Modern teaching on plants

TEACHING ACTIVITIES FOR PRIMARY SCHOOL

EDUCATION for PLANT LITERACY

Co-funded by the European Union

Modern Teaching on Plants – Teaching Activities for Primary School

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1 Introduction

Ulla Kemi, Renata Ryplová and Ilkka Ratinen

The role of plants as life-enablers and as major players in climate change mitigation is undeniable (Amprazis & Papadopoulou, 2020). They play an important role in the circulation of matter, solar energy and water, e.g. through photosynthesis and transpiration. Despite their crucial role in the complex living system on earth, as well as on climate change mitigation, plants have traditionally received less attention in primary school education, compared to animals (e.g. Wandersee & Schussler, 1999; Nyberg & Sanders, 2014). Animals are often more attractive than plants, especially to children. Already pre-school and lower grade school children are able to name exactly the species of animals, but not plants (Patrick & Tunnicliffe, 2011; Amprazis *et al.*, 2019). As plants are not moving like animals, they can easily be taken as an unimportant part of the environment, thus neglecting their important role on earth. This is known as plant blindness (Wandersee & Schussler, 1999). Plant blindness is a challenge that needs to be tackled, as understanding and appreciating the importance of plants is a basis for sustainable living (Amprazis & Papadopoulou, 2020).

To prevent plant blindness, plants should be better integrated into school curriculum. In primary school education, plants should be made visible and their role as the originator and maintainer of life must be brought to the attention of children. However, there is a lack of sophisticated and modern learning materials for primary school in the field of botany topics. Primary and secondary school teachers indeed suggested that teaching botany related subjects would be more interesting with active teaching methods (Kletečki *et al.*, 2023).

This practice book represents 12 in-person and two online activities for primary school. Because the age of primary school children varies among different European countries, these activities are suitable for the ages 6 – 12 years, while the exact recommended age is always indicated for each particular teaching activity. The background information on the teaching methods used, as well as the basis of biological phenomena, are explained in detail in the *Plant Literacy Teachers' Handbook*, available for free at https://planteducation.eu/. All teaching activities were piloted in education in different European countries (FI, CZ, AT, D, NL). They were used in teachers' education as well as in practice with children attending primary schools.

1.1 Role of science in society and education

Ilkka Ratinen

Socioscientific issues (SSI) in education represent a pedagogical strategy that empowers students to take into consideration the ethical and moral dimensions of science-related issues. This approach involves social interaction and a construction of moral judgments, as part of scientific literacy (Zeidler *et al.*, 2005) such as plant literacy. As plants have gained less attention than animals in schools, the SSI framework may help to establish relations with plants in the environment fostering learners' engagement within and beyond school, crucial for nurturing responsible citizenship (see Zeidler, 2014). Without knowledge of plants and how they function and interact with other species and the climate, responsible attitudes toward them cannot take place. Indeed, knowledge is not enough. We also need to know how to inspirationally teach plants for the kids. SSI helps to create the context because it aims to facilitate learners' decision-making skills, enhance their scientific literacy, promote intellectual growth, foster moral development, and encourage community engagement within local, social and global contexts (Chowdhury *et al.*, 2020). Forests, meadows, gardens and other places where plants are growing, offer unique learning environments for the implementation of SSI in science classes.

Plants interact in many ways with soil, water and atmosphere and without plants the world as we now live in would not exist (for a detailed description of plant role in human environment see *Plant Literacy Teachers' Handbook*, https://planteducation.eu). Plant literacy, as an extension of scientific literacy, is pivotal in achieving Sustainable Development Goals (SDGs) because it empowers learners to understand plants more deeply, and accordingly act on issues plants are maintaining (e.g. O_2 levels), promoting (e.g. biodiversity) and regulating (e.g. climate). Therefore, plants are always related to SDGs. Addressing environmental concerns is central to SDGs, as is evident in goals like clean water access and climate action (SDG 6 and 13) (Nilsson *et al.*, 2016), that are both connected to plants. Engaging plant education with SSI facilitates SDGs by fostering critical thinking and scientific literacy. SDGs provide a framework for addressing SSI in plant education and also education policy which fosters knowledge of plants' role in life on earth. Educational institutions and societies must reinforce plant literacy to ensure a sustainable future, e.g. by embedding SSI in classrooms to promote plant literacy.

1.2 Science education

Ilkka Ratinen

In the classroom and outdoors, learning about plants can be facilitated by inquiry-based education. The rules and detailed description of this teaching approach are described in *Plant Literacy Teachers' Handbook* (https://planteducation.eu), which highlights key aspects of the role of science in education and society as outlined by the National Research Council (Minner *et al.*, 2010). The key aspects are presented below:

1. **Engagement** with Scientifically Oriented Questions. In education, learners are more likely to be engaged when *they encounter questions* that have a scientific orientation. This suggests that posing inquiries with a scientific context can stimulate curiosity and greater interest among learners.

   Why does the same tree look different in Lapland and Vienna?

2. Priority to **Evidence**. Learners are encouraged to prioritize evidence. This implies that the scientific method, which relies on empirical evidence, plays a crucial role in the learning process. By giving precedence to evidence, learners are better equipped to develop and assess explanations grounded in scientific principles.

   The following pictures represent the differences. What is the evidence? What can you see?

3. Formulating **Explanations** from Evidence. The process of science involves constructing explanations based on evidence. Learners are expected to not only gather information, but also synthesize it to formulate well-founded explanations. This reinforces the idea that scientific knowledge is derived from a systematic analysis of evidence.

   Two pieces of evidence are not enough for scientific reasoning. Get more evidence online and synthesize your explanation.

4. **Evaluation** of Explanations in Light of Alternatives. A critical aspect of scientific thinking involves evaluating one's explanations in the context of alternative explanations. This fosters a deeper understanding of scientific concepts and encourages learners to consider multiple perspectives, reinforcing the importance of open-mindedness and critical thinking.

Now you have looked at just one species, the birch. How about other flowering plants besides trees? How do they differ? Compare also flowers from Lapland and Vienna. What sort of differences can you now see?

5. **Communication** and **Justification** of Explanations. Effective communication is a key skill in science. Learners are expected to not only formulate explanations but also communicate and justify them. This emphasizes the importance of clarity and a coherent expression of scientific ideas, as well as an ability to defend one's reasoning based on evidence.

   The more evidence you have, the more you can see a pattern. What do you think are the main reasons for different plants in Lapland and Vienna?

The overall implication of these points is that plant education goes beyond the mere acquisition of facts; it involves active engagement with questions, evidence-based reasoning, critical evaluation of ideas, and effective communication of scientific understanding. Moreover, the emphasis on evaluating explanations in light of alternatives aligns with the dynamic and evolving nature of scientific knowledge.

1.3 Role of arts in science education

Ulla Kemi and Renata Ryplová

One goal of science education is to make science more attractive to children, encouraging them to learn science and maybe even one day becoming scientists themselves. However, there are fewer and fewer children and young people interested in becoming scientists (Braund & Reiss, 2019). Including art in science education has been recognized as a possibility to make science more understandable and scientific careers more attractive to children. It has also been suggested that it is impossible to gain scientific learning without involving the arts (Braund & Reiss, 2019).

Combining art with science education can help learners to express their thoughts, ideas and feelings in a way that the considers the potential of creativity (Izadi, 2017). Artistic expression is often influenced by cultural factors, and thus combining arts with science education can help children to understand the diversity of cultures (Izadi, 2017), which is necessary for achieving sustainable global future. Some scientists argue that creative thinking is one of their most important skills as scientists (Braund & Reiss, 2019). Including arts in science education may help learners to develop their skills important in learning science and in scientific careers.

Specifically, in botany lessons, children who participate in art activities involving drawing plants or modeling parts of plants have been found to have an increased ability to recognize the details and functions of plants. According to a study by Bowker and Tearle (2007), making realistic drawings of plants can lead to a better understanding of their anatomy and ecological relationships. Music can also contribute to the retention of information, even for a topic as difficult as photosynthesis. Songs about photosynthesis or the water regime in plants engage the children, making it easier for them to remember key concepts of these processes (Lynch & Simpson, 2021).

Incorporating dramatic elements such as role-playing, where children act out parts of plants (e.g., roots, leaves or seeds) not only promotes an understanding of the function of these plant organs, but also develops an empathetic understanding of their role in nature (Braund & Reiss, 2006). However, approaches combining multiple art forms appear most effective (Wilson, 2011).Modern challenges, such as achieving a sustainable future, require modern solutions. Creative problem solving can be trained at school by combining art with science education. Art can help learners to recognize the connections between different scientific fields (Izadi, 2017).

The combination of the STEM (Science, Technology, Engineering, Mathematics) and Arts (Arts) learning approach is STEAM. (For the detailed description of this teaching approach, see the *Plant Literacy Teachers' Handbook*, https://planteducation.eu). It is an innovative pedagogical approach that integrates different disciplines to promote creativity, critical thinking and hands-on learning. In addition, STEAM education promotes empathy for plants by presenting them to children as living organisms with an irreplaceable role in nature. Wilson's (2011) study shows that integrating multiple art forms in environmental education leads to a deeper emotional connection with nature, which is a key prerequisite for developing environmental responsibility. STEAM education promotes the development of plant awareness in children and contributes to the development of their ability to connect theoretical knowledge to real environmental challenges, making it an important tool for preparing the young generation for the environmental challenges of the future.

1.4 Role of playfulness in learning

Marjaana Kangas

Playfulness is an integral part of humanity and learning. It is a state of mind and attitude characterized by intrinsic motivation and a willingness to explore the world around (Csíkszentmihályi, 1990; Brown, 2009). Playfulness produces a joy of learning and is supported when learners are offered opportunities to create, enhance and personalize the conditions and circumstances under which they are learning (Reeve, 2022). Playfulness can be associated with the creation of imaginary play worlds and being open to playing with ideas and new possibilities (Egan, 2005). Playfulness in learning lights up the brain and promotes thought experiments and inventing unconventional solutions. Many innovations and scientific inventions are rooted in the human capacity for playfulness; thus, it is an essential process in scientific creativity (Bateson & Martin, 2013).

Playful learning denotes a holistic, interactive, and learner-centered approach bridging the gap between academic learning and playful exploration. Playful learners are active knowledge co-creators who can share ideas and use their imagination. They likely engage deeply with content and use creativity in problem-solving. Playful learning recognizes creativity, emotions, narrativity, collaboration, and embodiment as essential elements in learning (Kangas *et al.*, 2017) which can be harnessed for learning science. Learning is a mind-on, hands-on and body-on activity. Using appropriate media, digital tools, or art-based tools plays a key role in playful learning. Just as scientists use a variety of tools in their work, playful learners are encouraged to utilize a range of learning tools as a part of their exploration.

Playfulness in science education opens new opportunities for inquiry-based and exploratory learning. Encouraging learners to ask questions, children consider "what if" scenarios (Craft, 2005) and make observations and connections between different phenomena. In playful learning, students do not merely follow given instructions and rules but act as active knowledge co-creators, developing and testing their own hypotheses. This approach can enhance learners' curiosity, joy of learning, creative thinking, and problem-solving skills—while also strengthening their sense of agency (Boysen *et al.*, 2022).

1.5 Role of modern technologies and digital measuring devices in botany learning in primary schools

Renata Ryplová, Jan Pokorný, Vladimír Jirka and Petra Hesslerová

The integration of modern technologies, such as advanced measuring devices, digital tools and online learning platforms, has reshaped the educational landscape across various subjects, including botany topics in primary schools. Recent primary school children are members of the alpha generation, also called “the touch screen generation” (Pogue, 2015), who are accustomed to obtain information through digital technologies, tablets, mobile phones etc. from their early childhood. Accordingly, teaching with the help of these technologies is quite natural for them.

The emergence of modern technologies offers opportunities to make botany more accessible and engaging. Tools such as digital microscopes, augmented reality (AR) applications, and online gamified learning platforms enable interactive and more visually appealing education, which aligns with the learning preferences of today’s digital-savvy pupils (Smith *et al.*, 2020).

Modern technologies encourage collaborative learning by allowing students to collaborate on projects using cloud-based tools. This not only enhances teamwork skills but also promotes peer-to-peer learning, which has been linked to improved academic outcomes (Smith *et al.*, 2020).

Hands-on use of digital measuring devices provides pupils with practical skills that are valuable for their future education and careers. Additionally, these tools make the learning process active rather than passive, fostering critical thinking and problem-solving abilities (Johnson *et al.*, 2021).

Digital visual devices: Modern visual devices like digital microscopes allow students to explore the microscopic world of plants in high resolution. Such devices make the intricate details of leaves, stems, and cellular structures visible, thereby sparking curiosity and interest. A study by Johnson and colleagues (2021) demonstrates that students who use digital microscopes show a 40 % increase in comprehension and retention compared to those using traditional tools. The incorporation of high-quality visuals through digital tools likewise appeals to the visual learning preferences of primary school pupils.

Online learning platforms: The use of online platforms for botany projects has allowed students to collaborate and access diverse resources. These platforms also enable teachers to personalize content based on individual student needs, fostering better understanding and engagement (Lee & Wu, 2022).

Digital measuring devices - Thermovision cameras, IR thermometers, solarimeters (Figs 1 – 3): Thermovision cameras and infrared (IR) thermometers are promising tools for enhancing botany education in primary schools, enabling students to visualize and measure plant processes accompanied by temperature changes in real time. These devices facilitate a deeper understanding of key biological concepts such as transpiration, and plant-environment interactions by providing accessible, hands-on experience.

One of the primary applications of thermovision cameras in botany education is the study of plant transpiration (Ryplová & Pokorný, 2020). During transpiration water is vaporized from plant leaves through stomata creating a cooling effect. Thermovision cameras allow students to observe temperature variations on leaf surfaces, correlating these patterns to stomatal activity. Studies by Grant *et al.* (2006) have shown that such visualizations make abstract concepts tangible, improving comprehension and retention among young learners.

For evaporation, i.e. the transition of water contained in the plant from liquid to a gaseous state, 50 – 70 % of the incident solar energy is used. This energy is stored in the water vapour as latent heat and therefore cannot be used to heat surrounding air. In this way, plants cool themselves and their surroundings. A mature tree with a crown radius of 4 m evaporates about 200 litres of water during a clear summer day in central Europe (we consider about 10 hours of sunshine). We know that for the vaporization of 1 litre of water at normal pressure and 20 ^{o}C temperature 2.45 MJ of energy is used. This is approximately 0.68 kWh of incoming solar energy. Thus, to evaporate 1 l of water, 0.68 kWh of solar energy is consumed. Hence, to evaporate 200 l of water, this mature tree consumes 136 kWh of solar energy. If the tree is cut down, the incident solar energy will not be stored in water vapour but will heat the surface on which it falls; from this surface the surrounding air will warm up. Therefore, in areas without water and without vegetation that evaporates water, we measure a higher surface temperature using a thermal imaging camera or IR thermometer (Pokorný *et al.*, 2010).

Fig. 1. Small thermovision camera.

Fig. 2. IR thermometer.

Fig 3. Solarimeter.

Using a thermal imaging (thermovision) camera (Fig. 1), even young children can see how the surrounding vegetation is cooling humans or other animals (Fig. 4).

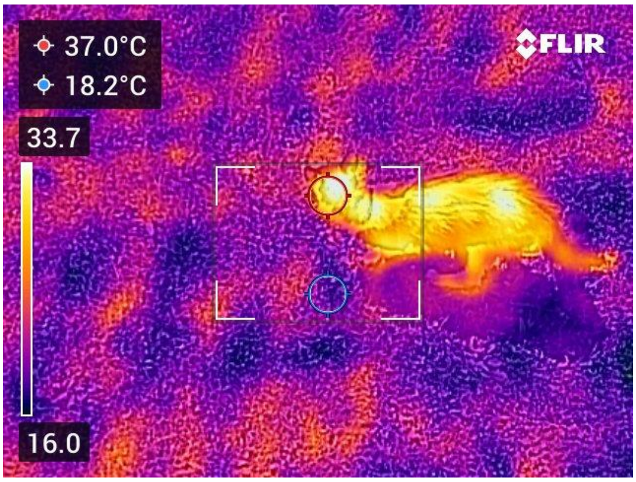


Fig. 4. During the hot days plants can also cool the animals. There is a cat on the grass in this thermovision picture. The surface temperature of the body of the cat is 37 °C, while the surface temperature of the grass is 18.2 °C.

On a clear summer day, the surface temperature of the human body is higher than the temperature of the shade of a tree (Fig. 5).

Fig. 5. The people cool themselves in the shadow of trees in the city park, because the temperature of their bodies is higher than the temperature in the shadow of the tree.

Comparing the surface temperatures measured by IR thermometers and the intensity of incoming solar radiation measured by a solarimeter in the shadow of a tree and the free space, children can discover the cooling function of vegetation (Figs 6 and 7).

Fig. 6. In the shadow of a tree, the temperature 24.1°C can be measured along with incoming solar radiation 74 W.m^{-2}.

Fig. 7. In the same time in the open space on the pavement the incoming solar radiation is 826 W.m^{-2} and surface temperature 46.7 °C.

2 In-person activities for primary school

2.1 Mapping temperature around us

Ilkka Ratinen and Ulla Kemi

This activity indicates the variation of temperature caused by vegetation. The task is based on an inquiry-based learning and art-based learning.

Objectives:

- Learn how plants cool the environment
- Learn to make a thermal map
- Learn to plan, implement and evaluate a guided inquiry and art-based learning exercise

Needed time:

- 90 mins

Needed material:

- Thermocamera
- IR thermometer
- Painting accessories
- Mobile camera app

Level:

- 12 – 13 years old

Phases:

1. **Engagement**: Take thermocamera pictures from nature and explore them with students. Discuss the temperature variations and the reason behind them. Collect learners' prior knowledge.
2. **Explore**: Students are outside in sunny weather. They are asked to choose a tree they want to measure. Before measuring the temperature, they must decide how many measurement points are needed for painting a thermal map of the tree. The easiest way to estimate this, is by taking a photo of the tree and editing it by adding a grid over it. When all measurements are complete, the work continues indoors. In the classroom, students paint the tree they measured and photographed. The colors used are to be based on a scale determined by the learners for the given temperature range. The finished paintings show the same principle of temperature variation as the real thermocamera image, but with much lower resolution (i.e., fewer pixels).
3. **Explain**: After the inquiry and art-based experiment, students form groups to discuss the results and reflect on how and why temperature varied around the trees. They also compare the difference between the real thermocamera image and their own painting.
4. **Elaborate**: Students form a group tasked with making an exhibition in the school corridor. In this exhibition, they share their learning experiences with a larger audience. The exhibition includes an information table that explains the theory of transpiration and its application in simple thermal mapping.
5. **Evaluate**: Students collect peer-assessment from the visitors at the exhibition. For this purpose, a tablet is placed next to the exhibition.

Peer-assessment rubric

Criteria	😊	☹	**Cannot say**
Based on this exhibition, I understand that plant transpiration cools the environment			
I understand the basis of thermal imaging			
I know how to paint a thermal map			
I think the exhibition was interesting			
I would like to do similar exhibitions			

2.2 The energy consumed by transpiration cools the plant surface

Ilkka Ratinen and Ulla Kemi

This activity indicates that transpiration requires energy and absorbs energy from the plant surface. The task is based on an inquiry-based learning approach.

Objectives:

- Learn how plants transpirate
- Learn how transpiration cools the plant surface
- Learn to plan, implement and evaluate a guided inquiry-based learning exercise

Needed time:

- 45 mins

Needed material:

- IR thermometer
- 2 branches with leaves
- 2 vases for branches
- Water

Level:

- 12 – 13 years old

Phases:

1. **Engagement**: Videos for motivation (e.g. *Hungry SciANNtist: Transpiration in plants*, https://www.youtube.com/watch?v=KaRNwqYOrZg), thermocamera images and discussions about the role of transpiration. Students reflect on their everyday experiences, such as the significance of sweating. Pupils can also conduct some experiment related to transpiration, although this activity especially focuses on energy.
2. **Explore**: Students set up the experiments using two vases: one with water and one without, both containing a branch with leaves. First, students form hypotheses about the surface temperature of the leaves. They then use a thermometer to measure the initial temperatures of the leaves. After that, the vases with plants are placed in a bright location. Temperature measurements are repeated after 15 minutes, and students write down their observations. While waiting for the experiment to progress, students learn about the movement of water in plants (e.g. *Thatbioguy: Water transport in plants*, https://www.youtube.com/watch?v=5CMrK8rlzZw, teacher explanation will be required).
3. **Explain**: After the experiment, students form groups to discuss the results and reflect on how and why the plant surface measurements varied. They also reflect on how the studied theory connects to their experiment.
4. **Elaborate**: Students are given a group task to reflect on their prior knowledge in relation to the experiment. The discussion focuses on transpiration and its connection to microclimate. The theoretical background on water transpiration introduced in the first phase is linked to the students' everyday lives through practical examples.
5. **Evaluate**: Students evaluate the success of the experiment in teacher-led discussion (closing-down science lesson). Throughout the project, students fill in the self-assessment rubric and then discuss with their peers what they have learned.

Self-assessment rubric

Criteria	Your points	Possible points
Engagement: I participated in the discussion and if I didn't understand, I asked for help.		20
Explore: I understood what we were researching and why, and how the research design was constructed and implemented.		20
Explain: I was able to explain why we got a certain result and I was able to justify the result based on what I had previously learned.		20
Elaboration: I was able to look at the research and findings in a different, broader context or topic.		20
Evaluation: I was able to critically evaluate our research, its results and my own learning.		20
Total		100
Comments:		

2.3 The best detective – Outdoor game on cooling function of vegetation in school garden

Renata Ryplová, Jan Pokorný and Petra Hesslerová

This is an outdoor game on cooling function of vegetation using thermovision cameras. The best environment for this learning activity is a school garden, but it can also be organized in a park near the school, etc.

Objectives:

- To discover the cooling function of vegetation
- To recognize, that the plant cools our environment due to water vapour

Needed time:

- 45 min

Needed material:

- Artificial plants
- Living and artificial potted plants of the same art
- Thermovision camera
- Two towels of the same color; one dry and one wet (or any other highly absorbent material like kitchen sponge etc.)

Level:

- 8 – 12 years old

Phases:

1. **Motivation and research question (5 mins)**

   Classes are held outside on a sunny day. For initial motivation, the teacher uses an artificial potted plant and a living potted plant which are as similar to each other as possible. The artificial plants are often so well made that they are indistinguishable from the living ones. The teacher asks the students to take a thermal image using a thermovision camera of both plants (Fig. 8) and asks why one has a cooler surface than the other when they appear the same at first glance.

Fig. 8. Artificial and living potted plants and their thermovision picture. The surface temperature of the living plant is significantly lower.

2. Examination and Explanation (10 mins)

The pupils guess and eventually find out that one of the plants is artificial. Next, the teacher prompts the students to take a thermal image of the dry and wet towel after exposure to sunlight (Fig. 9). The students will find that the moist substance has a lower temperature in the thermal image. The teacher explains that water evaporates from the wet substance, using solar energy to evaporate, so, this energy is hidden in the water vapour and cannot heat the air. Therefore, the surface of the moist substance is cooler. Similarly, a living plant, unlike an artificial plant, evaporates water and therefore its surface is cooler. In this way, the children using their own inquiry, recognize that the cooling function of vegetation in our environment is based on water vapour.

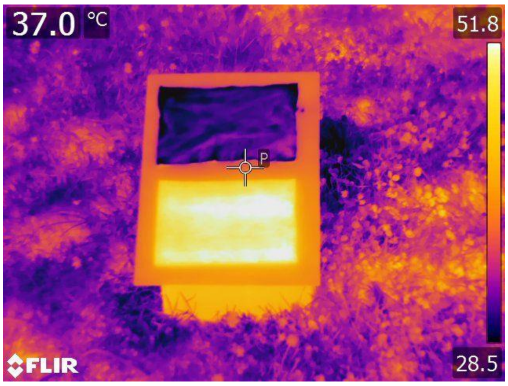


Fig. 9. Thermovision picture of the wet (upper part) and dry (lower part) towel exposed to the solar radiation.

3. Outdoor game using thermovision camera (20 – 25 mins)

Who is the best detective? Children work in groups of 3 – 4. The teacher preplaces the artificial plants in the vegetation (lawn, bushes) so that they blend in as much as possible with the surrounding vegetation. The plants need to be placed in the vegetation so that they are exposed to sunlight. *Detectives often use thermal imaging cameras in their searches. We will use thermal imaging to look for intruders in the vegetation. Which group will find all the intruders the fastest?*

The teacher tells the pupils the number of artificial plants hidden in the vegetation and the approximate places where to look for them (e.g. the bushes behind the greenhouse, the lawn in the south-west corner of the garden, etc.). The groups then use thermal imaging to find the artificial plants by locating warmer spots in the vegetation (Figs 10 and 11). The teacher measures the time. The group which detects all the intruders the fastest, is the best detective and wins.

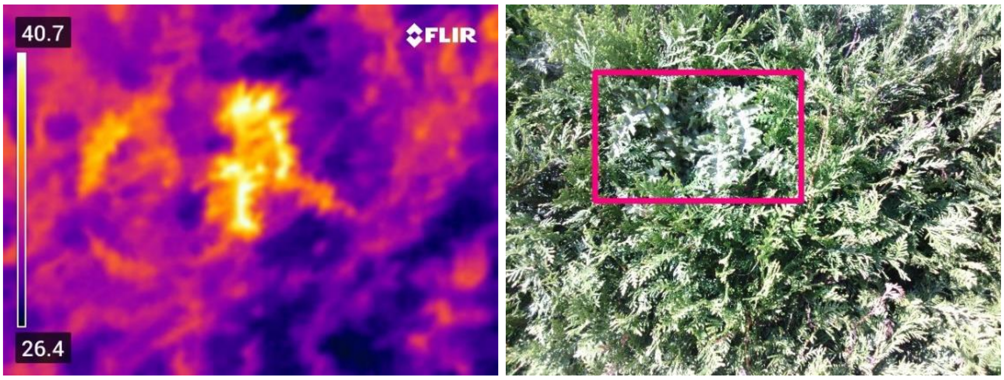


Fig. 10. Artificial plant hidden in the shrubs and its thermovision picture. The surface temperature of the artificial plant is about 40 °C while the surface temperature of the living vegetation is under 30°C.

Fig. 11. Discovering artificial plants in the vegetation using thermovision.

4. Final discussion and conclusion (5 – 10 mins)

The teacher summarizes the main observations and discusses with the children situations from their environment, where they encounter the cooling function of vegetation.

Self-evaluation form

To support learning, it is necessary to self-assess how learning and self-promotion have improved. Please evaluate the following points as truthfully as possible.

	😆	🙂	🙁	😖
I learned something new about plants				
I have learned why plants around me are important				
I actively participated in group work				
I was able to ask for help when needed				
The learning was fun for me				
I would like to do more such learning activities				
How is it possible, that plants cool our environment?				
What did you enjoy most during this learning activity?				
What did you not like during this learning activity?				

2.4 Water vapour as natural cooling device

Petra Hesslerová, Renata Ryplová and Jan Pokorný

Objectives:

This activity can be used as a training activity to practice measuring with a thermal imaging camera or infrared thermometer. It illustrates in a simple manner the physical principle of evaporation that underlies the cooling effect of plants. By incorporating this activity into Activities 2.1, 2.2 or 2.3, a STEM approach is brought in. The activity can be done anywhere outdoors on a hot day and in sunny summer weather.

Needed time:

- 60 mins (dependent on outside temperature and sunshine; the warmer the better)

Needed material:

- Two PET bottles filled with water of the same temperature
- Wet towel
- Thermovision camera

Level:

- 8 – 12 years old

Phases:

1. Take two PET bottles and fill them with water of the same temperature (Fig. 12).
2. Measure their initial temperature with a thermographic camera (Fig. 13)
3. Place them on a concrete/asphalt surface.
4. Wrap one of the bottles in a wet towel and measure the temperature of the bottles (Figs 14 and 15).
5. Leave both bottles exposed to sunlight for about 30-60 minutes.
6. Continuously monitor the temperature of both bottles with a thermal imaging camera, write down the readings (Fig. 16).
7. After 30-60 minutes, unwrap the bottle from the wet towel, measure temperature of both bottles (Fig. 17). The bottle wrapped in the towel should have a lower temperature due to evaporation of water from the wet towel. The evaporation of water uses up heat - the water bottle cools.

Variations:

For a more interesting demonstration of the experiment, a chocolate/butter bar may be used, so that the experiment will be faster. You can also wrap both bottles by the towel of the same color – one will be dry, one wet.

Fig. 12. Experiment preparation aids – two PET bottles filled with water of the same temperature, thermovision camera and a towel.

Fig. 13. Both bottles have a starting temperature 18 °C.

Fig. 14. Wrap one of the bottles in the towel soaked in cold water.

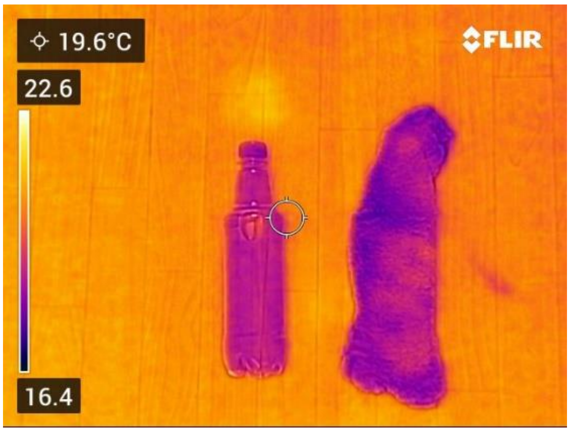


Fig. 15. At the beginning of the experiment the temperatures are equal.

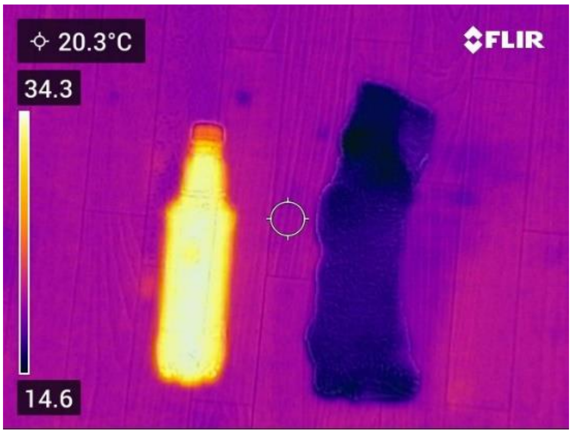


Fig. 16. After some time (depending on the intensity of the sunlight), the water in the first bottle has warmed up, while the wet towel remains cold.

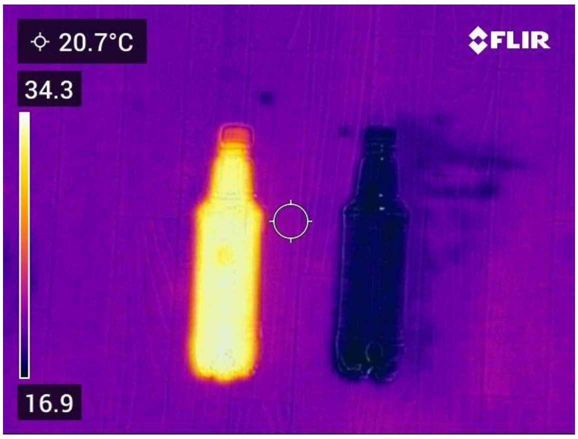


Fig. 17. After removing the cold towel, the water in the bottle remains cold.

2.5 Not all leaves are the same

Ilkka Ratinen

Aim:

The aim of this activity is to explore, through a combination of science, mathematics and computer science, the importance of different sorts of plant leaves and their orientation towards light in the context of ecological competition. This exercise combines the study of the leaves of heliophytic (light-loving) and sciophytic (shade-loving) plants with the measurement and tabulation of solar radiation intensity.

Needed time:

- 2 x 45 mins

Needed material:

- Leaves from different parts of the canopy of a single tree (leaves taken from the sunny part (heliophyte) and the shady part (sciophyte) must be clearly distinguished). Preferably beech, linden or birch. Segmented leaves with a divided leaf blade, called lobes (e.g. oak) are not suitable.
- Square transparent film with grids of one cm^2 in size
- Solar intensity meter (lux)
- Solar meter (W/m^2)
- Computer and Excel (in class)

Level:

- 12 – 13 years old

Research questions:

- Do tree leaves have the same properties?
  Leaf area and color (whether there are different shades of green)
- How are the leaves positioned on the branches in relation to the light?
  Amount of light received by the leaves

Phases:

1. **Measure solar radiation** (students should be familiar with the concepts)

   Choose a research site where you can measure solar radiation. Measure the radiation intensity both in an open space and on the leaves of your choice (light-favouring and shade-favouring).

   Use a solar intensity meter (solarimeter) and measure the light intensity (lux values) and/or a solar radiometer and measure the solar radiance (W/m^2) at both locations.

2. **Measure the area of the leaves**

   Collect the leaves that you measured in the previous step (both light- and shade-favouring). Place each leaf on a transparent measuring scale and count how many squares of 1 cm^2 cover the leaf. Calculate the area of the leaves by adding up the number of squares covered.

3. Construct the table

Make a table with the following columns: plant, leaf type (heliophyte or sciophyte), leaf area (cm^2), radiance (lux) or solar radiation (W/m^2). Enter all the measured data in the table.

4. Calculate averages and present results

Calculate the average values of the different measurements (leaf area, radiant intensity or solar irradiance) in Excel.

Draw a graph in Excel indicating the relationship between leaf area and solar radiation intensity.

Learners' self-evaluation form

In order to support learning, it is also necessary to self-assess how learning and self-promotion have improved. Please assess the following points as truthfully as possible.

Claims related to the research project	**Strongly disagree**	**Disagree**	**Agree**	**Strongly agree**	**Cannot say**
I find learning about plants inspiring					
I have learned new things about plants and their importance in life					
I have learned about the world of plants to the best of my ability					
I want to learn more about plants					
I understand why trees have leaves that prefer light and shade					
I understand how the size of a leaf affects its ability to absorb sunlight					
I understand that leaves are arranged differently in the tree canopy					
I am willing to share what I have learned with others					
Continue: *I think the best thing about studying plants is…*					

2.6 Exploring the colors and odors of flowers

Ilkka Ratinen

Aim:

The aim of this activity is to understand why flowers are colorful, why they smell, how flowers attract pollinators and why pollination is important for plants. This exercise will help students understand the importance of the natural ecosystem and how even small details, such as the colors and odors of flowers, are part of the bigger picture.

Needed time:

- 45 mins

Needed material:

- Material for taking notes (notebook, pen)
- Magnifying glass (optional)
- Plant identification book or mobile device for plant identification (optional)
- A variety of colorful and fragrant flowers from a garden or open nature

Phases:

1. **Opening up (10 mins)**

   Ask students if they have noticed that flowers have different colors and smells. Why do they think this is the case? Discuss together that the colors and odor of flowers attract pollinators such as insects like bees and butterflies, which help flowers to reproduce by transferring pollen from one flower to another.

2. **Examining the flowers (20 – 30 mins)**

   Take students outside to the school playground, a nearby alley or a park. Ask them to look for flowers of different colors and odors. Students can examine the flowers and use a magnifying glass to look at details or take photographs of the flowers for later examination. Differentiation can be increased through plant identification. Pupils record what colors they see and what the flowers smell like. In addition, ask pupils to record whether they notice insects near the flowers.

3. **Sharing of observations and discussion (10 – 15 mins)**

   Gather students together and ask them to share their observations. Discuss why certain flowers might attract more insects than others. The teacher can point out (if students' answers are not clear) that the bright colors and odors of flowers are ways of attracting pollinators.

   Explain that pollinators help plants to reproduce by transferring pollen from one flower to another. Without these pollinators, many plants would have difficulty producing seeds and fruits.

4. **Closing down (5 – 10 mins)**

   The teacher summarizes the main observations and conclusions learned during the discussion: flowers are bright and fragrant to attract pollinators. These insects help plants to reproduce through pollination, which is important for biodiversity as well as the food chain.

Teacher may also give students a homework assignment to monitor whether they see more pollinators around the flowers in their homes and ask them next time what they have observed.

Self-evaluation form

In order to support learning, it is also necessary to self-assess how learning and self-promotion have improved. Please assess the following points as truthfully as possible.

Criteria	**Points**	**Possible points**
I took part in the discussion, and if I didn't understand, I asked for help.		1-5
I understood what we were researching and why, and how the research design was constructed and implemented.		1-5
I was able to explain why we got a certain result, and I was able to justify the result based on what I had learned earlier.		1-5
I was able to look at the research and results in a broader context or topic.		1-5
I was able to critically evaluate our research, its results and my own learning.		1-5
Total		5-25
Comments		

2.7 Plant diversity and adaptation: Investigating plants with small transportable microscopes (Easi-Scope)

Ulla Kemi and Saara Krook

In our daily lives, our observation of plants is limited by our limited vision. Plants are much more than what we can see with the naked eye. Microscopes can be expensive and only a few children have access to conventional microscopes at school. Transportable, small and easy-to-use microscopes (e.g. Easi-Scope by TTS Group, UK) are therefore a suitable alternative. It is possible to connect the microscope to a mobile device and take pictures or make short videos when exploring the object with the microscope. Often up to 40x magnification is possible.

Exploring plants with a microscope enhances children's observation skills, plant literacy and overall understanding of the natural world.

Children can explore the objects they find and select them themselves, or the topic may be chosen by the teacher. For instance, you can focus on the structure and tissue of leaves or the structure of flowers. Children can also be asked to find for example at least 10 different kinds of shapes or colors. To keep the childrens' attention on the research task, it is a good idea for the teacher to define a topic instead of an open-ended assignment.

Needed time:

- 45 mins

Needed material:

- Mobile microscopes connected to smartphones or tablets, (e.g. Easi-Scope by TTS Group, UK)
- Smartphones or tablets
- Material for taking notes (notebook, pen)
- Sampling equipment (small tweezers, scissors, jars)
- Plant material

Level:

- 7 – 12 years old

Phases:

1. **Introduction**

   The teacher briefly talks to the students about the structure of the plant (opening up). As a preliminary indication of leaf structure, cell layers, leaf veins and air spaces can be mentioned, depending on the age of the students and on their prior knowledge.

   Discuss what children could study with a mobile microscope: leaves, flowers, tree bark, moss, etc.

2. **Collecting the samples**

   Children can choose to study leaves, flowers, grass or other plants according to the topic chosen by the teacher. The teacher can ask students to look for different structures, types of plants or parts of plants.

   Children are instructed to collect samples that are small enough to fit into the microscope's field of view. At the same time, it is stressed that nature must be respected and that trees, for example, must be waved or harmed. The safest advice is to select only parts of the plant that have already fallen to the ground.

Samples are collected in groups of 2 – 3 students.

3. **Examining samples with a mobile microscope**

Once the samples have been collected or the plant to be examined has been selected, the students attach a mobile microscope to their smart device and examine the sample under the microscope (Fig. 18).

Children can take pictures of their samples on their mobile devices and zoom in on details such as cell and leaf veins or the structure of petals.

4. **Notes**

Children observe what the samples look like under the microscope. They can draw notes, take pictures or write down what they see. Taking pictures is easy with Easi-Scope and the images are saved in the smart device's photo gallery. From there they can be accessed for later review.

Examples of questions children can answer:

What do the cells in a leaf look like?
Can you see different layers on the surface of the leaf?
How do the petals of a flower look different in a microscopic picture?
How do the petals of a flower look different from each other?

5. **Sharing results and discussion**

Children are in a large group, and the small groups share their findings with others. The key is to go through the different observations and compare how, for example, the leaves of different plant species differ from each other.

The teacher can supplement the information and provide more information about the structure of plants and their importance for the life functions of plants (closing down).

6. **Reflection and evaluation**

Discuss what you have learned about plant structures. Consider how plants could have been studied differently.

Guided inquiry: the teacher gives a ready-made topic, such as leaf structure, and the children focus on that. They can compare leaves of different tree species or analyze leaves taken from different habitats.

Open inquiry: children can focus on the natural sites of their choice and make independent observations using a mobile microscope.

Self-evaluation form

To support learning, it is necessary to self-assess how learning and self-promotion have improved. Please evaluate the following points as truthfully as possible.

Claims related to the research project	😆	🙂	🙁	😖
I participated to do the task and the research				
I understood what our research was about				
I actively participated in group work				
I was able to ask for help when needed				
I understood the different results we obtained, and I was able to justify them				
I can connect my conclusions with my own environment				
I can critically analyze and evaluate the results of my research				
I learned something new about plants				
I learned something about the different stages of research				
I practiced my research skills				
I can identify the stages of conducting research				
What was the most memorable thing you learned during your research project?				
Which plant-related topic would you like to know more about?				
What would you do differently during the project?				

Case study

Transportable Easi-Scope microscopes were used by pupils on the 5th grade (about 12 years old) in primary school at a school in Northern Finland at the beginning of May, 2023. The challenge was that the spring at this latitude is very late and there was even some snow still on the ground, i.e., growing season had not started yet. It was aimed at exploring the signs of spring with microscopes (e.g. new leaves), although it was not possible. However, children were allowed to collect natural objects they wanted to explore with microscopes. It motivated the children to figure out that even in the very early spring / late winter you can see signs of living tissue in plants. For instance, the children explored the needles of conifers, moss and lichen (Fig. 19). It was also interesting to see that one can explore the structure of the leaves also in dead leaf material.

Later, a quiz was held based on the pictures children took – who knows what is in which picture?

Fig. 18. Children examining the plant material they have collected.

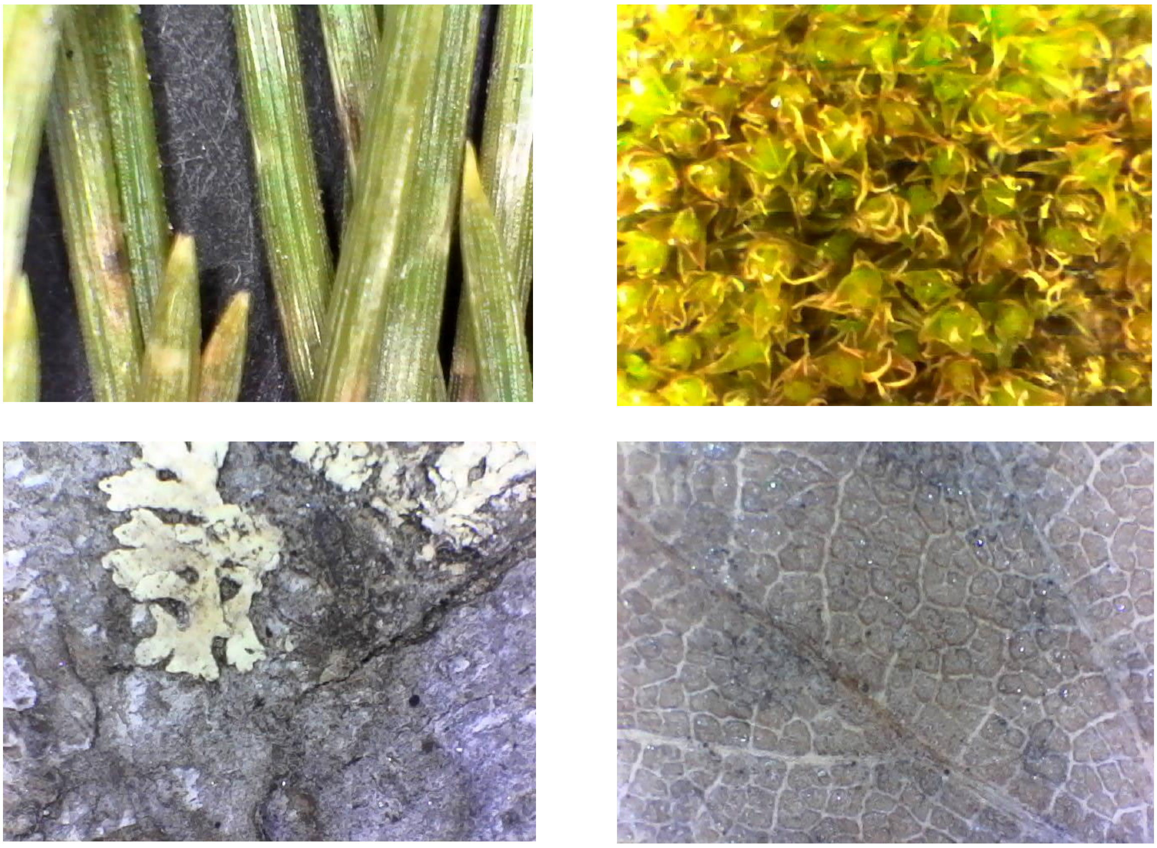


Fig 19. Examples of pictures taken by the children of selected plant materials.

2.8 Burdock and co-spreading plants

Eveline Neubauer, Birgit Steininger and Ulla Kemi

In this activity, the students explore and deepen their understanding of plant seed dispersal. They learn about different seed dispersal strategies through independent research. They also examine the consequences of climate change, specifically how the extinction of animals can affect seed dispersal, as they are no longer able to carry out this important task.

The experiment starts with the children working outside in small groups for about 15 minutes and collecting seeds from different plants (Fig. 20). The children are asked to think together about how the plants are able to spread their seeds and their ideas are written down.

This phase is followed by group presentations: the groups present seeds they collected and describe the seed dispersal strategies they have thought about. The teacher gives feedback in the discussion and provides new ideas, if they are needed. This phase lasts about 30 minutes.

A list of all suggested seed dispersal strategies is made.

Seed dispersal can be done for example by

- Animals (for example burdock, cherry pits)
- Wind (for example, dandelions)
- Water
- Humans
- Plants themselves (self-propagation)

It is also important to discuss the impact of climate change on seed dispersal. For example, what are the consequences of climate change for plants with different seed dispersal strategies? What if water becomes increasingly scarce due to droughts – which seeds can no longer spread? What would that mean for the whole ecosystem?

In the final phase (about 10 minutes), results are documented. The children store the collected seeds and write or draw the dispersal strategies in their notebooks. With more time, the children can create posters about different seed dispersal strategies. This is followed by a poster tour.

Fig. 20. Children exploring the seeds they have found.

2.9 Forest ecosystem – Everything is somehow interconnected

Eveline Neubauer, Birgit Steininger, Ulla Kemi and Saara Krook

This fun and engaging activity is designed to help children understand the importance of each factor in an ecosystem. The aim of this game is to demonstrate in a playful way how important all factors are in maintaining a balanced ecosystem. In addition, this activity reveals that the balance of an ecosystem is disrupted when one or more factors are missing.

This activity can be done either in a group or in pairs.

2.9.1 Group version

Needed time:

- 30 – 45 mins

Level:

- 11 - 15 years old

Phases:

1. Make a circle and ask each participant to think about the role they would like to play or draw lots for roles within the group. Roles can be for example human, bear, grass, moss, tree, fox, water, light, carbon dioxide, soil and fungus. You can also add other parts of the ecosystem if you wish. Examples of the role cards are attached (Fig. 21).
2. One person starts by explaining their role.
3. The person invites another person who is important to him/her (e.g. a tree absolutely needs light). The people hold hands, establishing a connection between the tree (participant 1) and the light (participant 2). In the end, everyone should be connected in some way (Fig. 22).
4. Once this is done, the facilitator asks the group: What happens when the trees fall away? The facilitator asks thought-provoking questions such as, what factors (participants) are the trees associated with, why?
5. Finally, the characteristics of the ecosystem are discussed.
6. After this exercise, it is advised to make a written or drawn reflection. The children can think about why trees and other plants in the forest are dying due to climate change, and why this has such catastrophic consequences for the entire ecosystem. What is the role of humans in the ecosystem?

2.9.2 Pair work version

Needed time:

- 30 mins

Needed material:

- Ecosystem role cards (e.g. Fig. 21)
- Pieces of string

Phases:

1. Before the exercise, prepare the ecosystem role cards (e.g. Fig. 21). They can be printed out and then squares are cut out. Children can also make their own cards. One pair of learners needs one set of cards.
2. In pairs (or in groups 3 learners), make connections between the cards using pieces of string (Fig. 23). The group also discusses with each other why the link exists and why it is relevant. If the exercise is done in a class of several students, small groups may come up with different solutions. These will be discussed in the next step.
3. Once the small groups are ready, the whole group reflects on the solutions.

    - *What kind of connections were found between the components of the ecosystem?*
    - *What happens if one factor is removed?*
    - *Why are trees and other plants in the forest dying due to climate change, and why does this have such catastrophic consequences for the entire ecosystem?*
    - *What is the role of humans in the ecosystem?*

4. After the exercise, each pair fills in the peer review underneath.

Peer review

To support learning, it is also necessary to review how learning and self-promotion have improved. Please assess the following points as truthfully as possible.

Criteria	😊	☹	**Cannot say**
Based on this exercise, we understand the importance of factors related to ecosystem balance.			
We understand the basics of natural balance.			
We understand that in nature, the balance is constantly changing.			
We found the exercise interesting.			
We would like to do similar exercises.			

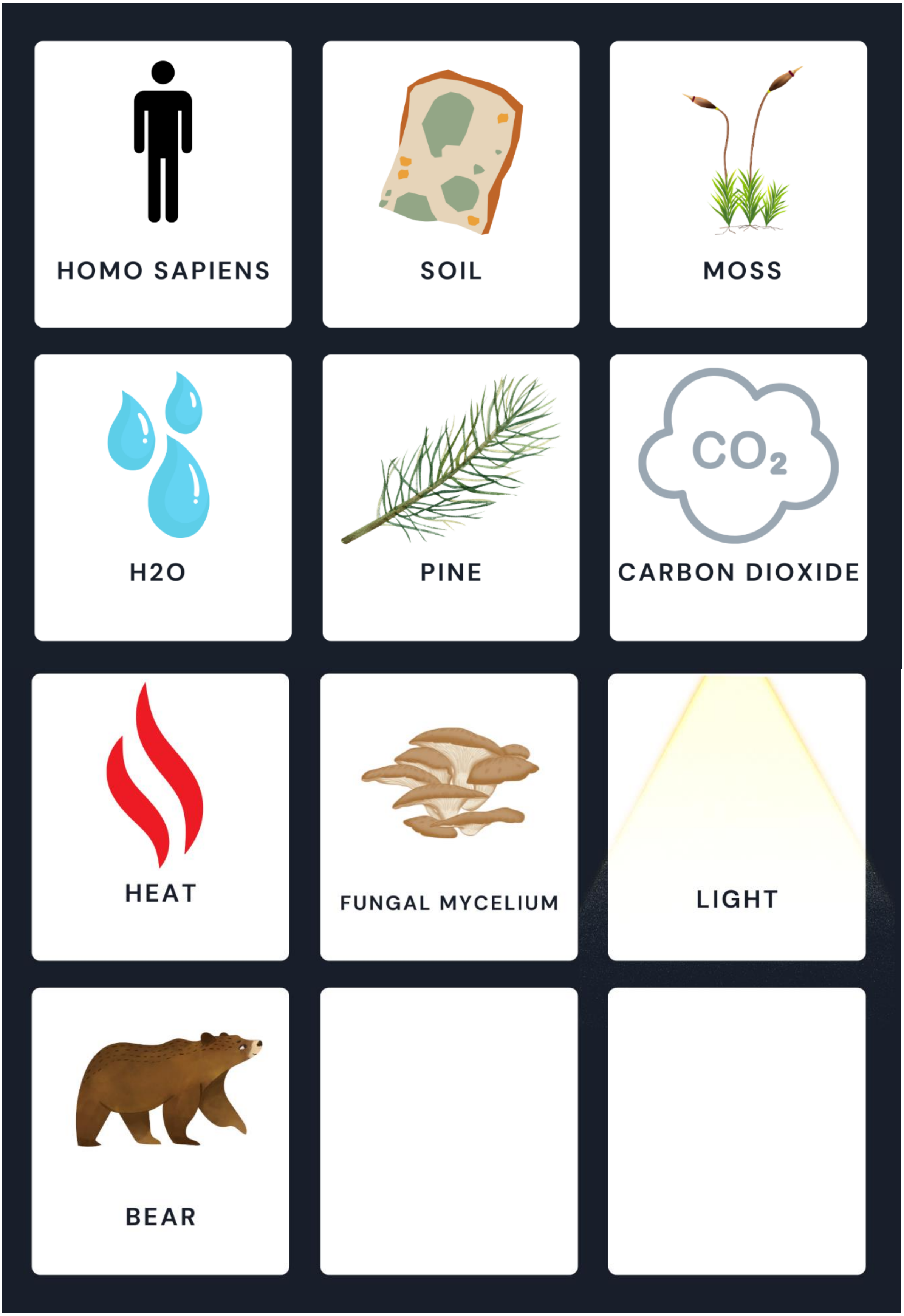


Fig. 21. Example of role cards for the ecosystem play.

Fig. 22. A group of learners is visualizing connections in an ecosystem.

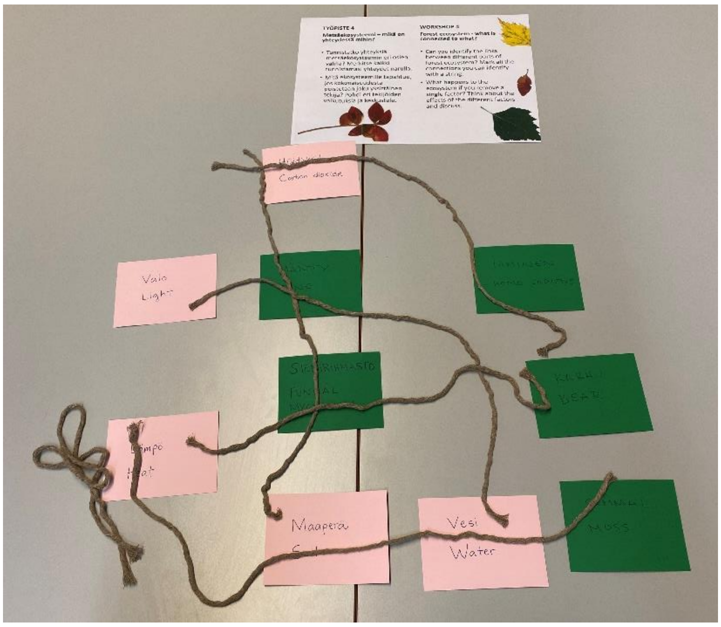


Fig. 23. A table version of the connections in an ecosystem.

2.10 What have we learned from plants?

Jan Petr and Zbyněk Vácha

This activity is based on inquiry-based and STEM-oriented learning.

The activity includes two tasks aimed at finding parallels between the structure or function of plant organs and solutions commonly used by humans. Students will become aware of the adaptations of seeds and fruits for the propagation of plants and see the application of these principles to technical product solutions.

A suitable example of plant inspiration is the joining of materials with Velcro tape. The next task focuses on the construction of a simple paper model of a helicopter whose flight characteristics can be improved by observing the wind-distributed seeds and fruits of plants, specifically of lime trees.

Both tasks are complemented by the observation of real natural plants using optical aids (magnifying glass, stereomicroscope, etc.). This offers students a close-up view of plant organs and the Velcro technical solutions inspired by them. The second task also develops students' technical skills.

2.10.1 Natural hook-and-loop fastener

This task is aimed at comparing the structure of Velcro tape and the fruits or fruiting bodies of selected plants.

Theoretical basis:

Zoochory is a method of spreading seeds, fruits or whole fruiting bodies by animals. It is a key process that allows plants to occupy new habitats where they can germinate and grow.

There are two main types of zoochory:

1. **Epizoochory**: seeds or fruits attach to the surface of the body of animals, such as fur or feathers. To do this, different structures such as hooks or spines have evolved. Examples of plants that use epizoochory are the dicot (*Bidens*), avens (*Geum*), agrimony (*Agrimonia*) or the burdock (*Arctium*) (Fig. 24).
2. **Endozoochory**: The seeds or fruits are consumed by animals and pass through their digestive tract. These plants usually have fleshy fruits, such as the cherry (*Cerasus avium*) or elderberry (*Sambucus nigra*).

Zoochoria has a significant ecological impact. For example, the disappearance of species that were key seed dispersers may lead to threats to those plants dependent on this mode of dispersal as well as to biodiversity disruption.

Velcro has been around since 1941, when Swiss engineer Georges de Mestral was inspired by the fruits of burdock caught on his dog's fur during a walk out in the countryside. The principle is to fasten two strips of cloth, one with thousands of tiny hooks and the other with thousands of tiny loops. The hooks are inspired by the structure of a burdock's fruiting body and the loops of fiber are the equivalent of fur or woven fabric (Fig. 25).

This principle was patented and industrial production began. Since then Velcro is used in a wide range of applications. It is mainly used in clothing, footwear or wherever it can replace buttons, snaps or zippers. It is generally used to attach objects or parts to surfaces, to fasten upholstery, carpets, to temporarily hold various tools, to close bags, backpacks or suitcases. It is used in healthcare, aviation and many other fields of human activity, including games.

Needed material:

- Velcro tape cuttings (about 5 cm long)
- Fruits or fruiting bodies of plants spread on the surface of animal hair (e.g. avens (*Geum*), agrimony (*Agrimonia*), burdock (*Arctium*), bedstraw (*Galium*))
- Magnifying glass (stereomicroscope)
- Various types of fabrics (flannel, corduroy, cotton etc.)

Phases:

1. **Engaging**

   Brainstorming aimed at giving examples of where Velcro is used everywhere.

   Students list and write on the worksheet all the uses of Velcro they have encountered in their environment or life. They can work in pairs or groups to compare their ideas.

   They can demonstrate the presence of Velcro on their clothes, backpacks, bags or shoes. They are likely to mention some toys (e.g. a game of catch-ball, etc.).

2. **Exploring**

   Students observe the structure of the fruit with a magnifying glass (microscope) and draw the shape of the hooks on the worksheet. They then look at the construction of the Velcro tape and compare how similar the layer with nylon hooks is to the anatomy of the fruit.

   Students will try attaching plant fruits to fabric scraps and can compare which ones have the strongest attachment. They will attempt to attach a layer of Velcro tape with hooks to fabric scraps and also to a second layer of Velcro tape.

3. **Explanation**

   Students will explain why do the two layers of Velcro tape hold so tightly together and why do they hold more tightly on some fabrics, weakly on others, and not at all on others.

   It is important to discuss: why did this ability develop in plants?

4. **Extension**

   What other plants can use the principle of Velcro tape to spread themselves? Have you encountered them in nature? Students do not have to give specific plant names, but can look up examples of plants in atlases, on the Internet, and can search for such plants around their school or home.

   Students can think about which animals are best able to distribute fruits in this way.

Fig. 24. Fruits of burdock.

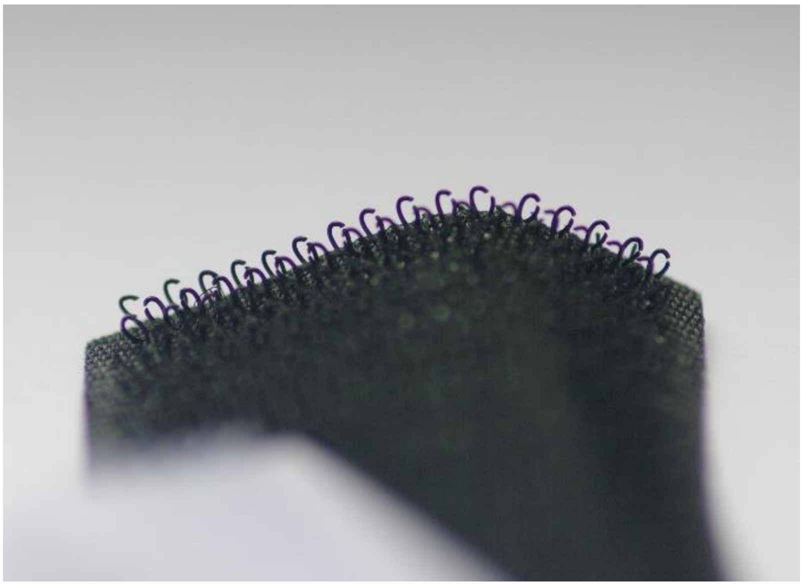


Fig. 25. Macrophotography of Velcro hooks.

Worksheet

Natural hook-and-loop fastener

Give example(s) where Velcro is used:

………..

………..

Many plants use a similar method of attachment. You have some of them in front of you.

See if they stick to fabric cuttings or your clothes. You can try different kinds of fabrics.

Take a good look with a magnifying glass at how these plants are equipped to do this and simply draw two examples.

Look at the Velcro tape. How does it resemble the plant you observed?

Think about why plants have evolved the ability to attach?

…….

Do you know any other plants that can attach to animal fur or your clothes?

…….

2.10.2 Learning to fly from plants

The task focuses on the improvement of the design of a simple paper helicopter inspired by the anatomy of seeds and fruits spread by the wind. Students can refine the technical design of the helicopter by observing the anatomy of a lime tree (*Tilia*) fruit (Fig. 26).

Theoretical basis:

Anemochory is the way seeds or fruits of plants are spread by wind. It can be implemented in different ways and two methods are common in our conditions:

1. Plants have light seeds that are easily carried by the wind.
2. The seeds or fruits have a special structure that allows them to be carried by the wind. Some seeds have wings, blanched edges or fluff that help them fly. In particular, the structure of the wings or fringes can cause the seeds or fruits to rotate and thus be carried slower to the ground and can be carried over longer distances. For example, the seeds of the maple tree (*Acer*) have wings that allow them to rotate and sink slowly to the ground.

Examples of plants using anemochory (Fig. 27):

- Dandelion (*Taraxacum*): the fruits are equipped with hairs.
- Maple (*Acer*), lime tree (*Tilia*), ash (*Fraxinus*), elm (*Ulmus*), hornbeam (*Carpinus*): the fruits have wings that allow them to rotate and slowly sink to the ground.
- Birch (*Betula*): the fruits are very light and have a lobed rim.
- Conifers: the seeds have wings and rotate as they fly down to the ground.

Needed material:

- Paper
- Scissors
- Paper clips
- Glue
- Seeds and fruits of conifers, dandelion, maple, lime tree, elm, hornbeam, birch (recommendation: some fruits should be collected at the appropriate time and stored for experimentation)

Phases:

Safety note: students must work carefully with scissors.

1. **Engaging**

   Students will try flying different seeds and fruits. They can test how far these objects fly, how fast they sink to the ground, how fast they rotate, etc.

2. **Exploration**

   Students cut out and build models of a helicopter. However, one of them flies poorly, or falls to the ground with almost no rotation. The other rotates and comes down to the ground more slowly. Pupils are given a lime tree fruiting body to observe and compare its anatomy with their helicopter construction. They will experience how the lime tree fruit flies and glides to the ground. They will probably not immediately figure out where the problem is in the helicopter design. They might state that the paper helicopter has a pair of wings and the lime tree fruit has only one wing (botanically it is a bract) or the total weight of the model, etc.

3. Explanation

Guide students to realize that the fruit of a linden tree rotates and slowly sinks to the ground due to several factors:

- It has a nut ballast that directs flight.
- The individual nuts grow on a thin stalk that offers no resistance to rotation, while the wide base of the helicopter model prevents rotation.
- The leaf is shaped in such a way as to encourage rotation

4. Extension

Which other plants can use the wind to propagate themselves?
What about pollen dispersal and transmission?

Fig. 26. Fruits of lime tree.

Fig. 27. Seeds and fruits of anemochoric plants.

Worksheet

Plants teach us to improve technical solutions.

Make two simple models of a "helicopter" from the prepared cut.

Test how the models fly and spin.

Maybe some of the models will fly badly.

Which one flies better?

Take a good look at the fruit of the lime tree and see how it flies.

Can we use the results of seed and fruit observations to improve the model?

Suggest a modification to improve performance of the model (it should fly slower and spin more) - look at the plants provided, they may help you to improve the model.

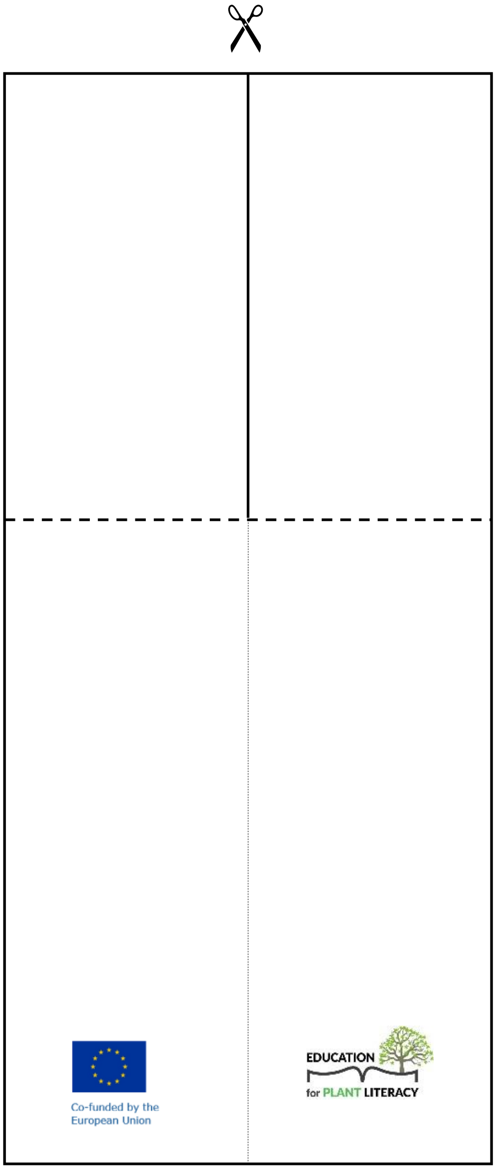
You can use: paper, scissors, paper clip, glue, skewer(s), etc.

Do you know of any other plants that use a similar method of flight to spread their seeds?

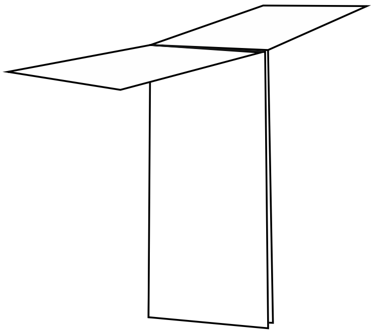
……..

Comment:

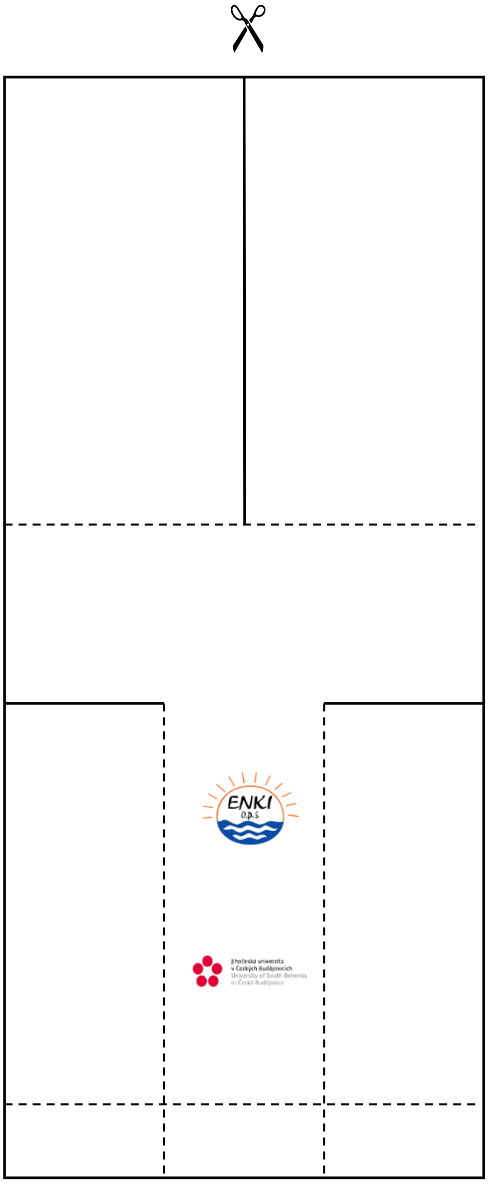
A cutout of the helicopter models is attached.



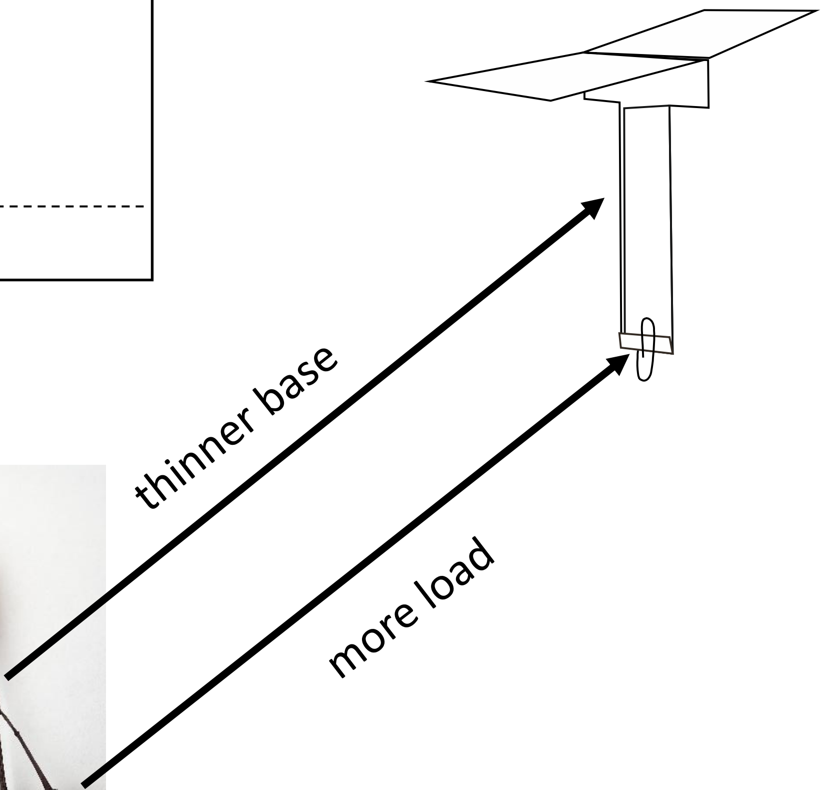
this does not fly very well



too thick and light base - puts drag and doesn't keep balance



this flies much better



the fruiting of the lime tree will help us:

2.11 Looking at plants and nature

Yvor Broer and Lene Mogensen

In this activity different perspectives on plants and biodiversity are explored. This is done by looking at different pictures of nature while stepping into the shoes of different persons. Primary school pupils will explore the "taken-for-granted" ideas about plants from different persons in society and discuss their own perspectives. There will be a small introduction followed by group discussions and summary in plenary.

Needed time:

- 45 mins

Level:

- 8 – 13 years old (can be adjusted to older students by adding some complexity)

Needed material:

- Poster, pictures and worksheet (Figs 28 – 30)

Goals of the activity to be reached:

- To understand why different groups in society look differently at plants (and nature) for very good reasons.
- To be aware that our actions towards plants are based on our taken-for-granted ideas about nature and plants.
- To understand how you look at plants yourself.

Theoretical background of the activity

The exercise should not stand alone, but be integrated with STEM work on biodiversity and ecosystems.

According to social constructionist theory, we do not perceive the world objectively. There is not one reality, but different versions of reality, depending on our perspective on it (e.g. Bruner, 1986; Wetherell & Potter, 1987). To clarify this point, one can imagine different people looking at a sheep from different perspectives, e.g.:

- a girl visiting a farm house and noticing the woolly fur of the sheep
- a butcher wondering if he will still have a job when less and less people eat red meat
- a farmer wondering if he should do organic farming instead
- a vegetarian/vegan thinking that eating red meat contributes to climate change
- a wolf thinking of the sheep as its next meal
- Picasso contemplating which colors to use to express how he experiences the sheep
- a veterinarian considering how much antibiotics one sheep can take
- Plato wondering if the sheep will still be there when he turns his back towards it

What each person describes and how they interpret what they see will depend on each of their limited view on the topic. Especially when dealing with complex issues like biodiversity, the world is so complex that no single person is capable of not over-looking every one of its different aspects. Everyone will only see part of it from their perspective, based on their experiences, knowledge, interests etc. Accordingly, we accept many different perspectives and we do not all agree. Everyone has good reasons for believing what they believe, but what seems obvious from one perspective might, however, look completely differently from another (Mogensen, 2012).

This activity looks at the taken-for-granted ideas of different members of our society when it comes to plants: how students are influenced by these ideas and how they may take an active stand and form their own opinion?

Phases:

1. **Introduction**: Introduce the group to the theory around taken-for-granted ideas about nature and plants. Show them the poster/slide with the different perspectives on a sheep (Fig. 28). And then instruct them to explore the perspectives of different persons when looking at two different pictures of nature (one of cultivated farm land vs. one with more biodiversity or a garden with a big lawn vs. a wild garden, Fig. 29).
2. Group discussion: Split the class into smaller groups of 3 – 4 pupils. Hand out the pictures of nature (Fig. 29) as well as the worksheet with different persons (Fig. 30), and ask the group to discuss what each of the persons notices the most on the picture, and what they like or do not like on the picture.
3. Debriefing: Ask the class for feedback from their discussions:

   What do each of the persons notice the most?
   What are they happy to see on the picture?
   What are they not so happy to see?
   Do each group have preferences for different kinds of plants? Why is that?
   How do you look at the different pictures yourself?
   What do you like or dislike, and why is that?
   What is our responsibility towards plants?

General competences promoted through the learning activity:

- To understand how our views on plants and biodiversity are informed by our experiences, interests, values etc.
- To be able to step into the shoes of different people and understand why they look differently at plants
- To be aware of the pupil’s own perspective on plants
- To understand that how we treat plants depend on how we look at them.

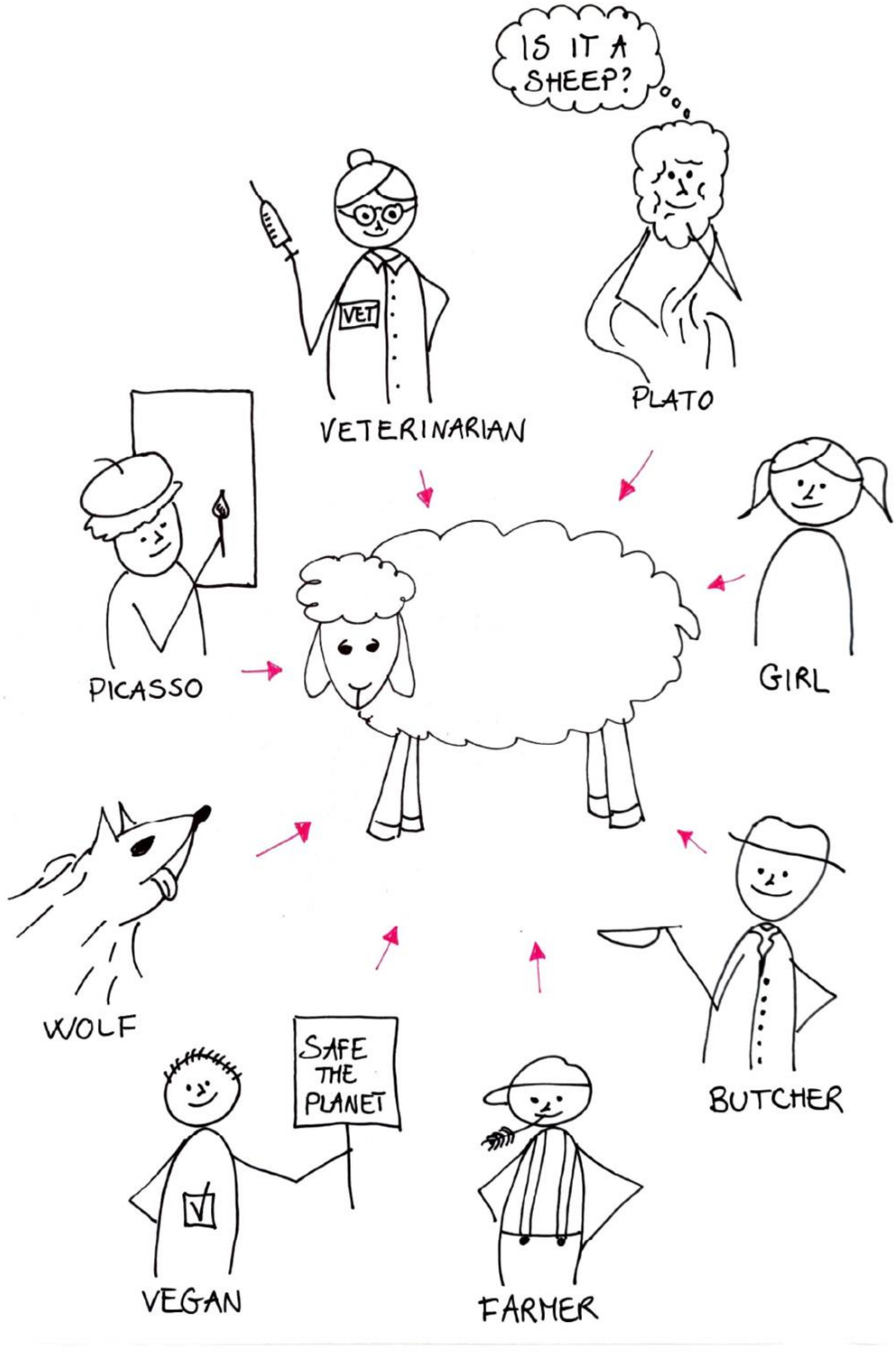


Fig. 28. Poster with a sheep.

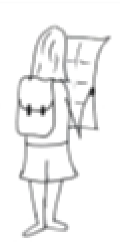
Fig. 29. Sets of pictures of nature habitats.

Discuss:
What does each person see?
What do they like?
What don't they like?
How do you explain that?

Fisherman

Farmer

Biologist



Tourist

Business person

Hedgehog

Bee

😉

You

Fig. 30. Worksheet with different possible perspectives.

2.12 Reindeer in a fell ecosystem game

Saara Krook

What kind of ecosystem do reindeer form together with birch? Do we understand the concept of an ecosystem and the energy cycle involved? In this activity, we will learn about the ecosystem that reindeer form together with birch in the mountainous areas of Lapland. At the same time, we learn how energy circulates in the ecosystem. Reindeer influence the mountain vegetation and landscape in many ways. This game makes visible and understandable for students the balance of the ecosystem and how even small changes affect the balance. The game is also applicable to other mountain ecosystems. The game highlights the role of plants as primary producers in the energy cycle in ecosystem.

Objectives:

- Introduce the concept of an ecosystem and the energy cycle in an ecosystem; energy circulates in an ecosystem.
- Learn about preserving the diversity and uniqueness of the ecosystem and maintaining its balance.
- Use playfulness and forms of drama to deal with the ecosystem.

Level:

- 8 – 12 years old

Needed time:

- 30 – 45 mins

Needed material:

- Something to mark 6 pcs squares on the floor/ground and the circle of oval. This could be done, for example, with cones or else drawn on the ground.
- About 50 pieces of “energy tokens”, e.g. Lego blocks, stones, i.e. of a size that you can hold several pieces (about 5 at a time) in your hand
- A djembe drum

Theory to understand the idea of the game of the fell ecosystem is explained in Fig. 31.

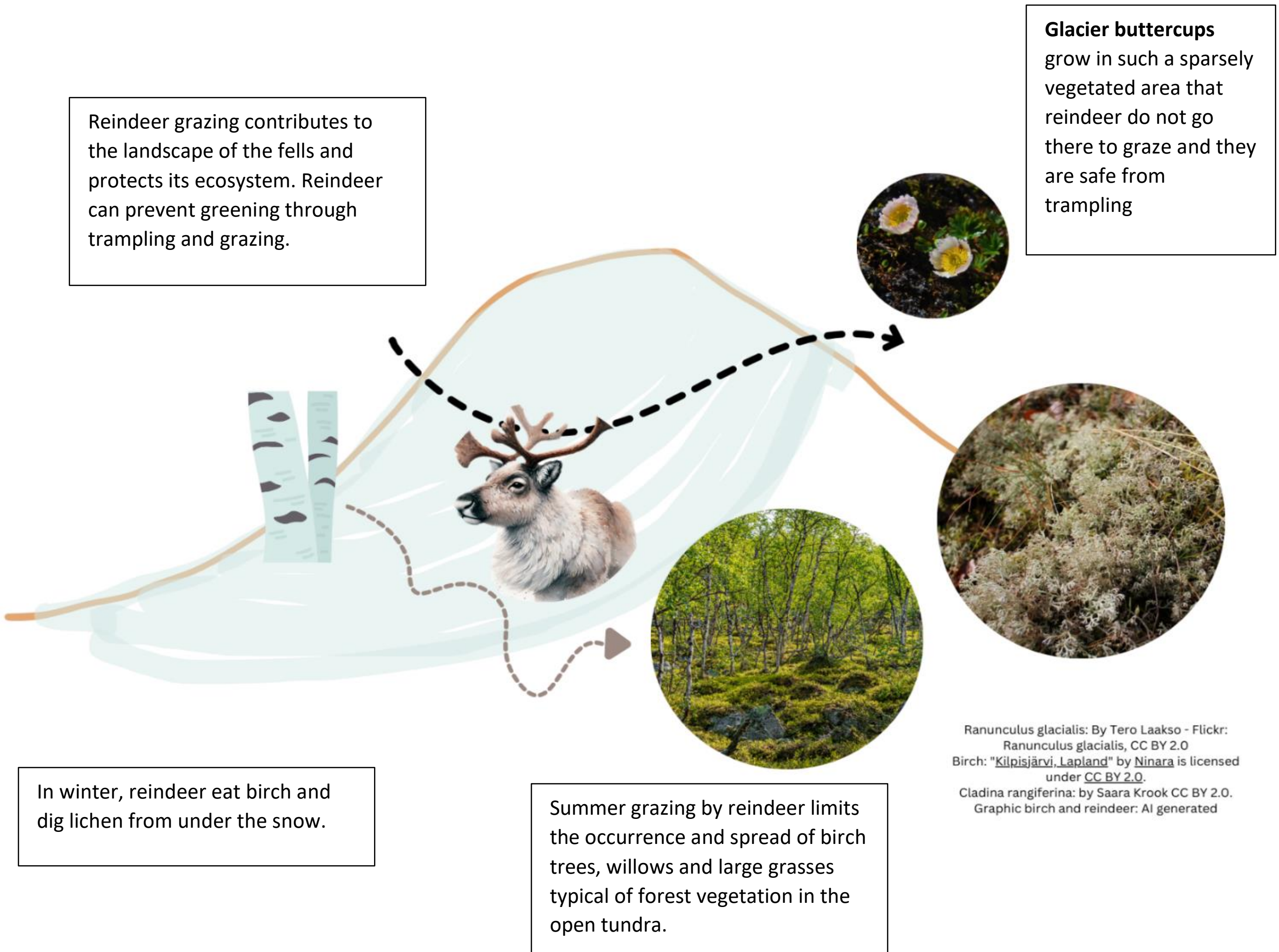


Fig. 31. Fell ecosystem.

Phases:

1. **Building a game area**

   The game area includes a large oval. You mark the outermost edges of the oval, for example with cones.

   Starting from the edge of this oval, 6 queued squares are made; in the last square sits a glacier buttercup (see role allocation in Figs 32 and 33).

   In the oval, the birch trees are placed inside the oval on one side and the reindeer are placed outside the circle on the opposite side to the trees. The starting point of the reindeer is marked.

2. **Allocation of game roles**

   Students, independently or under the guidance of a teacher, are assigned to the following roles:
   - 10 students are birch trees
   - 5 students are reindeer
   - (1 student is a glacier buttercup (*Ranunculus glacialis);* it is also possible to use an object representing a flower)
   - The teacher is Mother Nature (a student may also play this role)

The game is for 16 – 17 students with the above-mentioned roles. If there are more or less students in the class, the number of reindeer and trees can be decreased/increased accordingly, remembering to keep the ratio the same. There are 2 times more birch trees than reindeer, so if there are 2 reindeer, there will be 4 birch trees = 6 pupils in total.

Mother Nature is located close to the birch trees. Mother Nature shares 3 energy tokens to each birch tree before the game starts.

3. **Aims and rules**

Birch trees want to spread to a new area up the fells (square steps). There are, however, a few conditions to this spreading:

- To move to the next square, the birch must have 4 energy tokens in its hands. The energy tokens can be shared freely between birches but note that if a birch has no energy tokens in its hands, it dies (= moves out of the game). A dangerous situation occurs if a birch has only one energy token on hand.
- Moving to the next square consumes one energy token from the birch.
- The birch must be connected to other birches, i.e., there must be no empty space between two birches. In nature, trees are connected to each other through fungal mycelium.

A herd of reindeer circles the pasture , walking calmly outside the oval edge. If the birch trees spread out to the next square, the reindeer's route changes so that they walk over the square which is next to the birch but in empty space. The reindeer need energy, which they get from the birch trees. The energy is collected by the reindeer as follows:

- During one round, a reindeer takes one energy token from one birch. All reindeer walk a round, so after one round they have one energy token each. The round starts at the starting point and ends at the same point. The reindeer herd may only start a new round when the entire reindeer herd, i.e. all reindeer, have reached the starting point of the round.
- At the end of the round, the reindeer leave the energy collected in Mother Nature's basket. The energy has been used up in the reindeers' heat and vital functions.

Mother Nature plays the drum to a steady heartbeat while the game is on. At the same time, she counts the number of laps the reindeer have taken, and after every second lap, stops the reindeer at the starting point and gives the trees new energy tokens. Mother Nature gives one energy token per tree. Mother Nature's heartbeat reflects the timelessness of Lapland, where the passage of time is tracked by something other than a clock.

Glacier buttercup also has its own energy cycle. If a student plays the role of the glacier buttercup, the student will play that the role by moving like a delicate flower on a fellscape in his or her own square. For this student, two containers are provided, one of which is filled with 3 energy tokens. One by one, the glacier buttercup moves the energy tokens to the second basket and vice versa.

4. **Game over**

The **game is over** if the birch trees spread so far that the reindeer trample the glacier buttercup. This also means that the fell ecosystem has changed.

For the teacher: *At this number of trees, reindeer and energy tokens, the ecosystem should remain in balance so that the trees do not die but cannot spread out either. This is not told to the students beforehand, but the game is played long enough for the students to notice this balance.*

After a discussion, you can change the number of reindeer or trees. By increasing the number of reindeer, the trees will die one by one. Again, by increasing the number of trees and decreasing the number of reindeer, the trees can spread out over the fells.

5. **Reflection**

Together with the group, discuss your observations. Here are some questions to help you discuss:

- How do reindeer maintain the landscape in the fells?
  By grazing and trampling
- How does energy circulate in nature?
  We did not discuss photosynthesis, but plants produce energy by photosynthesis. Although plants produce energy, they also need it to grow. Reindeer get energy by eating plants.
- What happens if there are too many reindeer?
  The ecosystem is out of balance and the vegetation gradually disappears.
- What happens if there are no reindeer?
  The tundra's nature would green up in areas where it has not been green. The rock and ice ecosystem would eventually disappear as new plants would take over their habitat. For example, glacier buttercups would lose their habitat. This would mean a loss of biodiversity.

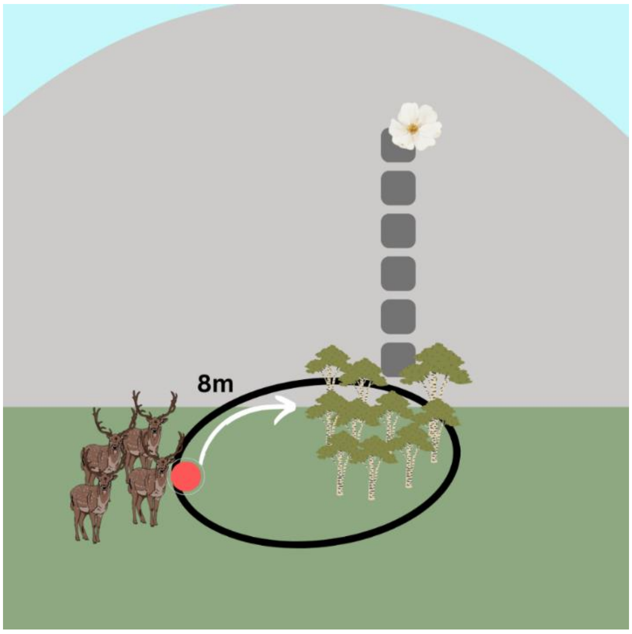


Fig. 32. Set up of the game.

Fig. 33. An example set up of the game.

Self-evaluation form

	😉	☹
Based on this lesson, I can list the things that affect the ecosystem.		
I understand what ecosystem balance means.		
I noticed that the balance of the ecosystem can change.		
The lesson was interesting.		
I would like to play a similar game again in the future.		

Case study

Reindeer in a fell ecosystem -game was tested with 3rd graders, i.e. 9-year-olds. In the first round of testing, the rules of the game were to distribute energy tokens every 30 seconds rather than on a round-by-round basis. With these rules we played two rounds, the first of which ended due to the spread of birch. The reindeer players did not move together and ate energy too slowly. For the second round of play we increased the number of reindeer and together with the reindeer learning the idea of the game, the trees quickly died off. A third round with these rules could have resulted in a balance. But even though the game rounds had not been successful, in the educational discussion after the games, the students had understood which factors affect the balance of the ecosystem and talked about them with the right terms. The objectives of the game were therefore met, even if the game itself did not go according to the objectives.

The rules were then updated to remove the time limit and to calculate energy intake on a per-round basis. With these rules, the game was tested with another group of students. Monitoring the game became easier for the group and a balance was achieved in the first round. The game provided a great opportunity to practice cooperation and emotional skills. The risk of the game is that if the reindeer take energy from only one tree, the one playing the role of the tree may experience injustice and therefore resentment. But if the trees are in open cooperation with each other, the adjacent tree can directly supply new energy to the tree that is being consumed disproportionately. The teacher knows his/her group best, but the importance of this cooperation should be stressed before the game.

The game helps to understand the laws of functional ecosystem. At the same time, it develops cooperation skills and strengthens the group's emotional skills. The game should be adapted to the needs of the group to make the experience meaningful and educational for all.

3 Online activities for primary school

3.1 Biodiversity on the map

Ulla Kemi, Renata Ryplová and Zbyněk Vácha

Environmental conditions can vary significantly between different locations, even within Europe. The length of the growing season can differ greatly, as well as environmental conditions during the growing season, e.g. light, temperature and amount of water. Plant species adapt to these varying environmental conditions by differentiation, leading to diverse plant phenotypes in different parts of Europe. It is important to understand characteristics of one's own environment, but also how it differs from other regions. For example, nature plays a unique role in everyday life in different locations.

This activity requires at least two groups of students from different locations. They can be from the same country, but also from different countries.

Objectives:

- Learn to identify and document the key features of nature around you
- Learn how natural environments are different in different locations
- Learn to understand the diversity of plants
- Learn to understand the role of plants in different environments
- Learn to use online maps

Needed material:

- A device for taking photos, e.g. a smart phone or a tablet
- A shared online map, e.g. on Padlet

Workflow:

Choose a topic you want to focus on. If possible, engage the students in choosing it. The topic can arise for instance from the observations of the students or from the current news, and it can be for example:

- Typical forest in your region
- Forest use in your region
- Nature as part of the city
- Nature as part of the schoolyard
- Different leaf shapes
- Number of different kind of plants students can find in a given time
- Plants of different size
- Diversity of colors

Students take photos of the selected topic.

Add photos of each location on an online map. This is possible for example on Padlet, where you can add a map on the background and add pictures/text at different locations.

Examine the pictures with the pupils. Discuss these questions or ask the pupils to make their own conclusions:

- What kind of differences do you see?
- How do the environmental conditions differ between different locations?
- How are plants adapted to different conditions?

- What is the vegetation in different locations needed for?
- You can also combine the observations e.g. with temperature maps

Case study

This activity was piloted by students in northern Finland and southern Czech Republic in April and May in 2023. The Finnish students were students of the sustainability and outdoor education oriented primary school program (4 students) or sustainability education program (2 students) and the activity was part of the science education course. Czech students participated in the science education course in frame of the teachers for the primary school educational program.

The activity was undertaken in international groups consisting 4 or 6 students. A teacher made a shared Padlet with map (Fig. 34) for each group and the students added pictures of typical forests in their region on the map (Fig. 35). Then, each group arranged an online meeting and discussed these topics:

- *What have you learned from the pictures taken by other students?*
- *What kind of observations and conclusions can be made based on the differences you see?*
- *What is the vegetation in your country needed for?*
- *How can plants live in the climate condition in your country? How have they adapted to the local climate conditions?*
- *How could this kind of exercise be used with school children?*
- *What else would you like to learn from fellow students from other countries?*

Based on feedback, the students found this activity interesting, and they enjoyed the group work. Afterwards the students suggested that it would have been interesting to focus on the nature in city environments in different locations.

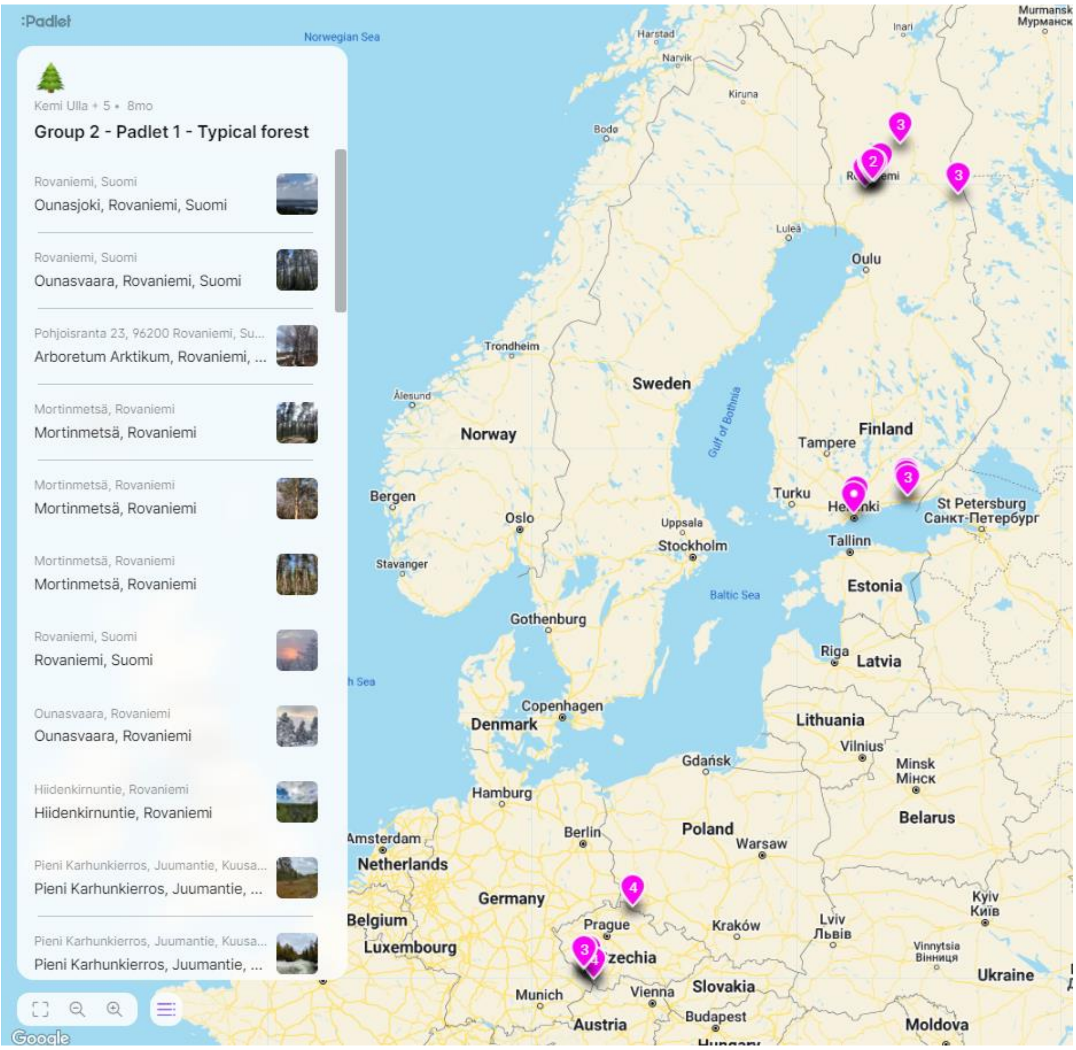


Fig. 34. International students added pictures of the typical forests around them on a map on Padlet.

Northern Finland

Southern Czeck

Fig. 35. Examples of the pictures added on the map by Finnish and Czech students.

3.2 Online biodiversity exhibition

Eveline Neubauer, Birgit Steininger, Ulla Kemi, Renata Ryplová and Martin Lindner

In this fun activity, learners get to use their creativity and the natural materials they find around them. The activity can be performed by only one group but fun increases with more groups – either national or international. The theme of the art exhibition can be for instance:

- Diversity of colors
- Diversity of shapes
- Diversity of leaves
- Diversity of flowers
- Diversity of trees
- Shades of green
- Plants along the way

Needed material:

- Paper plates
- Double-sided tape
- Flowers in the garden or other small natural objects

Workflow:

Select a theme for the online exhibition.

A strip of double-sided tape is attached to a paper plate. Students can now create colorful pictures by sticking flowers, leaves or other small natural objects on the plate, according to the selected theme. Take pictures and post them on a shared online location such as a Padlet wall.

Case study

An online exhibition was made by different kinds of groups of students in the spring or early summer in 2024. Groups of learners in Finland, Czech Republic, Austria and Germany participated. Each group selected their own theme and made artwork with natural materials (Fig. 36).

<u>Rovaniemi, Finland</u>
Participants: 8 primary school teacher students and 16 pupils (12-13 years)
Theme: diversity of shapes or green color

<u>České Budějovice, Czech Republic</u>
Participants: 50 botany education students
Theme: diversity of colors

<u>Vienna, Austria</u>
Participants: 10 students (botanical exercises)
Theme: Diversity of leaves

<u>Halle, Germany</u>
Participants: 30 primary school teacher students
Theme: Plants along the way

Fig. 36. An online exhibition was made on Padlet between April and July in 2024. The participating groups selected their own theme based on the season and the course.

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