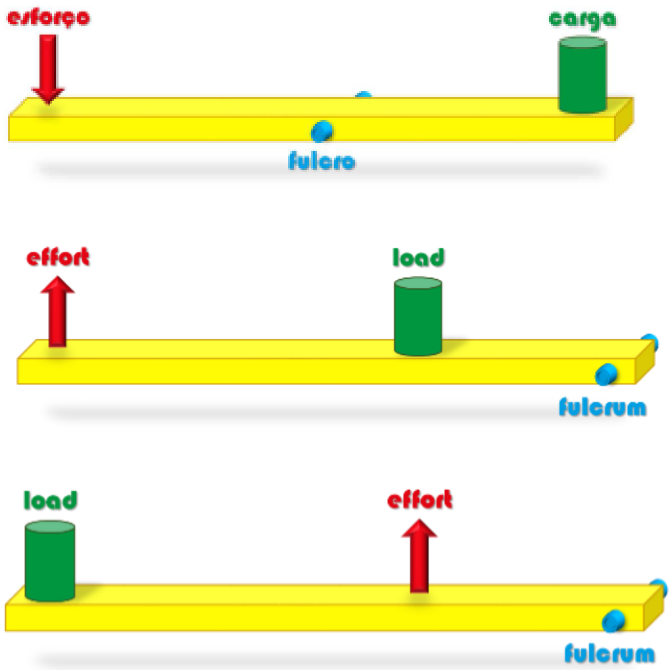
You can read more about the various mechanisms used in the AutoSTEM project toys in the Step By Step Teacher Guide where they are explained in more detail.

Within the mechanisms developed by the project there are variants of the linkages mechanisms.



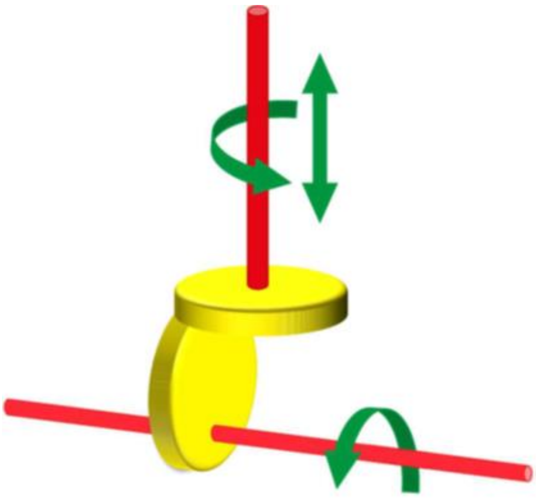
This mechanism results in different articulated toys that move when the mechanism is manually activated. One of the examples regularly used is the Snapping Crocodile, a crocodile that open its mouth when used.

Another example of mechanism is the lever which can also have some variations depending on the decoration and positioning of the lever and the way it is activated.



In this example a variation of the talking elephant can be seen, where the lever is activated manually with the fulcrum in the middle.

Finally, the third most used mechanism in the toys of the AutoSTEM project is the rotation mechanism. This mechanism, by means of two axes, can rotate an object placed at the end of the vertical axis. This mechanism is usually presented with a ballerina that rotates.



This is also a mechanism that can present various decorations and is therefore very versatile.

Step by Step – Teachers and Students Role

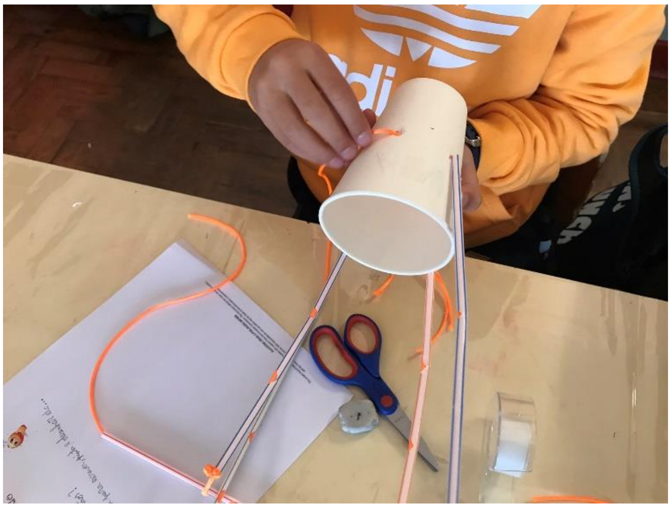
You can read more about the roles of the two players in the guided play situation in the Step by Step Teacher Guide

Children's activities

In order to make an automaton, children have to follow a series of activities that entail the acquisition of skills. The skills are

- Observing and analysing an automaton

- Conceiving their own automata



- Experiencing STEM content while constructing the automata

- Playing with the autómata

- Reflecting on the work developed

The teachers' role

- Identifying children's Zone of Proximal Development
- Choosing learning objectives
- Planning the activity

To help this process the AutoSTEM project has developed a series of resources that can be consulted in this QR code.

- Scaffolding the production of the automata

- Link the construction process to STEM content or other subjects
- Working with a scenario or story
- Collecting feedback

In the document presented above you can also find some resources to guide and facilitate this process.

Learning Cycle

The AutoSTEM project uses the Experiential Learning Theory developed by Kolb (2015) into the **Experiential Learning Theory** (ELT), in particular a version proposed by Connors and Seifer (2005).

Kolb (2015) expanded by Dewey's pedagogical theory that emphasizes the importance of experience and reflection (Dewey, 1934, p. 35) in a learning cycle with four steps:

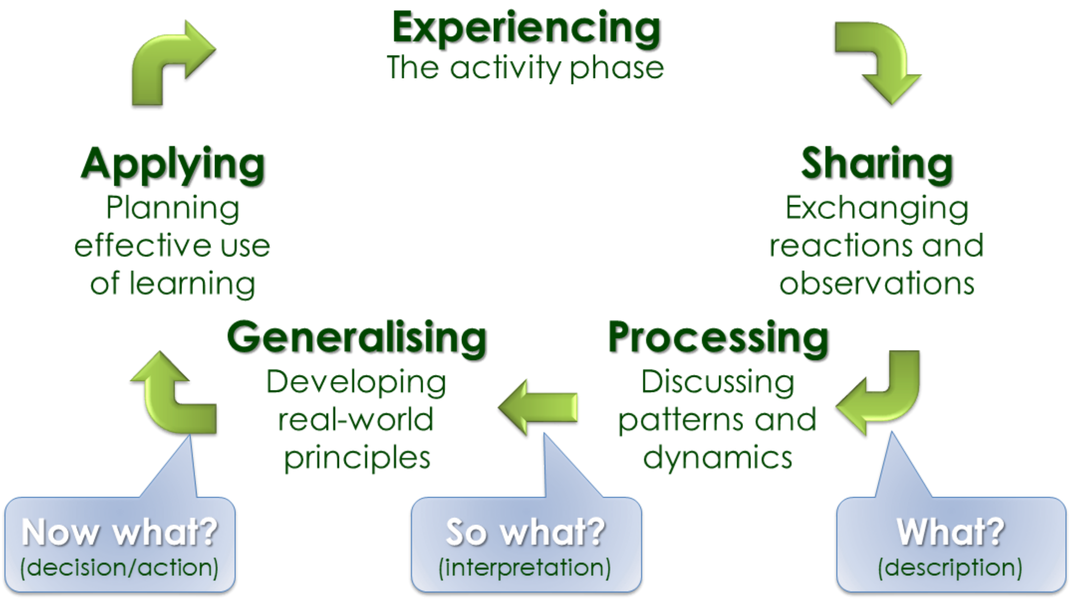
Concrete Experience (CE)– having an experience while doing something

Reflective Observation (RO) – reviewing what you have done and reflecting on the experience

Abstract Conceptualisation (AC) – concluding and learning from the experience and

Active Experimentation (AE) – planning and trying out what you have learned, which leads to a new concrete experience.

Connors and Seifer (2005) variant of Kolb learning cycle has five steps and is combined with questions by Borton (1970):
The figure below shows all these components.



To learn more about the AutoSTEM Learning Cycle you can refer to one of the chapters of the online course where the whole cycle is presented in more detail.

Consult This QR code to get access to the online course

If you want to know more about a specific stage of the cycle you can access these QR codes that direct you to each one of them.

3.2.1 Experiencing: the activity phase

3.2.2 Sharing: exchanging reactions and observations

3.2.3 Processing: discussing patterns and dynamics

3.2.4 Generalizing: developing real-world principles

3.2.5 Applying: planning effective use of learning

Resources for Reporting & Evaluating

A very important factor in the implementation of the activities of the AutoSTEM project is reflection by the teacher/educator. In this sense, a series of resources were created to facilitate and guide this process.

Resources for planning & reflection

Planning workshop with children

Observation guide

Piloting survey for teachers

Reporting template

Resources for parents

Parental permission form

Questionnaire for parents

Pre intervention resources

Prequestionnaire 4-5 years old

Prequestionnaire 6-7 years old

Pre interview guide

Post intervention resources

Postquestionnaire 4-5 years old

Postquestionnaire 6-7 years old

Post interview guide

Other resources

Certificate of participation

Attendance sheet

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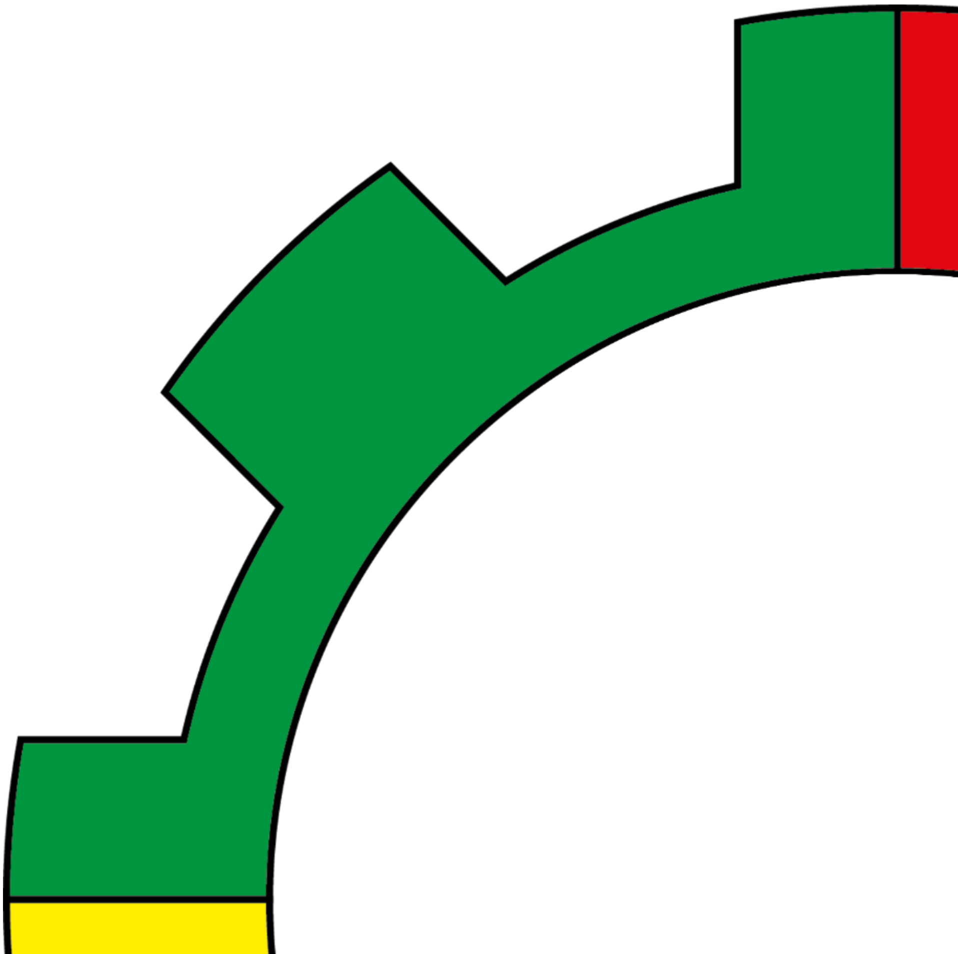
02

Automata



The AutoSTEM Automata: Pedagogical Guidelines & Construction Instruction

Automata	Age level	Subjects covered	Propulsion method	Construction Materials
JellyBird	4 – 7	Mechanisms, mathematics	Manual	Paper, thin cardboard
Talking Elephant	4 – 7	Mechanisms, biology, mathematics, physics	Manual	Card box, tape, cardboard, wooden skewer, scissors, glue stick, colouring pens/pencils, cork or plastic bottle top, ruler
Dancing Doll	4 – 7	Mathematics, physics and mechanisms. biology	Manual	Coloured paper, foam rubber, cardboard, skewers, straws
Balloon Car	5-7	Mathematics, physics and mechanisms	Breath	Thick paper, skewers, bottle caps, straws, balloon, sticky tape
Balloon boat/ Amphicar	4 – 7	Physics, mechanisms, transfer of energy	Breath	Drink carton, skewers, bottle caps, straws, balloon, sticky tape
Snapping Crocodile	4 – 7	Mechanisms, engineering, mathematics	Manual	Cardboard, split pins
Catapult	4 – 8	Mathematics, physics and mechanisms	Manual	Wooden sticks (for ice cream), rubber band, bottle cap, split pin
Acrobat	4 – 7	Physics, mechanisms, biology	Manual, turning	Coloured paper, cardboard, wooden skewers, split pins
Wind Turbine	4 – 7	Physics, mechanisms, mathematics, biology, engineering	Manual	Paper cup, wooden sticks, tape, scissors, box

Colour Spinning Disk	4 – 7	Mathematics, physics and mechanisms	Manual	Paper, skewer, colouring materials
Eco Car 1	4 – 7	Mathematics, physics, mechanisms	Manual	Wooden sticks, straws, bottle caps, wooden skewers, hot glue, rubber bands, tape, ruler
Eco Car 2	5 – 8	Mathematics, physics, mechanisms, engineering	Manual	Wooden sticks, straws, bottle caps, wooden skewers, hot glue, tape, thread
Elevator	4 – 7	Mechanisms, engineering, mathematics	Manual	Carton, skewer, wheel or disc, matchbox, Sticky tape, String
Drawbridge	5-8	Physics and mechanisms, engineering, mathematics	Manual	Thick cardboard, string, sticky tape, skewers
Returning tin can	4 – 7	Physics engineering, mathematics	Manual	Cylinder shaped box or bottle. 9V battery, Sticky tape, Scissors, Rubber band, Paper clips
Moving Shapes/ Two Faces	4 – 7	Mathematics, physics, engineering, mechanisms	Manual	Cardboard, ruler, pencil, awl, scissors, split pins
Grabbing Hand	4-7	Biology, mathematics, mechanisms	Manual	Paper cup, straws, thread, tape, scissors, ruler, pencil or pen

The JellyBird

Pedagogical Guidelines & Construction Instructions

Video Tutorial

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The JellyBird

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How the Jellybird can be used to learn areas of STEM subjects
- How to construct the Jellybird

How the Jellybird can be used to learn STEM areas

What is the Jellybird

The Jellybird is a moving toy made from paper, and cardboard that makes bird like movements when constructed.

STEM subjects can be introduced when constructing the Jellybird. We detail some ideas below. The teacher can adapt these suggestions to their own class and context and plan their own activity (see the templates below).

Target group

The Jellybird example is designed for children from 4 to 7 years old. Teachers can adapt the idea to other ages.

The teacher can decide, depending on her/his knowledge of the children, whether they should work in groups or individually.

Learning goals

When constructing the Jellybird several learning goals can be achieved:

- To learn about physics and mechanisms
- To develop engineering competences of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
- To learn biology concepts
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Jellybird, how it functions and is constructed.

Observing

Firstly, the teacher shows a model of the Jellybird. The teacher can ask, why did it move? Here is a link to a video example, that shows it in use
https://www.youtube.com/watch?v=tJ-Qda2kHrA

Exploring and learning about physics and mechanisms.

Children can observe the Jellybird and make comments and ask questions about how it functions. Teachers can talk about movement in a very simple way.

Starting to construct the Jellybird and learning mathematics

When the children colour the Jellybird, they have to use their spatial imagination to visualise how the parts will fit together and what the bird will finally look like. The teacher talks with the children about the different parts, their shapes and placement:

- The body is round, but not a circle. It is oblong and pointed at one end. There is a left-hand side and a right-hand side of the body.
- The wings are rectangles. A rectangle has four sides and is oblong. There will be one wing on either side of the bird.
- The eyes are round, almost like circles. There will be one eye on either side of the body.
- The beak is a triangle. It has three corners. The sharp corner points outwards. The bird uses the beak to pick. The beak will be in the front.
- The tail is a trapezium. It has four sides. The widest side points outwards. The bird uses the tail to steer. The tail will be in the back.

Since we need two supports that must be cut out of carton material, the teacher talks about the concept twice. The children use one template twice to get two supports.

When the children stick the beak and the tail to the body, the teacher talks about the inside and outside of the bird. The children must stick the beak and the tail to the inside. Furthermore, the teacher uses the concepts round and pointed. The children must stick the beak to the round side and the tail to the pointed side.

When pushing the support that carries wings through the body, the teacher can talk with the children about the mathematical concepts narrow and through. The support must go through the narrow gap.

When bending the wings, the teacher talks with the children about the concepts down, either side, left-hand side, and right-hand side. The children must bend the wings down on either side, one on the left-hand side and one on the right-hand side of the bird. The wings are symmetrical, they have a mirror symmetry, i.e. they look the same on either side but point in different directions – one to the left and one to the right.

When playing with the bird, the teacher talks with the children about motion and the concepts up and down. We move the support up and down. The wings flap up and down. The bird flies upward in the air and then forward.

Figure 1. Examples of children playing and building JellyBirds.

Variations on the Jellybird and adding scenarios and narratives

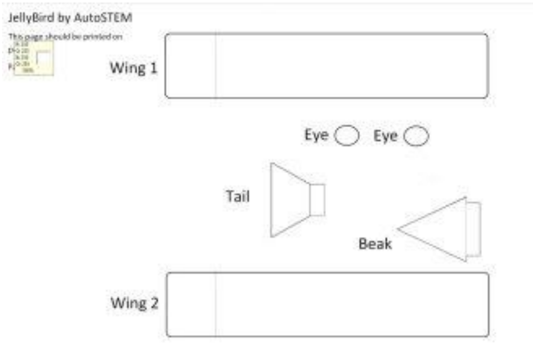
On finalisation, the Jellybirds, can then be used in additional ways. Some ideas include,

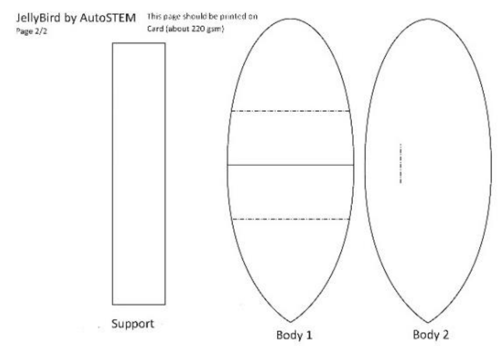
- Creating groups that mimic how flocks of birds fly together, here are 2 examples:
- Starlings' murmuration: https://www.youtube.com/watch?v=eakKfY5aHmY
- Flying with geese https://www.youtube.com/watch?v=XYdPnuGXo78
- Bringing preschool into the home. The birds could be used within a bedtime story. Here's a freely available example https://www.storyjumper.com/book/index/20310568/The-Bird-Who-Couldn-t-Fly#
- Adding additional wing shapes (also opportunities for other geometric shapes)

How to construct the Jellybird

Parts and tools required

- Standard computer printer capable of printing card up to 220gsm
- A4 standard printing paper (can be coloured paper)
- A4 card (about 220gsm, can be coloured card)
- Scissors
- Gluestick (To stick the parts together, gluesticks are best but Sellotape can be used, but make sure colouring is completed before assembly).
- Food packaging carton (for the carton material)
- Colouring materials (felt tip pens or paints)

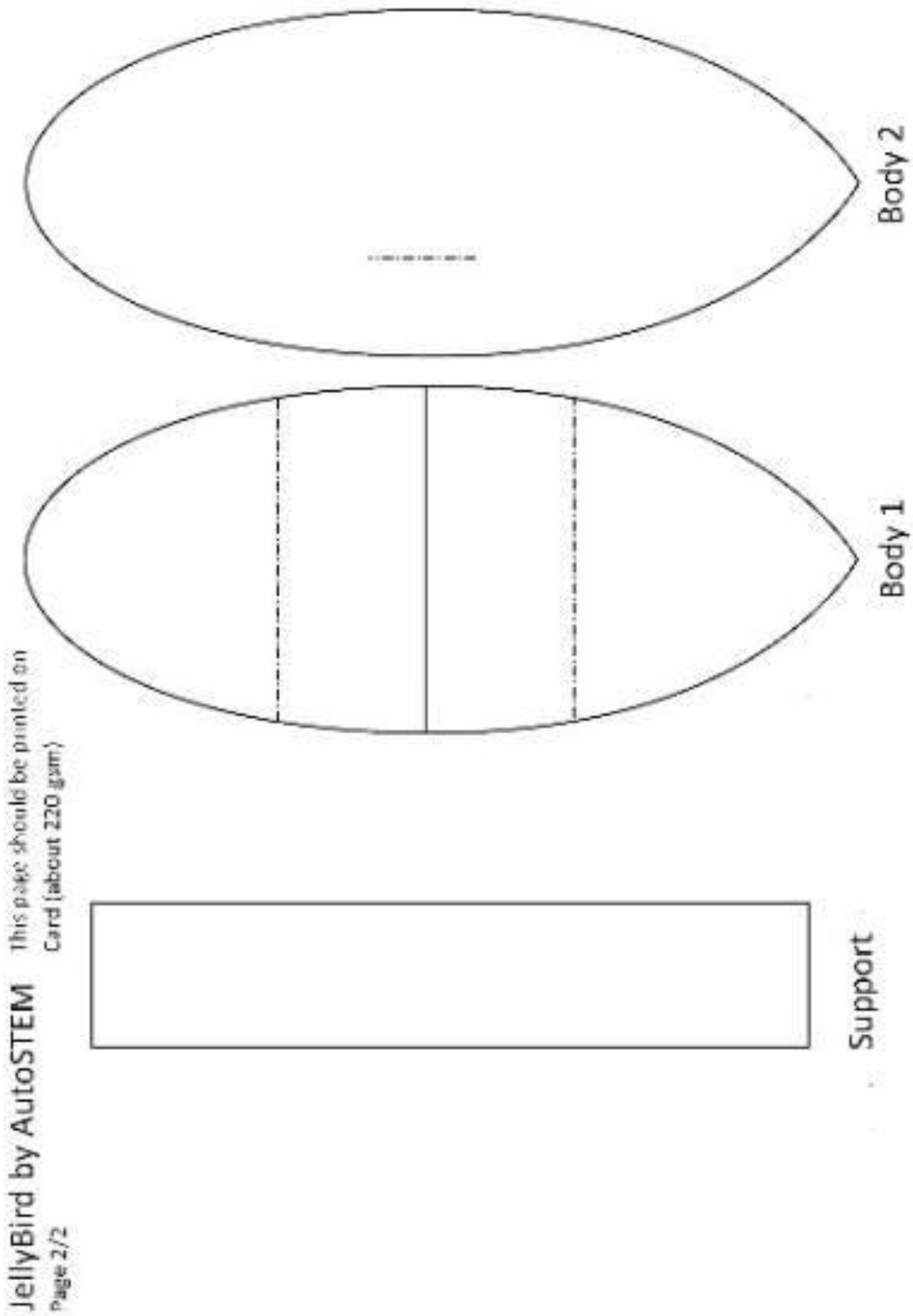




Method

It is best to watch the video https://www.youtube.com/watch?v=SNUSeYg0itE before starting the construction:

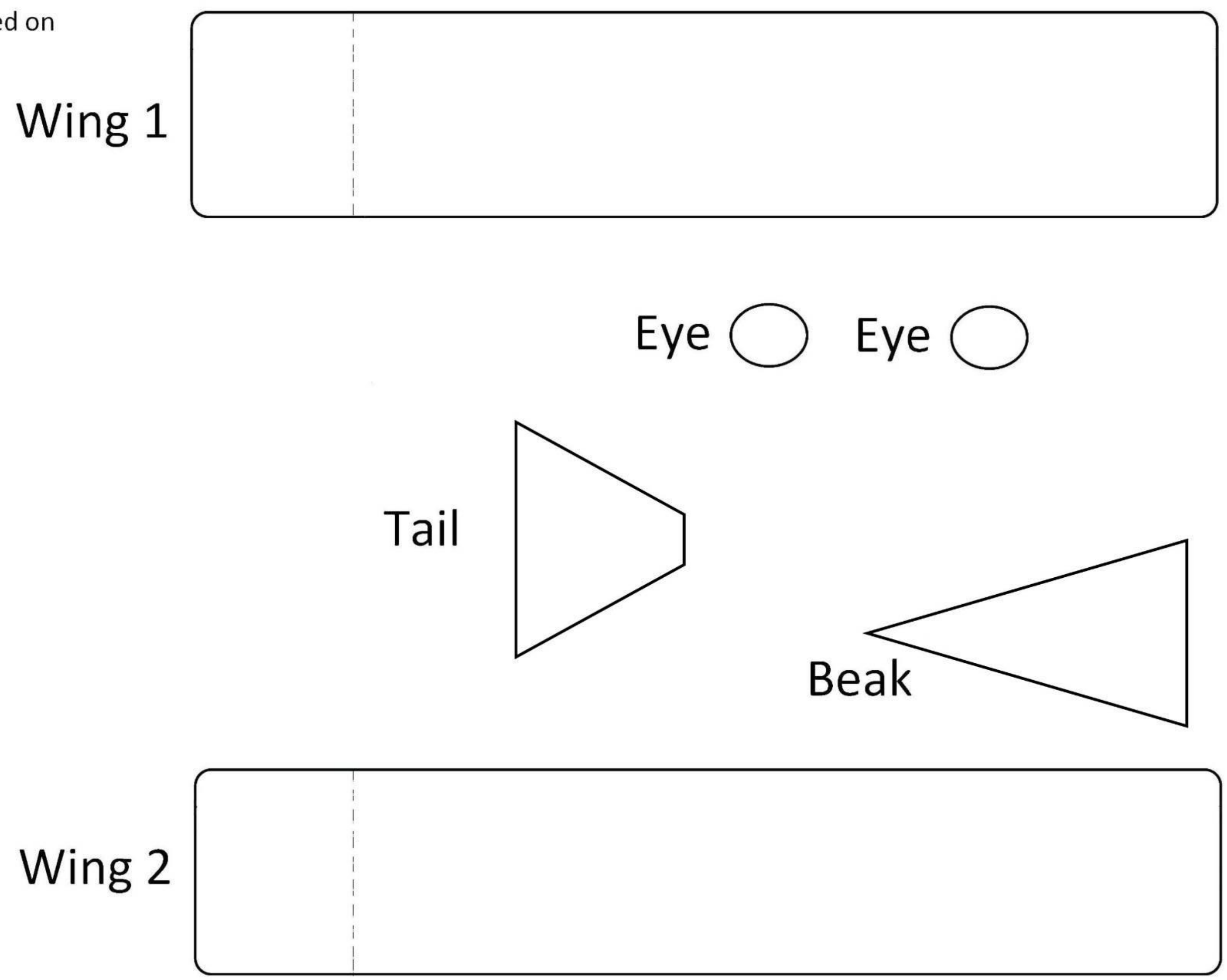
1. Print page 1 on paper, you can find the template at the end of this script
2. Print page 2 on card, you can find the template at the end of this script
3. Cut out all the parts
4. Colour the parts, make sure that the correct sides are coloured.
5. Take the 'Support', place it on Food packaging carton material, and cut around shape. It might be easier to draw around the parts first. Do this twice!
6. Stick the 'Beak' and 'Tail' on 'Body 1'
7. Stick 'Body 1' to 'Body 2' so they fit each other exactly. Do not stick inside the dotted lines as the wings go through the centre. You can use a gluestick or sticky tape.
8. Stick 'Wing 1' to one 'Support' made of carton material from the dotted line on the wing.
9. Stick 'Wing 2' to the other side of the same 'Support'. Again use the dotted line on the wing as the guide.
10. Stick the other 'Support' made of carton material to the side of 'Body 2'. The top of the support in line with the dotted line.
11. Stick the 'Eyes' on either side at the round end.
12. Push the 'Support' that carries the wings through the narrow space between the 2 'Body' parts, so that the top of the support is in line with the top of the body. The wings should be above the body.
13. Bend the wings on either side of the body.
14. You are now ready to fly. Holding the fixed 'Support', move the loose 'Support' (with the wings) up and down. You are flying.


JellyBird by AutoSTEM
Page 2/2
This page should be printed on
Card (about 220 gsm)
Support
Body 1
Body 2

JellyBird by AutoSTEM

This page should be printed on paper

Page 1/2



03

04

05

The Talking Elephant

Pedagogical Guidelines & Construction Instructions

Video Tutorial

01 02

The Talking Elephant for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes:

- What is a Talking Elephant
- How the Elephant can be used to learn STEM areas
- How children can construct the Elephant

How the Elephant can be used to learn STEM areas

What is the Talking Elephant

A Talking Elephant is a simple automata toy that is suitable for construction by children from the age of 4 years. It consists of a cardboard box that has the face of an elephant at the front and at the back a lever that a child can use to make the elephant's mouth open. It allows children to anthropomorphize the elephant automata and use it as an object of play while still gaining
educational insights.

Figure 1. Children building and playing with a Talking Elephant.

Mechanisms and levers

The mechanism is very simple. A wooden stick with something, like a cork or bottle top pushed on to the end that pushes the face of the elephant forward and upward. The movement is manual without any complex mechanism. To make the movement, the teachers guides the children to find the centre of the back of the cardboard box.

Zoology concepts

It allows the exploration of biology/zoology and natural science concepts.
Some ideas include exploring :

- The names of the body parts
- The vocalization (Trumpeting)
- The physical characteristics (the skin, the trunk)
- Movement (walking, catching with the trunk etc)
- Eating habits
- Reproduction
- Species evolution

It also opens up the possibility of talking about geography associated with the elephant's habitats, for example, their geographical location.

Introducing the elephant to the children

When introducing the elephant, the teacher should challenge the children to observe and analyse the movement, without showing the lever. The teacher can ask the children how they think the elephants mouth is opening. The teacher can also pretend to talk for the elephant, for example, 'Hello class, I am a talking elephant' while moving the mouth to match the speech. Perhaps the children can make a drawing how they think the mouth is opening. This can be a first contact with lever mechanism, using a playful approach. https://www.youtube.com/watch?v=E8RA9Kw_IaE

Mathematical concepts

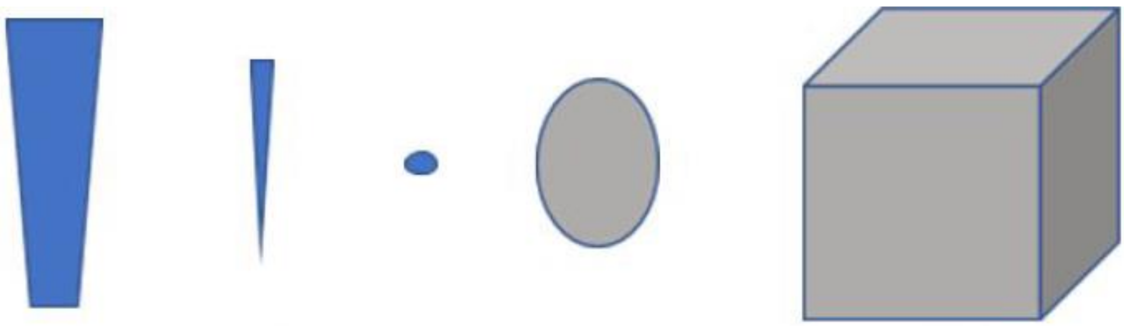
The construction and use of the Elephant allow the teaching of a number of mathematical concepts within the construction and assembly process.

Exploring and learning physics

Children will observe the Elephant and formulate comments and questions about how it moves.

During construction

The teacher talks with the children and asks them about the shapes they are using including the body. The teacher can also discuss the shapes and where they are placed.



Trunk x1 Tusk x2 Eye x2 Ears x2 Body x1

Figure 2. The elephant's parts

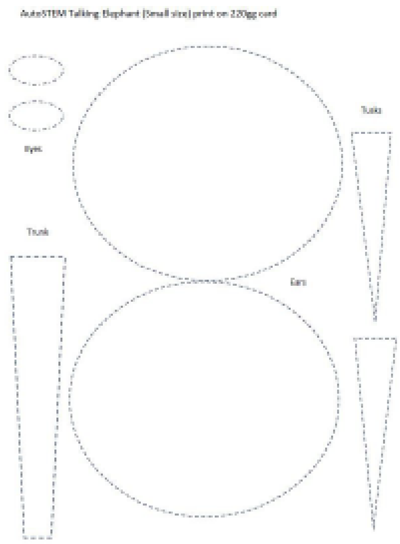
What does the elephant and its parts look like?
Each of the body sides is rectangular. A rectangle has four sides and is oblong. There are 6 sides to the body.
There are 2 ears, and they are oval. It is an idea to have an example of a circle, so you can show the difference between a circle and oval. You can use the eyes but might want to use a larger circle for clarity.
The eyes are round, like circles. There will be one eye on either side of the face. The tusks are triangles. Each tusk is a triangle. It has three corners. The sharp corner points downwards.
The nose of the elephant is a trapezium. It has four sides. The widest side is at the top. What does the elephant use its nose for? Do you know the special name there is for an elephant's nose?

The teacher talks with the children about the cardboard box that has to be folded and transforms into the Elephant's body.

The children are asked to count the sides of the box and to imagine how many will have to be glued and how. They should also decide which side will be the face of the elephant.

How to construct the Elephant

Parts and tools required



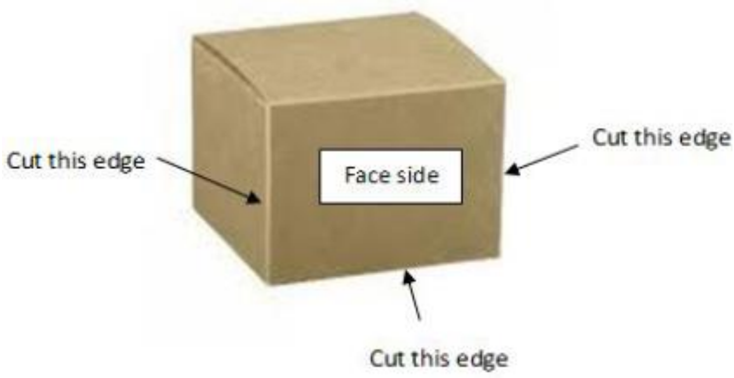
- Template to be printed on A4 card (20gm) can be coloured card - Please note - the templates are available in 2 sizes so that you do not need to look for a particular size cardboard box. You can download the templates from the website.
- Brown parcel tape
- A rectangular box that is flat (not made up)
- A wooden skewer, long enough to reach from the front (face) to the
- back of the cardboard box
- Scissors
- Glue stick
- Colouring pens/markers/pencils
- A cork or plastic bottle top
- Ruler

Method

It is best to watch the video before making the elephant (video)

1. Print the supplied template on an A4 card (20gm)
2. Cut out the shapes from the template
3. Colour the shapes that have been cut out (this can also be done afterwards)
4. Assemble the Box, using parcel tape to close it tightly
5. Cut the side that will be the face, at the bottom and 2 sides, along the

folds. Leave the fourth side attached.



Children make the cardboard box, sealing the top and bottom with Sellotape or parcel tape. They cut through the box on 3 sides as shown in Figure 2. This will be the elephant's face. For younger children, adults may have to help make the cuts.
Then the children are given the card templates with the shapes; and cut the shapes out with scissors.
They find the centre of the side 'Opposite' to the face and find the centre point by drawing 2 diagonal lines from one corner to the furthest opposite and then from the second corner

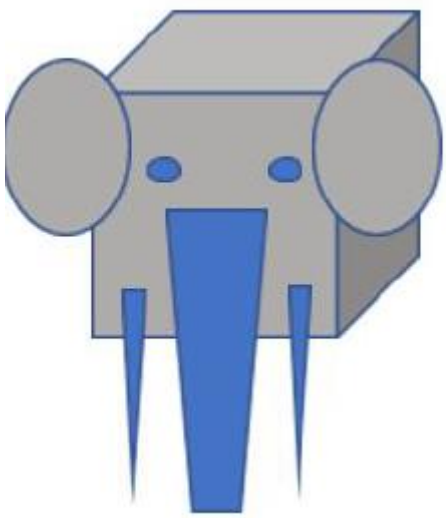
to the furthest opposite. Where the lines cross, is the centre point. Teachers may like to ask their children how they will find the centre point themselves, as an exercise?
Make a hole in the cork or bottle top big enough to push the end of the skewer through. The cork/bottle top should fit tightly on the end of the skewer.
Once the hole has been made, the children can be asked to guess how to make the movement:

Once the centre point is located:

1. Make a hole just large enough for the wooden skewer to move through
2. Push the skewer through
3. Push the cork or plastic top on to the end of the skewer that is inside the box
4. The children should now test if moving the skewer moves the face? If it doesn't let them find out what is wrong, only help if there is a real problem

Then, here comes the moment to glue the features of the elephant tolt's head: the ears have to be glued outside the side of the face, the trunk has to be central, the tusks at the sides of the nose and finally the eyes have to have equal distance from the trunk.

Once the face is completed, it is time to open the mouth and let the Elephant talk!



The Dancing Doll

Pedagogical Guidelines & Construction Instructions

Video Tutorial

03

04

05

The Dancing Doll for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How to construct Dancing Doll
- How the Dancing Doll can be used to learn STEM areas
- Variations of the Dancing Doll

How the Dancing Doll can be used to learn STEM areas

What is the Dancing Doll

The Dancing doll is a paper doll that fits on the top of a box. It turns around when a hand crank is activated. Inside the box there is a mechanism that makes the motion.

Figures 1 & 2. An example of Dancing doll and the mechanism

The following are ideas how to introduce STEM concepts when constructing the Dancing Doll. The teacher can adapt these suggestions to their own class and context and plan their own activity (Plan template).

Target group

The Dancing Doll example described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Dancing Doll several learning goals can be achieved:

- To learn about physics and mechanisms, in particular, mechanical energy and transferring energy from the manual turning of a handle into making the doll move.
- To develop engineering competences of analysis and construction.

- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
- To learn biology concepts about parts of the human body.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Dancing Doll, how it functions and how to construct it.

Observing

The first thing the teacher does is show a model of the Dancing Doll turning around. The teacher can ask, why did it move? Here is a link to a video example, that can be used. https://www.youtube.com/watch?v=_1tldldgBPo

Exploring and learning about physics and mechanisms.

Children can observe the Dancing Doll and make comments and ask questions about how it functions.
Teachers can talk about the friction drive in a very simple way. Using friction transfers a force from one wheel to another, hence the name friction drive. A very simple way to do this is to allow the edge of one circular disk to rub on the under surface of another disk.

Starting to construct the doll and learning mathematics and biology

Continuing with learning about shapes and numbers.
The teacher talks with the children asking what is needed; the teacher can talk about the different parts, their shapes and placement. This is a link to a description of a cone https://mathblog.com/reference/geometry/cone/
What does the body look like? The body is a cone.
What does the face look like? Children can paint eyes, nose and mouth, as well as hair.
Once the two parts are completed, it is time to put them together! Here it comes the moment to glue the two parts of the Dancing Doll. Children can also discuss and offer ideas on how they would make arms for the dancing doll, they can talk about what shapes the arms are.
In this scope, the construction and use of the Dancing doll also opens up the possibility to talk about parts of the human body.

Constructing the mechanism to develop engineering competences

Continuing with ideas that can be used for observing and learning about shapes and numbers, and also about a friction drive.
Children can then explore examples of this motion and start to explore materials needed to construct it.
The teacher continues talking with the children about the box and the pieces and materials to construct the mechanism.
Children construct the mechanism following the method described in How to construct Dancing Doll.

Variations on the Dancing Doll and adding scenarios and narratives

Other themes and characters can be used instead of Dancing Doll. It can be a carrousel, e.g. a carrousel of numbers, a planet, another doll, e.g. typical from children's country, smiling vs sad face or whatever teachers and children can imagine.

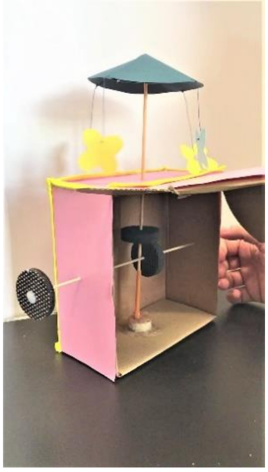
Different **scenarios** can be developed for the Dancing Doll. The scenario can be used at the beginning of the activity or the end.
For example, a circus can be used to contextualize the activity. Other characters can be added? What do they do? Which mechanisms can be used?

Narratives and stories can also be used.

Save the word!

Diana Azevedo
Helena Fernandes
Inês Ramos
Yanara Borges
Luís Portela

Portuguese Dancing Doll – Viana do Castelo
Adriana Pedrosa
Cátia Simões
Madalena Araújo
Rita Costa



Carrousel

Anália Santos
Inês Machado
Joana Almeida

Carrousel of numbers

Anália Santos
Inês Machado
Joana Almeida

Figures 3,4, 5 and 6. Examples of other automata using a rotation mechanism

How to construct Dancing Doll

To make the actual Dancing Doll part (or any other character) a wide variety of material can be used including: coloured sheets, foam rubber (pieces or sheets), cardboard, wooden sticks, straws, coloured ribbons, fabrics, crepe paper, coloured paper, newspapers, recycled or natural materials, in fact, anything the teacher and children can think of. We provide a template (Annex 4) that has a template for a dress and a head.

Parts and tools required

- Template for the cone. (see at the end of this scritp)
- A box for the mechanism. (a shoe box or similar small box will do).
- Gears that can be made from bottle tops, cardboard or foam/rubber mats (for example ones used for camping or gym).
- Long sticks of wood (skewers) The ones used for cooking are perfect as the children can cut them easily.
- Drinking straws
- Scissors
- Glue stick and/or hot glue gun
- Colouring pen or pencils
- Coloured cardboard

Since the materials that can be used are very wide and easy to find, the teacher can ask the students to find objects that might otherwise be thrown away (bottle tops, paper...) in this way we can add conservation and reusability in to the teaching of the workshop.

Method

It is best to watch the video https://www.youtube.com/watch?v=Lvvxnfe2wTw before starting to make your Dancing doll.

1. Create the Doll from the template shapes in the template (Annex 4)
    a. Cut out the shapes, and make a cone around the skewer and stick it, and then stick the circle as a head
2. Open the box and make the mechanism.
    a. Make a mark in the centre of either end of the box and make holes just big enough to take a skewer. The centre of the two end sides and the top of the box is found by placing 2 diagonal lines across the end with a pencil and ruler.
    b. Cut out of your foam/cardboard in to 2 round shapes or take bottle tops (these will be your gears)
    c. After making a hole in one gear thread a skewer through the gear. The skewer must be long enough to fit through both sides of the box.
    d. Push the skewer through the 2 sides of the box. You might need to take the gear off and push the skewer through one side, then insert the gear before pushing through the second side.
3. Make a hole in the top of the box large enough to take a straw
4. Stick a 5 cm piece of straw through the hole you have made in the top of the box and glue it into place
5. Push the second skewer with the doll though the straw and then add the second gear to the bottom of it.
6. You can add a handle on the end of the horizontal stick using a bottle cap.

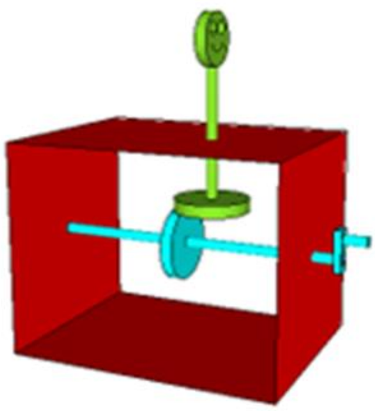
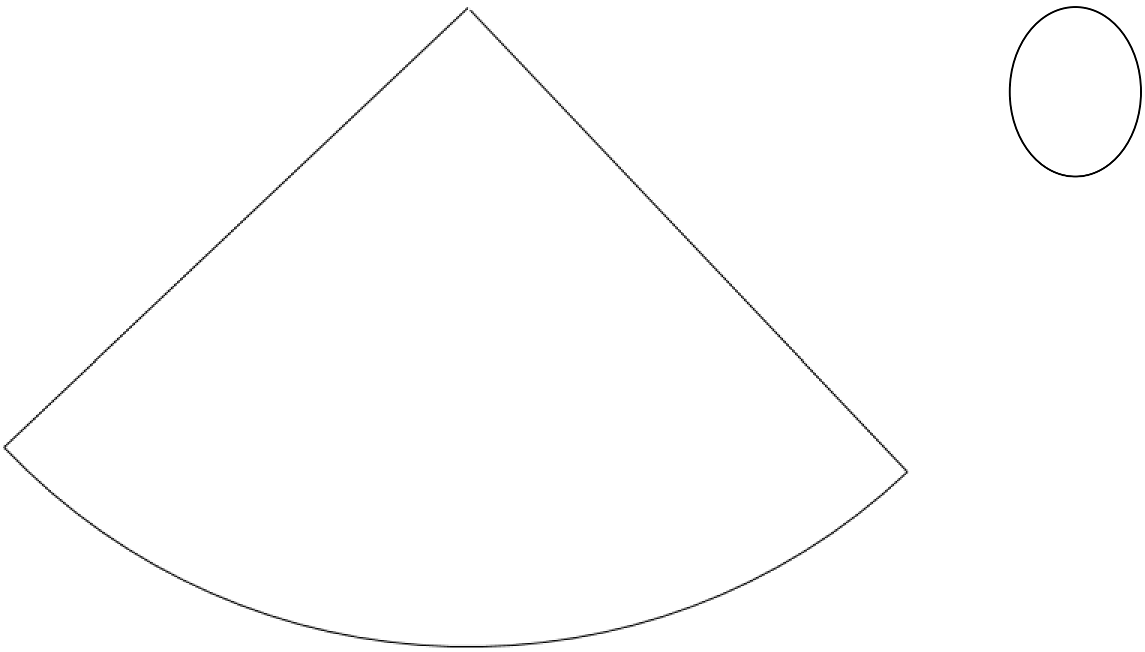
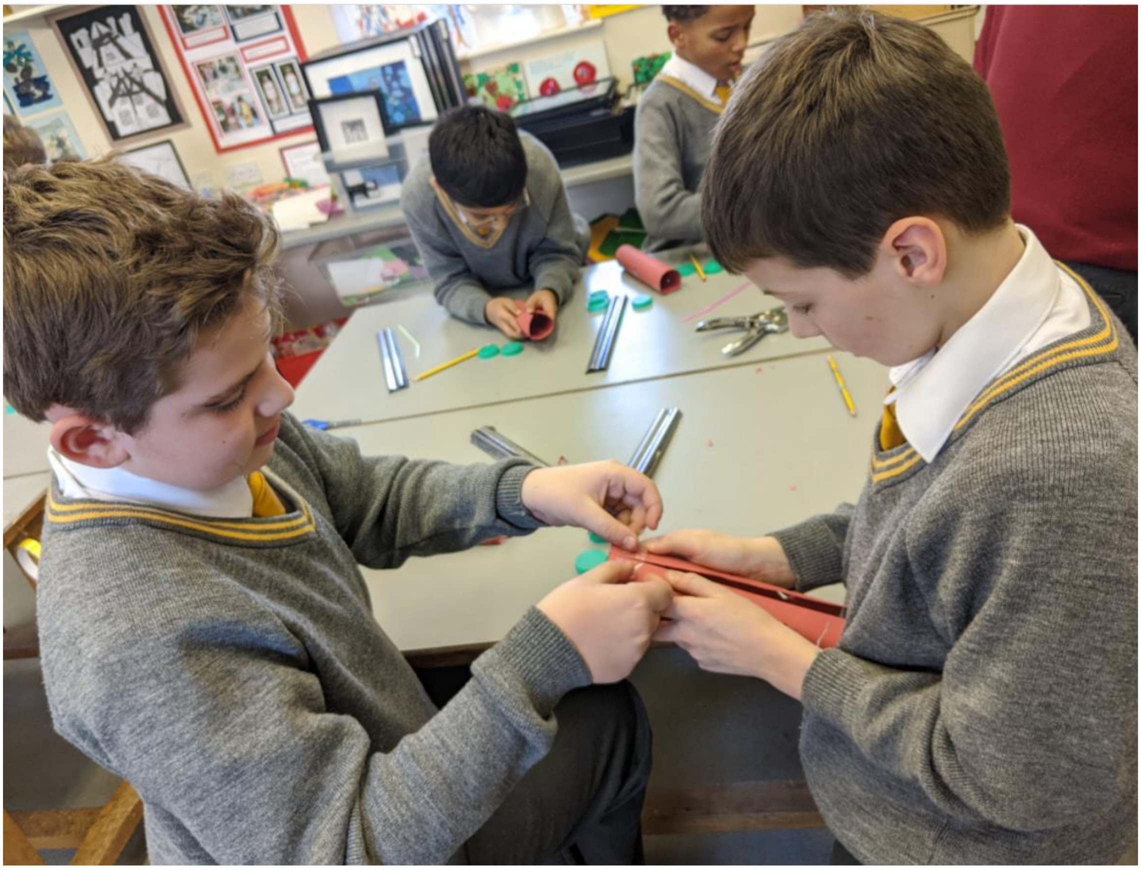


Figure 7. The mechanism

Components of the Dancing Doll – a cone and head



The Balloon Car



Pedagogical Guidelines & Construction Instructions

Video Tutorial

03 04 05

The Balloon Car for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- What is the Balloon Car
- How the Balloon Car can be used to learn STEM areas
- Variations of the Balloon Car
- How to construct Balloon Car

How the Balloon Car can be used to learn STEM areas

What is the Balloon Car

The Balloon Car is a toy car made from standard cardboard, straws, wooden skewers, bottle tops and a balloon. It will move on its own when the balloon is inflated.

It results in a toy that can be used by the children in many ways, and opens up a number of subject areas for further learning. A moving car is a very motivating and exciting toy for children; it is nice for the children to be allowed to play with their cars, once they have made them.

Figure 1. An example of Balloon Car

The following are ideas how to introduce STEM concepts when constructing the Balloon Car. The teacher can adapt these suggestions to their own class and context and plan their own activity.

Target group

The Balloon Car example described here is designed for children from 5 to 7 years old. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Balloon Car several learning goals can be achieved:

- To practice measuring and using a ruler
- An introduction to simple fractions

- To learn about physics and mechanisms
- To develop engineering competences of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Balloon Car, how it functions, and how to construct it.

Observing

The first thing the teacher does is show a model of the Balloon Car and make it run on the floor. The teacher can ask why it moved.

Exploring and learning about physics and mechanisms.

Children can observe the Balloon Car, make comments, and ask questions about how it functions.

Teachers can talk about how energy is transferred by blowing up the balloon and how the energy is stored by the balloon.

Starting to construct the Balloon Car and learning mathematics

The teacher talks with the children asking what is needed to make the car. The teacher can talk about the different parts, their shapes, and placement.

The teacher can talk about tubes/cylinders

The teacher should scaffold the measuring process as they fit and dependent on the age and competences of the children.

It is possible to allow the children to make mistakes at this stage, and then let them find out how to correct their mistakes, themselves, For example, if the car body touches the floor it may not run at all, or, if the holes are not made parallel the car will move to one side or the other when running. They can solve these problems.

Variation on the Balloon Car and adding scenarios and narratives

Expanding on the idea

Different **scenarios** can be developed for the car. The scenario can be used at the beginning of the activity or the end.

The initial car idea can quite easily lead to further ideas and explorations. The teacher can ask the children for their ideas, perhaps, looking at the way vehicles are used in the world outside, different shaped cars.

One idea is to add loads like lorries and vans do. This then asked the question what happens when a load is added and why?

The car can be constructed with other bodies, like milk- or juice cartons. This reduces the time it takes to build the car. The car is then close related to the Amficar.

A **scenario** for the Balloon Car can be a car race. Another to make a city with all types of cars you need for services.

Narratives and **stories** can also be used.

How to construct the Balloon Car

To make the actual Balloon Car you will only need basic parts and tools that are found in every school. Below we list the parts needed and alternatives.

Parts and tools required

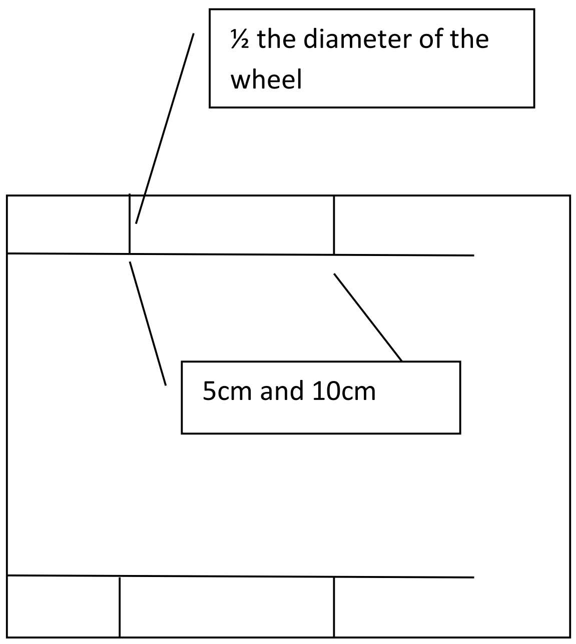
- A sheet of A4 card (up to 220 gms) Coloured or white (car body)
- 2x Straight paper or plastic straws (axle holder straws)
- 1x Bendy paper or plastic straw. A straight straw can be used but the this is can be little more difficult (balloon holder straw)
- 2x Long sticks of wood (skewers) The ones used for cooking are perfect as the children can cut them easily. (axles)
- 4x plastic bottle tops (for wheels) – these should be in matching pairs.
- Scissors
- Sellotape or other sticky tape
- A bradawl or other tool to make holes in the Bottle top wheels
- A ruler (with centimetres)
- Pencil
- Colouring pen or pencils

Since the materials that can be used are very wide and easy to find, the teacher can ask the students to find objects that might otherwise be thrown away (bottle tops, paper...) in this way we can add conservation and reusability into the teaching of the workshop.

Method

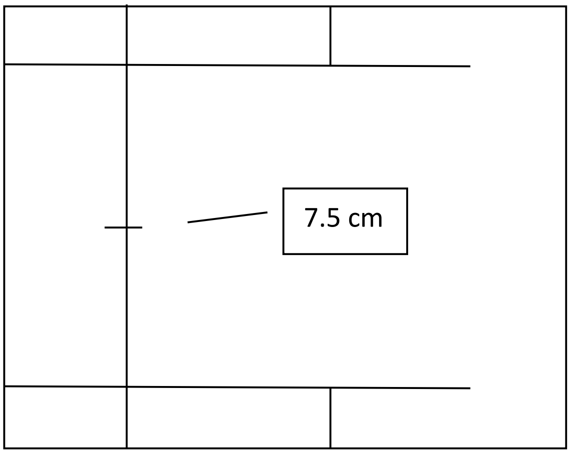
It is best to watch the video: https://www.youtube.com/watch?v=0KaWSrfF5Fc

Fold the A4 card in to half, along the long edge

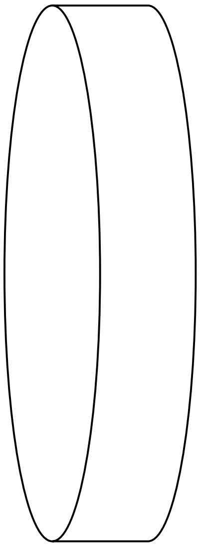


1. Cut the card into 2 along the fold, use scissors.
2. Measuring and cutting the holes in the **car body**

a. Place the card flat and measure with a ruler and pencil. On one long side (the long side is 21cm) measure from the edge; ½ the diameter of the wheel. So if your wheels are 4cm each then you will make a mark at 2cm. Do this at least 2 times (twice).
b. Draw a line between the two marks you have made.
c. Measure along the long line from the short edge (the short edge is 15cm) 5cm and make a mark on the line, and then do the same at 10cm.
d. Repeat steps 3 to 5, on the other long side of the card. Make sure you start your measuring for the 5 and 10 cm marks at the same end as the first one.
e. Now make the hole for the bendy straw (balloon holder straw). Draw a line with the ruler and pencil between the 5cm marks across the card (it will be 15cm long). Measure 7.5cm (7 1/2cm) along the line and make a mark on the line. This is halfway along the line.



3. Making the holes for the axles and wheels:
    a. Fold the cardboard along one of the lines, and make a small hole on the mark at 5cm and 10cm. Then with scissors cut a hole large enough to push the **axle holder straw** through. It is important that the hole does not go below the line towards the edge of the card but stays above. This is so the wheels will be level. Unfold the card and flatten it,
    b. Fold the cardboard along the second line and repeat the hole making and cutting at the 5cm and 10 cm marks on that side. Make sure the holes are big enough to push the straw through. Then unfold the card and flatten it again.
4. Rolling the card into a tube – **car body**. You will need 2 people to do this job:
    a. Cut 3 pieces of sticky tape (about 4/5 cm each) stick one end of each piece of tape to the side of the table carefully
    b. Hold the card lengthways in 2 hands and slowly roll it in to a tube
    c. One person makes the sides of the cardboard touch a little along the long side. The second person then takes one piece of sticky tape and sticks the 2 long sides



together at one end. Be careful not to stick over the holes. Repeat this process at the other end, and then finally in the middle.

5. Cut one of the **axle holder straw** into a piece 10cm long. Repeat with the second **axle holder straw.**
6. Cut the wooden skewer, **axle**, into a piece 15cm long. Repeat with the second **axle**.
7. Making the holes in the **wheels**:
   a. Place a ruler across the diameter of one **wheel** and draw a line, turn the ruler and draw a second line. Make a hole at the point where the lines cross. Do the same process for all the 4 **wheels**.
   b. Check the holes in the **whe**els are big enough for the **axles** to go through, but do not make them too big as the **wheels** might fall off.
8. Final assembly:
   a. Push the **axle holder straws** through the 2 holes on each side of the **car body.**
   b. Push the **axles** through the inside of the **axle holder straws**
   c. Put the **wheels** on either end of the **axles**
   d. Cut a 4cm piece of sticky tape and stick the end carefully to the side of the table.
   e. Put the balloon open end over the bendy end of the **balloon holder straw** and fold it as tightly as possible over the end of the **balloon holder straw**
   f. Stick the sticky tape around the folded end of the **balloon holder straw** as tightly as possible
   g. Push the **balloon holder straw** into the **car body** through the hole at the top of the body that you made earlier, straight end first. Push it till the end can be seen at the end of the **car body**.

Making the car move

Place the completed car on to a flat surface (table or floor) check that no part of the **car body** is touching the table or floor. If it does the car might not work.
Lift the car and blow in to the end of the **balloon holder straw** so that the balloon inflates. When the balloon is quite big, squeeze the straw, quickly put the car on the flat surface, and let it go weeeeeeeee. You can now colour the cars at this stage. It might be easier to take the wheels off first.

The Balloon Boat & Amphicar

Pedagogical Guidelines & Construction Instructions

Video Tutorial

03 04 05

The Balloon Boat and Amphicar

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How the Amphicar can be used to learn STEM areas
- How to construct a balloon-powered Amphicar

How the Amphicar can be used to learn STEM areas

What is the balloon-powered boat and Amphicar?

The Amphicar is a toy that is a boat and a car at the same time. When building it, the children can stop when it is a boat or continue to make a car that can still be used as a boat like the classical Amphicar. The AutoSTEM Amphicar is made from a standard milk or juice carton, straws, wooden skewers, bottle tops and a balloon. It will move on its own on land or water when the balloon is inflated.

It results in a toy that can be used by the children in many ways and opens up a number of subject areas for further learning. Moving cars and boats are very motivating and exciting toys for children. It is fun for the children to be allowed to play with their Amphicars, once they have made them.

Figure 1. An example of the Amphicar

Target group

The Balloon Car example described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Amphicar several learning goals can be achieved:

- To practice measuring

- To use a ruler to draw a straight line (or for measuring)
- To learn about physics and mechanisms
- To develop engineering competencies of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Amphicar, how it functions, and how to construct it.

Observing

The first thing the teacher does is show a model of the Amphicar and make it run on the floor and on water. The teacher can ask, 'Why did it move?'

Exploring and learning about physics and mechanisms.

Children can observe the Amphicar, make comments, and ask questions about how it functions.

The following concepts can be introduced and explored

- **Energy:** different types of energy:
  - work (The child does work by inflating the balloon.)
  - elastic energy: potential energy due to the deformation of the balloon
  - rotational kinetic energy (the rotation of the wheels)
  - translational kinetic energy (the forward motion of the Amphicar)
  - thermal energy (Heat is created by friction.)
- **Force:** The child uses force to inflate the balloon. The balloon applies force on the air, pressing it out through the straw. According to Newton's third law (action equals reaction), the force of the backwards streaming air (called the thrust) creates an equal force in the opposite direction on the Amphicar (called the propulsion) that pushes the Amphicar forwards.
  - Buoyancy (upthrust): an upward force exerted by a fluid that opposes the weight of an immersed object. The Amphicar's buoyancy is larger than the gravitational force that pulls it downwards. Therefore it floats on water. If the weight is too big, it will sink.
  - Friction: the force resisting the motion when the wheels roll on a surface (rolling friction) or the boat floats through the water (fluid drag)
- **Pressure:** the force applied perpendicular to the surface of an object per unit area over which that force is distributed
- **Conservation of energy:** Energy can be converted but not destroyed.
  - The child's work is converted into elastic energy (of the balloon and the pressurised air inside the balloon),
  - elastic energy into translational energy (of the air jet and the car),
  - translational energy into thermal energy (of the water)
  - or on land into rotational energy (of the wheels) and rotational energy into thermal energy (the wheels and the ground 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.
- **Parts of a boat:** hull, deck, bow, stern, port, starboard, and jet engine
- **Parts of a car:** wheels, axles, and bearings for the axles

Starting to construct the Amphicar and learning mathematics

The teacher talks with the children asking what is needed to make the Amphicar. During the construction, many mathematical concepts can be used, introduced, or discovered.

- **Counting:** two straws (one will be divided into two parts), four bottle tops, one skewer that will be divided into two parts
- **Measuring length:** Straws and skewers have to be cut into pieces of a given length. Older children can use a ruler, younger children can use fingerbreadth and handbreadth as units.
  Direct comparison
  - to make a hole in the bottle top that is 'just' big enough for the wooden skewer to pass through,
  - to find the right size for the hole in the deck, and
  - to measure the length of the bearings.
- **Designing (shapes):** The boat's hull is a cuboid with a triangular prism at the bow. The stern is a square. The hole in the deck is a rectangle. The wheels are circles (cylinders).
- **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 Amphicar), through (the axles go through the bearing), perpendicular

Expanding on the idea

The initial car idea can quite easily lead to further ideas and explorations. The teacher can ask the children for their ideas, perhaps, looking at the way vehicles are used in the world outside, different shaped cars.
One idea is to add loads as lorries and vans do. This then asked the question what happens when a load is added and why? The children can investigate how much load can be added before the boat sinks.

How to construct the balloon-powered boat and Amphicar

To make the actual balloon-powered Amphicar you will only need basic parts and tools that are found in every school or preschool. Below we list the parts needed and alternatives.

Parts and tools required

- For the boat
  - 1x standard one-litre milk or juice carton
  - 1x paper drinking straw
  - 1x toy balloon
  - Sellotape or another sticky tape
  - Scissors
  - a marker pen
  - a ruler
- For the Amphicar (in addition to the above)
  - 1x paper drinking straw
  - 1x wooden kitchen skewer (about 4mm wide and at least 20cm long)
  - 4x plastic bottle tops (each set of 2 must be the same size) for wheels

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 (milk carton, bottle tops, …). In this way, we can add conservation and reusability into the teaching.

Method

It is best to watch the video.
If you want to make only the boat, watch https://youtu.be/jlE5rlU5gQo.
If you want to make the Amphicar, watch https://youtu.be/vdocyNN3osl.

The boat

1. Take one straw and measure two fingerbreadths (about 3 cm or 1½ inch) from the end alongside the straw and mark this point. Do the same at the other end of the straw, too (see figure 2).

Figure 2. Measure two finger-widths on each end of the straw

2. Open the upper side of the boat
   a. Lay the milk or juice carton on its side so that the top is on the right and the opening points away from you. This will be the hull of the boat. The side facing upwards is the upper side, the deck of the boat. The side facing downwards is the bottom. The side with the opening is the port (larboard, left-hand side) and the other side is the starboard (right-hand side). The bottom of the carton is the stern (rear end) and the top of the carton is the bow.

Figure 3. The carton becomes the hull of the boat

   b. Lay the straw on the upper side of the boat so that one mark is on the rear starboard corner and the other mark meets the port edge (see figure 4).

Figure 4. Measure with the straw the size of the hole to cut in the deck

   c. Mark the point where the mark meets the port side.
   d. Take the ruler and draw a line across the deck from the mark to starboard perpendicular to the port side.
   e. Use the scissors to prick a hole in the deck (The teacher might help with this.) and cut away all of the deck that is between the line and the stern. Only the foredeck remains.
3. Use the scissors to prick a hole in the stern just above the middle of the bottom edge of the stern. The hole shall be 'just' big enough for the straw to pass through and still be tight.
4. Attach the balloon to the straw.
   a. Slip the balloon's open end over the one end of the straw and fold it as tightly as possible around the straw.
   b. Wrap the sticky tape as tightly as possible around the folded neck of the balloon and the straw.
5. Take the other end of the straw and push it from the inside of the hull through the hole in the stern until the mark sits in the hole.
6. Attach the straw with sticky tape to the foredeck and to the stern. The sticky tape at the stern shall be at the outside and seal the hole around the straw.

The boat is now finished and can be used. If you like, you can colour it with paint. Continue with step 7 if you want to make an Amphicar.

The Amphicar

7. Take the second straw and cut it into two pieces that are as long as the boat's width. These will be the bearings for the axles.
8. Making the holes in the wheels:
   a. Take a bottle top, find the centre, and make a hole. Many bottle tops are so soft that you can use the pointy end of the skewer to make the hole. If the plastic is too hard, you have to use a hammer and a nail. Do the same for all the four wheels.
   b. Check the holes in the wheels are big enough for the skewer to go through, but do not make them too big as the wheels might fall off.
9. Cut the wooden skewer into two pieces, each 10cm long (the length of the bearing plus two fingerbreadths). These will be the axles.
10. Final assembly:
    a. Use sticky tape to attach the two bearing straws to the bottom of the boat. They should be about a handbreadth apart and be perpendicular to the length of the hull.

b. Put a wheel on one end of each axle.
c. Push the axles through the inside of the axle holder straws.
d. Put the remaining wheels on the other ends of the axles.

11. Place the completed car on to a flat surface (table or floor) check that no part of the car body is touching the table or floor. Otherwise, the car might not work. If the straw that sticks out at the stern is too long, you can shorten it by cutting a piece away.

The Amphicar is now finished and can be used.

Making the Balloon boat and Amphicar move

Lift the boat or Amphicar and blow into the end of the balloon holder straw so that the balloon inflates. When the balloon is quite big, squeeze the straw, quickly put the boat in the water or the Amphicar on to a flat surface and let it go weeeeeeeee. The Amphicar can drive down a slope at the shore, enter the water, and continue as a boat.

The Snapping Crocodile

Pedagogical Guidelines & Construction Instructions

Video Tutorial

The Snapping Crocodile for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How the Snapping Crocodile can be used to learn STEM contents
- How to construct a Snapping Crocodile

How the Snapping Crocodile can be used to learn STEM areas

What is the Snapping Crocodile

A cardboard moving toy, which makes use of the scissors arm mechanism. It has the face of a crocodile but can be changed into a dinosaur or any other animal. With the help of the scissors arms, the child can make the crocodile's mouth open and close, snap, pinch, and grasp light objects. It allows children to analyse the mechanism and use it as a toy while gaining educational insights.

Developed by Ana Isabel Cobra, Beatriz Rodrigues, Catarina Sampaio, Jéssica Ribeiro, and Maria Beatriz Medina

The following are ideas on how to introduce STEM concepts when constructing the *Snapping Crocodile*. Teachers can adapt these suggestions to their class and context and plan their own activity.

Target group

The Snapping Crocodile example described here is designed for children from 4 to 7 years of age. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Crocodile several learning goals can be achieved:

- To learn about physics and mechanisms, in particular, linkages.
- To develop engineering competencies of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including patterns, shapes and numbers.
- To learn biology concepts about the animal and its environment
- Other soft-learning goals can be included like problem-solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Crocodile, how it functions, and how to construct it.

Observing

The first thing the teacher does is show a model of the Crocodile. The teacher can ask, why and how does it move.

Exploring and learning about physics and mechanism

When introducing the Crocodile, the teacher should challenge the children to observe and analyse the movement and especially the possibility to pinch objects. The teacher can ask the children how they think the mouth is opening. The teacher can also pretend to talk for the crocodile, for example, 'Hello class, I am a snapping crocodile' while moving the mouth to match the speech. Perhaps the children can make a drawing of how they think the mouth is opening. This can be a first contact with the mechanism, using a playful approach. Teachers can talk about linkages in a very simple way. A linkage is a rigid element with a hinge at each end to connect it to other elements. Linkages are used to link different elements together and to transfer motion to one place to another.

Starting to construct the crocodile and learning mathematics, physics and biology

The construction and use of the crocodile allow the teaching of several STEM contents within the construction and assembly process.

Children will observe the toy ask questions and try to explain how it moves. Examples of similar movements can be shown. When you move the ends of the two rectangles on one side against each other, the other side moves away (the arm stretches out) and the ends on the other side move against each other, too (the crocodile bites). This is illustrated in figure 2.

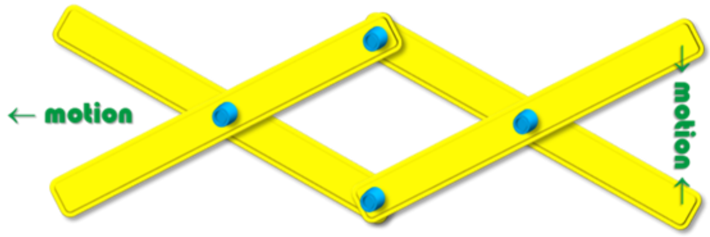


Figure 2. The linkage of the scissor arm and its motion mechanism

The teacher talks with the children and asks them about the shapes they are using to build the body and how many do they need. You need six or eight rectangles that have to be of same length and width. The children explore how to find the centre of each rectangle. The teacher scaffolds this exploration. One way to find the centre point is to draw the two diagonal lines of the rectangle. The centre point is where the lines intersect.

Next, the children make a hole in the centre of each rectangle and form a cross with two rectangles by putting the holes on top of each other. They attach the rectangles to each other with a split pin through the centre holes. Each rectangle needs two more holes, one on each end with about the same distance from each of the three closest sides of the rectangle. Then the children attach each cross to the next one with split pins. Guided by the teacher, the children can discover that there is a right and a wrong way to assemble the parts of the crocodile. This is an opportunity to teach how a mathematical feature (a pattern) is related to aesthetics and functionality. Figure 3 illustrates this:

a) This is the right way. It is a pattern with all the orange rectangles being above the yellow ones.
b) This is not as nice as a) because the pattern is broken. The yellow rectangle in the middle is above and not below the orange ones. It still works fine.
c) This does not look nice and it works not as good as a) and b). The yellow rectangle in the middle is above the orange rectangle in the middle but below the other two rectangles. There is a tension between the two rectangles in the middle. This increases friction. It is harder to move the scissors arm.

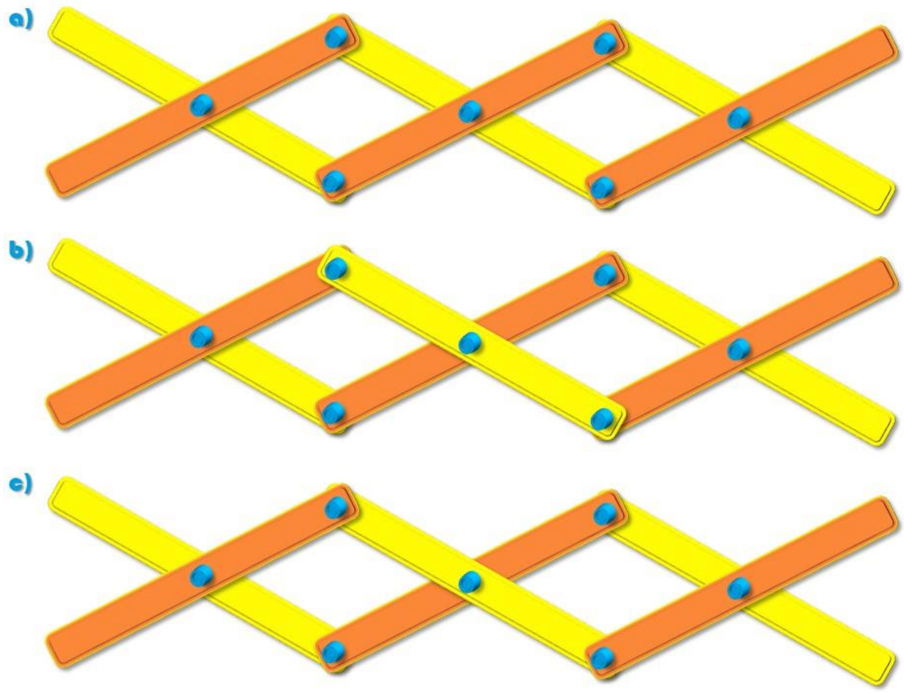


Figure 3. Different ways how to assemble the parts of a scissors arm

The crocodile (or other animals) can be used to explore biology and other science content, for example, the crocodile's

- Environment where it lives
- Physical characteristics of its body
- Movement (walking, swimming)
- Eating habits
- Reproduction
- Affinities with other species (reptiles)

Constructing the mechanism to develop engineer competences

Once the different parts are completed, it is time to put them together! Children construct the mechanism following the method described in the section *How to construct a Snapping Crocodile* and explore how linkages function.

Variations on the crocodile and adding scenarios and narratives

Other themes and characters can be used instead of a crocodile and different scenarios can be developed. The scenario can be used at the beginning of the activity or the end and, overall, can be co-built with the children. For example, a river can be used to contextualise the activity (see https://www.autostem.info/the-river-nile/)

Figure 3. Example of another toy using the same mechanism, developed by Ana Beatriz Figueiredo, Ana Rita Ferraz, Inês Lopes, Jaqueline Sacramento, and Raquel Silva.

How to construct the Snapping Crocodile

Parts and tools required

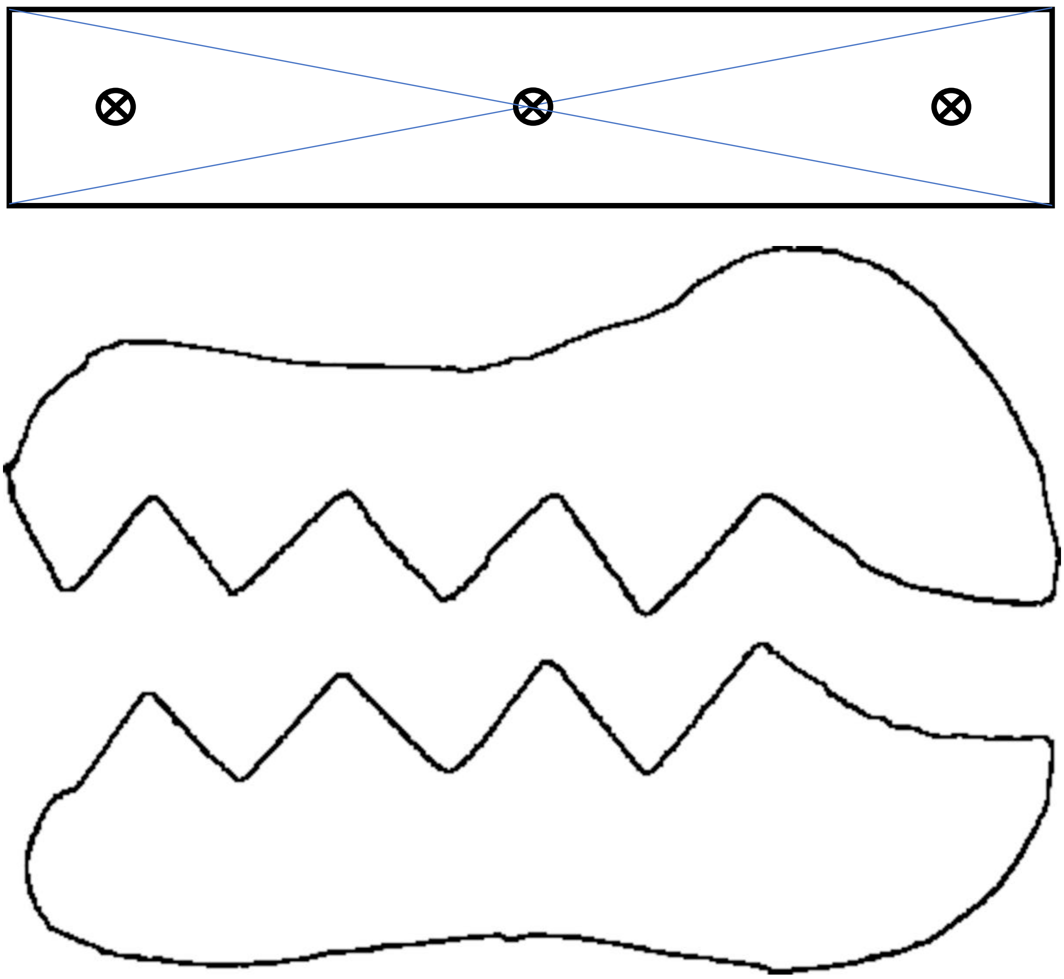
- Crocodile's head (see template at the end of this script) or other narrative elements
- Cardboard to cut out 6 or 8 rectangles size 3 x 15 cm
- A wooden skewer or an awl to make holes
- Scissors or a knife for cutting
- 7 or 10 split pins

Since the materials that can be used are easy to find, the teacher can ask the children to find objects that might otherwise be thrown away (e.g. a cardboard box). In this way, we can teach conservation and reusability in the workshop.

Method

It is best to watch this video first: https://youtu.be/ZyEbltnjeJY

1. Cut out the 6 or 8 rectangles from cardboard (3 x 15 cm)
2. Find the centre of each rectangle and make a hole
3. Make two more holes at the two ends of each rectangle (see template at the end of this script)
4. Attach pairs of rectangles to each other with split pins through the centre holes
5. Attach the pairs of rectangles with split pins to each other as shown in figure 3a)
6. Stretch the scissors arm to its full length
7. Put the parts of the crocodile's head together so that the teeth fit into each other
8. Glue the head to one end of the scissors arm so that the upper part is attached to one rectangle and the lower part to the other rectangle



03 04 05

The Catapult

Pedagogical Guidelines & Construction Instructions

Video Tutorial

01

02

The Catapult for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes:

- How the Catapult can be used to learn STEM subjects
- How to construct a Catapult

How the Catapult can be used to learn STEM subjects

What is the Catapult?

The Catapult is a toy that is extremely simple to make. It has the capacity to fire a small, lightweight projectile (payload) a short distance. The **AutoSTEM** Catapult is made from wooden sticks that are used for ice cream or for naming seeds in a garden, elastic bands, a bottle top and glue or a split pin. It can be used indoors or outside.
It results in a toy that can be used by the children in many ways and opens a number of subject areas for further learning. Catapults are very motivating and exciting toys for children. It is fun for the children to be allowed to play with their Catapults once they have made them.

Safety

The payloads and forces utilised by the catapult do not present any safety problems. Children can wear goggles if the teacher wishes but they are not necessary as the size and weight of the payload projectiles is small.

Figure 1. An example of the Catapult with a volunteer

Target group

The Catapult example described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.
The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Catapult several learning goals can be achieved:

- To learn Mathemativs including counting, addition, use of table, measuring. Simple statistics
- To learn about physics and mechanisms
- To develop engineering competencies of analysis and construction.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The catapult is a simple machine that can be used as a very effective tool to teach STEM, particularly Maths, Physics and Mechanics, the construction is very simple.

Observing

The first thing the teacher does is show a model of the Catapult and make it fire. The teacher can ask, 'Why did it fire?'

Exploring and learning about physics and mechanisms.

Children can observe the Catapult, make comments, and ask questions about how it functions.

The following concepts can be introduced and explored

- **Energy:** different types of energy:
  - Work (The child does work by pulling down the lever arm.)
  - Potential energy due to the deformation of the lever arm when it is pulled down
  - Kinetic energy due to motion of the lever arm when it is released
- **Force:** The child uses force to pull down the lever arm with the bucket. According to Newton's third law (action equals reaction), the force of the downwards pull creates an equal force in opposite direction on the Catapult (called the propulsion) that pushes the payload forwards.
- **Conservation of energy:** Energy can be converted but not destroyed.
  - The child's work is converted into potential energy,
  - The potential energy is converted into translational kinetic energy of the payload when the lever arm is released
- **Parts of a catapult:** Fulcrum, lever arm, bucket. Payload

The Catapult and learning mathematics

- The teacher talks with the children asking what is needed to make the Catapult. During the construction, many mathematical concepts can be used, introduced, or discovered.
- **Counting:** 13 wooden sticks divided into two parts for the fulcrum and lever arm, one bottle top, 3 large elastic bands
- **Locating:** use spatial concepts like rear, front, under, top, bottom, centre (find the centre of a circle), aiming
- **Measuring length:** children can use a ruler to measure how far the payload went, younger children can use fingerbreadth and handbreadth as units. It is also possible to decide by direct comparision which payload went furthest.
  - If fastening the bottle top with a split pin: to make a hole in the bottle top that is 'just' big enough for the split pin to pass through is direct comparison, too.
- **Measuring weight:** use a scale or balance depending on the childrens age. Different weight payloads can be used, and children can see if the different weight makes a

difference to how far the payload goes, Younger children can check which is heavier and which is lighter. Older children can use a measuring scale.

- **Using tables:** the catapult can be used to introduce a simple table within a game (see below).
- **Using a target:** the catapult can be used with a target, a target is supplied in this template, the simpler target used with the younger children up to 5, more advanced children use the one with numbers up to 10.
- **Introducing statistics:** using the table the children can calculate a number of concepts, shortest, longest, average

How to construct the Catapult

To make the Catapult you will only need basic parts and tools that are found in every school or preschool. Below we list the parts needed and alternatives.

Parts and tools required

- For the Catapult
    - 13 x Frozen ice wooden sticks
    - 3 x Strong elastic bands
    - 1x plastic bottle top (Bucket)
    - Sticky tape
- For fixing the plastic bottle top either:
    - Hot melt glue gun OR
    - 1 x split paper fastener
    - A tool for making small holes in wood/ a nail can work
- The payload (any one or all can be used as payloads, or the children could select objects themselves)
    - A button
    - Plastacine
    - Any other soft small toy that will fit in the bucket
    - Counting bears
- Target if required (2x templates supplied at the end of this script)
- Simple piece of paper with circles
- Optional – a standard pencil

Method

To make the Catapult watch [this video]

The catapult

1. Take 13 ice cream wooden sticks and divide them in to three piles, one has 3, the second 9, the third has 1. The pile of 9 will be the fulcrum. 3 stick will be the aiming device and include the Lever stick, the final stick will be the Aiming stick.
2. Pile the 9 sticks into a tight pile with the ends matching at both ends. Tie the pile of 9 sticks at one end with one of the elastic bands. You will need to wrap the band around a number of times. Tie the other end with the second elastic band the same way.
3. Attach the plastic bottle top (bucket) to the middle of the Aiming stick and to the end of one of the remaining sticks (Lever stick).

Hot melt glue joining method	**Split pin joining method**
Stick the plastic top to the middle of the Aiming stick (find the middle)	Make a small hole in the bottle top big enough for the end of a split pin to go through
	Make a hole in the centre of another stick, this will be the Aiming stick. (find the middle)
Stick the middle of the Aiming stick, with the top attached, to one end of the Lever stick	Make a hole in one end of the Lever stick. It is helpful to wrap some sticky tape around where the hole is made as the wood can split when making the hole.
	Push the split pin through the prepared holes in the Bottle top, Aiming stick and Lever stick. Once the pin has gone through push the 2 ends up so they fit tightly under the stick.

4. Pile up the remaining 3 sticks again and tie the end without the bottle top with the final elastic band.
5. Push the pile of 9 sticks between the Lever stick of the second pile at the untied end, and the other 2 at a right angle. This will result in the sticks being separated at one end while still tied together at the other. Push the sticks approximately half the distance of the sticks. The 9 stick pile can be stuck in to position but that is not necessary.
6. Alternatively, instead of the 9 sticks you can use the pencil to separate the Lever stick and the other 2.

The Catapult is now finished and can be used.

Using the catapult

There are a number of ways that the catapult can be used by children, we identify a number of 'Games' below with tables that can be used to record results were appropriate.

Maths Games using the catapult

Game 1. Each child fires the catapult 3 times and the group records the distance in a table. The next child in the group does the same and on.

Childs Name	Distance (hands or centimetres)
Fire 1	
Fire 2	
Fire 3	

Game 2. Each child fires the catapult 3 times and the group records the distance in a table. The next child in the group does the same and on. The tables are then taken, and calculations completed on the results, depending on the age of the children.
Calculations are total distance, the average, shortest and longest.
A video how to use this game can be seen here.

Childs Name	Distance (hands or centimetres)	Show the shortest/Longest
Fire 1		
Fire 2		
Fire 3		
Total distance (Fire 1 +2+3)		Average distance (Total distance/3)

Game 3: using different payload weights. The simplest way to use varying payload weights is:

1. Plasticine balls
2. Counting bears. They come in three different sizes

These can be weighed simply as heavier and lighter by the youngest children using a balance. Older children can use a scale. Children can also suggest different items, this may bring in air resistance later on.
Again, the children take 3 goes with each weight, measure the result and then record in the table below.

Childs Name	Distance (hands or measurement)	Weight of payload
Firing payload 1		
Fire 1		
Fire 2		
Fire 3		
Firing payload 2	Distance (hands or measurement)	Weight of payload
Fire 1		
Fire 2		
Fire 3		

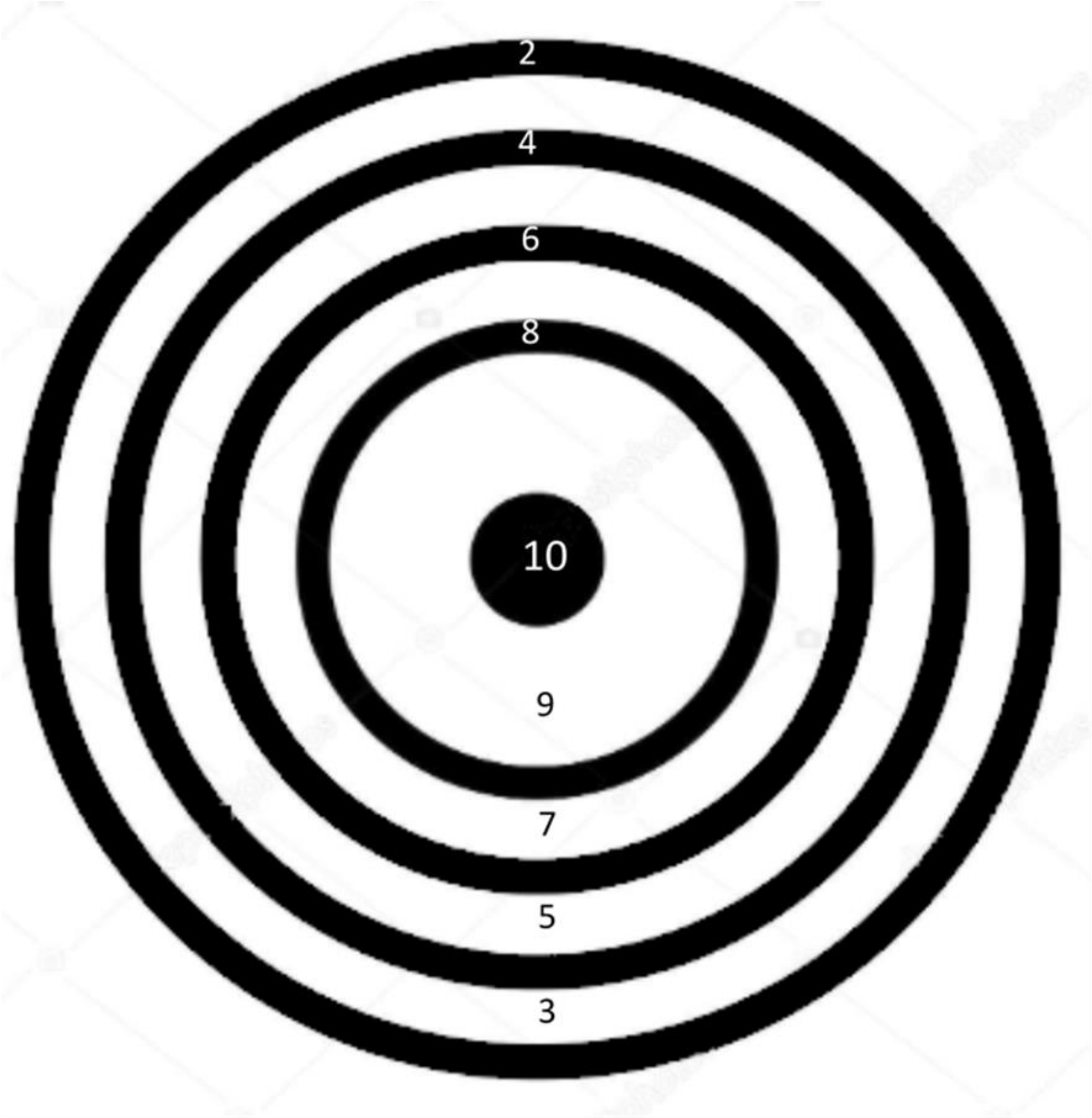
After the exercise is complete the children have to explain why there is a difference. They may need to try this several times to find a significant difference.

Game 4: Aiming at the target. There are 2 targets supplied in Annex 2, one with numbers up to 3 and one up to 10. This is purely a competitive game that involves addition. The teacher can easily add additional elements if they wish. Again, use tables to record results. It can be as simple as child with the highest total is the winner.

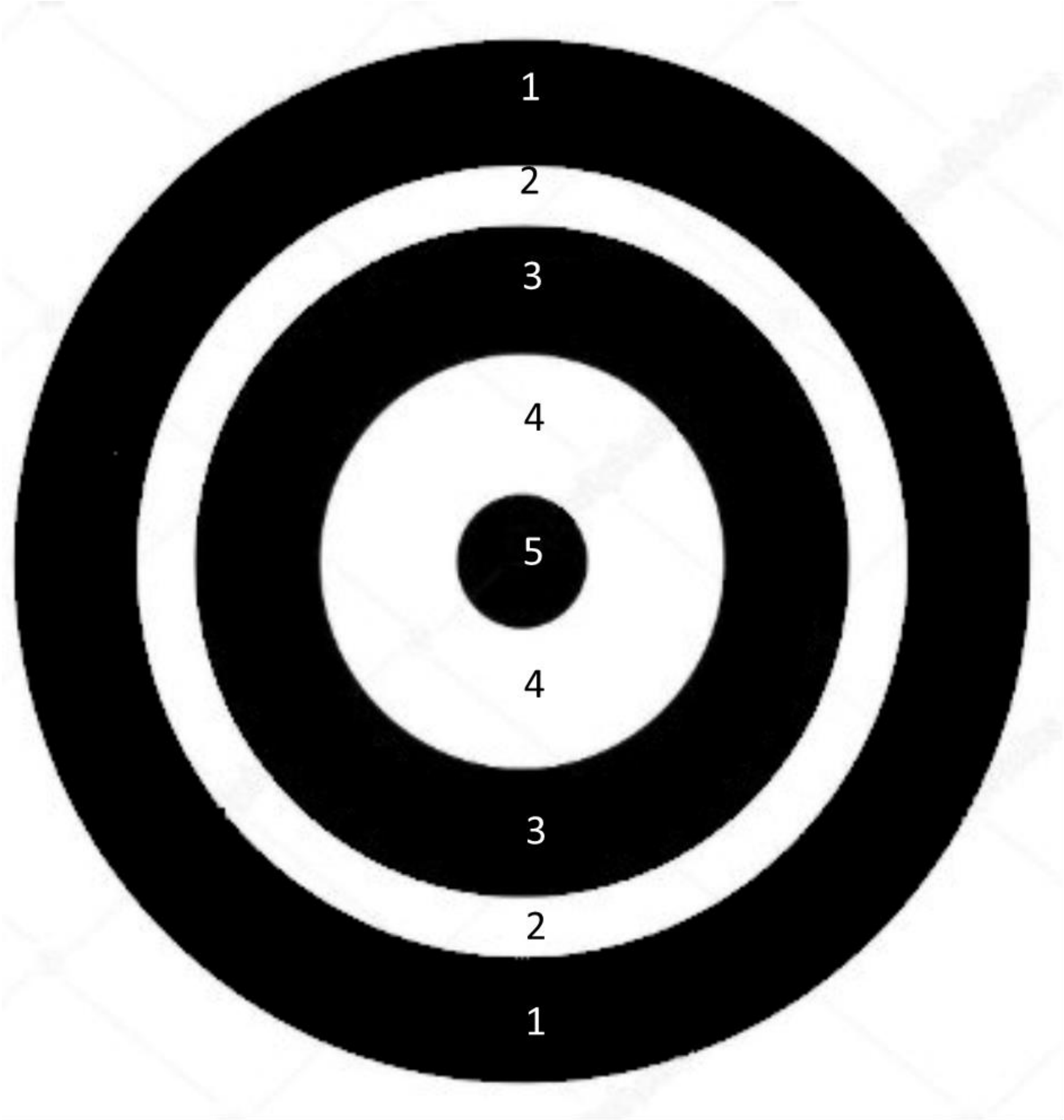
It might be an idea to use different coloured payloads so the children can identify their own goes.

Templates for The Catapult

Target up to 10



Target up to 5



03 04 05

The Acrobat

Pedagogical Guidelines & Construction Instructions

Video Tutorial

The Acrobat

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How the Acrobat can be used to learn areas of STEM subjects
- How to construct the Acrobat

How the Acrobat can be used to learn STEM areas

What is the Acrobat

The Acrobat is a moving toy made from paper, wooden skewers, corks/plastic discs and split pins, that makes acrobatic movements when the linkages are complete, and a rotation movement is made manually.

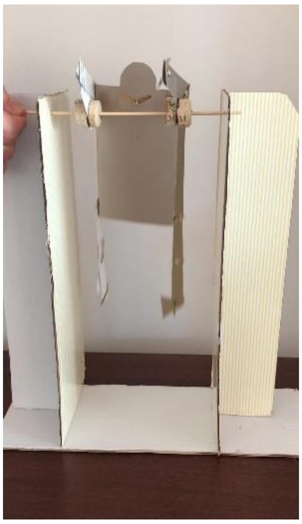


Figure 1 & 2 - An example of an Acrobat

STEM subjects can be introduced when constructing the Acrobat. We detail some ideas below. The teacher can adapt these suggestions to their own class and context and plan their own activity (Plan template).

Target group

The Acrobat example is designed for children from 4 to 7 years old. Teachers can adapt the idea to other ages.

The teacher can decide, depending on her/his knowledge of the children, whether they should work in groups or individually.

Learning goals

When constructing the Acrobat several learning goals can be achieved:

- To learn about physics and mechanisms, in particular, linkages.
- To develop engineering competences of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.

- To learn biology concepts about parts of the human body.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Acrobat, how it functions and is constructed.

Observing

Firstly, the teacher shows a model of the Acrobat. The teacher can ask, why did it move? Here is a link to a video example, that shows it in use

Exploring and learning about physics and mechanisms.

Children can observe the Acrobat and make comments and ask questions about how it functions.
Teachers can talk about the linkages in a very simple way. A linkage is a rigid element with a hinge at each end to connect it to other parts. Linkages are used to join different elements together and to transfer motion to one place to another.

Starting to construct the Acrobat and learning mathematics and biology

Learning about shapes and numbers.
The teacher talks with the children asking what is needed; the teacher can talk about the different parts, their shapes and placement.
What does the body look like? What do the arms and legs look like?
What does the face look like? Children can draw or paint eyes, nose and a mouth on the acrobat.

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 Acrobat' below and explore how linkages function. Paper fasteners can be used to link the different parts of the body, as can be seen in video tutorial. When all the parts are joined, a wooden skewer can be pushed through each of the hands. The hands should be secured in place to the skewer using four Round pieces (two pieces for each hand).

Variations on the Acrobat and adding scenarios and narratives

Other themes and characters can be used instead of an Acrobat.
Different scenarios can be developed for the Acrobat. The scenario can be used at the beginning of the activity, or the end. For example, a park, a playground or a circus can be used to contextualize the activity. Other characters can be added. For example, the children can draw or paint the acrobat as a clown or a superhero, or an animal, they can explore and be creative. What do they do? What mechanisms can be used?
Narratives and stories can also be used.

Figure 3. Examples of other automata using linkages and a rotational mechanism

How to construct the Acrobat

To make the Acrobat part (or any other character) a variety of materials can be used, including: coloured sheets and paper, cardboard, wooden sticks/skewers, split pins, newspapers, recycled or natural materials (found materials), in fact, anything the teacher and children can think of. We provide a template (see Annex 1) that has a template for a body a head, arms, legs, feet and hands.

Parts and tools required

- Templates for the Acrobat (Annex 1)
- Coloured cardboard for the Acrobat
- Pieces of cardboard for the support (cardboard from boxes is most suitable)
- Split pins
- Round pieces to secure the hands, Cork, cardboard or foam rubber mats (for example ones used for camping or gym).
- Long sticks of wood (wooden skewers) The ones used for cooking are perfect as the children can cut them easily.
- Scissors
- Colouring pen or pencils

The materials that can be used are very widely available and easy to find. The teacher can ask the students to find materials that might otherwise be thrown away (bottle tops, paper...) in this way we can add conservation and reusability into the teaching of the workshop.

Method

It is best to watch The Acrobat video tutorial before starting to make your own Acrobat.

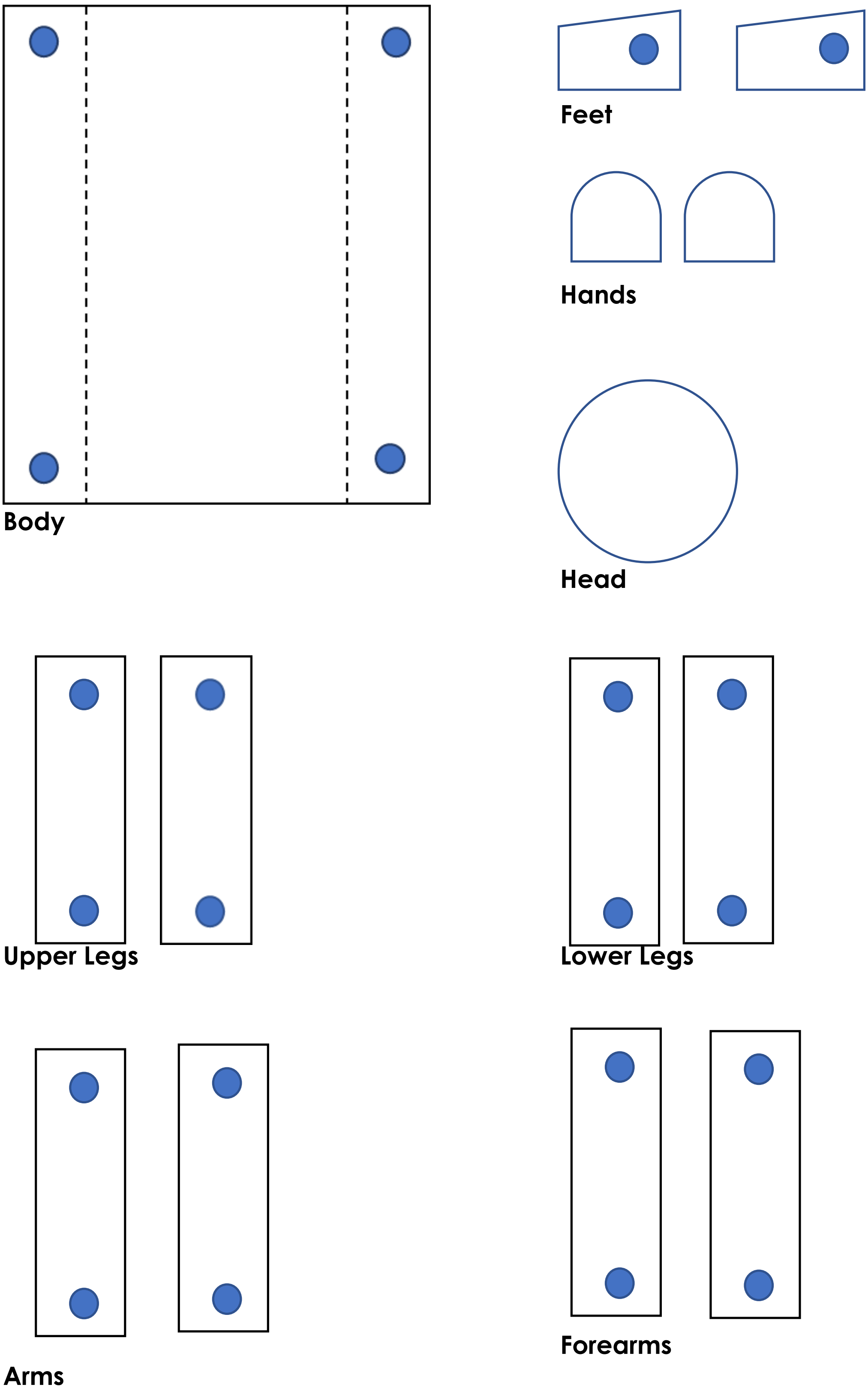
2. Create the Acrobat from the template shapes at the end of this script
    a. Cut out the shapes
    b. Fold the shapes on the dotted lines
    c. Bring the different parts of the Acrobat together by introducing split pins into the circles indicated in the templates. To make the holes for the split pins, a stick can be used or alternately scissors to make small cuts in the paper.
3. The support is built, it should be 30 cm high. You will need 2 pieces of box cardboard for either side. One piece should be a trapezium and the second a triangle. You can

see an example in Figure 4. Don't put the wooden skewer through the cardboard support at this stage, we will do it later.

Figure 4. The support

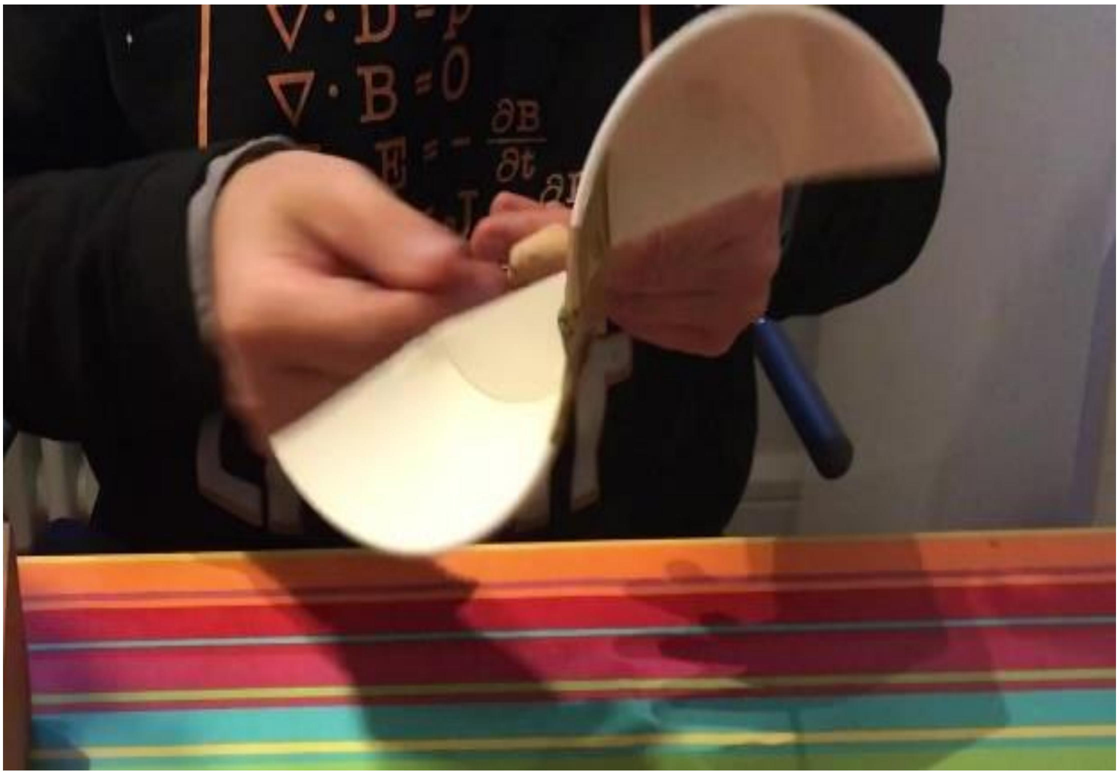
4. Cut four round pieces from your corks, cardboard, or foam so you have a total of four pieces.
5. Push one of the round pieces onto the skewer. Then push the skewer through one hand of the Acrobat, another round piece to secure the hand in place on the skewers. The hand should be fixed tightly by the round pieces so that it will rotate when the skewer is turned manually
6. Repeat the procedure for the other hand, using the same skewer.
7. Make a hole in each of the vertical supports you made previously in point 2 above and push the skewer through with the Acrobat.
8. The Acrobat is ready to play with.

Components of the Acrobat – Rectangles of different sizes for the body, arms and legs. A circle for the head



03 04 05

The Wind Turbine



Pedagogical Guidelines & Construction Instructions

Video Tutorial

01 02

The Wind turbine for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes:

- How the Wind Turbine can be used to learn STEM areas
- How to construct a Wind Turbine

How the Wind Turbine can be used to learn STEM areas

What is the Wind Turbine

The Wind Turbine is a turbine done with paper cups or paper sheets that turns around when acted by wind. It can be used to move other objects or devices.

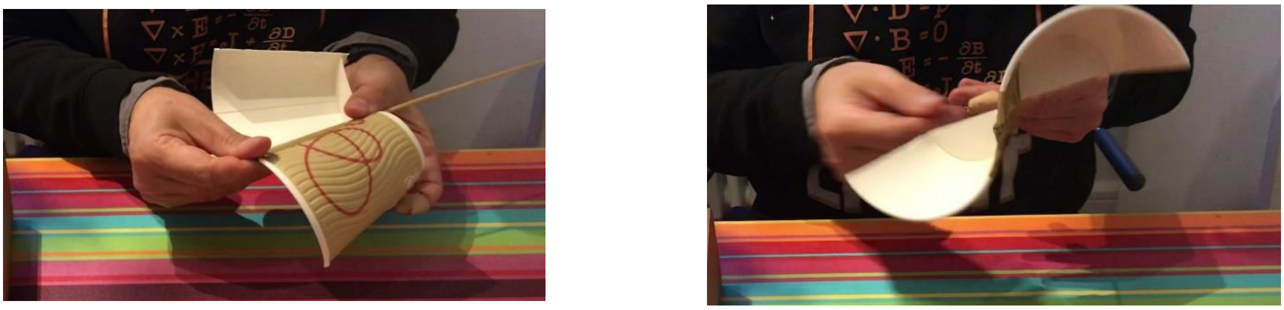


Figure 1 An example of a Wind Turbine

The following are ideas how to introduce STEM concepts when constructing the Wind Turbine. The teacher can adapt these suggestions to their own class and context and plan their own activity (Plan template).

Target group

The Wind Turbine example described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.
The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Wind Turbine several learning goals can be achieved:

- To learn about physics and energy sources, in particular, wind energy. It can also be used to learn about energy transformation, namely transferring the energy in the moving air into a mechanical device.
- To develop engineering competences of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes.
- To learn concepts related to the object choosed to move.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Wind Turbine, how it functions and how to construct it.

Observing

The first thing the teacher does is show a model of the Wind Turbine turning around. The teacher can ask "why did it move?" Here is a link to a video example, that can be used.

Exploring and learning about physics and mechanisms.

Children can observe the Wind Turbine and make comments and ask questions about how it functions.
Teachers can talk about energy sources in a very simple way. They can also talk about energy transformation, namely transferring the energy in the moving air into a mechanical device.

Starting to construct the wind turbine and learning mathematics and biology

Continuing with learning about shapes.
The teacher talks with the children about the different parts, their shapes and placement.
This is a link to a description of a truncated cone.
What does the wing look like? The wings are two halves of a truncated cone.
Children can also discuss and offer ideas how they would make blades for the Wind Turbine; they can talk about what shapes the blades must have.
The turbine can be linked to another object, e.g. the Colour Spinning Disk, in order to make it move.

Constructing the mechanism to develop engineer competences

Children can then start to analyse materials needed to construct the wind turbine.
The teacher continues talking with the children about the pieces and materials to construct the mechanism.
Children construct the mechanism following the method described in How to construct Wind Turbine.

Variations on the Wind Turbine and adding scenarios and narratives

Wind turbine can be constructed with a sheet of paper and different objects can ben be linked to it.
Different scenarios can be developed for the Wind Turbine. The scenario can be used at the beginning of the activity or the end.
Narratives and stories can also be used.

Figures 3 and 4. Example of other wind turbine

How to construct the Wind Turbine

To make the actual Wind Turbine a paper cup, a wood stick, Scotch tape and a scissor are needed, as well as a box to support the turbine.
The wind turbine can also be done with a sheet of paper, a wood stick and tow cork slices.

Parts and tools required

- Paper cup for the truncated cone.
- Long sticks of wood (skewers) The ones used for cooking are perfect as the children can cut them easily.
- Scotch tape
- Scissor
- Box (a shoe box or similar small box will do).

Since the materials that can be used are very wide and easy to find, the teacher can ask the students to find objects that might otherwise be thrown away (bottle tops, paper...) in this way we can add conservation and reusability in to the teaching of the workshop.

Method

It is best to watch the tutorial video before starting to make your Wind Turbine.

1. Cut the paper cup in two equal parts.
2. Using Scotch tape, glue the wood stick with one half of the paper cup.
3. Use also Scotch tape to glue the other paper cup half with the stick. The parts of the paper cup must be put together considering the opposite side of each other.
4. The turbine is ready. Now you can use a box to support the turbine and in its opposite side to introduce an object, e.g, the Colour Spinning Disk. When there is enough wind, the turbine will rotate and make also the Colour Spinning Disk rotate.

The Colour Spinning Disk

Pedagogical Guidelines & Construction Instructions

Video Tutorial

The Colour Spinning Disk for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes:

- How a Colour Spinning Disk can be used to learn STEM subjects
- How to construct a Colour Spinning Disk

How the Colour Spinning Disk can be used to learn STEM areas

What is The Colour Spinning Disk

The Colour Spinning Disk is based on a physics experiment, usually called the Newton disk. This is a rotating disk whose surface is divided into different colours, that appear to be white or grey when it is spun quickly. The colours are the primary colures blue, red, and yellow and its variants, green, orange, violet. It can be implemented using only primary colours, e.g. red and yellow, or red and blue, or blue and yellow. In this case, it will appear to be orange, in the first situation, or violet or green, in the second and third situations, when the disk is spun quickly.

Figure 1. Spinning disk all colours

Figure 2. Spinning disk red and yellow

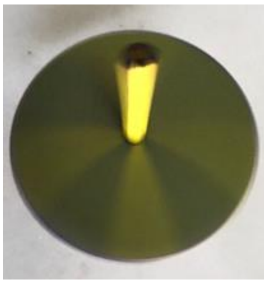


Figure 3. Spinning disk blue and yellow

Here are some ideas on how to introduce STEM concepts when constructing the Colour Spinning Disk. The teacher can adapt these suggestions to their own class and context and plan their own activity.

Target group

The Colour Spinning Disk described here is designed for children from 4 to 7 years old. Teachers can adapt the ideas to other ages.

A teacher can decide depending on their knowledge of the children whether the children should work in groups or individually.

Learning goals

- *Physics* - properties of light and colour.
- History of science
- Mechanisms - rotation mechanisms
- Forms of energy -mechanical and wind.
- To learn about perception mechanisms (persistence of vision).
- Mathematical concepts - including shapes, circles and triangles, numbers, and equal parts

- To develop engineering competences
- To develop competences of analysis and construction.

How to introduce STEM concepts during construction

The suggestions to explore STEM contents while constructing the Colour Spinning Disk are based on the pedagogical approach and general steps in the Step by Step guide.

Observing, formulating questions

You can start by showing a prototype of the Spinning Colour Disk (made before the lesson). Firstly, without motion and then rotating and ask the children: What happens?
Children watch the Colour Spinning Disk and make comments and ask questions about how it works.

Exploring and learning physics

Taking in to account the children's ideas the teacher can explain in a simple way the characteristics of colour mixing and the history of science. The Colour Spinning Disk is related with Newton's discovery of primary olours and the principles of light, although it is not certain that he used the spinning disk to illustrate those principles, as it is not recorded.

Starting to construct, continuing observing, learning maths and physics

The construction and use of the Colour Spinning Disk allows the teaching of a number of mathematical concepts within the construction process. The shape of the disk and its parts, the different colours and the colour sequence.
The teacher can ask the children What is the shape of the disk? The disk is a *circle* and is divided in 8 equal parts (other divisions may be considered).
The teacher can guide the children how to draw the slices of the circle or can use the template circle with the pre-drawn lines, the teacher can decide.
The children paint each slice using two primary colours, e. g. red and yellow, or red and blue, or blue and yellow.
The children make a hole in the center with a short pencil or a similar tool.

Playing with the Colour Spinning Disk and learning about physics and visual perception

After constructing the Colour Spinning Disk, chidren can play with it.
Teacher can talk again about the characterititics of colour mixing and also about visual perception. The spinning disk also illustrates a mix of light stimuli called temporal optical mixing. The concept that human visual perception cannot distinguish the details of high-speed movement is known as the persistence of vision.
The teacher can also ask questions about the mechanisms that triggers the movement. Other examples can be shown, e.g an wind spinner, that moves with air.

Variations of Newton Spinning Disk

Other themes and characters can be used as **scenarios** for the activity instead of the Colour Spinning Disk. It could be a toy wind spinner. a rainbow or a prism that shows the properties of light.
Narratives and stories can also be used.

How to construct the Colour Spinning Disk

Parts and tools required

- Template to be printed in A4 standard printing paper – Annex 3
- Sheet of cardboard
- Scissors
- Glue stick
- Coloring pencils/markers
- A short pencil or similar
- Ruler
- Pen

Method

1. Print the template
2. Cut out the circle
3. Draw 4 lines across the middle of the circle as shown in Figure 3 to 6.

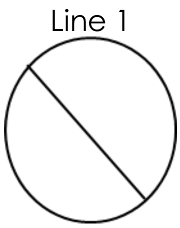


Figure 2: Line 1 from one side to the other, passing through the middle of the circle

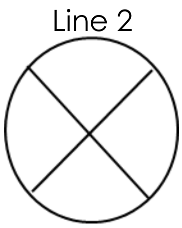


Figure 3: Line 2 from one side to the other, passing through the middle of the circle but from the other side so you form a cross

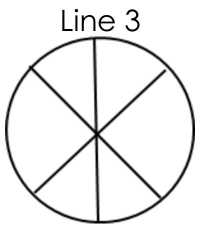


Figure 4: Line 3 between line 1 and 2, passing through the middle of the circle

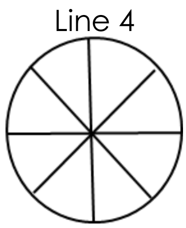
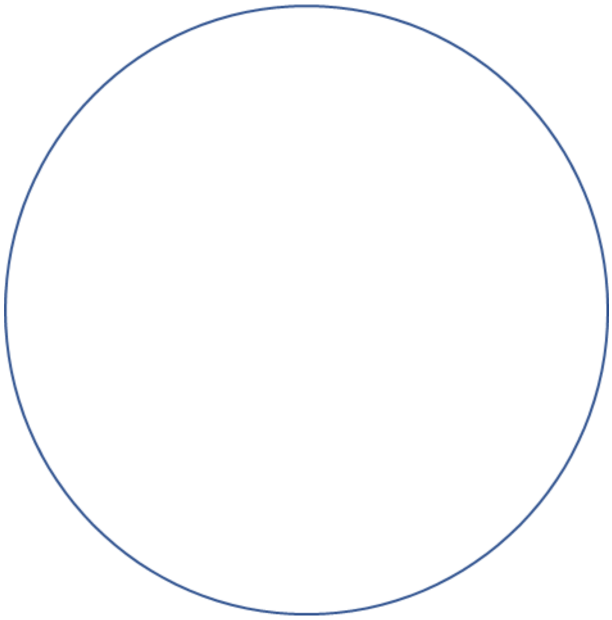


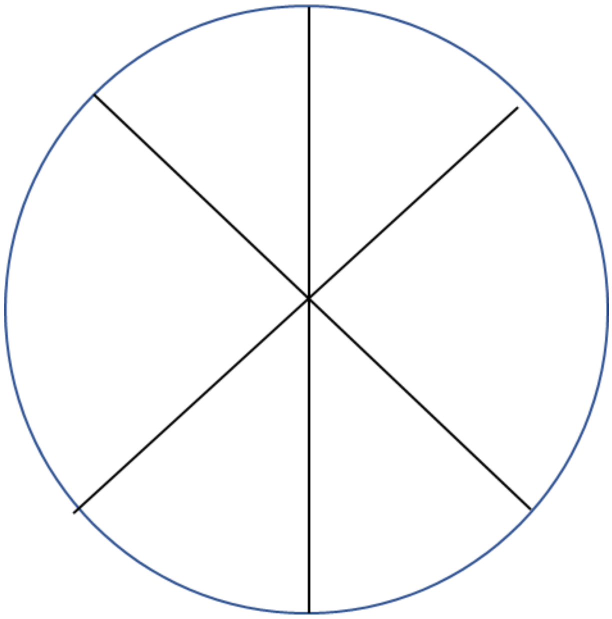
Figure 5: Line 4 between line 1 and 2 but on the other side of the circle and passing through the middle of the circle

4. You can add more lines across the circle if you want to divide it further. The more lines across there are, the better the result.
5. Colour the paper circle with the triangles following the sequence of two primary colors.
6. Place the cut-out circle on the cardboard and with a pencil draw around the circle.
7. Cut out the circle on the cardboard.
8. Stick the paper circle on to the cardboard circle with glue
9. Make a hole in the center of the paper circle that goes all the way through the cardboard one as well
10. Push a pencil into the center of the circles. The hole should be just big enough for the pencil to go through.
11. Place some sticky tape on the pencil just above the hole and the same below. This should be enough tape to stop the disk moving off the pencil
12. Spin the disk fast enough that the colours blur.

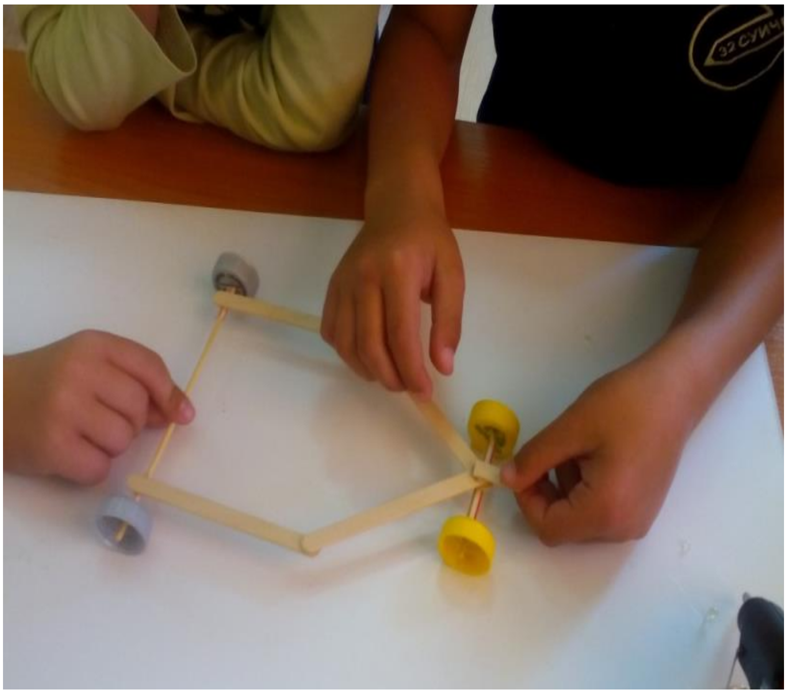
Template 1. Colour Spinning Disk template



Template 2. For the youngest children Template with pre-drawn lines



The Eco Car 1



Pedagogical Guidelines & Construction Instructions

Video Tutorial

03 04 05

The Eco-car 1 for AutoSTEM

Pedagogical guidelines and construction instructions

This guide has 2 parts:

- How the Eco-car 1 can be used to introduce a number of SETM concepts
- How to construct the Eco-car 1 (your children can make the Eco-car 1.

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

The construction and use of the Eco-car 1 allows the teaching of a number of STEM concepts within the construction and assembly process.

Introducing STEM concepts

The Eco-car 1, allows teachers to speak about aspects of mathematics and physics.

- **Mathematics**
  - **Counting**: five wooden sticks, one straw (will be divided into three parts), four bottle tops, two skewers
  - **Measuring length**: Sticks, straws and skewers have to be cut into pieces of given length (3cm, 4cm, 10 cm etc.). Older children will use a ruler, younger children can use fingerbreadth and span. 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.
  - **Designing (shapes)**: The car's chassis has the shape of an equilateral pentagon with adjacent right angles. If the rear part is a square, the front part will be an equilateral triangle, which has angles of 60°. It has mirror symmetry.
  - **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 rubber band.)
    - elastic energy: potential energy due to the deformation of the rubber band
    - 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
  - **Conservation of energy**: Energy can be converted but not destroyed. The child's work is converted into elastic energy (of the rubber band), 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 ground 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.

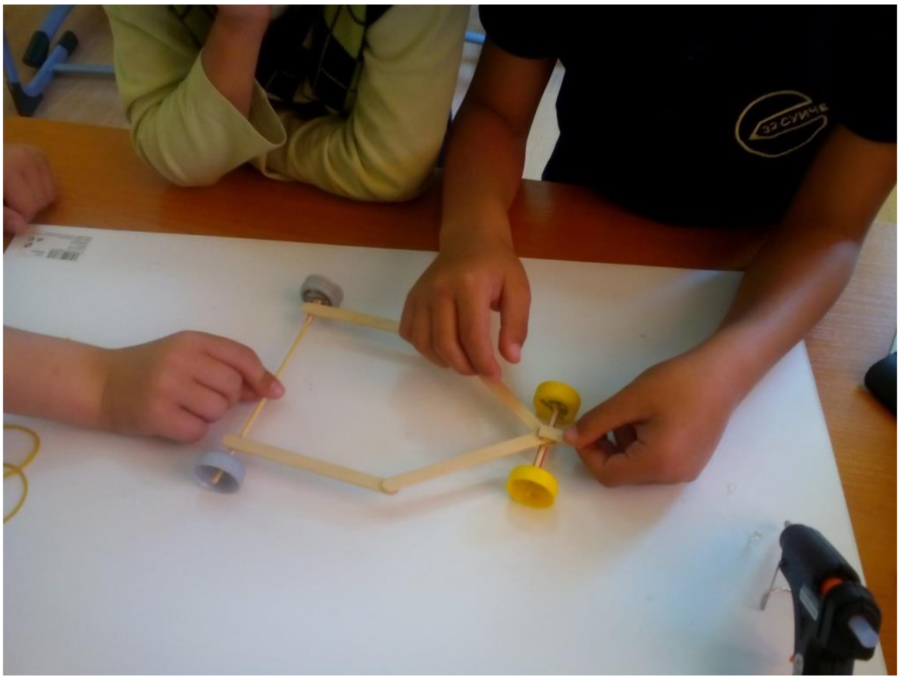


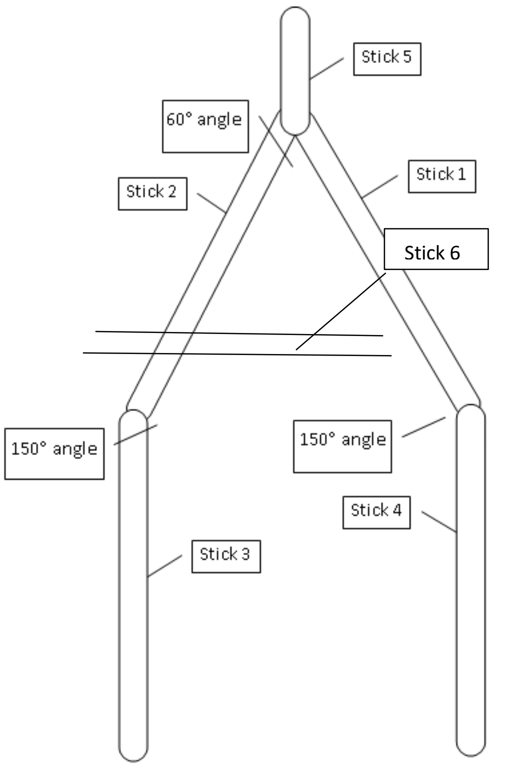
Figure 1. Children making the Eco-car 1

How to construct the Eco-car 1

Parts and tools required

- 5x Wooden sticks used for lollipops
- 1x Paper/plastic drinking straws
- 4x Plastic bottle tops (each set of 2 must be the same size) for wheels
- 2x Wooden kitchen skewers
- Hot melt Glue gun
- Long Rubber bands
- (Optional) Strong tape (electric insulating tape)
- Ruler

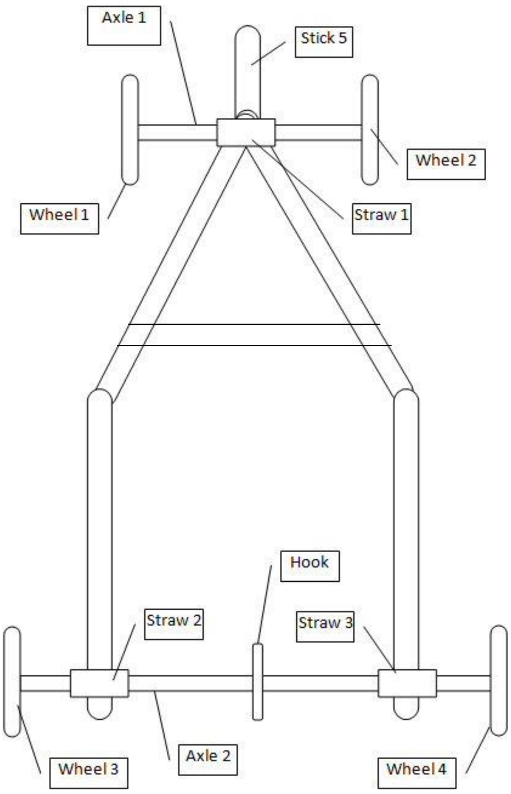
Method



It is best to watch the video before starting the construction:

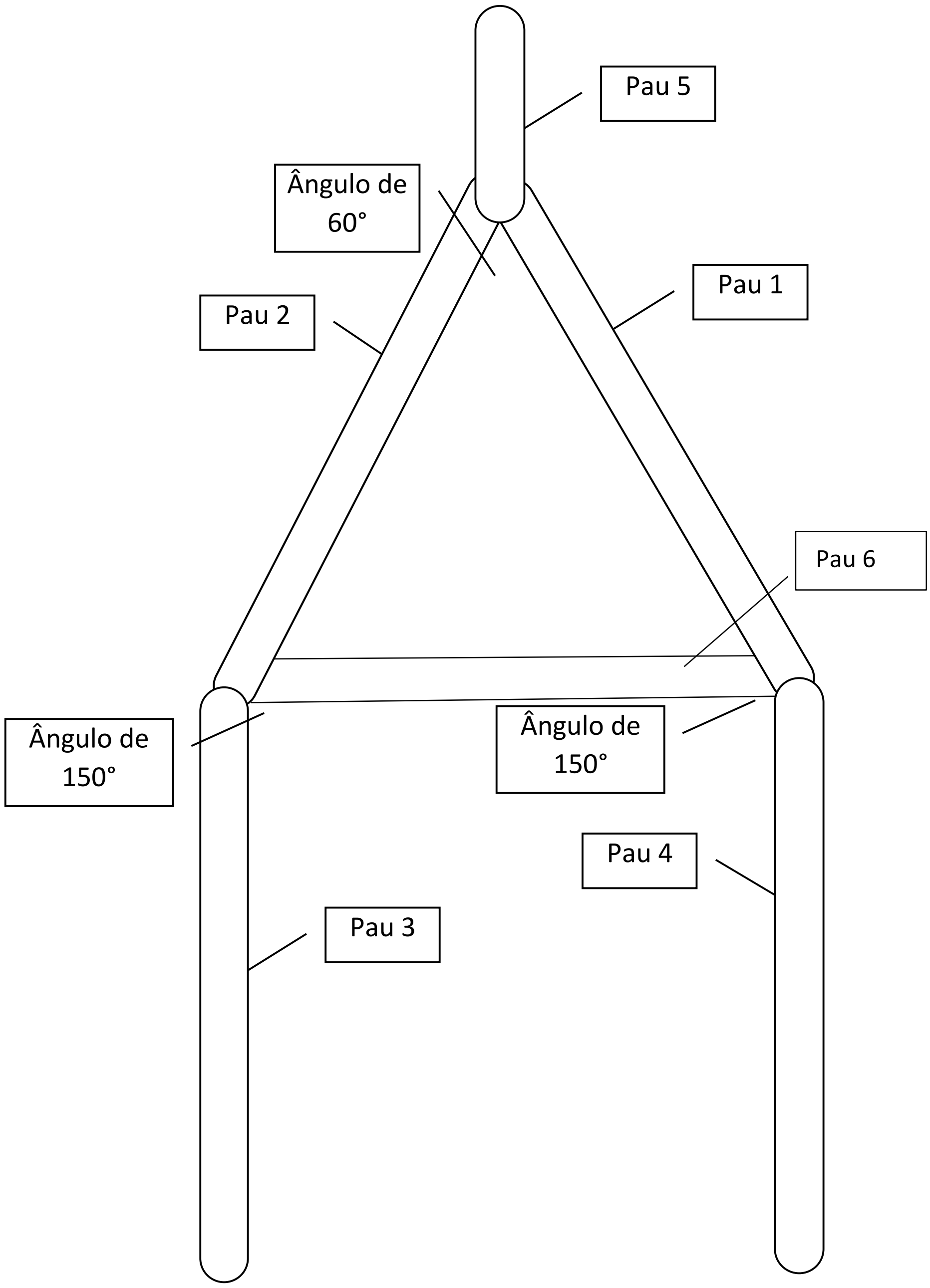
1. Stick the end of a lollipop stick (Stick 1) to a second one (Stick 2) to find the correct angle for the 2 lollipop sticks measure the length of one stick. Place the 2 lollipop sticks together at one end, when the distance is the same as the length you will have made the correct angle. OR you can measure an angle of 60° between the 2 lollipop sticks. Then stick them together with a glue gun.
2. Stick a third lollipop stick (Stick 3) to the end of stick 1, and Stick 4 to the end of Stick 2 so that Stick 3 and 4 are parallel and the whole shape has a mirror symmetry. The angle between Stick 2 and 3 and the angle between Stick 1 and 4 are both 150°.

3. Cut Stick 5 from a complete Lollipop stick. Stick 5 should be at least 4 cm long. Then stick Stick 5 above the join of Stick 1 and 2 pointing upwards, with at least 3 cm pointing out from the join.
4. Cut from your straws:
    a. 2 x 3cm pieces (Straw 2 and 3)
    b. 1 x 4cm piece (Straw 1)
5. Stick Straw 2 to the bottom end of stick 3 and Straw 3 to the bottom end of stick 4. They should be stuck at right angles to the sticks.
6. Stick the Straw 1 underneath the join of stick 1 and 2,
7. Make holes in the centre of the 4 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.
8. Cut one wooden skewer so that it is 6 cm longer than the total distance between the ends of Stick 3 and 4 (Axle 2).
9. Cut a second wooden skewer to 10cm long. (Axle 1)
10. Cut a third piece 3cm long from one part of the left over wooden skewers (Hook).
11. Thread one wheel onto one end of Axle 1 and Axle 2.
12. Wait until the glue you have used to make your Eco car 1, is set, before going to the next step.
13. Thread Axle 1 through Straw 1 and fix Wheel 2 on to the end.



14. Thread Axle 2 through Straw 2 and 3 and fix wheel 4 on to the end.
15. Measure the length of Axle 2. Make a mark on Axle 2 that is ½ the distance. Stick the Hook to the halfway point with the glue gun. It should be stuck at the Hooks halfway point but it is not a critical point.
16. Wait for the glue to dry well before the final steps.
17. Take the elastic band and hook one end over the Hook, and the other end over Stick 5.
18. Turn Axle 2 and wind the elastic band around the axle and the hook. When it is tight, place on a smooth floor and let go. Weeeeeeeeeee

If the Hook becomes detached then wind some strong tape around the join to make it stronger.


Pau 5
Ângulo de 60°
Pau 1
Pau 2
Pau 6
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Pau 4
Pau 3

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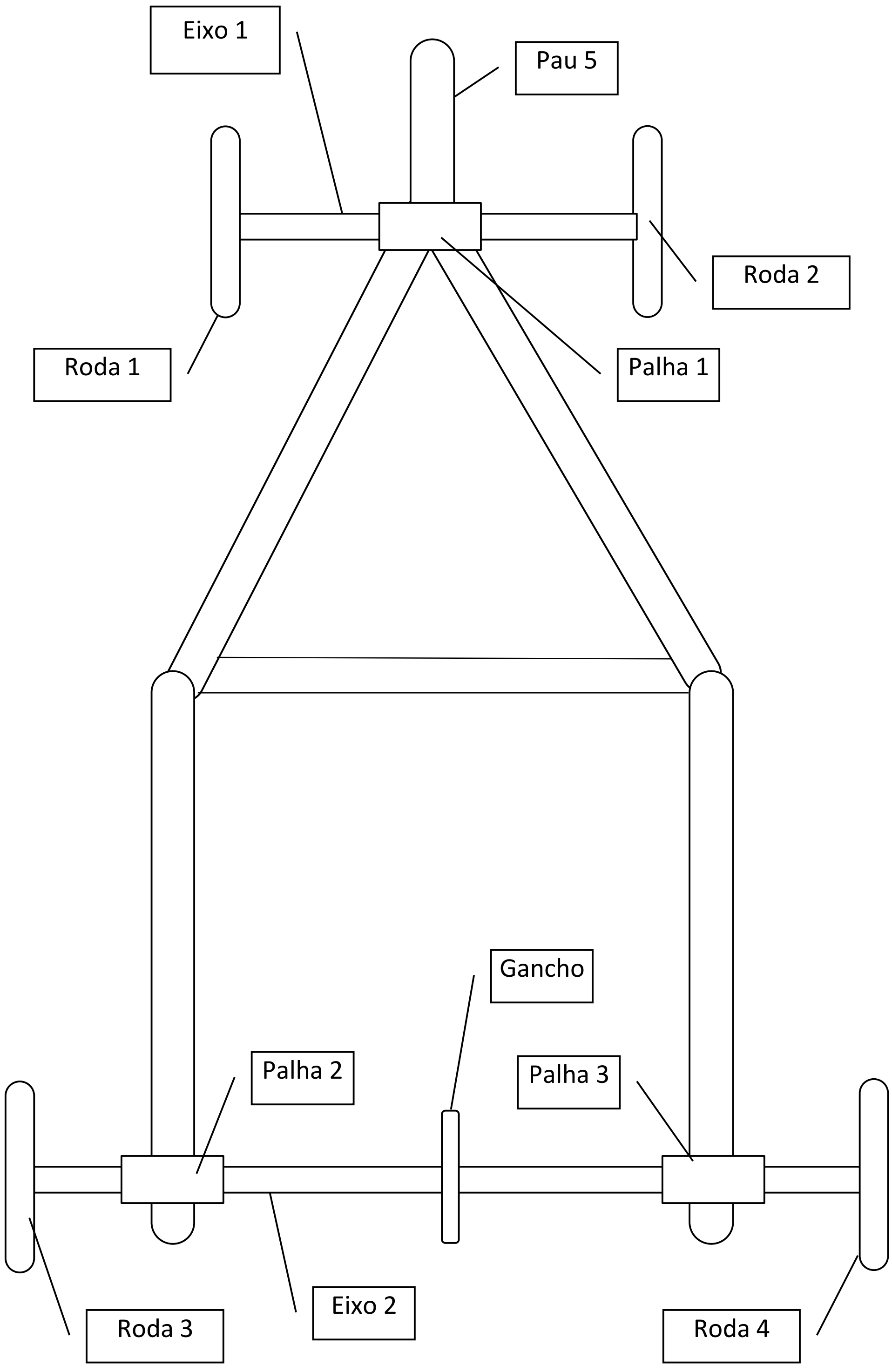
Eixo 1
Pau 5
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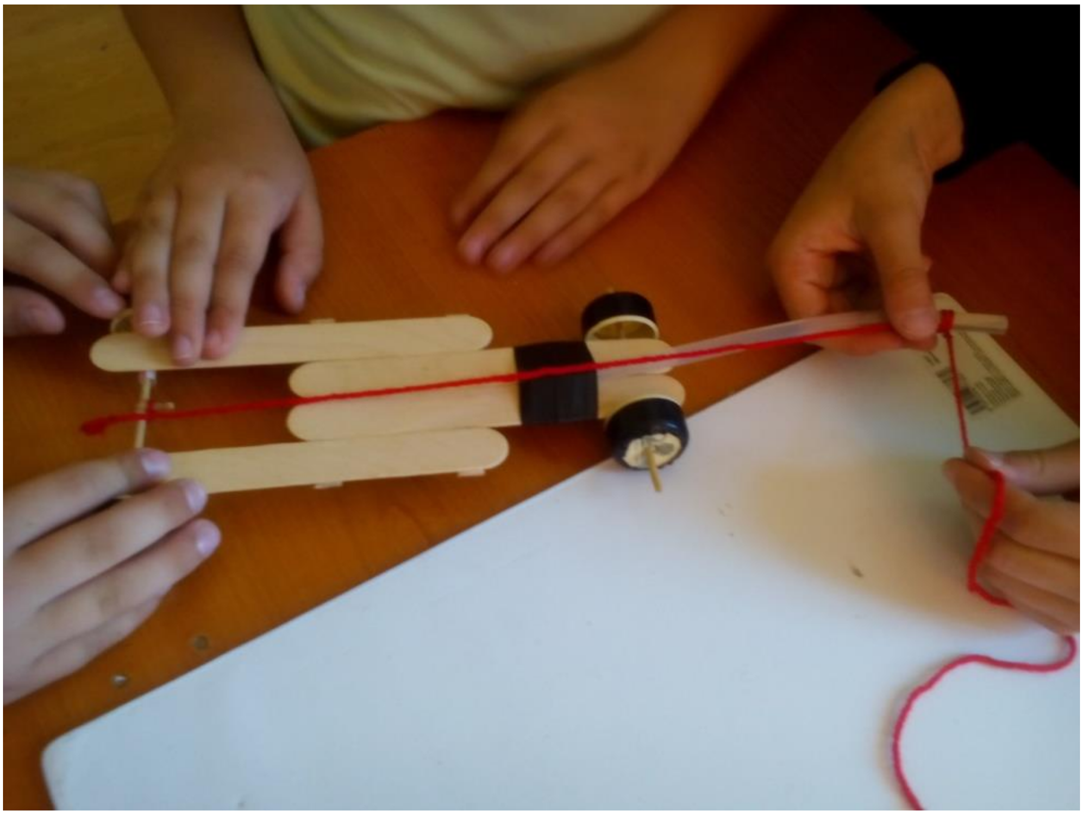
Gancho
Palha 2
Palha 3
Eixo 2
Roda 3
Roda 4

The Eco Car 2



Pedagogical Guidelines & Construction Instructions

Video Tutorial

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The Eco-car 2 for AutoSTEM

Pedagogical guidelines and construction instructions

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.

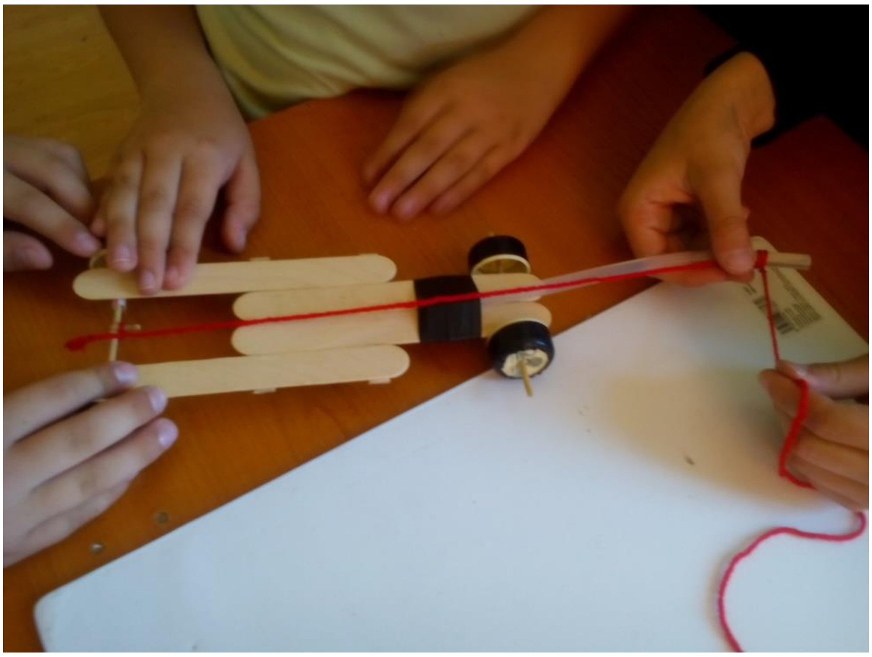


Figure 1: Children building the Eco-car 2

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

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.

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
- **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 contextualize 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.)
- 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/2YlnHwYQ3RM before starting to make your own Eco-car.

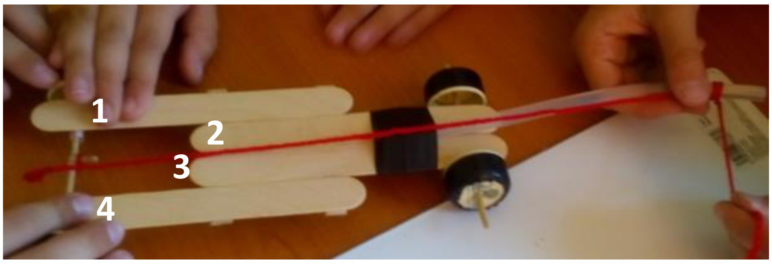


Figure 2: The Eco-car 2 with the four wooden sticks marked

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.

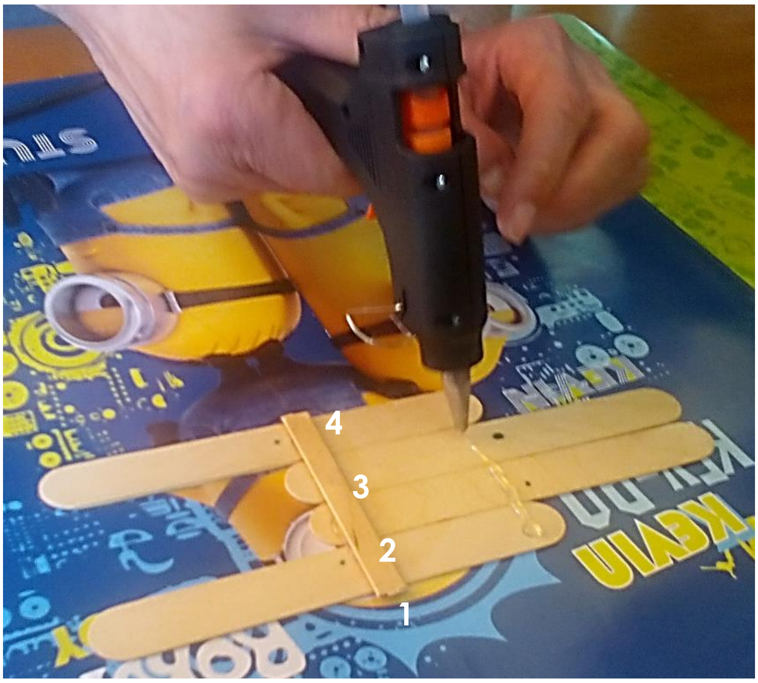


Figure 3: Joining the wooden sticks together

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)

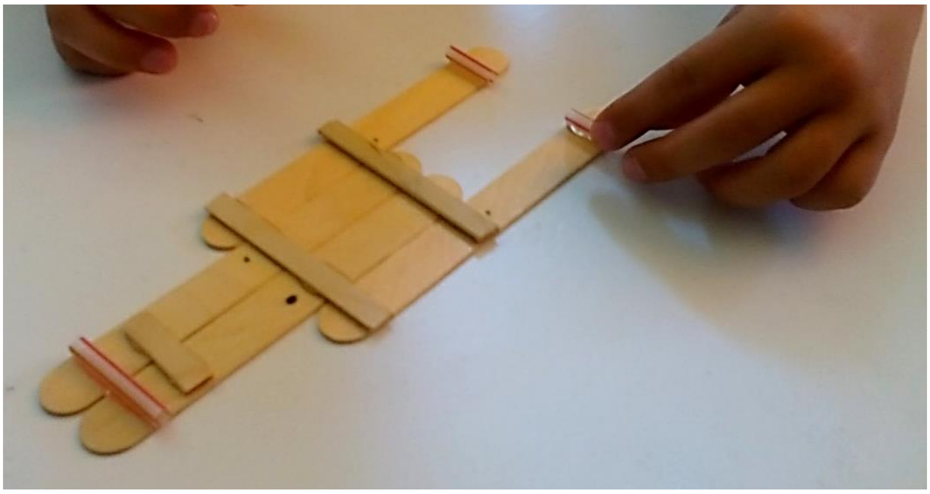


Figure 4: Glueing the straw pieces to the wooden sticks

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).
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).

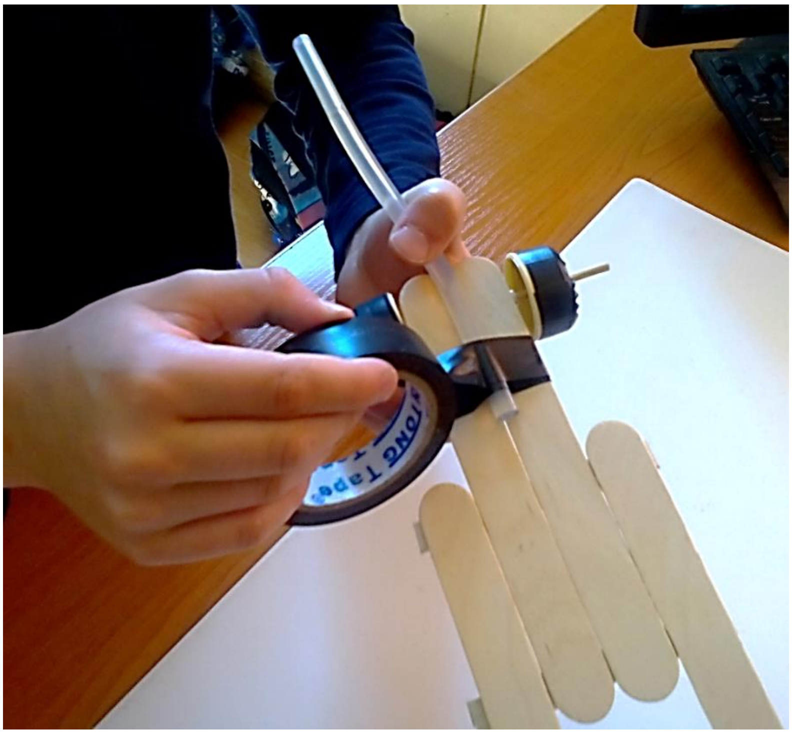


Figure 5: Attaching the strong straw to the car

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).

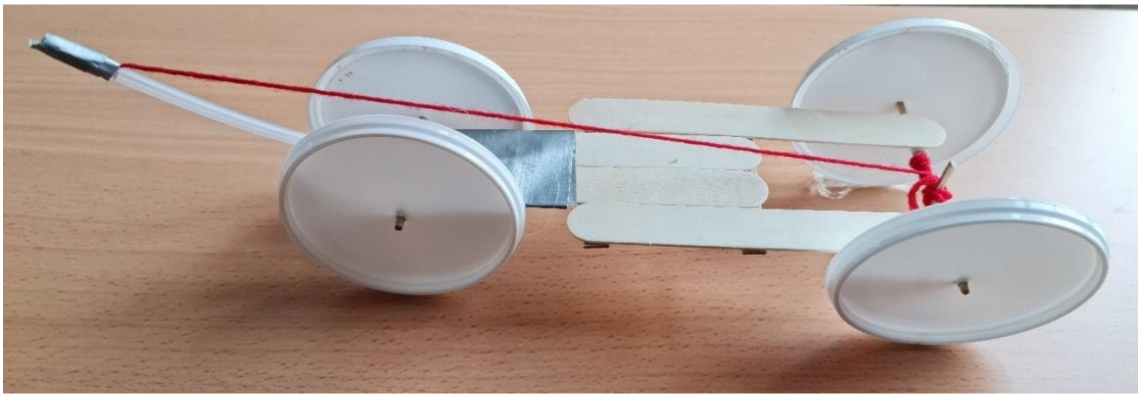


Figure 6: An Eco-car 2 with larger wheels

The Elevator

Pedagogical Guidelines & Construction Instructions

Video Tutorial

01

02

The Elevator for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes:

- How the elevator can be used to learn STEM areas
- How to construct the elevator

How the elevator can be used to learn STEM areas

What is the elevator?

The elevator is a small house made from a milk or juice carton. The house contains a winch that is used to lift and lower an elevator. It has two open doors, one door at the ground floor and one at the top floor on the opposite side of the building. The toy can be used to play Kim's game. Kim's game is an exercise in observation, memory and classification. There are also many different possibilities for the children to explore and play with the mechanical mechanisms used in this toy.

Figure 1. The elevator

The following are ideas how to introduce STEM concepts when constructing the elevator. The teacher can adapt these suggestions to their own class and context and plan their own activity (Plan template).

Target group

The elevator described here is designed for children from four to seven years old. Teachers can adapt the proposal to other ages. Teacher guidance is necessary when constructing the elevator.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing and playing with the elevator several learning goals can be achieved:

- To learn about physics and mechanisms
- To develop engineering competencies of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes, geometric terms and numbers.
- To practice measuring
- To train observational skills
- To learn classification
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

Observing and making hypothesis

The first thing the teacher does is to show a model of the elevator. After demonstrating the mechanism, the children can make hypotheses on why the elevator is moving, and why it can lift things to the top floor of the building. The children can then investigate the mechanism and see if their hypothesis were correct.

Exploring and learning about physics and mechanisms.

When you apply a force to the handle of the crank of the winch in order to turn it, you do work. This mechanical energy is transformed into the rotational kinetic energy of the winch spool. The rotational energy is transformed into translational kinetic energy of the string. The translational energy is transformed into gravitational potential energy of the raised elevator. The force needed, and the time it takes to lift the elevator is dependent on the thickness of the spindle.

Starting to construct the elevator, and learning mathematics and physics

Continuing with learning about shapes: During the construction of the elevator, the doors must be cut to the proper size and the size of the doors must be adapted to the size of the elevator floor (matchbox) and the size of the things one wants to play with. The length of the spindle must be adapted and the string that lifts the elevator must be cut to a suitable length. The centre of the wheel must be identified as well as the periphery, so these two terms can be introduced to the children.

Constructing the mechanism to develop engineer competences

The children can identify the different parts of the elevator after studying it. Together with the teacher, they can plan the building of the elevator.

The teacher continues talking with the children about the pieces and materials to construct the mechanism.

Children construct the mechanism following the method described in "How to construct the elevator".

Playing with the elevator

One possibility for play is Kim's game. Kim's game is played in the following way: One child is presenting several toys, five or more, depending on the age of the children. A second child studies the toys for a while and then turns away. The first child puts one toy in the elevator at the ground floor and mixes the order of the toys that are left. The second child can now guess which toy is in the elevator. After the child has decided which toy is missing, he or she can turn the elevator and see who is appearing at the door on the top floor. For this to work the two entrances of the elevator must be on opposite sides of the building. By playing Kim's

game the children will train memory, learn classification of objects and they will learn names e.g. if toy animals are used.
The children should be encouraged to find other ways to play with the elevator as well.

Variations on the elevator and adding scenarios and narratives

The elevator can be made from cartoons of different size. We would recommend using large cartons (1.5 – 2 Liters) to make it easier to build and play with the elevator.

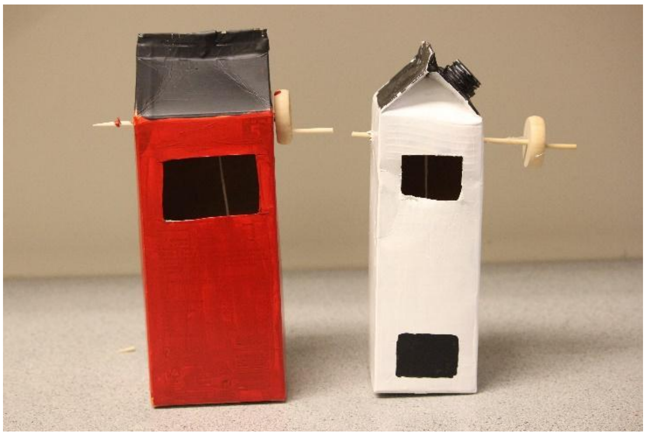


Figure 2. Variants of the elevator. We recommend using a large carton.

How to construct the elevator

Figure 3 Parts and tools required

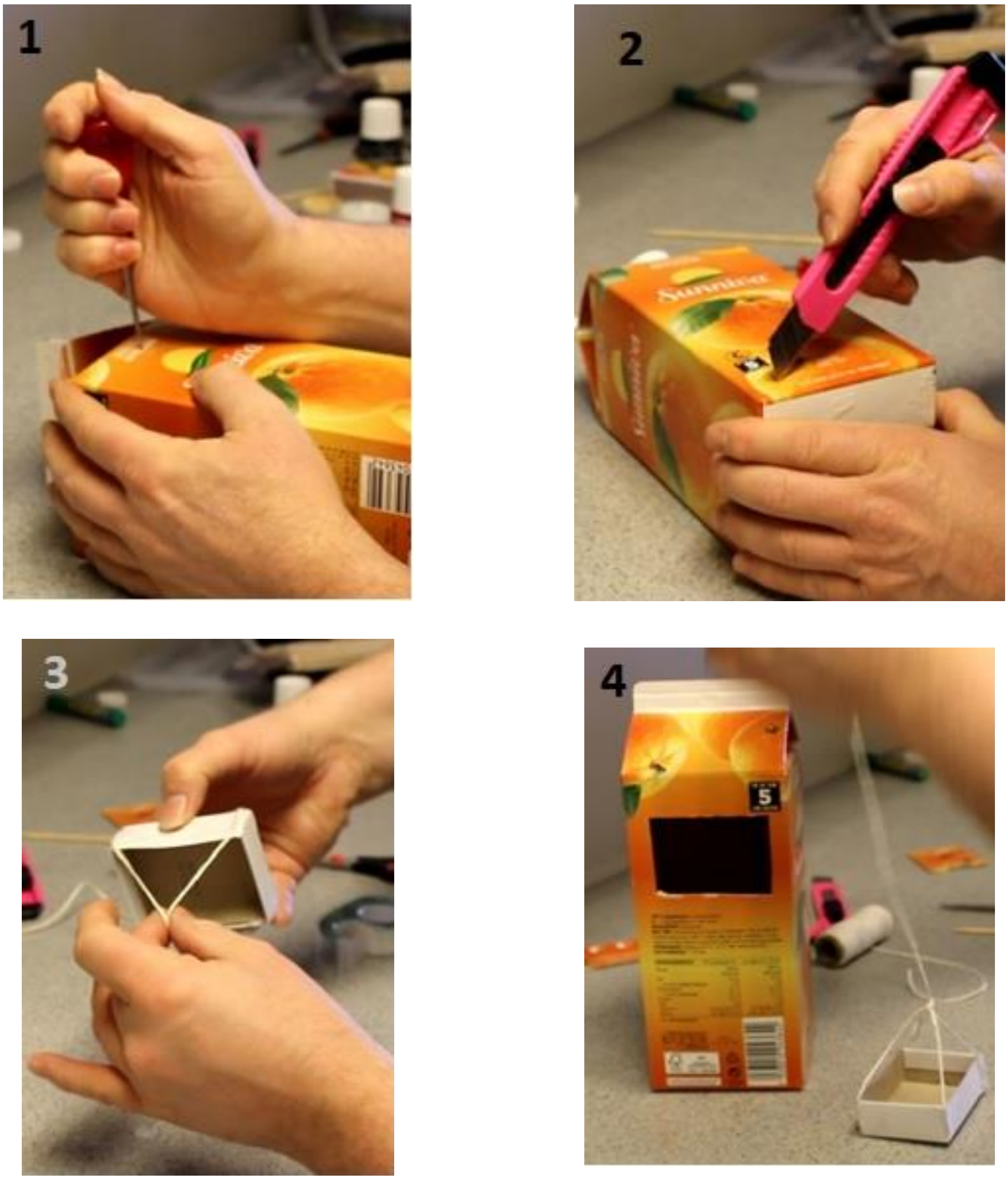
Parts and tools required

- A carton used for juice, milk or similar
- A wooden skewer
- A wheel made of wood (other solutions can be used)
- A matchbox
- Sticky tape
- String
- A drill with a drill bit matching the diameter of the wooden skewer
- A carpet knife or other sharp knife
- Glue (not shown)

- An awl can also be handy (not shown)
- (optional) Paint and paintbrush

Method

It is best to watch the video https://youtu.be/HNYxvmar4Ko before starting to make your elevator. Figure 4 and the guidelines below is a step-by-step guide on how to build the toy.



03 04 05

Figure 4. Building the elevator

1. Make two holes on two opposite sides of the carton, almost at the top of the sidewalls.
2. Cut holes for the doors. Make sure the holes are large enough for the things you want to put inside the elevator. Place one door at the ground floor. The other door should be placed on the opposite wall on the top floor. By placing the doors on opposite sides of the building, you can use the elevator to play Kim's game.
3. Cut a piece of string and attach each end to the two corners of the matchbox. Repeat on the opposite side.
4. Measure the height of the elevator, cut a suitable length of string (allow some extra length for the knots), and attach it to the two strings that are already attached to the matchbox. Make sure that the attachments to each of the four corners of the matchbox are of equal length so that the matchbox makes a level floor in the elevator.
5. Insert the spindle in one of the pre-made holes at the top of the sidewall
6. Attach the string to the spindle and put it inside the house together with the matchbox.
7. Drill a hole in the centre of the wheel and another close to the periphery.
8. Use a short part of the skewer to make a handle and glue it to the hole in the peripheral part to the wheel. Glue the wheel to the spindle.
9. Close the top of the carton with sticky tape
10. Paint the house.
11. Play!

The Drawbridge

Pedagogical Guidelines & Construction Instructions

Video Tutorial

03

04

05

The Drawbridge for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How the Drawbridge can be used to learn STEM content
- How to construct the Drawbridge

How the Drawbridge can be used to learn STEM areas

What is the Drawbridge

The Drawbridge is a toy bridge that can be raised to allow passage of a ship having masts too tall to pass under or to defend the entrance of a medieval castle. It is made from double-wall corrugated cardboard (from a big parcel), a wooden skewer, and string. The toy can be used by the children in many ways and opens up a number of subject areas for further learning. Moving bridges are very motivating and exciting toys for children. It is fun for the children to be allowed to play with their drawbridges, once they have made them.

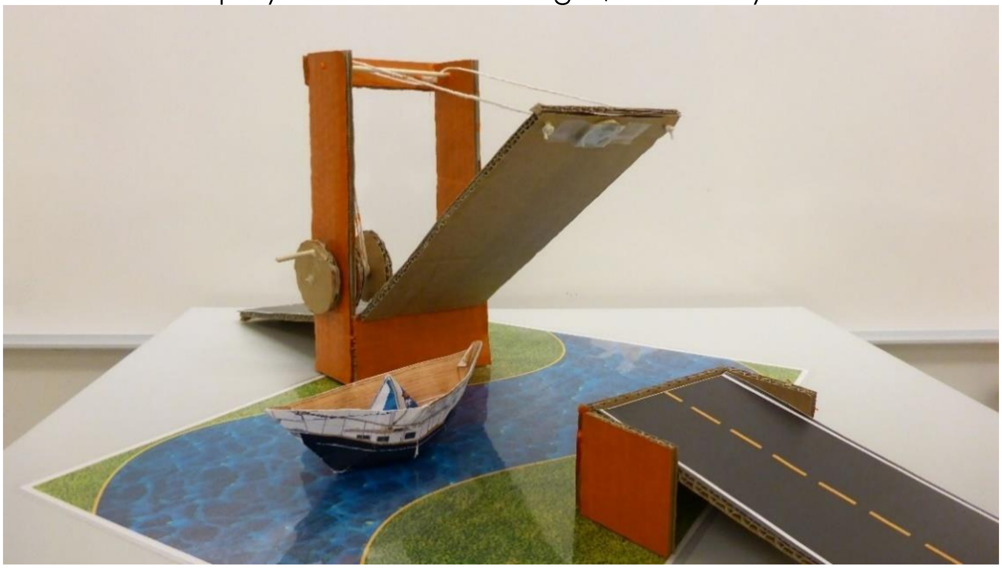


Figure 7. An example of the Drawbridge

Target group

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

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

- When constructing the Drawbridge several learning goals can be achieved:
- To learn about physics and mechanisms
- To develop engineering competencies of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
- To practice measuring
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

The starting point is the Drawbridge, how it functions, and how to construct it.

Observing

The first thing the teacher does is show a model of the Drawbridge and make it move up and down. The teacher can ask, ‘Why did it move?’

Exploring and learning about physics and mechanisms.

Children can observe the Drawbridge, make comments, and ask questions about how it functions.

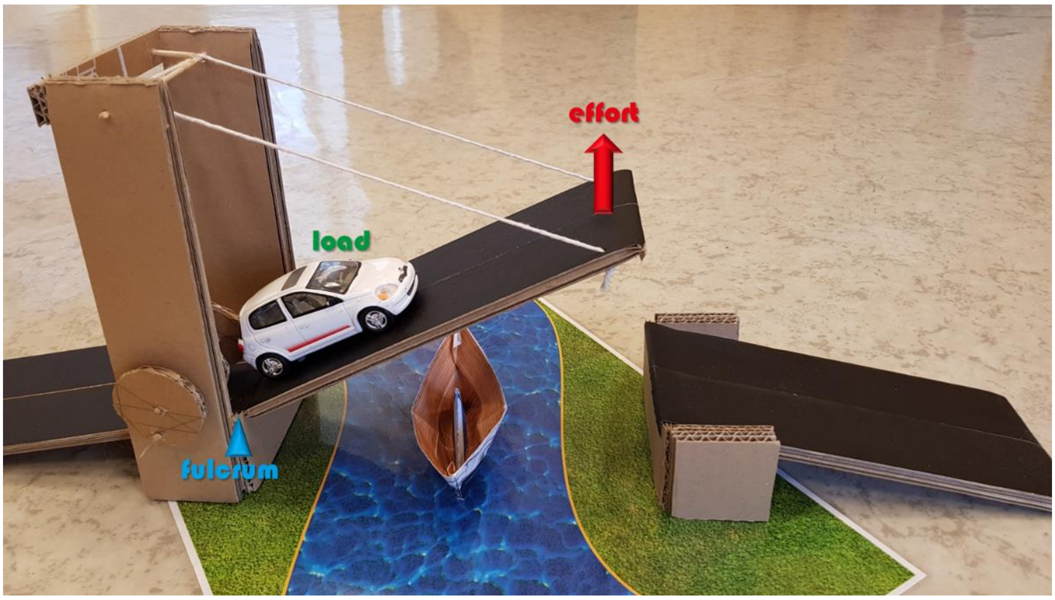


Figure 8. The Drawbridge is a type 2 lever

Our drawbridge is a **type 2 lever**. The **fulcrum** is where the movable deck is attached to the bridge tower. The **force** to raise the deck is applied on the other end. The further away this point is from the fulcrum (i.e. the longer the **lever arm** is), the lesser force is needed to raise the bridge. The **load** is the bridge deck itself or a car that may stand on the bridge while it is raised.

When you apply a force to the handle of the **crank** of the **winch** in order to turn it, you do **work**. This **mechanical energy** is transformed into the **rotational kinetic energy** of the winch spool. The rotational energy is transformed into **translational kinetic energy** of the string. The translational energy is transformed into **gravitational potential energy** of the raised bridge deck.

When releasing the crank, the process would usually reverse. That means the gravitational force would pull the bridge deck down again. But in our model, the **friction** between the winch’s **axle** and its **bearing** is so high that it **balance**s the gravitational force (the **weight**) of the bridge deck. Therefore, the raised bridge deck stays in place. In order to lower the bridge, you have to turn the hand crank in the opposite direction.

Starting to construct the Drawbridge and learning mathematics

The teacher talks with the children asking what is needed to make the Drawbridge. During the construction, many mathematical concepts can be used, introduced, or discovered.

- **Counting**: parts **B** and **E** are needed **three times**, parts **A**, **C** and **F twice**, part **D** only **once**
- **Measuring lengths**: The string and the skewer have to be cut in pieces of specific lengths. The lengths can be found by **direct comparison**, measuring with body units

(an **arm span**, i.e. the distance, fingertip to fingertip, created by stretching one's arms straight out from the sides of the body) or standard units (**metre** and **centimetre**).

- **Designing (shapes)**: Parts **C** to **E** are **rectangles**, **A** is a **square**, and **B** is a **circle**.
- **Locating**: use spatial concepts like **under**, **over**, **through**, **top**, **bottom**, **centre** (find the centre of a circle), **up**, **down**, **around**, **clockwise**, **counter-clockwise**, **rotation** (the motion of the spool), **translation** (the motion of the string).

Expanding on the idea

The initial bridge idea can lead to further ideas and explorations. The teacher can ask the children for their ideas. Are there other mechanisms of drawbridges? Are there other types of movable bridges? One famous example is the Tower Bridge in London that has two movable spans (fig. 3). Our drawbridge can easily be modified to have two spans by doubling it.

Figure 9. The Tower Bridge in London (picture taken by Roberto Bellasio, Pixabay)

The drawbridge can be used in a *castle scenario* together with other automata, e.g. a trebuchet, a trapdoor or a hoist.
In a *traffic scenario*, the children can use the drawbridge together with the Balloon boat and the Balloon Car. They can extend the road and find a way to make a water channel that the bridge will span.

How to construct the Drawbridge

To make the Drawbridge you only need basic parts and tools that are found in every school or preschool. Below we list the parts needed and alternatives.

Parts and tools required

- about 40cm x 50cm double-wall corrugated cardboard (taken from a used package)
- a wooden kitchen skewer (If it is a short one, you might need two.)
- string (twine or cord of thread or yarn)

- glue (hot melt glue gun works best)
- sticky tape
- scissors
- a knife or guillotine to cut the cardboard
- a ruler
- (optional) paint

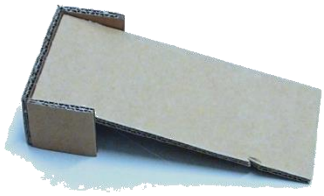


Figure 10. The opposite approach span

Method

It is best to watch the video https://youtu.be/Ah-I88JAAaE.

1. Cut out the templates from the end of this script.
2. Use the templates to cut the cardboard. It is best to place the cut-out paper on the cardboard, draw around them and then cut out the shapes.
3. Assemble the opposite approach span by gluing together pieces **E**, **C**, and both pieces **A** as shown on fig. 4.
4. Do the same with the bridge tower and the approach span that is connected to it by using pieces **E**, **C**, and both pieces **F**.
5. Glue piece **D** to the bridge tower (fig. 5).
6. Attach the movable bridge span **E** (fig. 6):
   a. Stick a piece of the strong sticky tape on one end of the remaining piece **E**.
   b. Stick it to the top end of the approach span by the bridge tower.
   c. Check that you can easily flap it up and down.

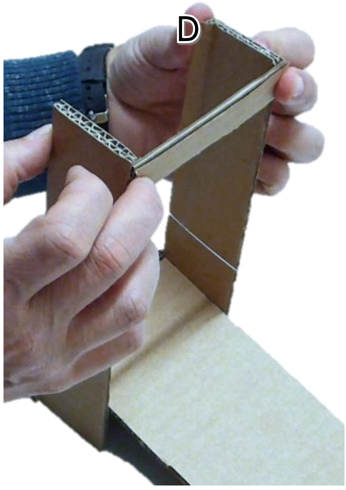


Figure 11. Glue piece D to the tower

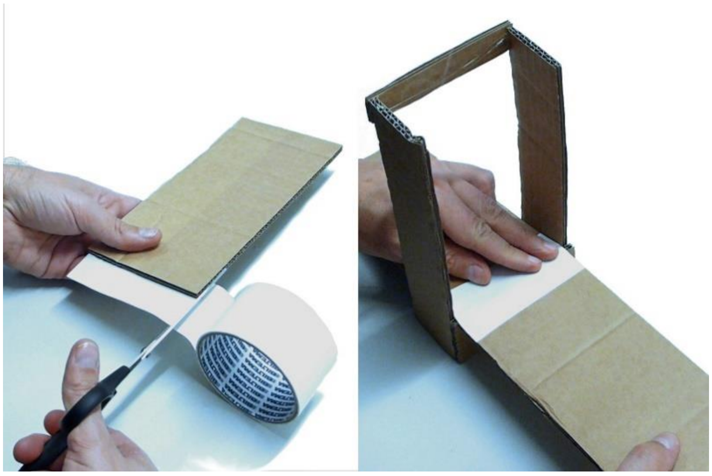


Figure 12. Stick a piece of sticky tape on piece* E *and attach it to the bridge

7. Make **pulley 1**:
   a. Use the pointy end of the skewer to prick a hole in either side of the top of the bridge tower. You can use template **F** that shows the position of **hole ①**.
   b. Push the skewer through both holes until the straight end sits in one hole.
   c. Mark on the skewer where it sticks out of the other hole in order to measure the length that is needed.
   d. Pull the skewer out of the holes and cut it at the mark.
   e. Insert it again between the two holes at the top of the tower. This is **pulley 1**.

8. Use the pointy end of the remaining piece of the skewer to prick two holes in piece **D**. You can use template **D** that shows the positions of **hole** ② and ③.
9. Make **pulley 2** and **3**:
   a. Mark on the remaining piece of the skewer the distance from piece **D** to the **pulley 1**.
   b. Cut two pieces of this length from the skewer.
   c. Insert one piece in **hole** ②. It shall go **under pulley 1**. This is the **pulley 2**.
   d. Insert the other piece in **hole** ③. It shall go **over pulley 1**. This is **pulley 3**.
10. Put the three circles **B** on top of each other and prick a hole in the centre through all three pieces. You might use template **B** that shows the position of **hole** ④ or let the children invent a clever method to find the centre.
11. Push the remaining piece of the skewer through the centre of one circle. Use this to find the position of **hole** ⑤ and prick it into the bridge tower. The hole must be on the same side of the tower as **pulley 3**. It needs to be that high enough that the circle is just above the bridge deck but can still rotate freely.
12. Measure a piece of the string by stretching your arms straight out from the sides of your body from. The string shall be one **arm span** long. Then cut the piece into halves. (Each piece of string will be about 80—90 cm.)
13. Measure a piece of the skewer 5 cm long and cut it off.
14. Insert this piece in one of the circles so that it sticks out on one side only. This is the **spool** of the **winch** with one **flange**.
15. Take a piece of sticky tape (about 1 cm wide and 5 cm long) and stick the ends of the two strings on to it (fig. 7).
16. Then wind the sticky tape together with the strings around the **spindle** of the **spool**, close to the **flange**.
17. Put a second circle on the **spindle** as the other **flange**.
18. Attach the **winch** to the inside of the tower by pushing the **winch**'s **axle** through **hole** ⑤.
19. Take the last circle and prick **hole** ⑥ close to the circumference. You can use template **B**.

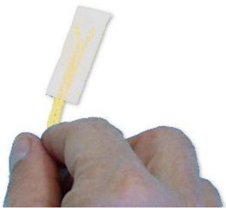


Figure 13. A piece of sticky tape

20. Insert the last piece of the skewer into **hole** ⑥ and attach some glue. This will be the **handle** of the **winch**'s **crank**.
21. Attach some glue to the hole in the centre of the **crank** and attach the **crank** to the free end of the **winch**'s **axle**.
22. Prick two holes in the bridge deck, close to each free corner. You might use template **F** that shows the positions of **hole** ⑦ and ⑧.
23. Turn the **winch** clockwise three full rotations so that the strings coil around the **spool**.
24. Take the **right-hand** string (the one that is closest to the edge) and pass it **upwards** and **through** the opening between **pulley 1** and **3** and finally **over pulley 1**.
25. Take the other string and pass it **upwards**, too, **through** the opening between **pulley 1** and **3**, to the **left over pulley 3** and **under pulley 2**, then **upwards through** the opening between **pulley 1** and **2** and **over pulley 1** (fig. 8).

26. Turn the bridge around and push either string **through hole** ⑦ and ⑧ without crossing the strings.
27. Mark on each string the point where it meets the hole.
28. Move the bridge span **upwards**.
29. Make a knot in each string at the marked point.
30. Cut away the part of each string that is behind the knot.
31. Use your creativity to decorate the bridge. You may print out the road paving (on Annex 5) three times and glue it on the bridge decks.

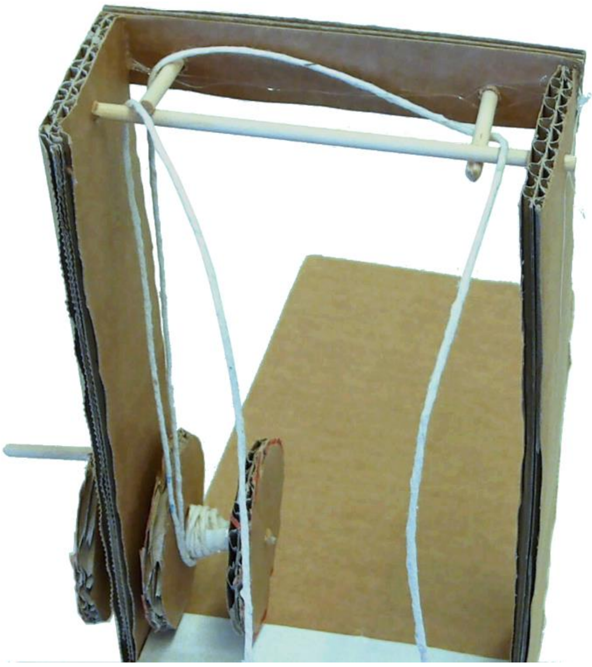


Figure 14. Arrangement of the strings

Test the bridge and make it move

You raise the bridge by turning the **crank clockwise**. When you turn the **crank counter-clockwise**, the bridge should move **downwards**. If it does not move downwards by itself, you have to increase the weight. You can use sticky tape to attach a coin to the bottom of the bridge deck, or you can use a spring from a ball pen to pull the bridge down (fig. 9).

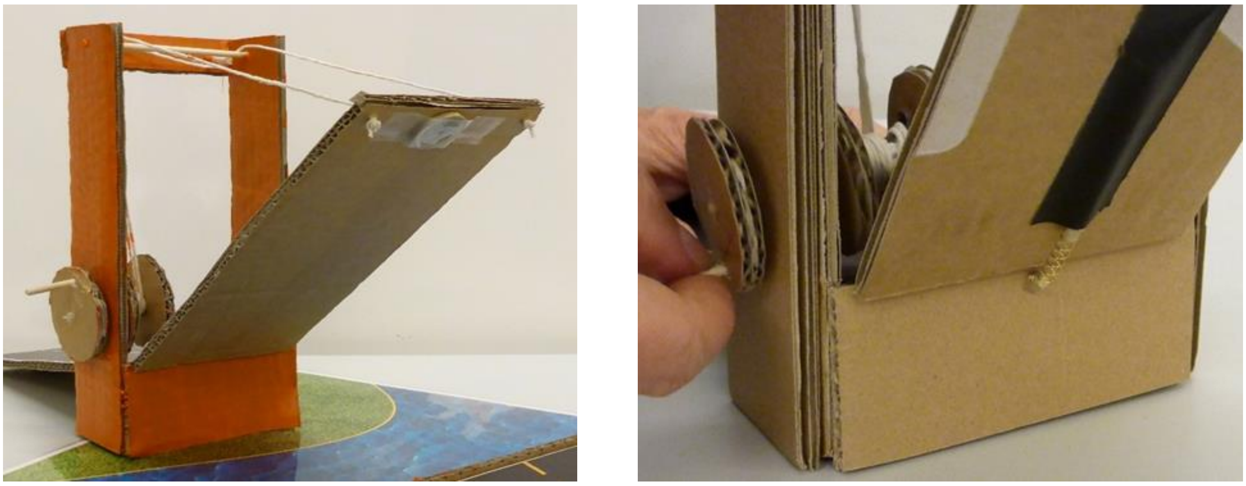
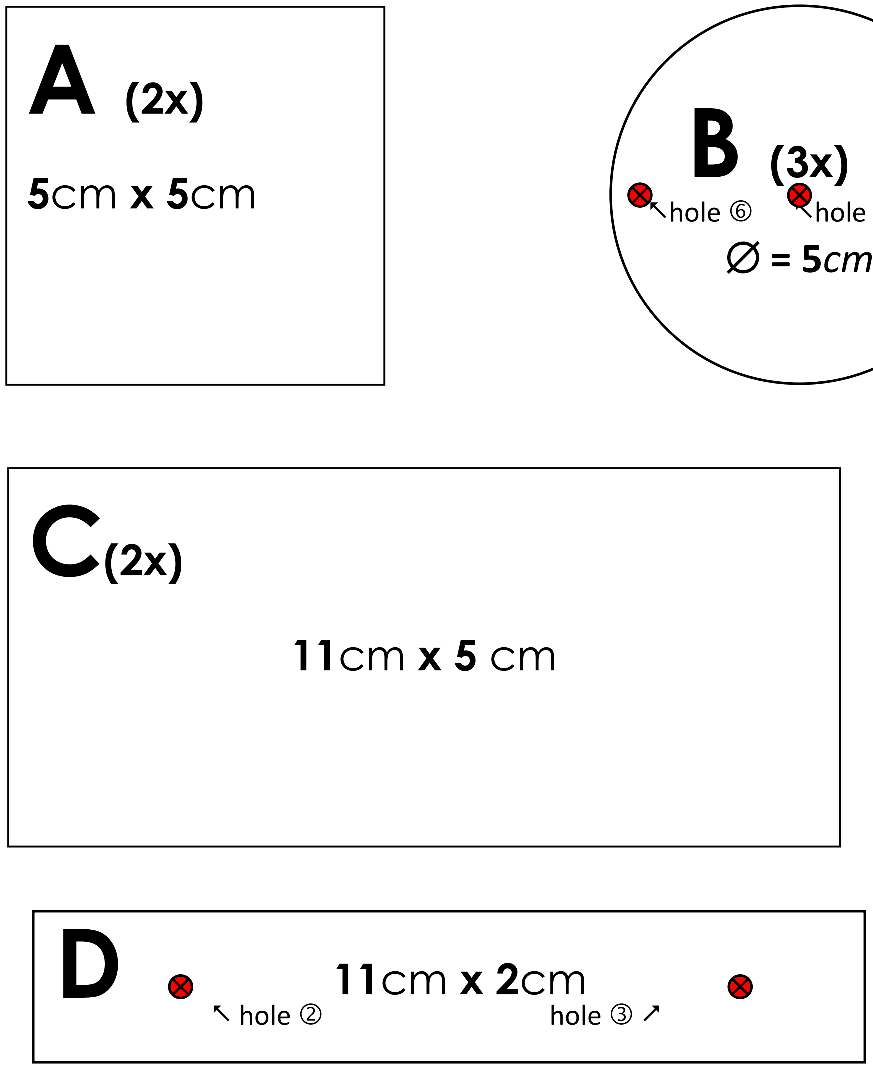


Figure 9. You might use a coin or a spring to pull the bridge down.

Templates for The Drawbridge



E **(3x)**

10cm **x** **22**cm

↙ hole ⑦

hole ⑧ ↘

hole ① ↗

F **(2x)**

5cm **x** **22**cm

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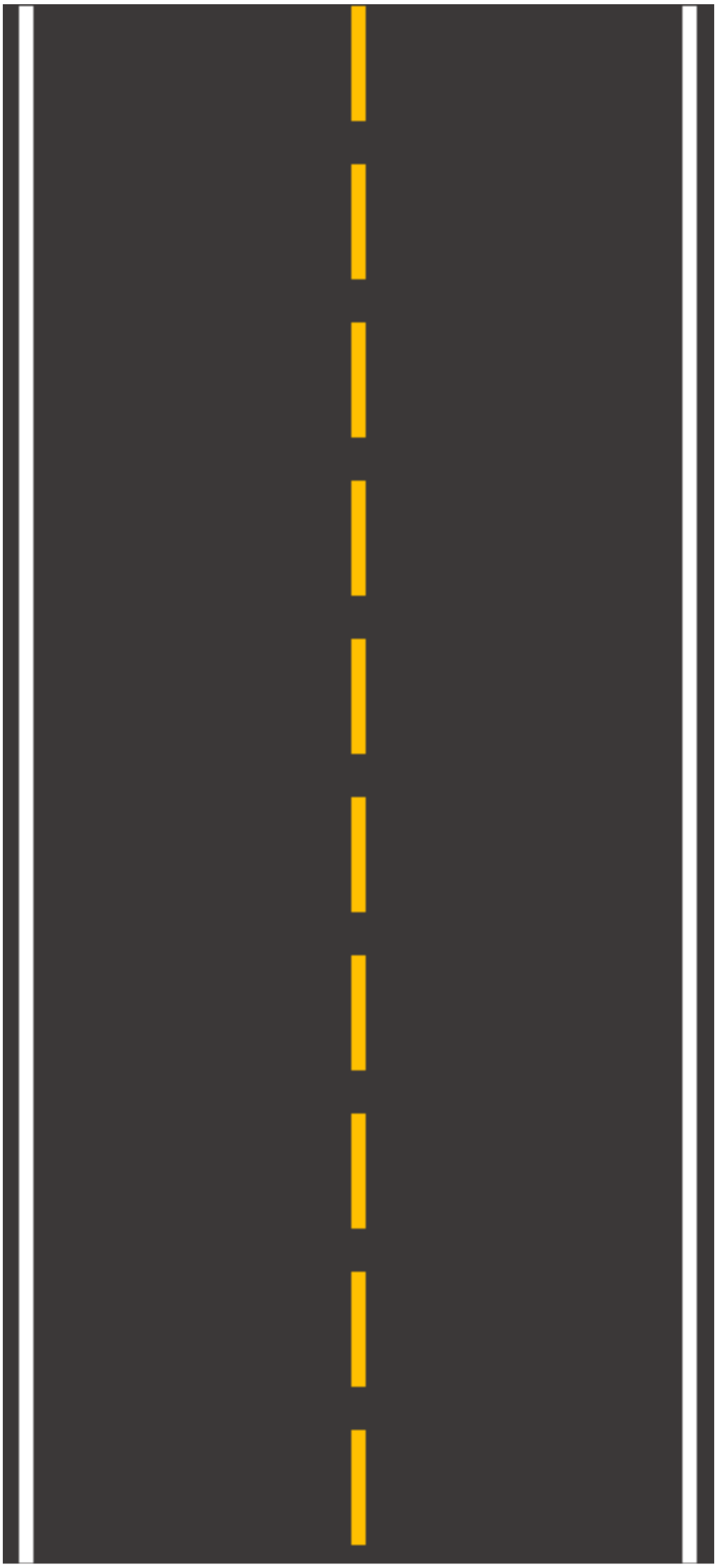


Road paving

01 02

The returning Tin Can

Pedagogical Guidelines & Construction Instructions

Video Tutorial

03 04 05

The Returning Tin Can for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes:

- How the machine can be used to learn STEM areas
- How to construct the Returning Tin Can

How the Returning Tin Can can be used to learn STEM areas

What is the Returning Tin Can

The machine consists of a rubber band that is twisted inside a cylinder shaped tin can. As the cylinder rolls across the floor, the twisted rubber band will make the can roll in the opposite direction as soon as it stops. Kinetic energy of the rolling cylinder is transformed to elastic energy stored by the rubber band and then back to kinetic energy as the cylinder rolls in the opposite direction.

Figure 1. The Returning Tin Can

The following are ideas how to introduce STEM concepts when constructing the Returning Tin Can. The teacher can adapt these suggestions to their own class and context and plan their own activity (Plan template).

Target group

The Returning Tin Can described here is designed for children from 4 to 7 years old. Teachers can adapt the proposal to other ages.

The teacher can decide depending on her/his knowledge of the children whether the children should work in groups or individually.

Learning goals

When constructing the Returning Tin Can several learning goals can be achieved:

- To learn about physics and energy sources, in particular, kinetic energy and elastic energy. It can also be used to learn about energy transformation, namely transferring the kinetic energy in the moving cylinder into elastic energy stored in the rubber band and then back to kinetic energy as the cylinder starts rolling back.
- For the youngest children the main goal is to let them experience the phenomena of energy transformation rather than learning abstract concepts like kinetic and elastic energy
- To develop engineering competences of analysis and construction.
- To learn mathematical concepts within the construction and assembly process, including shapes.
- The machine is partly made of reusable material (the box). This is an opportunity to raise the awareness of sustainability and reusability.
- Other soft-learning goals can be included; problem solving and creativity.

How to introduce STEM concepts during construction

Observing and making hypothesis

The first thing the teacher does is show a model of the Returning Tin Can. The teacher can ask "why did it come back?"

Exploring and learning about physics and mechanisms.

Children can observe the Returning Tin Can and make comments and ask questions about how it functions. After this, the students can dismantle the box to explore the mechanism and make inquiries about its function.

Teachers can talk about energy sources in a very simple way. The teacher can stimulate the students to reflect on why the box is returning, and where the energy comes from. Other words for energy might be used in the start like force or power even if these are not exact synonyms of energy.

Effects similar to the Newton disk can be obtained by adding different kinds of colour-patterns on the surface of the toy. See video at https://youtu.be/O09nW9SqoW0 and the section on the Newton disk found elsewhere on the AutoSTEM web pages.

Starting to construct the Returning Tin Can, and learning mathematics and physics

Continuing with learning about shapes: During the construction of the machine, the children must identify the centre of a circle to place the holes for the rubber band correctly. They will also get experience with the surface area of the cylinder wall when cutting the paper coating to the correct size.

Constructing the mechanism to develop engineer competences

The students can identify the different parts of the machine after dismantling it. Together with the teacher, they can plan the building of the machine.

The teacher continues talking with the children about the pieces and materials to construct the mechanism.

Children construct the mechanism following the method described in "How to construct the Returning Tin Can".

Variations on the Returning Tin Can and adding scenarions and narratives

The machine can be made of a bottle instead of a cylinder-shaped box. The children can experiment with different colour patterns to explore the visual effects that might occur.

Figure 2. Variants of the Returning Tin Can.

How to construct the Returning Tin Can

The different parts needed are shown in figure 3.

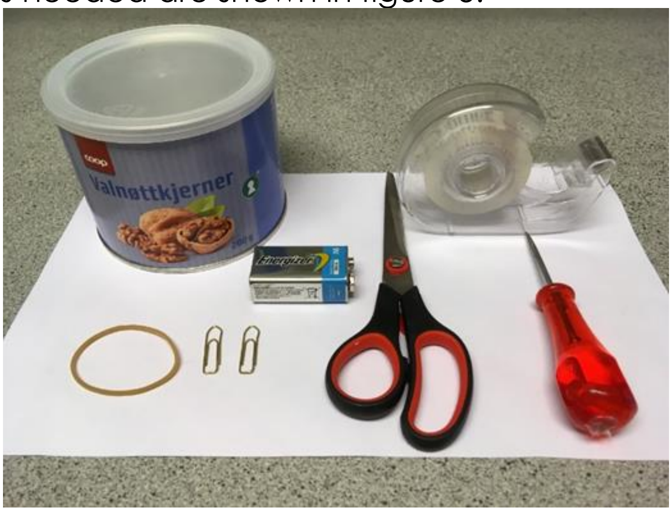


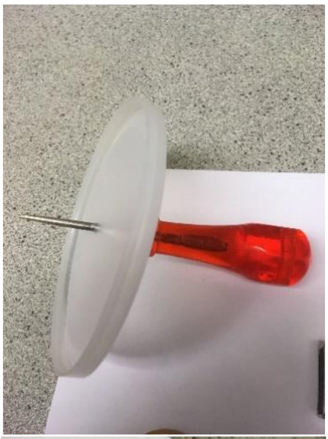
Figure 3. Parts and tools required

Parts and tools required

- Cylinder shaped box. In this case a box for nuts, be aware of allergies
- 9V battery. Use only discharged batteries. To be sure that there are no risk, the battery can be shortcut by the teacher prior to the activity by putting one blade of the scissors in contact with the two poles for a while
- Sticky tape
- Scissors
- Rubber band
- Paper clips
- Awl, another pointed tool could also be used, for example a four inch nail

Method

It is best to watch the video before starting to make your Returning Tin Can. Figure 4 and the guidelines below is a step by step guide on how to build the toy.



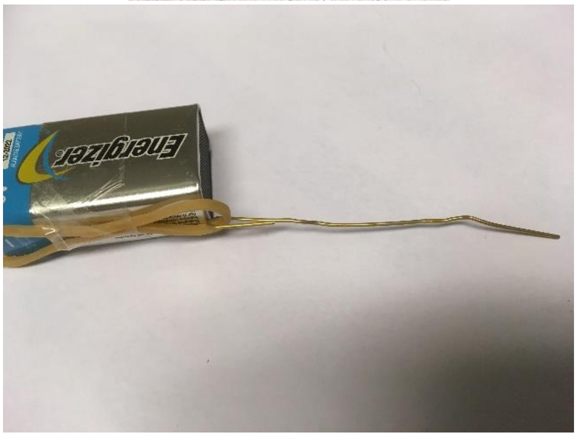
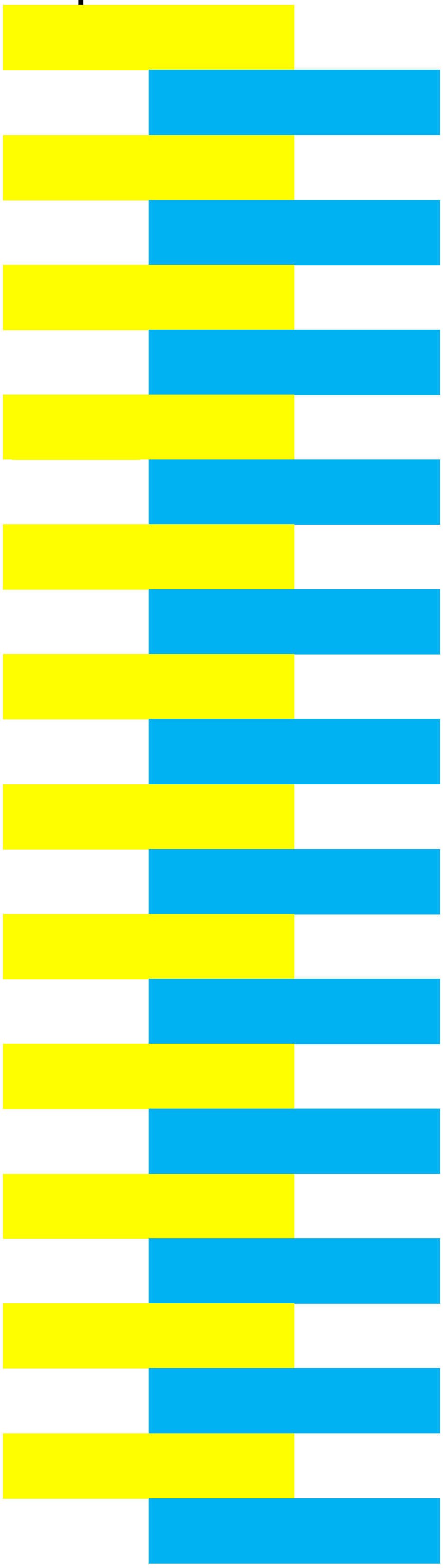


Figure 4. Building the always come back machine

1. Identify the centre of the lid and the bottom of the box and make holes with the awl. This may be done with the assistance of the teacher.
2. Using scotch tape, add the rubber band to the battery as shown above.
3. Unfold the paper clip and use it as a needle to thread the rubber band through the holes in the bottom and in the lid of the box.
4. Fold the paper clip so that it will not slip back into the box
5. Make the desired pattern on a paper and stick it to the box using scotch tape (see template at the end of the script).

Templates for The Returning Tin Can



The Moving Shapes

Pedagogical Guidelines & Construction Instructions

Video Tutorial

The Moving Shapes for AutoSTEM

Pedagogical guidelines and construction 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 learn STEM areas

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.

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 concepts during construction

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

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 scenarios and narratives

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.

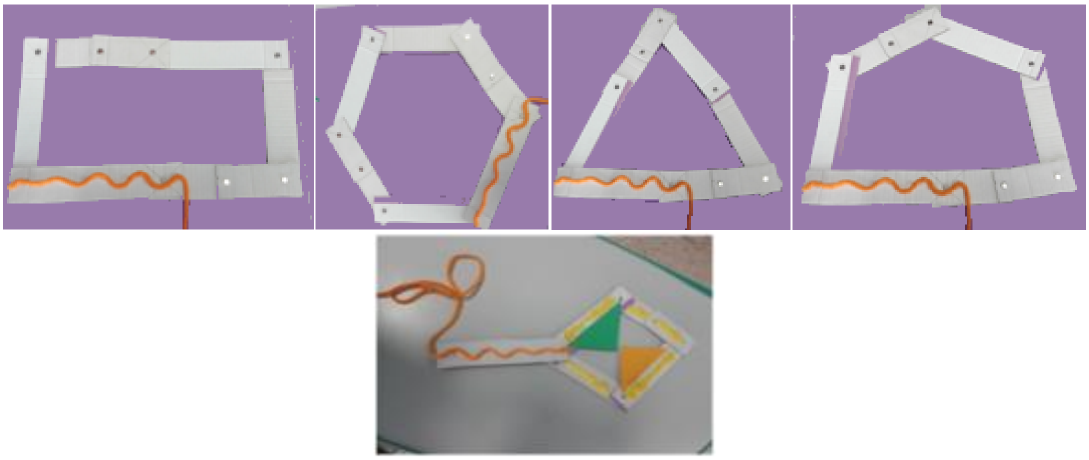


Figure 3. The transformation from the hexagon to the kite

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

Parts and tools required

- 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.

1. Cut out four rectangles of size 3x15 cm.

2. 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.)
3. 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.
4. 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.
5. 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

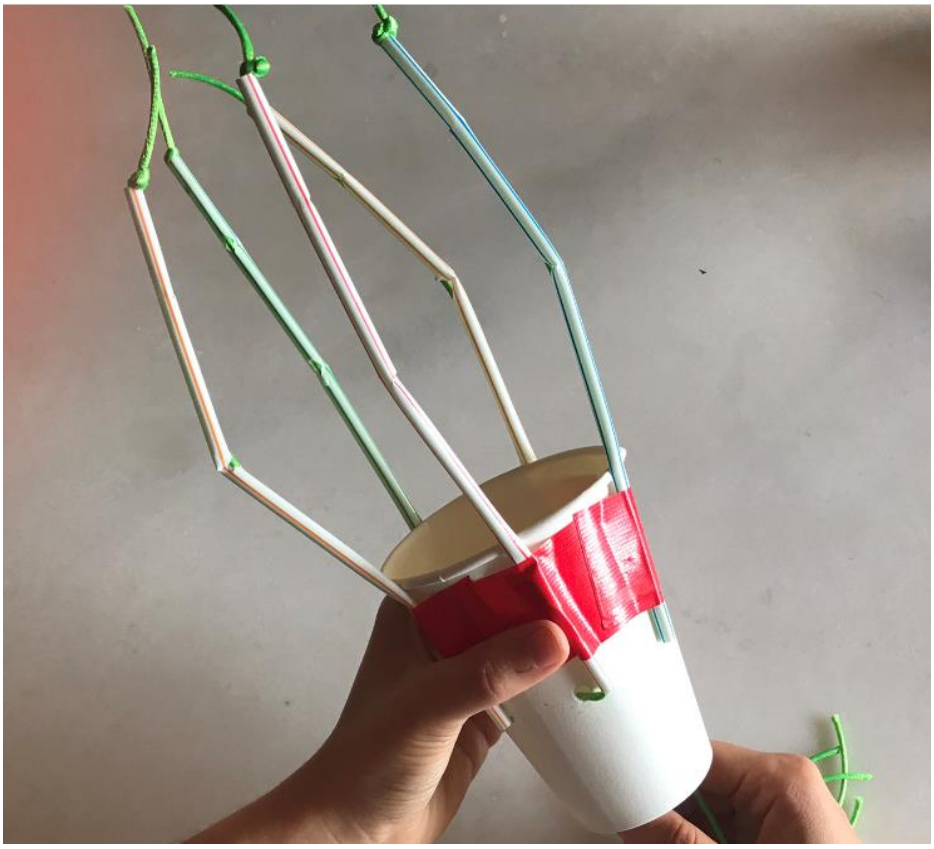
Figure 6. Starting with a square, bending one side outwards to make a pentagon, and finally straightening two sides to form a triangle

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

The Grabbing Hand



Pedagogical Guidelines & Construction Instructions

Video Tutorial

The Grabbing Hand for AutoSTEM

Pedagogical guidelines and construction instructions

This guide includes the following parts:

- How the Grabbing Hand can be used to learn STEM areas
- How to construct a Grabbing Hand

How the Grabbing Hand can be used to learn STEM areas

What is the Grabbing Hand

The Grabbing Hand is a toy that is a mechanical hand. The **AutoSTEM** Grabbing Hand is made from a standard paper cup, threads, straws and tape. It will move depending on the movement caused by pulling the ropes.
It results in a toy that can be used by the children in many ways and opens up a number of subject areas for further learning. Grabbing hands are very motivating and exciting toys for children. It is fun for the children to be allowed to play with their Grabbing Hands once they have made them.

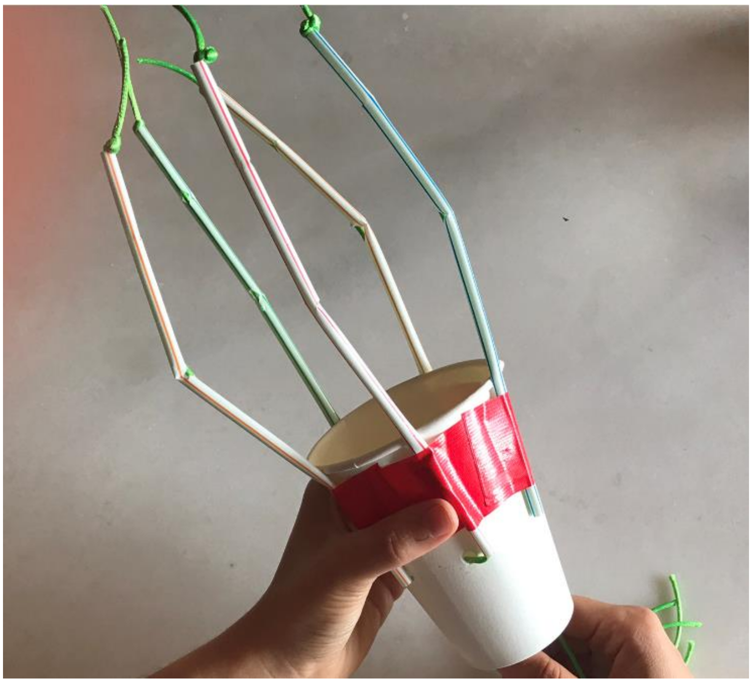


Figure 15: An example of the Grabbing Hand

Target group

The Grabbing Hand example described here is designed for children from 4 to 7 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 Grabbing Hand, several learning goals can be achieved:

- To learn mathematical concepts within the construction and assembly process, including shapes and numbers.
- To practice measuring

- To use a ruler for measuring
- To know about human body parts, namely, the hand
- To develop engineering competencies of analysis and construction
- Other soft-learning goals like problem solving and creativity can be included

How to introduce STEM concepts during construction

The starting point is the Grabbing Hand, how it functions, and how to construct it.

Observing the Grabbing Hand and learning about biology

First, the teacher shows a Grabbing Hand model and makes it move and grab something, like a rolled sheet of paper. The teacher can ask, 'How and why did it move?'

When children are observing the Grabbing Hand, the teacher can talk about the **human hand** and ask several questions about how it functions. Children may explore or analyse other images and their own hands

Starting to construct the Grabbing Hand and learning mathematics

The teacher talks with the children and asks what is needed to make the Grabbing Hand. During the construction, many mathematical concepts can be used, introduced, or discovered.

- **Counting:** one cup, five straws and five threads are needed.
- **Measuring length:** Straws have to be cut at three points. The children shall analyse how to measure the distance between them. Also, threads shall be cut into pieces of the same length. The children can use direct comparison, arbitrary units (e.g. fingerbreadth and cubit) or a ruler with standard units
- **Locating:** use spatial concepts like over, under, top, bottom, centre, around when constructing the Grabbing Hand.

How to construct the Grabbing Hand

To make the Grabbing Hand, 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

- Paper cup
- five straight straws (not bending straws)
- Thread (about 2-3 m)
- Sticky tape
- Scissors
- Ruler (optional)
- Pencil or pen

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, paper cups). In this way, we can add sustainability and recycling into the teaching.

Method

It is best to watch the video https://youtu.be/NTSMzVkndvM before starting the construction.

1. Measure three fingerbreadths from one end of the straw and fold it at that place (see Figure 16 and Figure 17). If the children are already familiar with rulers, they can

measure the length in centimetres. Three fingerbreadths are about 4 cm, and two fingerbreadths are about 2 cm.

Figure 16: Measuring three fingerbreadths

Figure 17: Folding the straw at the measured place

2. Cut diagonally in the fold, only up to 1/3 of the straw (Figure 18). The straw should end up with a hole (Figure 19) shaped like a diamond after you opened the fold (Figure 20).

Figure 18: Cut the straw diagonally at the fold

Figure 19: Already cut straw

Figure 20: After you opened the fold, the straw has a diamond-shaped hole

3. Measure two fingerbreadths from the first cut and repeat process 2. Make sure you are folding in the same way since all three cuts must be facing the same direction. A

trick is to place the first cut facing sideways while folding upwards (see Figure 21, Figure 22, and Figure 23).

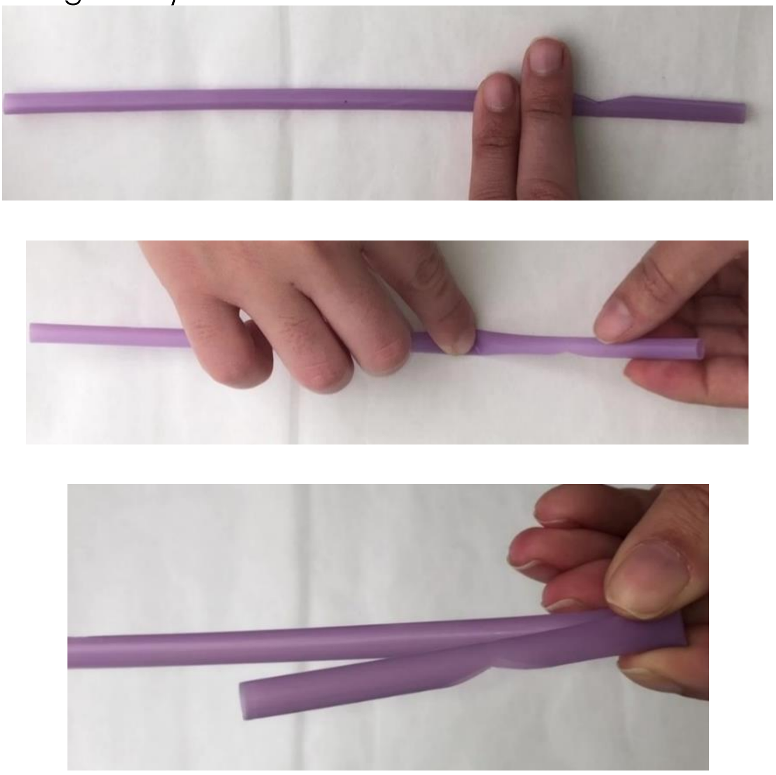


Figure 21: Measuring and folding for the second cut

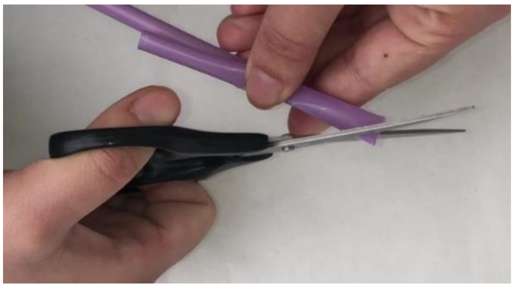


Figure 22: Cutting the straw a second time

Figure 23: The straw with two holes

4. Repeat process 3 one more time. Finally, the straw has three diamond-shaped holes (see Figure 24)

Figure 24: A straw with three holes

5. Repeat the whole process 2-4 with the remaining four straws.
6. Cut the thread into five pieces of about 50 cm each. You can use a ruler for measuring (see Figure 25) or a cubit (i.e. the length from the middle finger's tip to the bottom of the elbow).
7.

Figure 25: Measuring the thread with a ruler

8. Push each thread through one of the straws (see Figure 26).

Figure 26: A Thread pushed through a straw

9. Tie a knot in one end of each piece of thread (see Figure 27). The knot must be at the end of the straw that is closest to the first cut, and it must be big enough so that it will not pass through the straw. You may have to make several overlapping knots.

Figure 27: Making a knot in one end of the thread

10. Take the paper cup and cut away the bottom (see Figure 28). You can start by making a hole in the middle and cut around it until you reach the edge.

Figure 28: Cutting away the bottom of the paper cup

11. Use a pencil or a pen to make five holes around the paper cup equally spaced between them. These holes should be placed halfway up the paper cup (see Figure 29).

Figure 29: Making five equally spaced holes around the paper cup

12. Take the free end of one of the threads. Push it from the outside through one of the holes and finally through the big hole in the bottom of the cup.
13. Use sticky tape to attach the straw to the cup. Pay attention to the following two conditions: (1) Do not glue the thread to the cup. It is essential that the thread can move freely. (2) Locate the straw's three holes in a way so that the straw can freely bend towards the cup (see Figure 30).
14.

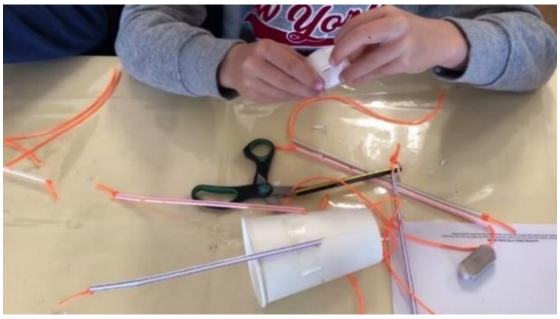


Figure 30: Attaching the straws to the cup

15. Repeat process 11-12 with the remaining four straws (see Figure 31).

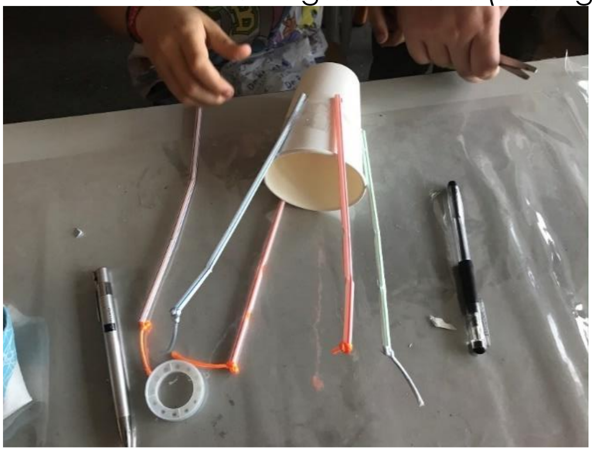


Figure 31: Paper cup with four straws already attached

16. Finally, you completed the Grabbing Hand. By pulling the five threads simultaneously while holding the paper cup, the straws bend towards each other like gabbing fingers (Figure 32).

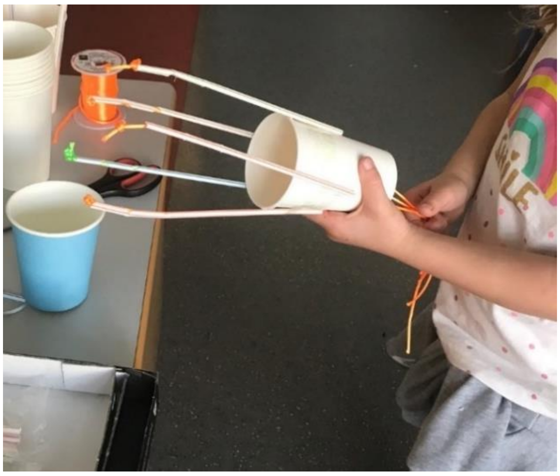


Figure 32: The Grabbing Hand is finished

Making the Grabbing Hand move

Hold the paper cup with one hand and pull all five threads with the other hand. This movement will make the straws to bend like fingers.

Advanced edition of the Grabbing Hand

Teachers developed a more advanced prototype of the Grabbing Hand (see Figure 33). You can watch it in action in the following video:
https://youtu.be/csXTpSfxXV4

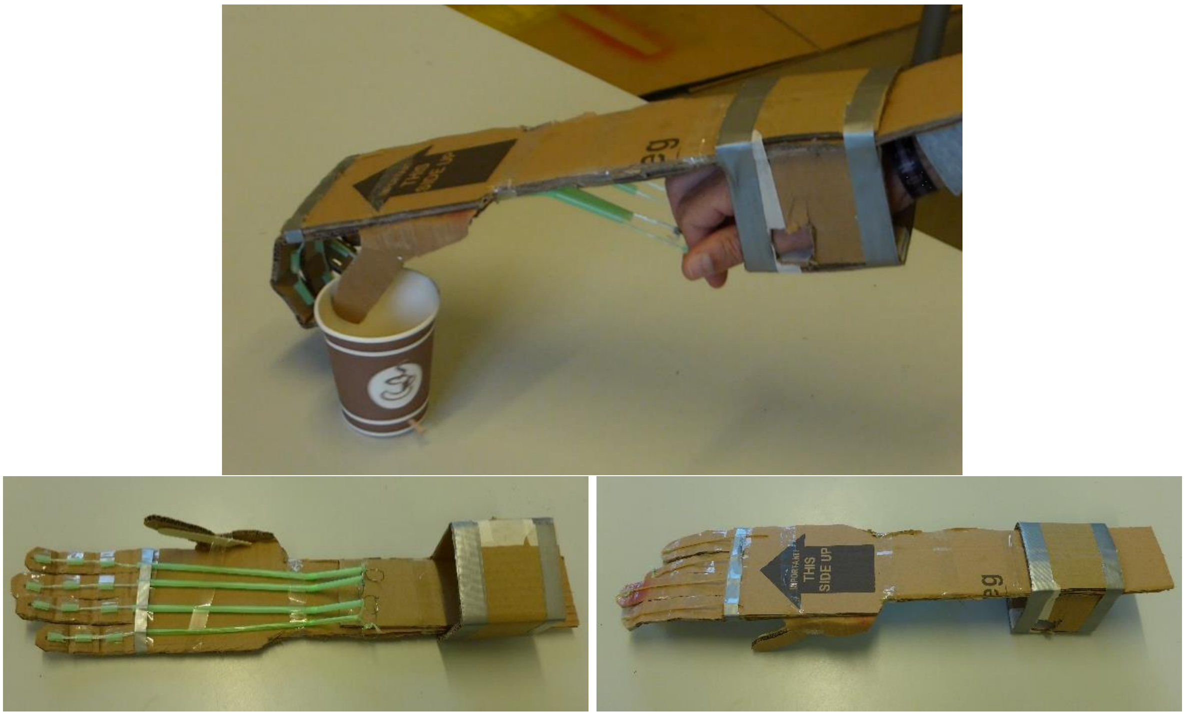


Figure 33: An advanced version of the Grabbing Hand















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03

Events & Workshops

Erasmus days 2020

AutoSTEM project celebrated Erasmus Days 2020 organizing three exhibitions that took place in Coimbra, from 15 to 17 October 2020, in schools were the project has been implemented.

Also, a workshop at Faculty of Psychology and Educational Sciences of the University of Coimbra, 16 October 2020.

Multiplier events

Throughout and at the end of the project some multiplier events were held, with the aim of making the project known and training teachers and educators to implement it.

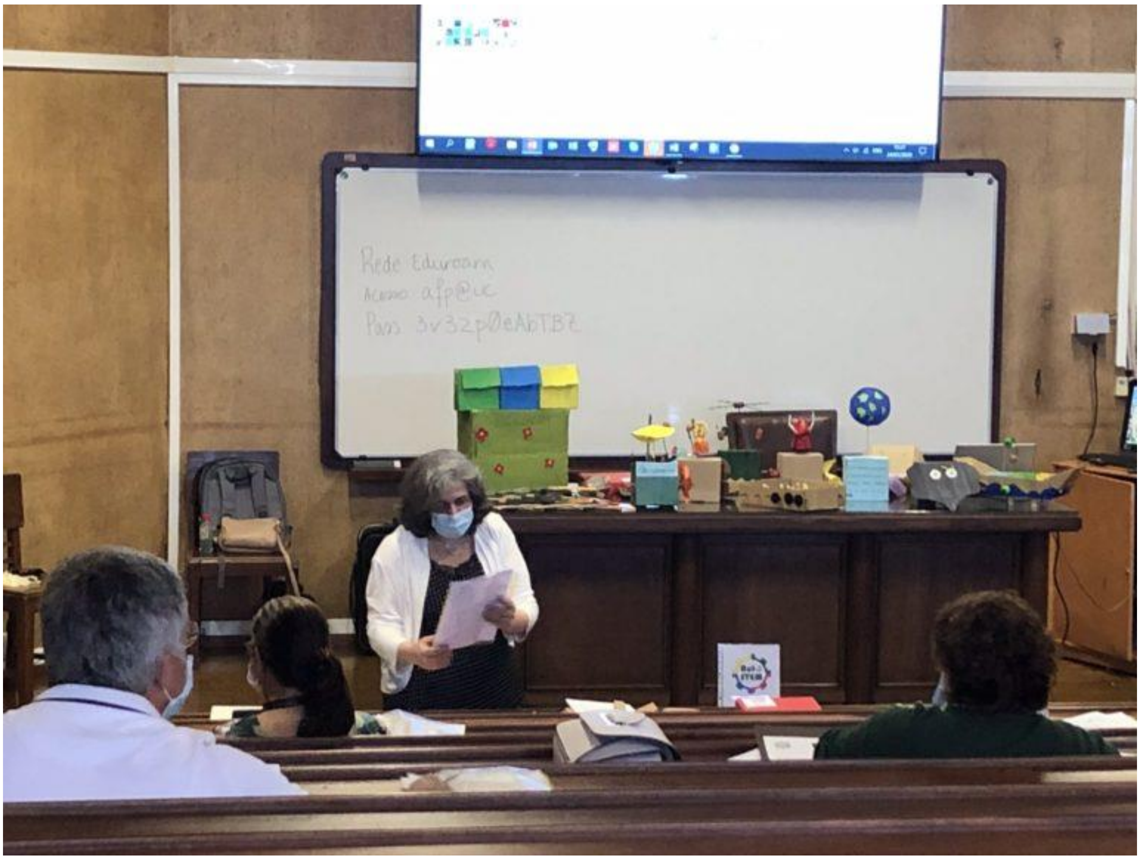
Portugal, Coimbra, 6th & 7th July 2021

Portugal, Coimbra, 6th, 11th & 25th May 2021

Italy, Perugia, 3rd July 2021

Bulgaria, Sofia, 23rd October 2020

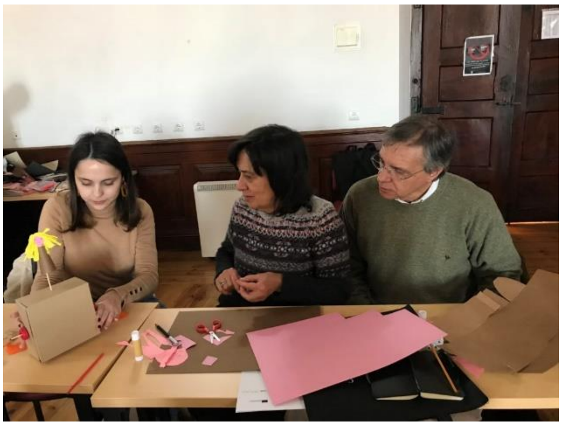
Portugal, Coimbra, 24th July 2020



Portugal, Coimbra, 17th May 2019

Workshops for teachers and educators

Portugal, Coimbra, 8th January 2019



Portugal, Coimbra, 4th April 2019

Portugal, Coimbra 9th October 2019

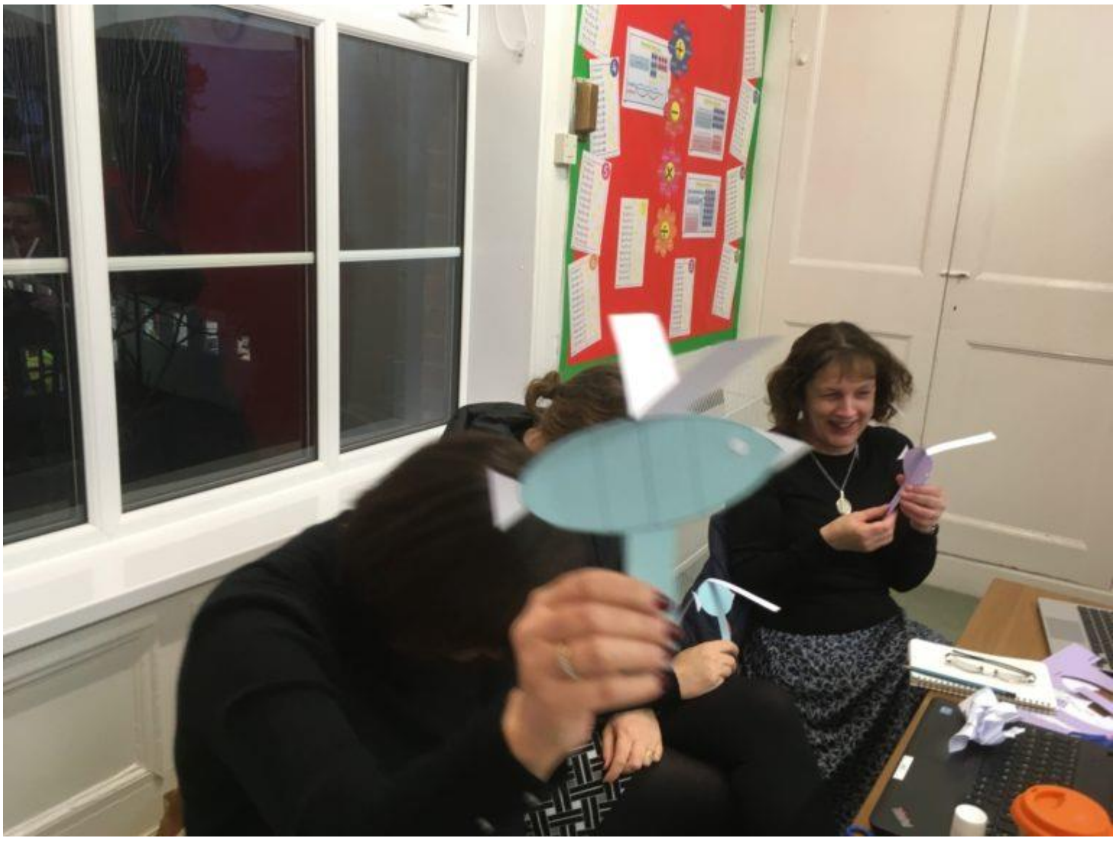




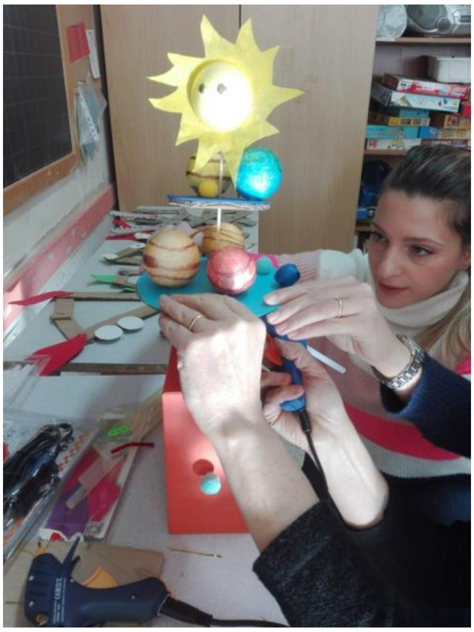

Portugal, Coimbra, 16th October 2019

Norway, 28th November 2019

UK, Chester, 8th January 2020



Italy, Perugia, 14th December 2020



Workshops for children

Bulgaria, Sofia, 20th September 2020









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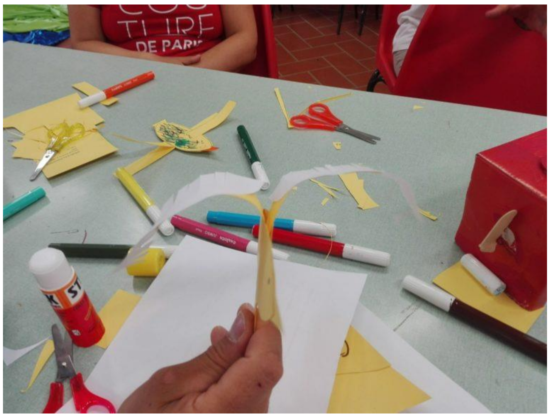
Italy, Perugia, 11th July 2019



Portugal, Coimbra, 10 May 2021

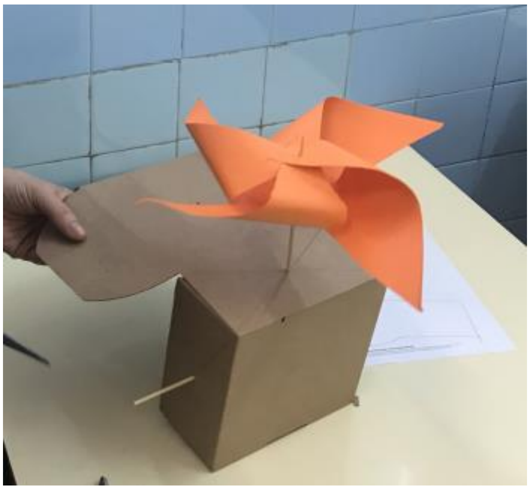
Portugal, Entre os Rios, May 2021

Portugal, Coimbra, 21 January, 3 &10 March 2020

Portugal, Coimbra, 9 March 2020

Portugal, Coimbra, 6 March 2020

Portugal, Coimbra, 13 February 2021



Portugal, Coimbra, 10 February 2020

Portugal, Coimbra, 5 February 2020

Portugal, Coimbra, 24 January & 7 February 2020

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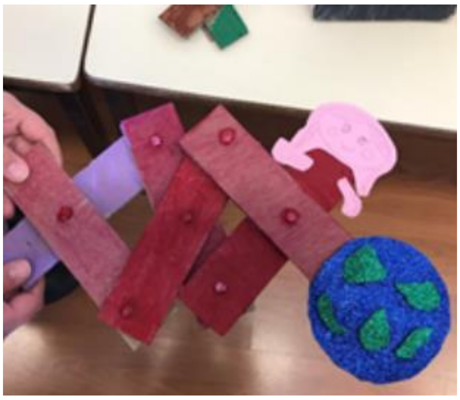
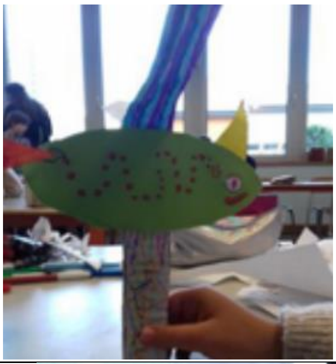
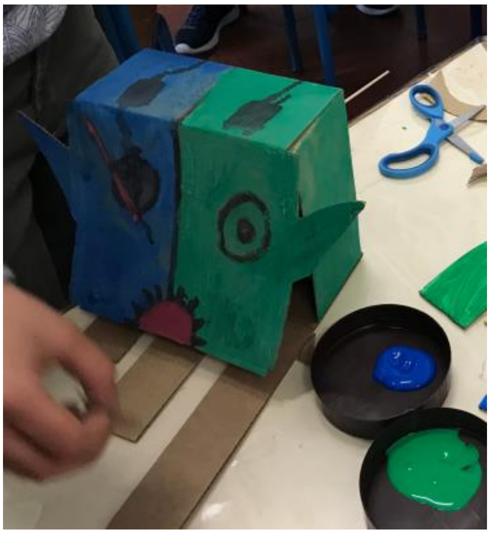
Portugal, Coimbra, 14 January 2020



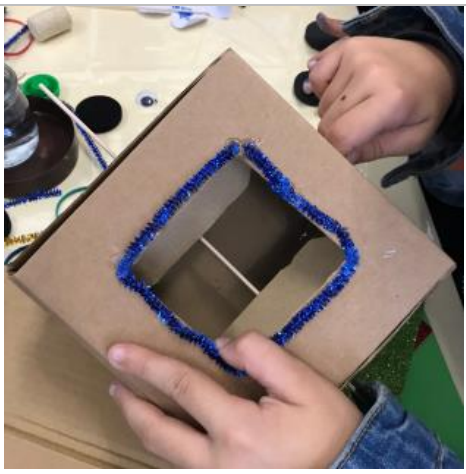
Portugal, Coimbra, 11 December 2019	
	
	
	

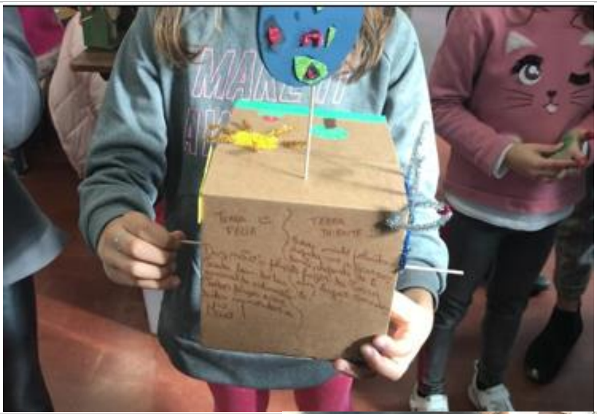
Portugal, Coimbra, 9 December 2019

Portugal, Coimbra, 28 November & 12 December 2019



Portugal, Coimbra, 12 & 21 November 2019





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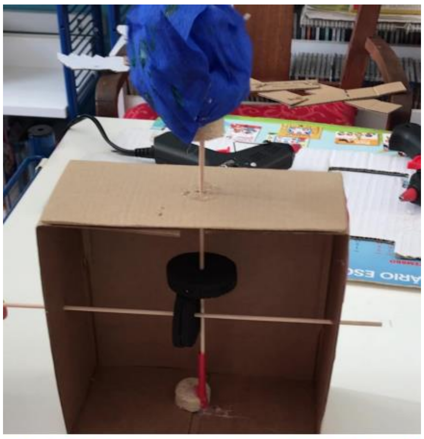
Portugal, Coimbra, 24th October & 7th November 2019



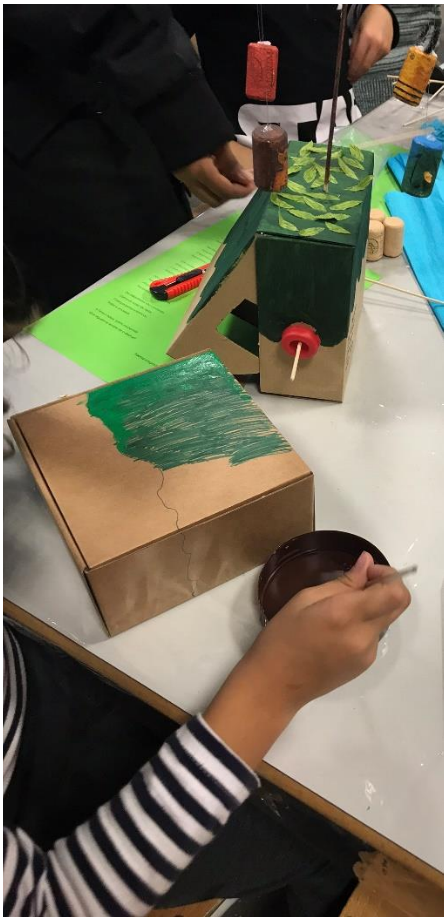
Portugal, Coimbra, 7th June 2019

Visit of the Portuguese National Agency

20th & 21st November 2019

You can check this QR code to watch a video of this day, a workshop with teachers and educators and a short interview about the project.

You can also see some photos of the workshop with children.

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04 Case Studies

Case Studies

The following case studies report on selected findings from the workshops and teacher trainings in the project partner countries. In total, the document contains twelve case studies from the AutoSTEM partners:

Case Studies with the target audience of learners aged 4-12

1. Including an AutoSTEM activity in the annual classroom project 'the garden'- ITALY
2. The Travelling (Jelly)Bird)- ITALY
3. Ulysses' boat – ITALY
4. When two hands are not enough: spontaneous cooperation between children when constructing automata - PORTUGAL

5. Children's engagement and learning in moving toys workshops in primary school – PORTUGAL

6. Integration of the AutoSTEM project in the curriculum. Making an Acrobat- BULGARIA

7. Development of skills for problem detection, choice of work strategy, decision making, activity planning - BULGARIA

8. From guided play to creativity: metamorphoses and stories of a bird – PORTUGAL

9. Using Automata in after-school Science Club - UNITED KINGDOM

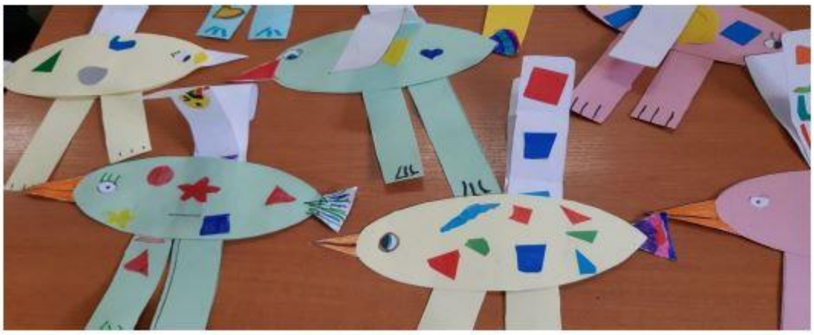
Case Studies with a target audience of teachers
10. Using self-made automata to teach STEM in early childhood teacher education – NORWAY

Case Studies with a target audience of SEN students
11. Outcomes of Automata for STEM activities with cognitive and physically impaired people – ITALY
12. Hearing and touch for seeing: Instructions to promote mental representation of geometric shapes in visual impaired people when constructing a moving toy - PORTUGAL

SCAN THIS QR CODE TO GET ACESS TO THE CASE STUDIES COMPLETE DOUMENT

AutoSTEM

Case Studies



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05

Online Course

Online Course

The *AutoSTEM Online Teachers' Course* is designed as a modular course that teachers and educators working with preschool, kindergarten, and young primary age children can use to understand the project better and learn how to use the project's resources autonomously.

There is no mandatory way to run through the modules. You can access each module autonomously and independently.

1. About the project
1.1 Automata + STEM = AutoSTEM
1.2 The AutoSTEM automata

2. Your turn to make automata

Your turn to make automata

Session 1 – Your first automata

Session 2 – Autonomous construction

3. Pedagogical background

Pedagogical background

3.1 Play based pedagogy & guided play

3.2 The learning cycle

3.3 Reporting & evaluating

3.4 Engagement & motivation

3.5 Spontaneous cooperation

4. STEM content

STEM content

4.1A Science – Physics

4.1B Science - Biology

4.2 Technology

4.3 Engineering - Creativity

4.4 Mathematics

5. AutoSTEM in your classroom

AutoSTEM in your classroom

5.1 Learning objectives

5.2 Lesson planning

5.3 Assessment

Consortium

The project involves a consortium that includes University of Coimbra, Portugal, coordinator, Eureka, Italy, Kindersite, UK, 32 School "St. Kliment Ohridski" Bulgaria, Queen Maud University College, Norway. Schools that want to implement the project and pilot the resources produced will be associated partners.

Partners:

Associated Partners:

The AutoSTEM team would like to thank all the teachers and children involved in the workshops, training and case studies, and wishes all those interested in STEM subjects meaningful and playful learning when using the AutoSTEM ideas and project materials.