Full STEAM

STEAM activities : Exploring Nature Outside the Classroom

Co-funded by the European Union

STEAM activities - Exploring Nature Outside the Classroom

Full STEAM

TECHNICAL SHEET

FullSTEAM: an approach to science teaching in non-formal settings

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CONTENTS

Introduction

In a world where people, cultures and knowledge are increasingly connected, it is a fundamental need for schools to function more and more effectively as a catalyst for rich learning experiences in which different disciplines are integrated to answer the questions that arise in students' daily lives. Students, who are generally used to formal learning contexts (in classrooms and/or laboratories), have a lot to gain from designing and implementing projects in other equally formative (non-formal) contexts. Learning science takes on a whole new meaning when you realize that the various sciences (mathematics, physics, chemistry, geology and biology) complement each other to provide answers to the problems we face. Finding answers to these questions can be made easier by using the technological tools available, with methodologies that mimic those used in engineering. And based on these areas of knowledge, there is also the development of artistic vision that can permeate projects, enriching them with the potential to make them more comprehensive and engaging learning experiences.

The set of activities presented here are mainly aimed at students in the second and third cycles of basic education, as it is considered that science teaching in these cycles has gradually moved away from pedagogical practices that favour direct contact with nature or other contexts that complement the classroom (such as museums and nature interpretation centers). It should also be noted that interdisciplinary projects, although valued in the context of the pedagogies recommended by the government, are often difficult to plan and, consequently, to implement. Therefore, the didactic proposals presented here could serve as a basis for organizing curricular activities.

This manual presents a sequence of projects that always include a learning phase in non-formal contexts, such as forests, gardens, beaches, urban environments and museums. However, in order to maximize their didactic potential, activities developed in these contexts require prior preparation and subsequent exploration and evaluation. Therefore, each proposal made throughout this manual includes a set of suggestions aimed at facilitating the work of the teachers involved in implementing each of the activities presented. To this end, the structuring topics for organizing the work are included on an initial page, and on subsequent pages there are more or less detailed descriptions (depending on the degree of openness desired) of the various steps involved in each didactic path. Since the activities have been designed and implemented by experienced teachers, where necessary, some suggestions are also provided to help clarify some of the options proposed. It should be noted that STEAM approaches, being interdisciplinary, will involve teachers from different disciplines who, naturally, may not master all the knowledge and skills needed to implement each project. Therefore, these suggestions could be fundamental in reinforcing the security of each of the teachers involved.

With the aim of facilitating teachers' work, this manual, developed as part of the "Full STEAM" project (Ref 2021-1-PT01-KA220-SCH-000030430), is the result of a collection of activities that reflect the creativity and experience of teachers from four different nationalities: Finland, Portugal, Iceland and Latvia. Although the proposed activities reflect the diversity of ways of teaching science, resulting from the teachers' training contexts (initial and continuing) and the curricular requirements inherent in the educational policies of each country, they are all based on the pedagogical principles of active learning, centered on didactic approaches in which the integration of STEAM (Science, Technology, Engineering, Art and Mathematics) skills is promoted.

→ Water Cycle Simulation ←

Lesson Context Lake or river **Grade (age group)** 12 – 15 years old **Activities Duration** **Outside:** 1,5 hours **Inside:** 1,5 hours	**STEAM Goals** **SCIENCE:** physics and phase/state evolution **TECHNOLOGY:** use of diverse tools **ENGINNEERING:** planning, calculating, projecting **ARTS:** construction of models (water cycle and natural environment) **MATH:** data collecting and treatment

Essential Questions	**List of Pre-required Concepts**
✓ How does the water cycle contribute to our environment? ✓ What impact does water quality have on ecosystems? ✓ How can we model and predict water flow? **Learning Goals / Objectives** 1. To demonstrate understanding of the water cycle and water conservation. 2. To analyze and improve water quality using simple engineering solutions. 3. To express water-related scientific concepts.	Basic understanding of states of matter (solid, liquid, gas). Introduction to environmental science, specifically ecosystems and pollution. **Preparation and Space Requirements** Classroom space for discussions and art projects. Access to outdoor area for water cycle simulation and water collection. Computer lab for research and data analysis activities. **Required Materials** Digital devices (tablets or laptops) with internet access. Art supplies (paints, brushes, canvas). Basic water testing kits for pH, nitrate, and phosphate. Materials for building filtration systems (charcoal, sand, gravel, cotton, plastic bottles). Worksheets and educational handouts.

Procedures

The main objective of this activity is to create a working model that simulates the water cycle, allowing students to observe the processes of evaporation, condensation, precipitation, and collection in real-time. Students will create small "ecosystems" using plastic bags, soil, water, and plants to observe evaporation, condensation, and precipitation.

Setup Instructions:

Preparation: Before the activity, gather all materials. Prepare a few examples to demonstrate to students.

Activity Phases:

Phase 1: Construction

- **Time**: «30 minutes
- **Process**:
  - Each student or group gets a ziplock bag.
  - Use a permanent marker to label the different parts of the water cycle on the bag (e.g., Clouds, Lake).
  - Place a small amount of soil at the bottom of the bag to simulate the ground.
  - Add small plants or grass clippings to simulate vegetation.
  - Pour a small amount of water mixed with blue food coloring into the bottom of the bag to represent a body of water.
  - Seal the bag tightly.

Phase 2: Initiation of the Water Cycle

- **Time**: 5 minutes
- **Process**:
  - Place the bag in a sunny spot or under a heat lamp.
  - Ensure the bag is positioned so that sunlight can heat it effectively.

Phase 3: Observation

- **Time**: 20 minutes
- **Process**:
  - Students observe changes in their water cycle bags.
  - They should notice water evaporating from the surface of the "lake", condensing into "clouds" on the top part of the bag, and eventually "raining" down as it condenses into larger droplets.

Phase 4: Discussion and Documentation

- **Time**: 15 minutes
- **Process**:
  - Students discuss what they observed in their individual simulations.
  - Encourage them to document the changes using either written descriptions or sketches in their science notebooks.
  - Discuss why the water cycle is important for ecosystems and human activity.
-

Follow-Up:

After the activity, students can research how changes in climate conditions might affect the water cycle in different ecosystems, promoting a deeper understanding of environmental science. This

activity also sets a foundation for further exploration into topics like climate change, weather patterns, and ecological conservation.
This activity provides a hands-on learning experience that helps students visually and practically understand the dynamics of the water cycle.

Teacher´s Notes

This activity involves simulating the water cycle using plastic bags to demonstrate evaporation, condensation, precipitation, and collection. To enhance the learning experience, consider conducting part of this activity outdoors, especially for the observation phase.

Choose a sunny day for the activity as it relies on the heat from the sun to accelerate the evaporation process. A sunny day will provide the best results for observing the water cycle in action. If conducting the activity in cooler months, you might need to use a heat lamp indoors to simulate the warming effects of the sun.

When taking the activity outdoors, ensure students are prepared for the weather with appropriate clothing and sun protection. Remind students about the importance of staying hydrated and applying sunscreen. Although the materials used are generally safe, remind students to handle the plastic bags and other components carefully to avoid tears or spills.

Use diagrams and real-time examples to explain each phase of the water cycle before starting the activity. Visual aids can help students visualize processes that take place on a global scale. Encourage collaboration by having students work in small groups to set up their simulation bags, fostering communication and problem-solving skills. Discuss the impact of the water cycle on local and global environmental issues, such as climate change and water scarcity. Explain how evaporation and precipitation contribute to weather patterns and climate. If possible, leave the setups for a couple of days, and have students record daily observations, noting any changes. This extended observation can lead to a deeper understanding of the slow processes of the natural water cycle.

After observing the water cycle, have students create artistic representations of the cycle. This could include drawings, models, or even digital animations, which can help consolidate their understanding in a creative format. Encourage students to compare their simulated water cycle with real-world systems by researching different climates around the world. How does the water cycle look in a rainforest versus a desert?

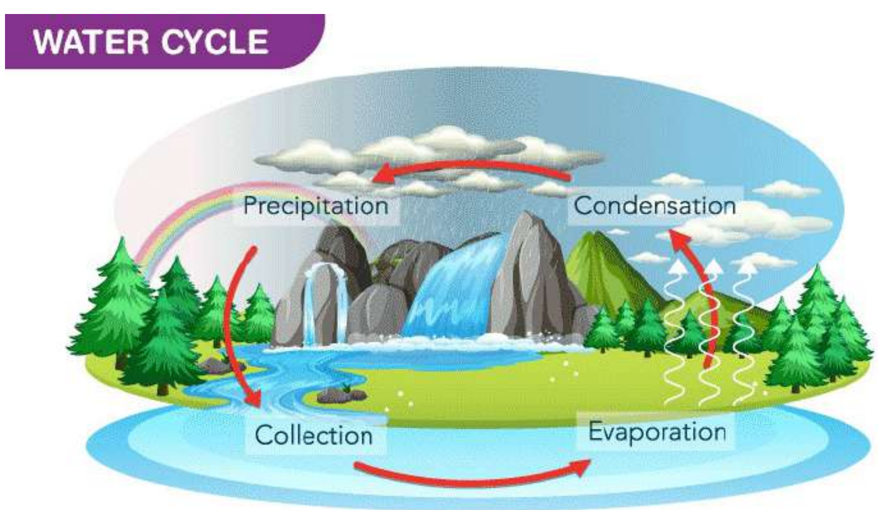

Figure 1 - Water cycle

Figure 2 - Ziplock bag with the layers

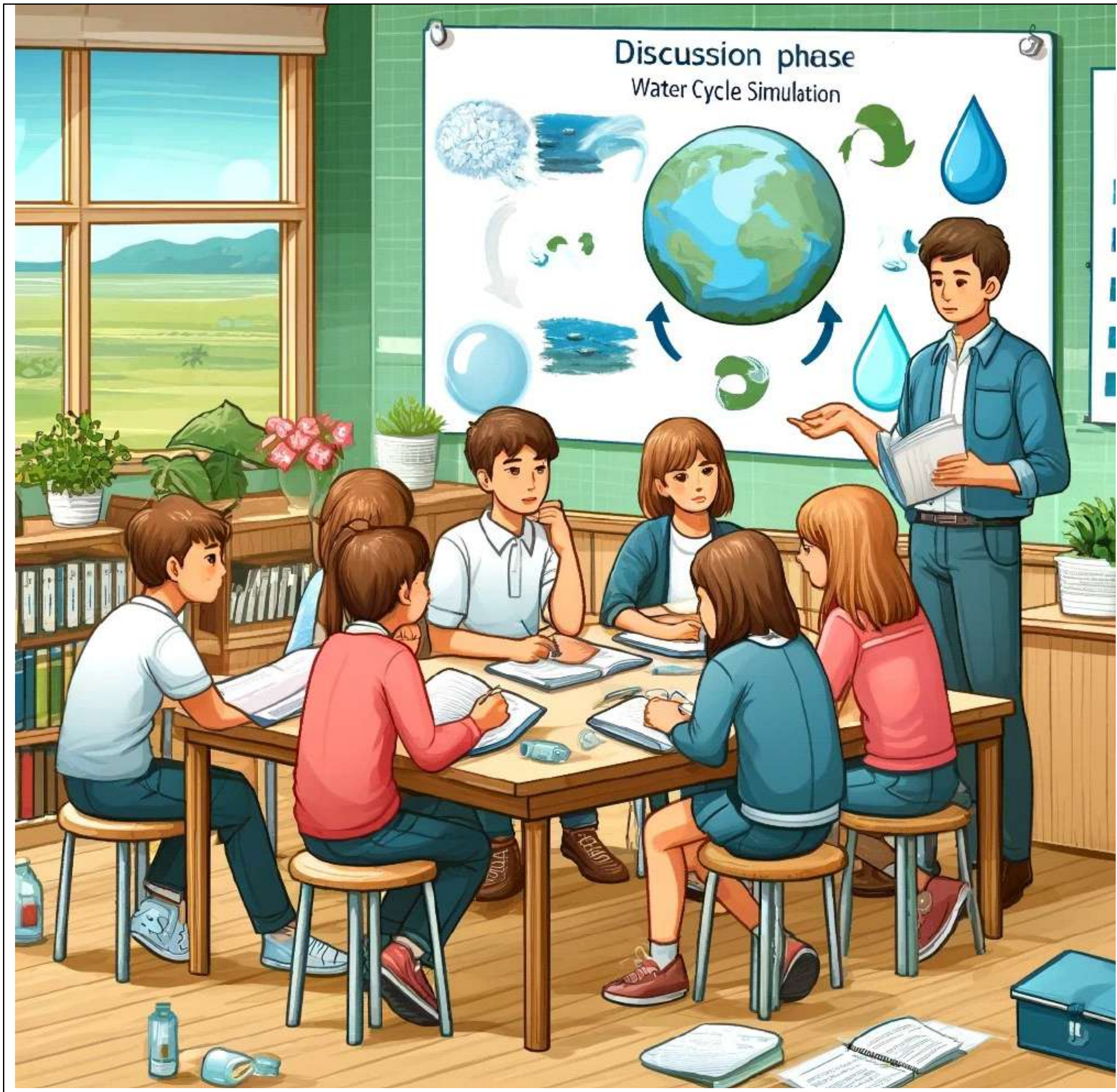

Figure 3 - Water cycle group discussion

Pedagogical References

https://www.sciencebuddies.org/blog/teach-water-cycle-lessons

https://www.tandfonline.com/doi/abs/10.1080/09500693.2015.1080880 Vo, T., Forbes, C. T., Zangori, L., & Schwarz, C. V. (2015). Fostering third-grade students' use of scientific models with the water cycle: Elementary teachers' conceptions and practices. International Journal of Science Education, 37(15), 2411-2432.

Student´s Worksheet

→ Water Cycle Simulation ←

Name: ______________________________ **Date:** _______________

Objective:
To observe and understand the processes of evaporation, condensation, precipitation, and collection in the water cycle.

Part 1: Construction

Instructions:
1. Fill the clear plastic ziplock bag with two cups of soil.
2. Add water until the soil is moist, not flooded.
3. Place a few small plants or grass clippings in the bag.
4. Seal the bag and hang it in a sunny spot or under a heat lamp.

Questions:
1. What does the water represent in this model?
2. Why is soil necessary for this simulation?

Observations:
- Note down how you set up your bag:

Part 2: Initiation

Instructions: Observe your bag as it starts to warm up. Look for changes in the water's state.

Questions:
1. Describe what happens to the water when the bag is heated.
2. What causes the water to change its state?

Observations:
- Draw a simple sketch of your bag in this phase:

Part 3: Observation

Instructions: Watch for water droplets forming on the inside of the bag and eventually "raining" down.

Questions:
1. Explain how condensation is forming inside your bag.
2. What does the precipitation look like in your model?

Observations:
- Draw where the condensation and precipitation occur inside your bag:

Part 4: Discussion and documentation
Instructions: Discuss your findings with your group and document the final results.

Questions:

1. How does this simulation relate to the real water cycle?
2. What did you learn about the importance of the water cycle?

Summary of discussion:

- Write down key points from your group discussion:

→ Water Usage Calculation ←

Lesson Context
Local park or school garden

Grade (age group)
10 – 13 years old

Activities Duration
Outside: 1,5 hours
Inside: 1 hours

STEAM Goals

SCIENCE: Understanding water flow and conservation
TECHNOLOGY: Utilizing tools for measurement and data collection
ENGINNEERING: Designing efficient water usage systems
ARTS: Creating visual representations of data
MATH: Calculating and analyzing water usage data

Essential Questions
- ✓ How can we measure and calculate water usage accurately?
- ✓ What impact do different water conservation strategies have on overall water usage?
- ✓ How can mathematical analysis help us understand and improve water conservation efforts?

Learning Goals / Objectives
1. To measure and calculate actual water usage.
2. To analyze the efficiency of various water conservation strategies.
3. To understand the broader environmental impact of water conservation

List of Pre-required Concepts
Basic understanding of units of measurement (liters, minutes).
Introduction to environmental science, specifically water conservation.

Preparation and Space Requirements
An outdoor area with access to a garden hose and water supply.
Classroom space for discussions and analysis.

Required Materials
Measuring cups (1-liter and 500-milliliter)
Timers or stopwatches
Garden hose with a flow nozzle
Buckets or large containers (10 liters or more)
Graph paper or graphing software
Worksheets with data recording tables
Calculators
Water conservation materials (e.g., low-flow nozzle, hose timer)

Procedures

The main objective of this activity is to measure actual water flow rates and apply mathematical calculations to analyze water usage and conservation strategies. Students will work in groups to measure water flow, apply conservation techniques, and analyze the data collected.

Setup Instructions:
Preparation: Before the activity, gather all materials and set up measurement stations outdoors with garden hoses and containers.

Activity Phases:

Phase 1: Introduction and preparation

- **Time:** 10 minutes
- **Process:** Introduce the objective of measuring actual water flow and applying mathematical calculations. Explain the importance of water conservation and how this activity simulates real-life water usage scenarios. Distribute worksheets and explain how to use the measuring equipment.

Phase 2: Measuring water flow

- **Time:** 20 minutes
- **Process:** Students work in small groups to measure the water flow rate from a garden hose. Using the hose with a flow nozzle, students fill a 1-liter measuring cup and time how long it takes to fill up. Record the time taken and calculate the flow rate (liters per minute). Repeat the measurement three times and calculate the average flow rate.

Phase 3: Applying water conservation strategies

- **Time:** 20 minutes
- **Process:** Students explore water conservation strategies, such as using a low-flow nozzle and setting a timer for controlled watering. Measure the flow rate using the low-flow nozzle and compare it to the standard nozzle. Use the recorded data to calculate potential water savings by applying these strategies.

Phase 4: Analysis and calculation

- **Time:** 20 minutes
- **Process:** Students use their recorded data to calculate total water usage for various activities, such as watering a garden for 10 minutes. Calculate the water savings achieved by using conservation strategies and express these savings as percentages. Create graphs or charts to visually represent the differences in water usage with and without conservation strategies.

Phase 5: Presentation and discussion

- **Time:** 15 minutes
- **Process:** Each group presents their findings to the class, discussing the effectiveness of the conservation strategies they tested. Engage in a class discussion about the broader implications of water conservation and how individual actions contribute to environmental sustainability.

Teacher´s Notes

This activity involves practical measurement and mathematical analysis to help students understand water usage and conservation. Choose a day with good weather for accurate measurements and ensure students are prepared for outdoor activity with appropriate clothing and sun protection. Emphasize the importance of accurate measurements and calculations for reliable data. Encourage students to think critically about the impact of their conservation strategies on both water usage and the environment. Discuss how these small changes can contribute to larger environmental sustainability efforts

Figure 1 - Example of outdoor activity

Figure 2 – Illustration of the analysis and calculation phase

Figure 3 - Illustration of the presentation and discussion phase

Pedagogical References

https://www.teachengineering.org

LaDue, N. D., Ackerman, J. R., Blaum, D., & Shipley, T. F. (2021). Assessing water literacy: Undergraduate student conceptions of groundwater and surface water flow. *Water*, *13*(5), 622.

Student´s Worksheet

→ Water Usage Calculation ←

Name: ______________________________ **Date:** _______________

Objective:
To measure and calculate actual water usage and analyze the effectiveness of different water conservation strategies.

Part 1: Measuring water flow
Instructions:
1. Use the garden hose with the standard nozzle to fill a 1-liter measuring cup.
2. Time how long it takes to fill the cup and record the time.
3. Repeat the measurement three times and calculate the average flow rate.

Data recording table:

Trial	Time (seconds)	Flow Rate (liters/minute)
1		
2		
3		
Average Flow Rate:		

Part 2: Applying water conservation strategies
Instructions:
1. Use the low-flow nozzle to fill the 1-liter measuring cup and record the time taken.
2. Calculate the flow rate with the low-flow nozzle.
3. Compare the flow rates and calculate the potential water savings.

Data recording table:

Nozzle Type	Time (seconds)	Flow Rate (liters/minute)
Standard		
Low-Flow		
Water Savings:		

Part 3: Analysis and calculation
Instructions:
1. Calculate the total water usage for watering the garden for 10 minutes with each nozzle type.
2. Express the water savings as a percentage.
3. Create graphs to visually represent the differences in water usage.

Questions:
1. Which nozzle type is more efficient in conserving water?
2. How much water can be saved over a week or month by using the low-flow nozzle?

Part 4: Presentation and reflection

Instructions:

1. Prepare a brief presentation to share your findings with the class.
2. Reflect on the impact of water conservation strategies on the environment.

Reflection:

- Write a short paragraph on how individual actions can contribute to water conservation and the broader environmental impact.

→ The Pollination Game ←

Lesson Context
Forest or garden.
Group work

Grade (age group)
12 – 15 years old

Activities Duration
Outside: 1 hour
Inside: 2 hours

STEAM Goals
SCIENCE: botany and ecology
TECHNOLOGY: use of diverse tools
ENGINNEERING: planning, calculating, projecting
ARTS: construction of models (pollinators and flowers)
MATH: data collecting and treatment

Essential Questions
- ✓ Which are the species that live in the forest/garden?
- ✓ How many pollinators were identified?
- ✓ What is the relation between the anatomy of the flower and the anatomy of the pollinator?
- ✓ What is the best design to build models of flowers and their pollinators, maximizing the efficiency of the pollinating process?

Learning Goals / Objectives
1. Identifying the species of the living organisms found in the garden.
2. Documenting which pollinators correspond to which flowers.
3. Researching about flowers and pollinators.
4. Establishing relations between the anatomy of flower and the anatomy of the corresponding pollinator.
5. Using the information collected to design and build models of flowers and their pollinators.
6. Testing the models.

List of Pre-required Concepts
Plant anatomy and reproduction.
Pollination and multiple pollinators.
Co-evolution.
Data collecting and treatment.

Preparation and Space Requirements
The visit to the garden should be scheduled when flowers are blooming, for maximum diversity of plants and their pollinators.
Check the garden space for availability and security.
If possible, ask students to bring a few clean items obtained in their domestic litter.

Required Materials
Mobile phone and app to identify animals and plants.
Worksheet (one per student).
Random materials obtained in the domestic litter.
Glue
Cheese balls.
Stationary materials usually used in artisanal handicraft´s projects.
Timmer and scale.

Procedures

The the main objective of this project is to build models of flowers and pollinators, using a STEAM approach.
This project will be divided in three phases: Visiting the forest/garden; Designing, building and testing the models; Pollination Game.

Visiting the forest/garden
Visit a forest/garden to study biodiversity in general, identifying plant species and the corresponding pollinators.

Designing, building and testing the models (flower-pollinator)
Researching about flowers and pollinators; include different groups of pollinators besides insects (spiders, lizards, birds, bats).
Discuss co-evolution to explain the complementary anatomies of flowers and their pollinators.
Design and build, with the materials available, the flower model and the pollinator model. Consider the fact that during the pollination game it will be important that the pollinator gathers the most pollen possible in the shortest time.
Use crushed up cheese balls to simulate the pollen.

Pollination Game
The objective of this game is to use the models created by the students to gather as much "pollen" as possible in the shortest time.
For that, it is important that all the competitors have access to the same amount of "pollen". One way if doing that is to use the same number of cheese balls per gamer, in each game. In the first round of the game each gamer uses his flower and its pollinator. In the second round of the game, flowers and pollinators will be unpaired.
Use the worksheet to write down and compare the times and amounts of "pollen" obtained in the first and second rounds. To measure the quantities of "pollen" students can use a scale.
Discuss the results.

Teacher´s Notes

This project involves visiting a forest or a garden. To do that, it is important to choose the best season to find multiple flowering plants, because we need as many different pollinators as possible.

Review the safety rules to observe on a field trip.

During their research students should be encouraged to find different examples of pollinators; for example, besides insects, reptiles, birds and mammals can also be pollinators (figure 1). It is also important that students pay close attention to the anatomy of flowers and the anatomy of their pollinators. Attention to these anatomical characteristics will help the students to plan the models that they have to design and built.

In some cases, co-evolution may explain the development of odd anatomical characteristics both in the flower, as well as in the animal. This process should be behind the options followed when designing the models. Figure 2 shows examples of a few models built by students.

Instead of building models that resemble real flowers and real pollinators, students may create flowers and pollinators that are imaginary. In this case, is still important that the anatomical complementarity be respected so that the students can also model the process of co-evolution.

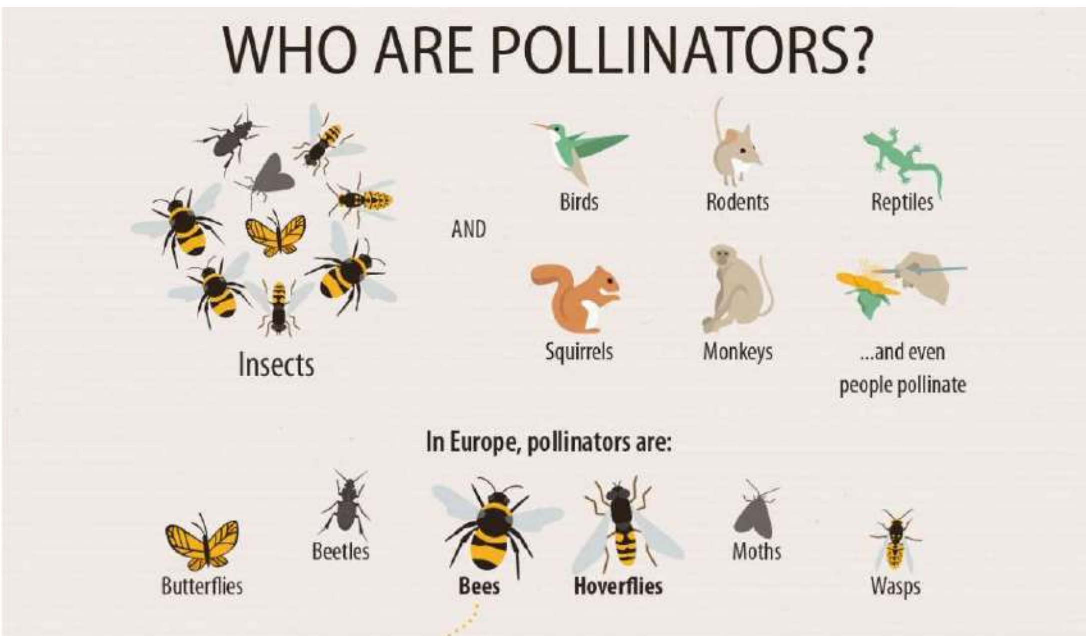

Figure 1> Examples of pollinators.

Figure 2> Examples of flower models and pollinators models.

Pedagogical References

https://www.europarl.europa.eu/topics/en/article/20191129STO67758/what-s-behind-the-decline-in-bees-and-other-pollinators-infographic (viewed on 30/04/2023)

https://www.wnps.org/blog/coevolution-and-pollination (viewed on 30/04/2023)

Capraro, R., Capraro, M., Morgan, J. (2013). *STEM Project-Based Learning*. Rotterdam: Sense Publishers.

Student´s Worksheet

Name - ____

→ The Pollination Game ←

This project involves visiting a forest or a garden to observe and study flowers and their pollinators. Use the information bellow to design your models to play the game.

Analyse figure 1 and review the typical structure of a hermaphrodite flower and the process of pollination.

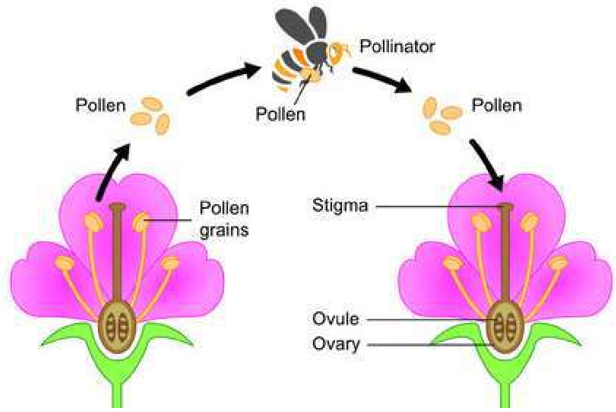

Figure 1> Pollination.

Coevolution and Pollination

The coevolution of flowering plants and their animal pollinators presents one of nature's most striking examples of adaption and specialization. It also demonstrates how the interaction between two groups of organisms can be a font of biological diversity.

Flowering plants are adapting to their pollinators, which are in turn adapting to the plants. Each of the participating organisms thus presents an evolutionary "moving target". The relationship between these distantly related *taxa* is symbiotic in the broad sense that characterizes life and that gives rise to the high degree of complexity and diversity that we perceive in nature.

If the rule in nature is "whatever works," our observations are that many things work, and that what works keeps changing. Our understanding is that each species evolves to its own benefit; in coevolution, these two self-interests collide, and remarkable things happen.

Coevolution can be complex, involving the interactions of numerous characteristics, or in some cases, it can be simpler, such as when the back and forth pressure favoring longer floral tubes and longer insect tongues or bird beaks can lead to extremes of each. Hummingbird beaks and the long-tubular flowers on some of the plants they pollinate are often used as examples.

Charles Darwin described an interesting case of pollinator-flowering plant coevolution in Madagascar: the star orchid, *Angraecum sesquipedale*, has foot-long spurs, with the nectary at the tip. In 1862, when Darwin examined this orchid, he predicted that a long-tongued moth would be found that pollinated it; no moth with that extreme length of tongue was known at the time.

Then, in 1903, he was proven correct when a long-tongued moth, *Xanthopan morganii praedicta* was discovered (figure 2). It was so-named because its occurrence had been predicted.

Adapted from: **https://www.wnps.org/blog/coevolution-and-pollination, by Joe Arnett**

Figure 2> ***Star orchid and long-tongued*** **moth.**

Pollinators and flower types

The table* below presents some pollinators in and the plant characteristics that have coevolved with them. These are generalizations, and you will see many exceptions if you look carefully.

Pollinator	Pollinator characteristics	Typical flower types	Example plants
Hummingbirds	Long bills, highly developed ability to perceive red, high metabolic needs, ability to hover.	Red or reddish flowers, long broad tubes, often pendent or horizontal, large nectar rewards.	Honeysuckle, currants, salmonberry, columbine.
Bees, including bumblebees, honey bees, and solitary bees	Perception of bilateral symmetry, blue and yellow colors and ultraviolet light; dexterity at manipulating plant parts, ability to strongly vibrate by buzzing, need for both nectar and pollen.	Flowers with bilateral symmetry, often in shades of blue or yellow, nectar guides in the ultraviolet spectrum, flowers that require dexterity to open, sometimes bell-shaped flowers.	Lupines, clovers, orchids, penstemons, ericads (buzz pollination).
Butterflies	High nectar needs, require sunlight for flying, long tongues	Bright colors, often tubular flowers, nectar rewards.	Phlox, milkweed, sunflower family.
Moths	Often fly at night, sensitive to fragrance, ability to hover.	White or pale flowers which may open at night and close during the day, releasing fragrances, pendant or horizontal flowers	Catchfly, stickseed, wild tobacco.
Flies, including mosquitoes	Attracted to odors (sometimes unpleasant to humans), generalists.	Generally open accessible flowers, often releasing odors flies find attractive.	Many composites, sandworts, mustards, lomatiums.

[*] Adapted from: **https://www.wnps.org/blog/coevolution-and-pollination, by Joe Arnett**

The Pollination Game Data

Collect the data during the game on the chart bellow:

ROUND 1			
TEAM	**MODELS**	**TIME**	**amount of "pollen" (g)**
A	Flower A Pollinator A		
B	Flower B Pollinator B		
C	Flower C Pollinator C		
D	Flower D Pollinator D		

ROUND 2			
TEAM	**MODELS**	**TIME**	**amount of "pollen" (g)**
A	Flower A Pollinator B		
B	Flower B Pollinator C		
C	Flower C Pollinator D		
D	Flower D Pollinator A		

CONCLUSIONS

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→ Earth Art With a Hidden Message * ←

** Inspired on an activity presented in the Eelliðaárstöð Power Plant (Iceland)*

Lesson Context
Forest or garden.
Group work

Grade (age group)
12 – 15 years old

Activities Duration
Outside: 2 hours
Inside: 2 hours

STEAM Goals
SCIENCE: ecology
TECHNOLOGY: computer language
ENGINNEERING: planning, calculating, projecting
ARTS: artwork installation
MATH: gathering and organizing data; finding patterns

Essential Questions
- ✓ Which are the species that live in the garden?
- ✓ Which rocks and minerals can be found?
- ✓ What is a computer network?
- ✓ How do computers communicate?
- ✓ What is the binary code?

Learning Goals / Objectives
1. Identifying the species of the living organisms found in the garden.
2. Identifying minerals and rocks.
3. Understanding the use of the binary code.
4. Designing an art installation made with natural objects collected in the forest/garden.
5. Include a binary code massage in the art installation.

List of Pre-required Concepts
Root, stem, leaf, flower.
Identification of plants and animals present in the forest/garden.
Identification of rocks/minerals present in the forest/garden.

Preparation and Space Requirements
Prepare the visit to the forest/garden.
Check the forest/garden space for availability and security.
After finishing their projects, students should take pictures because they might have to disassemble their art installations.

Required Materials
Field guide to identify plants and animals.
Worksheet (one for each student), mobile phone and some natural materials to build the art installation.

Procedures

With a STEAM approach, the main objective of this project is to build an art installation that includes a message written in computers' binary code.
This project will be divided in three phases: planning the art installation; visiting the forest/garden; building the art installation.

Planning the art installation
Explain what the binary code is and how it is used as a computer language.
Use the worksheet to stimulate students to practise the use of binary code.
Present the project by explaining how students have to gather natural materials to use as "zeros" (0) and "ones" (1), so that they can write their messages and at the same time build their art installations.
Allow time for organizing how many items will be needed to write the message (use the worksheet).
Become aware, through brief research, of the characteristics of Earth Art.

Visiting the forest/garden
Visit a forest/garden and study the biodiversity in general, identifying the species found.
Collect a group of natural materials to represent "ones".*
Collect a group of natural materials to represent "zeros".*

[*] Use the worksheet to gather the exact number of items needed.

Building the art installation
Allow for creativity.

Teacher´s Notes

This project involves visiting a forest or a garden to gather materials to build an art installation. It is very important to be careful and respectful when collecting natural materials. Make sure that the students know exactly what that may and may not collect.

Review the safety rules to observe on a field trip.

How computers communicate? Computers connect to other computers with cables and through networks. Binary code is the language to communicate information between computers, communication devices and many modern technologies. A binary code represents text, computer processor instructions, or any other data using a two-symbol simple system. The two-symbol used is often zero (0) and one (1) from the binary number system. When sending information through the fibre optic cable, the data is translated to binary code and the computers send extremely fast flickering lights to the recipient where:

- 1 (one) represents light;
- 0 (zero) represents no light.

Pedagogical References

https://www.youtube.com/watch?v=RGU5HzgPyUo (viewed on 30/04/2023)
https://tryengineering.org/teacher/lesson-plans/give-binary-a-try/ (viewed on 30/04/2023)
Capraro, R., Capraro, M., Morgan, J. (2013). *STEM Project-Based Learning*. Rotterdam: Sense Publishers.

Student´s Worksheet

Name: ____

→ Nature Artwork with a Hidden Message ←

This project involves visiting a forest or a garden to gather materials to build an art installation. At the same time, you have to include a hidden message in your art installation. To write that message you have to apply a language that computers use to communicate amongst themselves.
But how do computers communicate? Computers connect to other computers with cables and through networks. Binary code is the language to communicate information between computers, communication devices and many modern technologies. A binary code represents text, computer processor instructions, or any other data using a two-symbol simple system. The two-symbol used is often zero (0) and one (1) from the binary number system. When sending information through the fibre optic cable, the data is translated to binary code and the computers send extremely fast flickering lights to the recipient where:

- 1 (one) represents light;
- 0 (zero) represents no light.

Binary Alphabet

A	01000001	N	01001110
B	01000010	O	01001111
C	01000011	P	01010000
D	01000100	Q	01010001
E	01000101	R	01010010
F	01000110	S	01010011
G	01000111	T	01010100
H	01001000	U	01010101
I	01001001	V	01010110
J	01001010	W	01010111
K	01001011	X	01011000
L	01001100	Y	01011001
M	01001101	Z	01011010

Practice the use of the binary code by writing your name and the names of your colleagues:

____

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The hidden message:
Write down a message that describes how you feel when you are in contact with nature.

Normal alphabet: ____

Binary code: ____

____

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Do the calculations needed to find out how items you will need to represent zeros and out how items you will need to represent ones.

Enjoy building your installation. Remember to challenge other groups to discover your hidden message.

→Rainbow Fan←

Lesson Context
Forest or garden.

Grade (age group)
12 – 15 years old

Activities Duration
Outside: 2 hours
Inside: 3 hours

STEAM Goals
SCIENCE: botany and ecology
TECHNOLOGY: artisanal handicraft
ENGINNEERING: planning, calculating, projecting
ARTS: studying colours
MATH: geometry (angles, circles and triangles)

Essential Questions
- ✓ Which are the species that live in the forest/garden?
- ✓ Why do flowers have different colours?
- ✓ What gives the colour to a plant structure?
- ✓ Why does a plant need those coloured substances (pigments)?
- ✓ How can the coloured substances be extracted?
- ✓ What is the best design for a robust fan, built with natural biodegradable materials?

Learning Goals / Objectives
1. Identifying all the species of the living organisms found in the garden.
2. Finding pigments that exist in different plant structures.
3. Finding pigments in common items (spices, minerals, …).
4. Applying an extraction technique to make inks with different colours.
5. Investigating the structure of the rainbow to illustrate the fan.
6. Designing a robust fan.
7. Build and test the rainbow fan.

List of Pre-required Concepts
Root, stem, leaf, flower, species, pigments, color, rainbow, mixture, solvent, solute, circle, circumference, triangle, calculation of areas.

Preparation and Space Requirements
The visit to the garden should be scheduled when flowers are blooming, for maximum diversity.
Check the garden space for availability and security.
Ask students to collect different kind of materials that might be used to build the fan.

Required Materials
Mobile phone and app to identify animals and plants.
Worksheet, plastic bags, tweezers, magnifying glasses, mobile phone, app for species identification.
Paper, glue and some natural materials to build the fan.

Procedures

The the main objective of this project is to build a hand fan using natural materials collected in the forest/garden, using a STEAM approach.
This project will be divided in three phases: Visiting the forest/garden; Preparing different colour inks; Designing, building and testing the fan.

Visiting the forest/garden

Visit a forest/garden to study biodiversity in general, identifying the species found.
Collect plant parts with different colours to make the inks, for example: stems to obtain sap and petals/leaves to obtain pigments.

Preparing different colour inks

Different groups may prepare different colour inks.
Sap can be obtained by letting it flow directly to a Petri dish. Depending on the plant used, sap may have different colours.
To extract the pigments, it is necessary to macerate the leaves/petals in a mortar. Add a few drops of water to make the maceration easier. More water can be used to dilute the ink.
Experiment with the inks to find out the colour obtain after drying (the difference may be significant to the result that is desired).

Designing, building and testing the fan

Design a sturdy fan illustrated with a rainbow painted with ink made with the extracted from plant structures.
Allow time for a few tests. After that, choose the design that produces de best fan.

Teacher´s Notes

This project involves visiting a forest or a garden to gather biodegradable materials to build a fan. In order to do that, it is important to choose the best season to find multiple flowering plants, with petals with diverse colours that can be used in the construction of the rainbow fan. Other plant parts may also be used (sap, roots, bark…). Be aware of plant structures that might be toxic.

It is very important to be careful and respectful when collecting natural materials. Make sure that the students know exactly what that may and may not collect.

Review the safety rules to observe on a field trip.

When making the inks, also avail the students spices and a few fresh vegetables that might provide extra sources to make ink. For example: saffron, cinnamon, spinach, beet, ginger root, raspberries.

Figures 1 and 2 provide a few suggestions on how to build two different types or fans.

Figure 1> In https://krokotak.com/2016/07/diy-paper-hand-fan/

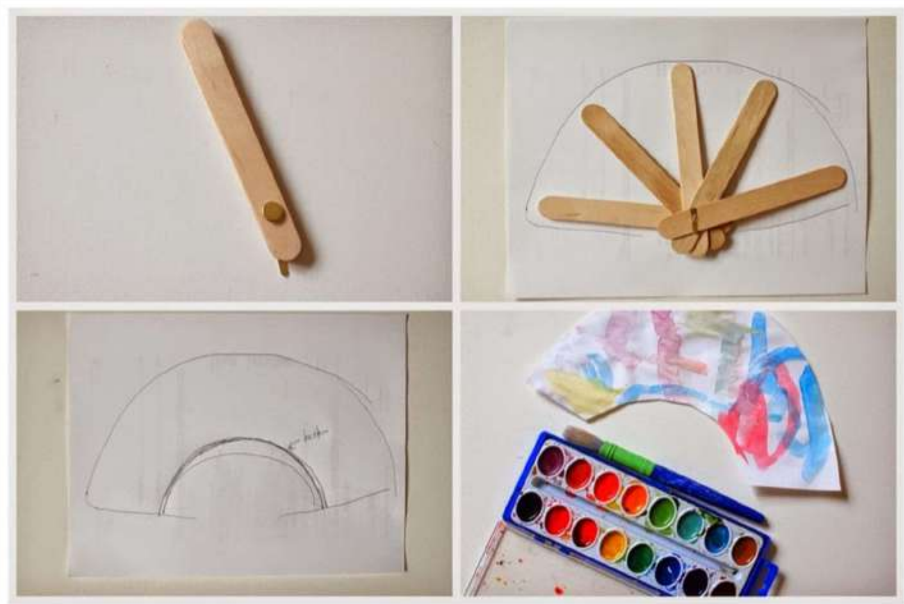


Figure 2> In https://www.pinkstripeysocks.com/2014/07/make-folding-popsicle-stick-fan.html

Pedagogical References

https://www.marthastewart.com/1516423/natural-ink-colors (viewed on 30/04/2023)
https://krokotak.com/2016/07/diy-paper-hand-fan/ (viewed on 30/03/2024)
https://www.pinkstripeysocks.com/2014/07/make-folding-popsicle-stick-fan.html (viewed on 30/03/2024)
Capraro, R., Capraro, M., Morgan, J. (2013). *STEM Project-Based Learning*. Rotterdam: Sense Publishers.

Student´s Worksheet

Name - ____

→Rainbow Fan←

Many times, when visiting Nature a person can find more than meets the eye. For that to happen it is important to listen to what others have to say, because they might know more than we do. This project involves visiting a forest or a garden and collecting the materials needed to make a hand fan.
To accomplish this project, it will help to have a checklist of all the things that you need to study and observe. Use the checklists below to find out whether you did everything needed to finish this project.

Visiting the forest/garden – checklist

- ☐ list of plants observed and identified;
- ☐ list of animals observed and identified;
- ☐ list of other living beings observed and identified;
- ☐ collection of biodegradable materials.

Preparing different colour inks – checklist

- ☐ dry the materials gathered in the forest/garden;
- ☐ put together the materials needed for making the inks - follow instructions;
- ☐ make inks with the materials that you gathered in the forest;
- ☐ experiment making inks with other materials, like spices and vegetables;
- ☐ make inks with different dilutions to find out the colours* you like the most.

[*] Bear in mind that you are going to make a rainbow fan, so you might want to trade with other students different colours and different shades of inks.

Designing, building and testing the fan – checklist

- ☐ design the fan you plan to build; ask the teacher and other students for their opinion;
- ☐ if needed, make a research about how to build a fan;
- ☐ use some geometric shapes to decorate your rainbow fan;
- ☐ assemble your fan and test it for sturdiness and efficiency;
- ☐ make the needed adjustments.

Use the space below to make notes or drawings during your project:

→ Plant Shadows←

Lesson Context	STEAM Goals
Lesson Context Forest, garden or school yard. **Grade (age group)** 10 – 15 years old **Activities Duration** **Outside:** 1 hour **Inside:** 2 hours	**SCIENCE**: chemical reaction, photochemistry, electromagnetic spectrum. **TECHNOLOGY**: evolution of photographic technology. **ENGINNEERING**: designing and building frames or stencils to create cyanotype prints **ARTS**: creating visually appealing compositions and understanding the impact of light and shadow in art **MATH**: measuring and calculating exposure times, understanding geometric arrangements and proportions and analysing patterns

Essential Questions

- ✓ What is a cyanotype, and how does it work?
- ✓ How does light cause a chemical reaction in cyanotype paper?
- ✓ How can we use natural sunlight to create art?
- ✓ What are the historical and modern applications of cyanotypes?
- ✓ What are the scientific principles behind the cyanotype process?
- ✓ How can cyanotypes be used in modern science and art?

Learning Goals / Objectives

1. Understanding the basics of the cyanotype process and the chemical reactions involved.
2. Exploring the role of UV light in photochemistry and the physics of light.
3. Investigating historical and modern applications of cyanotypes in science and art.

List of Pre-required Concepts

Basic understanding of chemical reactions, photochemistry and of the electromagnetic spectrum.
Geometric arrangements.

Preparation and Space Requirements

Access to a sunny outdoor space.
Indoor space with tables for preparation, development, and additional activities.

Required Materials

Potassium hexacyanoferrate III
ammonium iron III citrate
Watercolour paper or fabric
Clear acrylic sheets or glass
Objects for printing (leaves, flowers, stencils)
Water trays or buckets

Required Materials

Learning Goals / Objectives	
4. Analysing mathematical patterns and geometric concepts in cyanotype compositions.	Timer or clock Measuring tools (rulers…) UV light source (for controlled indoor exposure)

Procedures

The the main objectives of this project is to create cyanotype print and explore this process using a STEAM approach. A cyanotype uses an alternative process to create a photographic print. This technic uses a combination of iron compounds that are light sensitive. When exposed to sunlight, the chemicals react, creating a blue pigment. The project involves the following steps:

Introduction:
Explain the cyanotype process and show historical and modern examples emphasizing their scientific and artistic significance.
Discuss the science behind light-sensitive chemicals and UV light.
Introduce the concept of artistic composition and the importance of light and shadow.
Discuss the role of UV light in initiating these reactions and explore the electromagnetic spectrum.

Preparation:
Distribute cyanotype paper and explain the importance of keeping it out of direct sunlight until ready. Allow students to choose and arrange objects on their paper, considering artistic composition and geometric patterns. Use clear acrylic sheets or glass to hold objects in place if needed.

Exposure:
Take students outside and place their arranged cyanotype papers in the sun.
Discuss the effects of different exposure durations and light intensities.

Note: A UV light source can be used for exposure indoors.

Development:
Rinse the papers in water trays to stop the reaction and reveal the blue prints.
Allow prints to dry and analyse the results

Discussion and Reflection:
Discuss the results and the effect of different objects and exposure times.
Reflect on what students learned about light, chemical reactions, and artistic composition.
Reflect on the interdisciplinary nature of cyanotypes, combining science, technology, engineering, art, and math.

Additional Activities
Historical Exploration: Research the history of cyanotypes and their use by scientists like Anna Atkins.
Technological Connections: Explore how cyanotypes are used in modern photography and art.
Engineering Challenge: Design and build custom frames, stencils or UV light boxes for future cyanotype projects.
Mathematical Exploration: Calculate the area of different objects used, and discuss symmetry and geometric patterns in their compositions.

Teacher´s Notes

This project involves the creation of a cyanotype print. The cyanotype solution and papers should be prepared in advance according to the following steps:

1. Dissolve 8g of potassium hexacyanoferrate III in 50 mL of water.
2. Dissolve 10g of ammonium iron III citrate in 50 mL of water.
3. Mix the two solutions together.
4. Put the resulting solution in a dark bottle and keep out of the light until used. It will keep for a week or two (possibly longer).
5. Using a paintbrush, paint a thin, even layer of the solution onto thick watercolor paper.
6. Allow the paper to dry for 24 hours before use.

Schedule the outdoor activity when the sun is at its peak for best results. Before the activity provide historical and contemporary examples for inspiration and context. During the activity emphasize safety when handling chemicals, sunlight exposure and UV light. Suggest using natural objects like leaves and flowers for diverse and interesting prints. may have been collected in advance or their collection may be included as part of the activity
As additional activities document the process and results in journals for future reference and analysis or use the cyanotypes produced to document the existing flora of the garden/forest/school yard.

Figure 1- Example of an assembly before exposure and final results.

Pedagogical References

https://www.sserc.org.uk/resources/chemistry-resources/chemistry-resource-list/cyanotypes/
https://www.youtube.com/watch?v=rB8HFjSGVlM&ab_channel=EducationalInnovations
https://youtu.be/-keQ2nDm-os.
"Cyanotype: The History, Science and Art of Photographic Printing in Prussian Blue" by Mike Ware.
"Blueprint to Cyanotypes: Exploring a Historical Alternative Photographic Process" by Malin Fabbri.

Student´s Worksheet

→ Plant Shadows←

This activity involves creating cyanotype prints, an enchanting process that uses the power of sunlight and chemistry to produce deep blue images. Once exposed to sunlight, the "magic" happens—the paper develops into a beautiful blue print, capturing the shapes and details of your arrangement. A cyanotype uses an alternative process to create a photographic print. Also known as a blueprint, cyanotype prints are cyan-blue in color.
Throughout the activity, answer the following questions that will help you better understand the process and applications of cyanotypes.

Part 1: Artistic Composition

- What objects will you use? How will you arrange them? What do you expect your print to look like?

Part 2: Understanding Cyanotype

- Briefly explain the chemical process behind cyanotypes.
- What happens when the paper is exposed to sunlight? Why do we rinse the paper in water?

Part 3: Mathematical Analysis of Patterns

- What mathematical concepts can you identify in your composition?

Part 4: Historical Exploration

- Who was Anna Atkins? How did she use cyanotypes in her work? What are some modern uses of cyanotypes?

Part 5: Reflection

- What worked well? What would you do differently next time?

Do not forget to share your results and findings with your colleagues

→ Big and Small, The Tree and The Moss ←

- The visit to the cemetery or old garden in the city -

Lesson Context Old garden with tall tree and moss	**STEAM Goals** SCIENCE: **Biodiversity** TECHNOLOGY: **Documentation,** Measurements, take photos, digital drawing and presentation ENGINNEERING: **Make the measurement tool clinometer.** ARTS: Use the unique shape, texture and patterns of the trees and moss to create a personified pictures on your iPad* MATH: Measurements, calculations
Grade (age group) 8 – 12 years old	
Activities Duration **Outside:** 2 hours **Inside:** 4 hours	

Essential Questions

✓ Which are the characteristics of the trees and the moss that live in the garden?

✓ How can we recognise one type from another (trees and moss)

✓ How do we use a Clinometer to measure very tall trees.

✓ What is the best design for a Clinometer.

✓ Why is field of view (FOV) important when taking a picture

✓ What elements are important when you are drawing characters

✓ What is important to remember when doing a presentation.

Learning Goals / Objectives

1. Identifying all the species of the living organisms found in the old garden.
2. Identifying Characteristics of organisms
3. Learn different ways to measure tall and small things, digital and analog.
4. Basic composition of photography to deliver a good documentary.
5. Basic post processing
6. Use app to add drawing to a picture.
7. Keynote slide presentation app

List of Pre-required Concepts

Moss is classified as Bryophyta.

Moss reproduces via spores

Two basic categories for all trees: Deciduous trees and evergreen trees.

Trees reproduce asexually.

Leaf, stems, branches, trunk, root,

Clinometer, clippers.

Patterns, textures, lines, shapes, forms, color, tone, contrast, depth, frames, focus, depth of field, viewpoint.

Preparation and Space Requirements

Charge iPad and pen. Introduction before the field trip of trees, moss, photography, clinometer, and clippers.

The visit to the cemetery or old garden in the city should be ok all season but the moss is dull after a dry season.

Check the garden space for availability and security. Ask students to take pictures wide and closeup, super wide and super closeup.

Required Materials

iPad & pen, tape measure, clippers, paper, tape, drinking straws, string, paper clip

Procedures

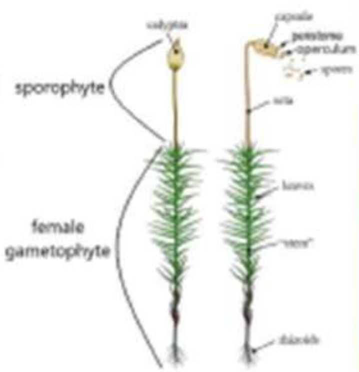
This project will be divided in four phases: Presenting the project and preparing the visit including designing, building the clinometer ; Visiting the old garden and split in groups, each group choose a tree and take pictures and measure the tree and the moss on the tree or in the nearest surroundings ; Post processing the pictures and create a personified pictures on the iPad* (can be used as the character presenting the slides); Slides presentation for the class about the tree and the moss; the BIG and the small.

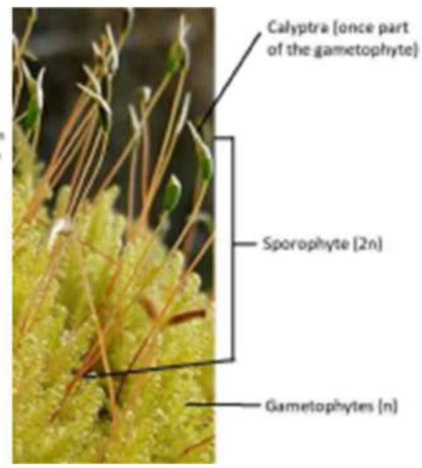
*Create a personified picture
Use the built-in Markup tools in Photos to bring everyday objects to life. Draw facial features, sketch other elements that help things in your photos tell imaginary stories.

- Choose a familiar object and imagine what it might say or do if it were alive.
- Take photos at eye level and close to your subject for a more personal feel.
- Avoid busy backgrounds that distract from the subject.
- Use Markup (in Apple Photos-> Edit) sparingly and let the object tell most of the story.
  (Everyone can Create Photo on iPad)

Teacher´s Notes

- Elaborate on why focus and Field of View (FOV) dose matter in taking pictures. The importance of Biodiversity and the big role of the trees for life on earth.
- Let pupils use Measure app after using clinometer to calculate the hight of the big tree.
- Give suggestions how good documentation looks like and what is personified picture.
- Present the security rules that are specific to visiting a old garden.
- Take a moment in the garden to let the pupils and yourself embrace a tree. Hugging a tree increases levels of hormone oxytocin. This hormone is responsible for feeling calm and emotional bonding.





… but we are going to [make it digital.]()

Student´s Worksheets

Interactive worksheets will be on the iPad to help the pupil’s to collect all pictures and data that is required of them. Also, it has information to guide the discussion of the different concepts covered during the activities.

→ Urban Life and City Birds←

<table>
<tr>
<td>Lesson Context
Urban Life and City Birds</td>
<td rowspan="3">STEAM Goals
SCIENCE:
Ecological data and habitats research

TECHNOLOGY:
3D mapping, VR Design and statistical graphs

ENGINNEERING:
Bird-Friendly Urban Design prototypes and building

ARTS:
Visualisation of the maps, design thinking sketches and 3D prototypes of Urban nests

MATH:
Statistical research into graphs, scaling of maps and scaling of prototypes</td>
</tr>
<tr>
<td>Grade (age group)
7th grade</td>
</tr>
<tr>
<td>Activities Duration
Outside: Research stage students will explore the city. (Possibly visit a science centre specialising on the research of birds)

Visiting Sudurnes Science and Learning Center on their exhibition on birds.

Inside:
In return to the classroom computers are needed for statistical research.

Innovation stage prepare material and computers that needed for software and the use of the Maker space area.</td>
</tr>
</table>

Essential Questions

How do urban environments affect bird life? Develop strategies for conserving bird populations in cities?

Learning Goals / Objectives

This project aims to investigate how urban environments affect bird life and to develop strategies for conserving bird populations in cities. By design and construct an urban oasis specifically tailored for birds, enhancing their urban living conditions, while also creating an educational and aesthetic space for humans.

List of Pre-required Concepts

This project does not require students to understand any scientific understanding of the bird however the ability to research and to work in a Team is required.

Preparation and Space Requirements

Research stage Students will explore the city. (Possibly visit a science centre specialising on the research of birds) In return to the classroom computers are needed for statistical research.

Visiting Sudurnes Science and Learning Center on their exhibition on birds.

Innovation stage computers are needed for software and the use of the Maker space area.

Required Materials

Outside research:
Portfolio diary for sketching and Mapping, Pencils.
Camera and sound recorder.
Print out of the city map.

Inside Research and Brainstorming Kits:

Portfolio diary and Chromebooks for research.

including Post-it notes, Sharpie markers, and stickable chart paper.

A3 paper for mapping. Larger print out of the City.

Innovation stage:
Chromebook, VR set (Make own if possible on timetable)

Makerspace area, cardboard and recycled materials.

Physical Prototyping Cart creative, constructivist supplies, including felt, yarn, foil, craft sticks, rubber bands, Play-Doh, Legos, and more.

Procedures

Timetable and Outline:

Lesson 1 80mins Outside:

Students beginning of individual research:

Emphasis and research

Begin with identification and mapping of bird species in your city and in your country.

- Identifying common bird species in your city.
- Identify birds that are not commonly seen in the city.
- Ecology: Understand what plants are beneficial for birds in terms of food and shelter
- Nutrition: Investigate and provide the best food options for the birds.
- Behavioural Observations: Study the behaviours of these birds in urban environments, including nesting, feeding, and social interactions.
- Data Collection: Gather data on factors affecting urban bird populations, such as habitat loss, pollution, and climate change.

Exploration and defining research

Outside classroom:

- Data Collection Tools: Use technology like smartphones, cameras, and audio recorders to collect data on bird species and their activities. Sketching and Mapping in their exploration by GIS mapping: Map birds and their environments (provide 2d maps for students to sketch on)

Lesson 2 80mins Inside:

Back in the classroom:

- Statistical Analysis: Analyse the data collected to identify trends and correlations between urban factors and bird populations.
- Research online for statistics.

Defining research:

Students will go into a **group of 4.**

From GIS mapping students will create **3D models** of their city to be explored on a **VR set or AR**.

Mapping areas of where each bird nests in the city. Each bird will have information when clicked

Species Identification:
Habitat Requirements:
Dietary Preferences:

Nesting Sites:
Water Sources:
Shelter and Perches:
Native Plants:
Seasonal Considerations:
Predator Management:
Nesting and Roosting Sites:

Lesson 3 & 4 160mins Inside:

Identity the problem:

Remaining in their **Group of 4**

From their 3D Mapping process students will identify birds that are in decline in the cities.

The students will create a new **Bird-Friendly Urban Design** with the following considerations in their designs **What does it take to thrive in cities, if you're a bird?**

Food Availability

Nesting Opportunities: Some urban structures, like buildings and bridges, offer nesting sites for birds. Nesting in crevices, ledges, and cavities helps protect birds from predators.

Shelter and Roosting: Urban parks, trees, and buildings can serve as shelters and roosting locations. Birds benefit from protected areas that provide cover from harsh weather conditions and predators.

Water Sources: Access to water is essential for many bird species. Parks with ponds, fountains, or even puddles can provide drinking and bathing opportunities for birds.

Adaptability: Birds that can adjust to noise, artificial light, and human disturbances have a better chance of thriving in urban environments. For example, some species may sing at different times to avoid the noisiest periods.

Migration and Seasonal Changes: Migratory birds may use urban areas as stopover points during their journeys, utilizing the available resources before continuing their migration.

Habitat Restoration: Cities that incorporate green spaces, native plantings, and wildlife-friendly urban planning can create better conditions for birds. Urban planners and conservationists can play a crucial role in enhancing urban habitats for birds.

Predator Management: Some cities implement predator control measures, such as managing feral cat populations, to reduce predation on urban birds.

Community Engagement: Public awareness and community efforts can help protect bird habitats, reduce litter and pollution, and prevent the destruction of nesting sites.

Conservation Programs: Local and national conservation programs may focus on urban bird species, creating conservation strategies and initiatives to support their survival.

Lesson 5 80mins Inside:

Engineering and Prototyping stage:

Each student in the Group will come up with a Design idea on paper. They will present their ideas to their peers in the Group. With constructive criticism the students will extract what ideas they like and blend their ideas into one **Final design**.

FINAL OUTCOME

Students will **prototype** their ideas by using recycled modelling materials as their Final piece keeping in mind the feedback that they received from their peers in the classroom.

Lesson 6 80mins Inside:

Exhibit and Presentation:

Each group will introduce their **final design** along with their 3D GIS Map

Teacher´s Notes

Explain rules of the science centre before their visit and collect bus tickets. Outline some notes that should be taken in their diaries.
Prepare research questions for their exploratory diaries
Suggest to students to collect any material such as leaves that helps them visualise their plan.
Prepare Design thinking sheets for the return to the classroom and give them space for 5 ideas each before they complete their A3 poster.
Make sure students know their password for 3D software.
Cardboard and other recycled material is required

Student´s Worksheets

What does it take to thrive in cities, if you're a bird?:

Food Availability:
Shelter and Roosting:
Water Sources:
Adaptability:
Migration and Seasonal Changes:

Attach Design thinking sheets here

→An Organic Hand That Can Hold a Small Stone←

<table>
<tr><td>Lesson Context
Waterside (seashore / by lake or river)</td><td rowspan="3">STEAM goals:
SCIENCE: study rock biodiversity, weigh rock and measure volume
TECHNOLOGY: measure weight, volume and density
ENGINNEERING: measure weight, volume and density
ARTS: paint a stone and decorate the artificial hand
MATH: calculate the density of the stone based on the density formula, calculate ratios for joints in a prosthetic hand</td></tr>
<tr><td>Grade (age group) 12-15 years</td></tr>
<tr><td>Activities Duration
Outside: one hour at the waterside

Inside: 4-6 hours</td></tr>
</table>

<table>
<tr><td>Essential Questions
· What species are there at the shore?
· How can we build an artificial hand to lift or hold a stone

Learning Goals / Objectives
1. To identify the types of rocks in the seashore.
2. To understand techniques for building an organic hand
3. Paint stone
4. Design an organic hand that can hold the stone
5. Build and test the artificial hand</td><td>List of Pre-required Concepts
Rock, mass, volume of irregular objects, density, artificial hand, joints (...)

Preparation and Space Requirements
A visit to the seashore should be timed when there is a low tide, for maximum diversity of rocks. The stones should be large enough to fit in the palm of your hand.

Ask the students to collect different types of stones that can be used to insert the artificial hand.

Required Materials
*Worksheet for measurements and the work process.
* A container for the stones to be used to carry home.
* Mobile/PC, type recognition app if available.
*Balance, overflow container, measuring cup and water to measure the volume.
*Building materials to make the artificial hand:</td></tr>
</table>

	*A4 cardboard paper, 3 drinking tubes, double-sided tape, string, scissors, fine brushes and acrylic paint.

Student´s Worksheet

Project description

In this project you work in pairs and get to know how to work according to STEAM methodology. STEAM stands for Science, Technology, Engineering, Arts and Mathematics.

1. The first step is to go to the shore, choose a stone that fits in the palm of your hand, each party chooses their own stone.
2. Up to school: Take a picture of the stones and try to find what kind of stone yours is by letting Google search for a similar picture.
3. Weigh the stones and find their volume, remember **1 ml = 1 cm^3**, calculate the density of your stone using the formula **Density = mass/volume.**
4. Paint your stone so that it is easily recognizable as your stone, express your artistic talents.
5. Create a fake hand by drawing a handprint on an A4 cardboard sheet and cut it out. Color and decorate the back of the hand as you wish. Then cut down a drinking tube and glue it to the hand so that the tubes form a joint. Thread the twine through each tube on the fingers and tie the twine tightly to the front hook. Then take a picture of the hand.
6. Record all your results on your worksheet.

Record your observations as best you can.

1. **Describe the appearance of the stone:**
RESPONSE:

2. **Post a picture of your stone here:**
RESPONSE:

3. **Can you tell from the picture what kind of stone you had and if so, what kind was it?**
RESPONSE:

4. **Write a detailed description of how you found the density of the rock.**
RESPONSE:

5. **Paint the stone and show your artistic skills. Post a picture of the stone when you have finished painting it here:**
RESPONSE:

6. **Create a fake hand by drawing a handprint on an A4 piece of cardboard and cut it out. Then cut down a drinking tube and glue it to the hand so that the tubes form a joint.**

Thread the twine through each finger and tie the twine tightly to the front hook. Post a picture of the hand you made here:
RESPONSE:

7. Place the stone in the palm of the artificial hand and turn the artificial hand upside down. Also try to lift the stone up. Can you let the hand you made hold the stone
RESPONSE:

8. Can you lift the rock with your artificial hand? Justify.
RESPONSE:

9. What was the most interesting/fun thing about doing this project? Justify.
RESPONSE:

→ Notebook ←

Lesson Context	STEAM Goals
Making the artistic notebook or graphic novel from different materials (Collage) with elements of poetry, at the Museum. Group work.	SCIENCE: climate change, second hand materials TECHNOLOGY: traditional arts and crafts ENGINNEERING: planning, calculating, projecting ARTS: composition, using art reproductions, introducing in art history MATH: angles, proportions
Grade (age group) 10-18	
Activities Duration **Outside: 1 h** **Inside: min. 2 h**	

Essential Questions

- ✓ Can everybody create?
- ✓ Empathy, be there and now?

Learning Goals / Objectives

1. To arise creativity
2. Realise a climate situation on the earth and what we can do.
3. Investigate the type of materials that we throw in the garbage.

List of Pre-required Concepts

What is a graphic novel?
What is paper?
What is a diary?
Little bit a history of book making

Preparation and Space Requirements

Collecting materials (see in Required Materials)
Space for one person ~ 2x2m

Required Materials

Scissors, glue, metal ruler with sharp sides, new and used paper, magazines, damaged poetry books ready for recycling, pencils, thread, sewing needles, textile, music.

Procedures

Preparation:

1) Materials and instruments. It should be done in advance and will take some time.
2) Short concentrated materials about book history, art history, history of paper making etc.:
   - they could be placed as separated facts on each table for the afterword discussion when the notebook is done;
   - it could be like a homework and presented in next lesson with finished notebook;
   - if teacher works with art works, he/she can send the information in advance to student/participant, who have to share the information during the workshop presentation of the ready notebook. A definitely artwork could be as an incentive of the story of the graphic novel; teacher can choose artwork with a portrait of any scientist like *Astronomer Copernicus, or Conversations with God by Jan Matejko* – it makes connection between art and science, engineering, technology, math.
3) Use a classroom where is possible students work alone or in small groups. Every working station consists of a table with materials and equipment on it. Books of art and science history and graphic novel making would be great (for the information, not for cutting!)

Workshop:

- Teacher explains the main task, circumstances and goals (inside or outside).

Introduction:
#why you need a notebook?
#one day diary
#from hands-on: minds on

- 1st lesson is outside the classroom: teacher asks to find objects in nature that characterizes a paper (tree, leaf, water, sun etc.).
- Students/participants returns to workshop and work in groups or individually.
- Depends on materials students find on the table, they starts to make a notebook (or graphic novel), first - collecting clear paper parts to make clear pages of a notebook and realise the size of it. NOTE: pages could be made by cutting or tearing, or by a paper guillotine! Enjoy the different processes! Feel the difference!
- Stitching the notebook , using "STEM STICH" https://www.instagram.com/reel/C1MIqpzvtTp/?igsh=ZG84eGhmNnp2ZWdp
- Then they make some studies about the art work/works for the cover and try to find how possible is to connect it with other STEAM parts or STEM. They could make a notebook leaf/leafs from the art works, supplementing them with a poetry or self-made story. They can use objects from nature too, creatively inserting them (for example) as notebook lids.
- During the working process in workshop participants listen to music: it could be sounds of nature, art work`s period music, live music etc.

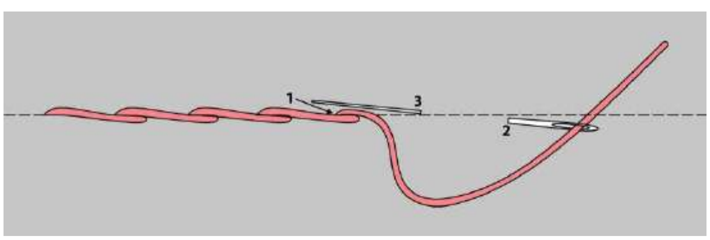
Teacher´s Notes

- If teacher works with definitely art works, he/she can send the information in advance to definitely student/participant, who have to share the information during the workshop presentation of the ready notebook. A definitely artwork could be as an incentive of the story of the graphic novel; teacher can choose artwork with a portrait of any scientist like *Astronomer Copernicus, or Conversations with God by Jan Matejko* – it makes connection between art and science, engineering, technology, math. https://www.theguardian.com/artanddesign/2020/nov/23/huge-portrait-of-copernicus-to-be-seen-in-uk-for-first-time

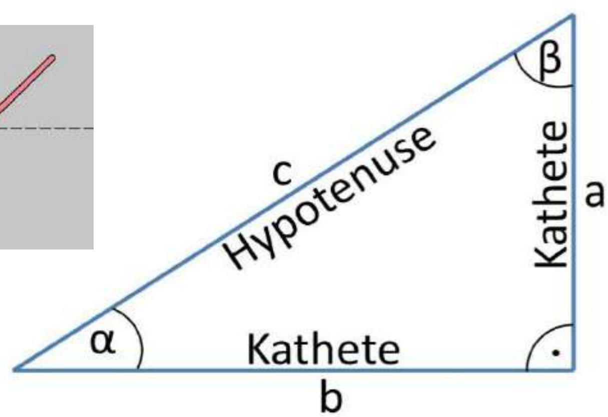
Other recomended works of art:

- Newton by William Blake https://www.thehistoryofart.org/william-blake/newton/
- The Geographer and The Astronomer, Wermeer, 17th century artwork https://www.facebook.com/watch/?v=10159246790815048
- Einstein playing a violin https://history.aip.org/exhibits/einstein/ae58.htm
- Goete: poet-scientist https://www.jstor.org/stable/4446805 https://designforsustainability.medium.com/the-tip-of-the-iceberg-goethe-s-aphorisms-on-the-theory-of-nature-and-science-ba6e12ebd5f1

- Music: during the outside lesson, students can record in their mobile phones the sounds they surrounded by and then play it during the workshop to arise the imagination!
- They can record sounds of paper – when it cutted, teared, wrinkled...
- They can record sounds of instruments working or making sounds with instruments carefully hitting the table with them or hitting instruments to each other or on different surfaces.



Embroidery stich, called "STEM STICH"

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Heart

→ Space Elevator←

Lesson Context
Science fiction: Making a Space Elevator at the Museum
Group work

Grade (age group) 10-18

Activities Duration
Outside: 1 h
Inside: 2 h

STEAM Goals
SCIENCE: history of the space elevator, Jule Vernes – science fiction or reality? Herbarium, plants, seeds, from the Earth to Mars, friction, gravity.
TECHNOLOGY: How to build a space elevator from a small box (but not a matched box – why not? How about the weight?)
Sound: what makes a sound? "Silent phones". Sound in the Universe. Nanotubes.
ENGINNEERING: history of experiments to build a Space Elevator
ARTS: space elevator in literature. How to create an astronaut from the materials around us?
MATH: geometry - the right angle, rectangle, square, circle etc. How long a cord must be? A distance from the Earth to Mars, how long would be a trip to reach Mars from Earth?

Essential Questions
Is the Space Elevator real?
Experiments in history
Who and how wrote about the space elevator in science fiction literature?

Learning Goals / Objectives
To understand gravity
To get involved in reading books
To arise curiosity/fantasy
To develop practical skills

List of Pre-required Concepts
Solar System
Space Elevator
Science fiction literature

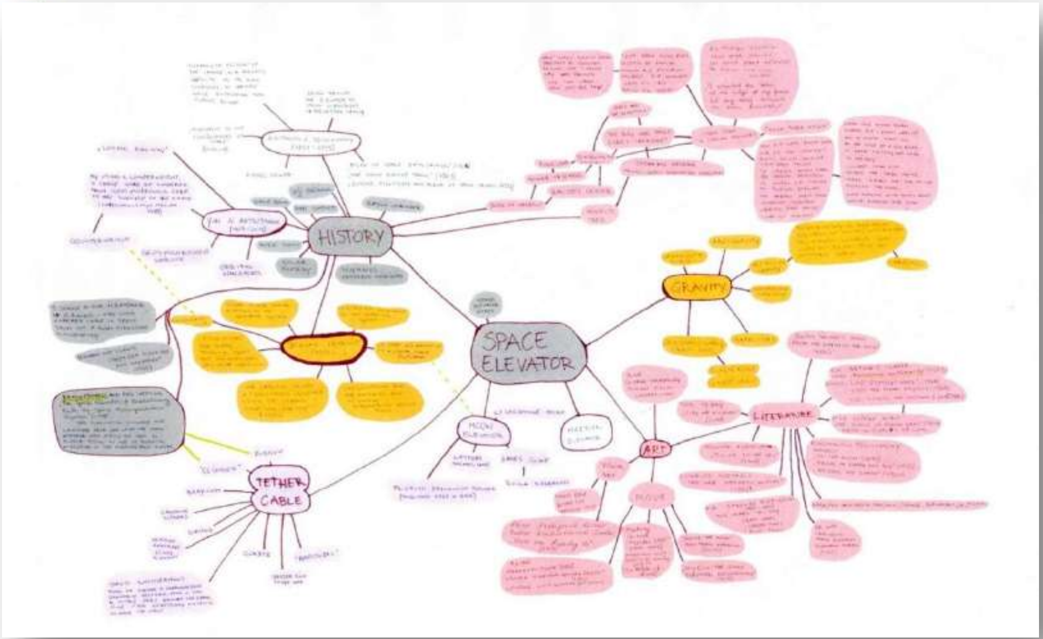
Preparation and Space Requirements
Collecting materials (see in Required Materials)
Space for one person ~ 2x2m

Required Materials
Wooden workpiece
Carboard cylinders/small boxes
Glue, scissors, ruler
Some old magazines and textiles
Thread (silk twisted - if possible)
Hanging place/hook
Student´s worksheet (one per student)

Procedures

- Before a workshop, the teacher must study the history of space elevator (see in teacher`s Notes) and collect the main points and persons of a topic. Teacher prepares a presentation about the topic – just 10 slides explaining the history, connection with science fiction and accentuates the main physical characteristics of the Space Elevator.
- Collecting materials: teachers can collect all of them by his shelves or ask students to bring some elements from home – like small cardboard boxes or cardboard cylinders (from a toilet paper roll), or old magazines. Teachers have to solve a problem with collecting the wooden workpieces.
- Introduction: teacher explains the main task, circumstances and goals (inside or outside). He/she can demonstrate a model of space elevator made by him/her, tell a little bit about the principles of friction, ask students what they know about the Solar System and experience in science fiction literature or movies they read or saw.
- Everybody goes to the workshop.
- Teacher`s presentation about the theme.
    - Students work individually or in groups. Depending on the materials on the table and according to the knowledge they received from the presentation, they try to build a Space elevator`s cabin.
- Students connect all elements of a model according to the scheme, hang it and try to "reach the Space". Grab the buttons in each hand, pull the cords down evenly, then move one hand after the other without releasing the tension.

- Where to get the wooden workpieces? This is up to circumstances in school. May be there is any woodworking workshops or masters. If not – teacher can use the simple principle of friction from here: https://www.pinterest.com/pin/393853929916668596/
- During workshop, some students can make a "Spider" – a scheme of possible future topics (see below)



Teacher´s Notes

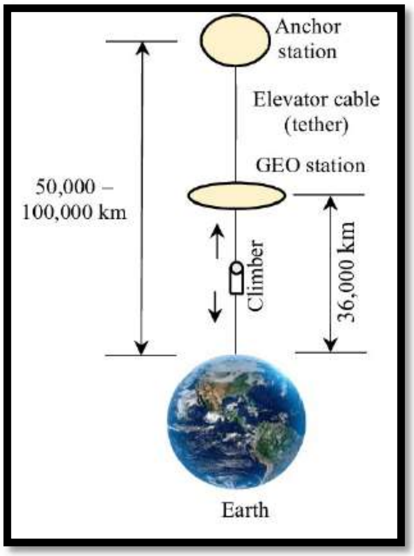
https://www.nbcnews.com/mach/science/colossal-elevator-space-could-be-going-sooner-you-ever-imagined-ncna915421
https://websites.umich.edu/~esrabkin/sf/space_elevator.htm
https://commons.wikimedia.org/.../File:Artsutanov_Pearson...
https://en.wikipedia.org/wiki/The_Fountains_of_Paradise...
https://www.researchgate.net/.../Basic-Space-Elevator...
https://www.newworldencyclopedia.org/entry/Space_elevator

Student´s Worksheets

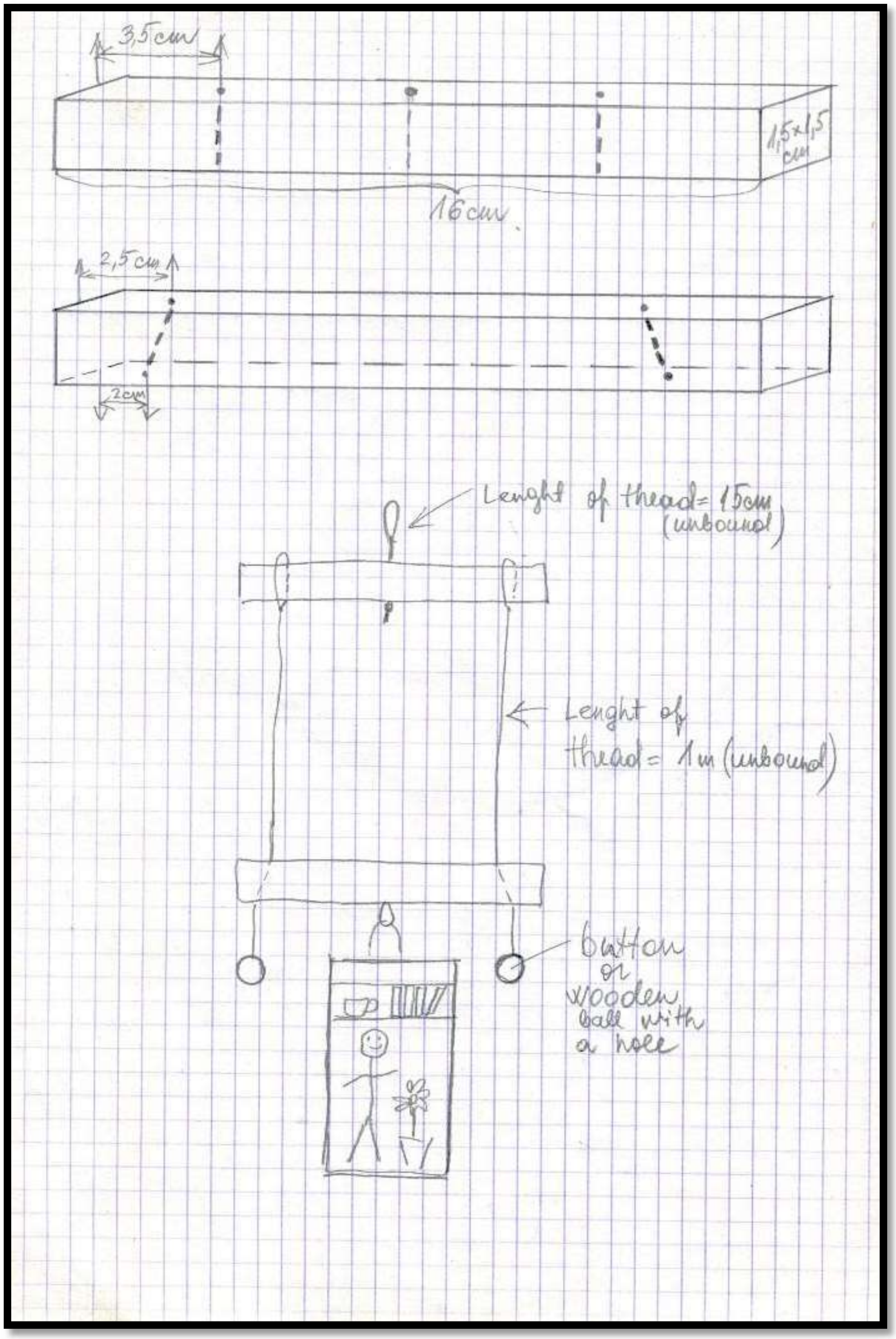
Name - ____

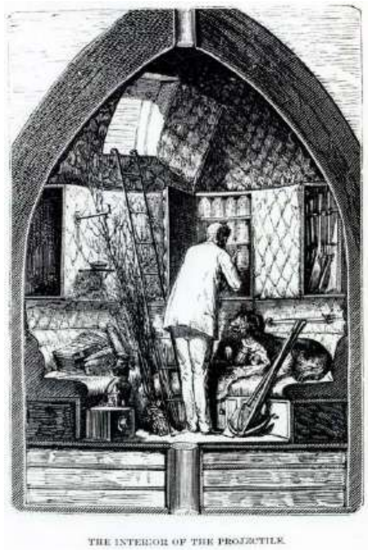
→ Space Elevator←

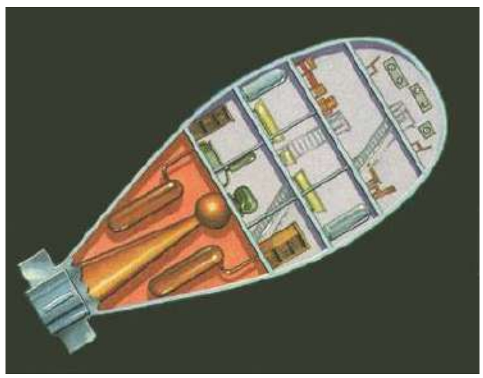
- https://www.researchgate.net/figure/Conceptual-figure-of-a-space-elevator_fig1_338936062



https://pioneersofflight.si.edu/.../illustration-jules... **Illustration from Jules Verne's From the Earth to the Moon** Jules Verne's 1865 novel From the Earth to the Moon featured a gigantic cannon in Florida that fired a capsule around the Moon. While this made for a good story, the visionaries knew the huge acceleration would have crushed Verne's travelers. **Credit:** *National Air and Space Museum, Smithsonian Institution* **Date:** 1865 **Photo Number:** SI A-4084-B


3,5 cm
1,5x1,5 cm
16 cm
2,5 cm
2cm
Lenght of thread= 15cm (unbound)
Lenght of thread= 1m (unbound)
button or wooden ball with a hole





Space Elevator Cabin by Konstantin Tsiolkovs

The up element The down element

→ Paper Water Lilies←

Lesson Context
Pond or a lake near the museum
Group work

Grade (age group) any

Activities Duration
Outside or Inside: 3 h

STEAM Goals
SCIENCE: humidity (chemistry), osmosis (biology)
TECHNOLOGY: very cheap and simple, differences of the same material
ENGINNEERING: why the ship floats and does not sink?
ARTS: Claude Monet`s paintings of water lilies
MATH: pentagon, observing and making diagrams

Essential Questions
What is humidity? How it affects the paper?
How fast?
Geometrical shapes

Learning Goals / Objectives
Understanding what is osmosis, how plants receive a water

List of Pre-required Concepts
Paper composition
Osmosis

Preparation and Space Requirements
Classroom or the place outside

Required Materials
A bowl with water
Paper:
- White, ordinary
- Tinted, ordinary
- Newspaper

A stencil of waterlily
A pen, scissors, markers

Procedures

First lesson (40 minutes)

A theoretical lesson to introduce students to Monet's paintings of water lilies. It could be a presentation, it could be processed with art books, it could be prepared with information by the teacher. This could be done inside or outside the classroom.

Second lesson (60 minutes)

- Using a stencil draw a water lily on three different sheets of paper double:

1) on ordinary white paper;
2) on ordinary coloured paper;
3) on the newspaper.

- With the scissors. cut the flowers.
- Fold the water lily leaves towards the center.
- Put one waterlily at time in the water: white goes first, then coloured, then – from a newspaper.
- Observe what happens, what is the difference!
- Repeat all processes, but fix a time when each waterlily opens!
- Finally – fix the time difference of sinking!

NOTE:
1) If you have time – make one more waterlily from white paper and colour it with markers. Then put it in the water and fix the time of "blooming". Is there any difference?
2) Try to draw your original shape of a paper flower! Does it work?

Third lesson (40 minutes)

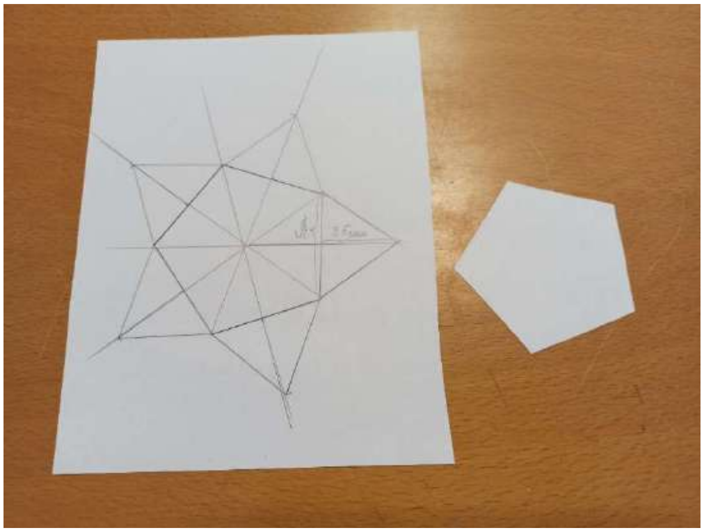
Discussion - what happens, what is osmosis, why there was a difference in waterlilies blooming? How about the shape in a centre: pentagon, sextagon or other shape?

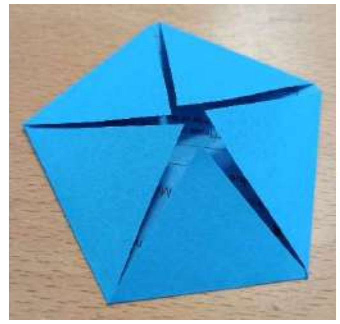
Teacher´s Notes

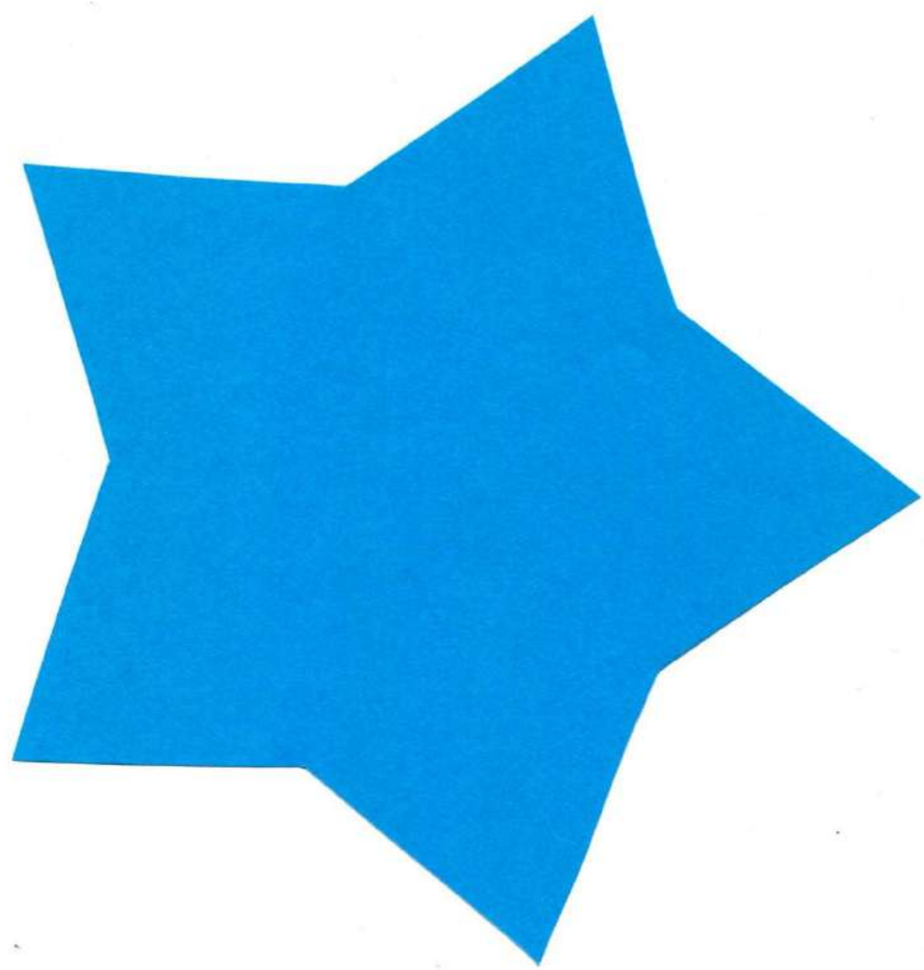
- Water lilies work better if the water is cold.
- You can try to use natural water sources like a lake, river etc., but keep in mind that paper flowers sink after a while!
- According to the students' age, you can give them a ready shape of water lily to ask them to just redraw and cut out or you can give just a shape of pentagon and ask them to draw a water lily based on it.

https://www.britannica.com/science/osmosis
https://mathmonks.com/pentagon
https://www.artic.edu/artworks/16568/water-lilies
https://www.claude-monet.com/waterlilies.jsp

Student´s Worksheets







→ Terrestrial Ecosystem ←

Lesson Context
Museum 's Garden
Group work

Grade (age group)
10-15

Activities Duration
Outside: ½ h
Inside: 2 h (+2 weeks observation till result)

STEAM Goals
SCIENCE: finding (how?) water source in nature or making water condensate, soil, seeds, acorns, roots, small plants with roots etc. Humans (ecology, biology). Time: Endless? Universe (astronomy).
TECHNOLOGY: ecosystem in closed container (no water, no wind); photography the plants, conversation about results with other participants via social media
ENGINNEERING: the power of living organism, the power of sunlight, do plants can generate electricity? What plants?
ARTS: Flowers and insects in art as Vanitas, drawing the process
MATH: observations: making a schedule - what happens with a jar during a day because of sunlight angle (humidity, growing speed, colour changes etc.). Measuring, calculating.

Essential Questions
Water source in nature
What do plants need for growing? How about humans?
E everything has its beginning and the end (like Sun).

Learning Goals / Objectives
Resources in nature
To understand processes in nature, life's cycle

List of Pre-required Concepts
Soil
Sun light over a year
What is a seed?

Preparation and Space Requirements
Soil availability
Working place 2x2m

Required Materials
A closable plastic bag or glass jar, nature materials: soil, seeds, roots, water source, a mobile phone, books about gardening, internet

Procedures

Preparing: a teacher collects all materials and set up a workplace

Workshop:

- Starts with a teacher`s introduction of tasks and circumstances. A short explanation: what are the seeds, their shapes etc.
- Take a closable cellophane bag or glass jar, fill it 1/3 with soil.
- Put some water in over the soil, make it very wet.
- Put a seed or seeds on the soil.
- If you want – you can put a small plastic toy on the soil – then it will be something artistic (STEAM)!
- Close a bag or jar very tight.
- Write your name, date and the name of seed - on the bag/jar with a marker.
- Put the bag/jar close to the window to allow an access to sunlight.
- Observation and recording of the results starts after one week.

Teacher´s Notes

- You can use a soil from the garden or can buy it in a package.
- Collect different types of seeds like beans, grass seed, flower seeds etc., but do not mix them. You can mixed them if you have a very big jar.

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