GRANT AGREEMENT NUMBER — **2019-1-PT01-KA201-060821** —

YARD4ALL

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

IO5:

Guide to develop science concepts by drawing in the permaculture garden

The Guide is based on the work within the project Yard4All.

Coordination:

Agrupamento Escolas D. Carlos I, Portugal.

Partners:

Aproximar Cooperativa Desolidariedade Social, CRL, Portugal
Agrupamento de Escolas de Alfornelos, Portugal
Asociația European Association for Social Innovation – EaSI Romania
AFEJI France; Formacion Para El Desarollo e Insercion, Sociedad Limitada – DEFOIN, Spain
Instituto Universitario de Lisboa, Portugal; Kezenfogva Osszefogas a Fogyatekosokert Alapitvany - Hand in Hand Foundation, Hungary
Norwegian University of Science and Technology (NTNU), Trondheim, Norway
Școala Gimnazială Nr. 28 Bucharest, Romania

Developed by lead contributions of (in alphabetical order):
Bichão, H., Cyvin, J., Norwegian University of Science and Technology NTNU), Trondheim, Norway & Carolino, C., Florencio, Elsa Escola D. Carlos I (AEDCI),Sintra Portugal Portugal.

The project Yeard4All has received co-funding by the Erasmus+ program of the European Union under grant no. 2019-1-PT01-KA201-060821. Neither the European Union/European Commission nor the project's national funding agency DAAD are responsible for the content or liable for any losses or damage resulting of the use of these resources.

Index

[1] Inquiry Unit.

INTRODUCTION

Underlying all activity in the Yard4all project (https://www.yard4all-project.org) is the aim of supporting schools/teachers towards inclusive and equitable education. Among the strategies for accomplishing the objective is the establishment of a school garden based on permaculture principles and bringing children with and without special education needs (SEN) together, in a context of non-formal instruction. This document intends to present guidance for schools/teachers to explore the science curriculum in the context of permaculture school gardens, with all children.

In this project, primary school children (age 6-12) were involved in all activities inherent to permaculture (i.e. making beds, planning, sowing, replanting, mowing, weeding, composting etc.). Coordinated with these activities, children engaged in the register of observations and experiences, by drawing in varied ways. Drawing will allow students to develop essential skills for science learning (such as observation, rigor, comparison, cooperation, discussion, analyses, synthesis, representation and communication among others) as well as valuable transdisciplinary and practical skills.

Further, the project has the aim of implementing practices of cooperative learning and communication through drawing. The focus is on learner-generated drawings, as tools for learning, reflecting and communicating, and as facilitators and prompts for children's scientific discussion. The aim of supporting inclusive education is present and the peer-to-peer models developed in the project (IO2) constituted a guideline for practice.

In summary, the permaculture garden and the practical activities are the context and pretext for science inquiry, using drawing as a support beam for construction of meaning and keeping in mind the development of skills of cooperation and inclusion by peer-to-peer support.

Early on, a draft was elaborated as a framework for pilots to be carried out by the teams of each partner and/or associated schools of the project Yard4All, and communities of practice were established to share practices and discuss experiences. Teachers were invited and guided to register their observations about the various activities in a "teachers diary", during implementation. These diaries were the backbone of our exchange of practices. The experiences collected during the implementation (pilot- testing by the partner and associated schools) were used to refine the original draft, by incorporating suggestions for improvement. The "Guide for developing science concepts in the school garden" (IO5), in this version has been therefore expanded to include examples

from practice. The guide is intended to establish a common ground for practice by providing ideas and practical clues for implementation of science and drawing activities in the permaculture school garden.

Structure of the guide

This guide proposes "Units of inquiry" (UI) which in turn are organized around the cycle of horticultural activities in the permaculture garden.

The UIs are presented first. These are constructed in a way that can offer flexibility and allow adaptation to different age levels, countries, school *curricula* and other local conditions. Part 2 "Tips for success" collects practical and methodological recommendations that emerge from a collective reflection on the piloting phases, facilitated by the Yard4 all Communities of Practice (Closed CoPs) carried out during the project period. These recommendations are also informed by relevant literature and are intended to provide scaffolding for the "local" planning of activities

Finally, we collect several cases in the Appendix "Exploring science concepts in the permaculture garden – in practice". These cases were collected during the piloting phase and exemplify ways to work with the children and with this guide. The cases are based on the documentation made available by the teachers piloting the activities which consisted of learner generated drawings, photographs, planning documents and teacher diaries.

Permaculture gardens in schools

Permaculture is perhaps the most widely practiced form of agroecology (Hathaway, 2016), and presents an alternative paradigm of production based on ecological principles such as recycling waste, minimizing energy and water use, maximizing genetic diversity, regenerating soil and promoting other beneficial biological synergies (Hathaway, 2016). Therefore, permaculture school gardens offer particularly valuable opportunities for education for sustainable development, crucial for the learner of the 21st century (Bell, 2016).

The practice of permaculture is innovative in the school context and can provide children with practical experience of sustainable production means, different from traditional horticulture. Furthermore, permaculture gardens represent a rich environment for the study of plants and animals, to explore ecological interactions, to analyze weather and soil and develop design and technology projects. This makes it a prima arena to explore a wide range of sciences themes

that could fit into science curricula. In order to support schools in establishing the permaculture gardens we have, in the scope of the Yard4All project (IO5), elaborated a "Guide for establishing permaculture gardens in schools".

Drawing to learn

"Just like words and numbers, drawing makes thought visible, accessible and capable of manipulation. In essence, drawing makes you think. Different kinds of drawing develop your capacity for different kinds of thinking" (Adams, 2014)

A considerable body of literature exists that indicates that purposefully drawing functions in various ways to facilitate young children's acquisition of science concepts and construction of meaning (see among others).Drawing in educational context serves as tool for teaching and learning, for communication, while setting up a pleasant learning environment, boosting confidence, building integrated curriculum and making the learning of children with special needs (SEN) easier (Chang, 2012). For children with SEN, general accommodations that consistently are found to improve learning, include teaching through multimodal instructional approaches (McGinnis & Kahn, 2014). Knowledge accumulated in the last three decades calls for the implementation of learning opportunities in which purposeful drawing is a central strategy (see for example Lin et al 2017).

The drawing process, and the drawings produced, provide the teachers and the community with "a door" into the mind of the children. For this to occur, the drawing process needs to be intentionally planned and conducted. The drawings themselves and the conversations taking place around them can reveal learning, knowledge, areas of interest, emotion and creativity. The drawings as artifacts are also great for sharing with the community (school and others) raising involvement and creating impact.

Although the incorporation of drawings in the process of children's science concept inquiry has been found beneficial to both teachers and students alike, it needs to be employed appropriately to reach the desired outcomes (Fiorella & Mayer, 2015) and research shows that teachers seldom scaffold children's drawing (Wilson & Bradburry 2016; Areljung et al. 2021). Therefore, learning more about what are the boundary conditions for learning by drawing, including those for children with SEN, and spreading this knowledge to practitioners, is needed. This guide (and the project Yard4All) is a contribution to support educators in developing and implementing activities that make use of drawing for learning science. During the project, training of educators (C1 and C3) in drawing to learn science and inclusive practices (C2), was provided.

What is drawing? Why is it so powerful for learning?

Drawing can be broadly seen as a generative sign-making process and therefore, like other forms of semiosis has the potential to enable the sign-makers to enact reasoning processes (Tytler, Prain, Aranda, Ferguson, & Gorur, 2020). Drawing is an activity that humans engage in at an early age, as soon as the fine motor control allows. This activity intensifies experience, and more importantly, allows children to reflect upon and re-work their experience, to understand it. Drawing motivates and gives tools to aid learning, promoting children's questioning, wondering, generation of ideas and problem solving (Adams, 2009). Drawing can help pupils link the internal world of memories, thoughts, dreams and desires with the exterior world experienced through the senses. This connection is essential for making science learning relevant and creating an important link between perception and cognition (Adams, 2009; Binder, 2017).

Other reasons to include drawing as a strategy for learning and instruction lie on the general benefits of drawing as an activity for children (see Box 1.). Among other things, drawing nurtures and builds confidence about learning, encourages persistence and risk taking (Adams, 2009). Drawing also contributes to the development of a wide range of physical and emotional skills, and attitudes that are important for the citizens of the 21st (UNESCO-IBE, 2022).

Box 1: Benefits of drawing checklist *(Adams 2009)*

Drawing is a symbolic language that makes use of certain codes and conventions

Different kinds of drawing prompt different kinds of thinking

Drawing skills are developed through practice

Drawing can help children to reflect on and re-work experience in order to make sense of it

Drawing can be a way of exploring feelings

Drawing can be used to describe and explain things

Drawing can be used to explore understand and communicate ideas

Drawing can be from observation, from memory and from imagination

Drawing helps you plan and invent things

Drawing helps make things happen

Drawing helps you learn

Drawing makes you think

Purposes of Drawing

Whereas, there are many ways to classify types of drawing based for example on subject matter (portrait, landscape), medium (pencil, charcoal, watercolor…) or method (observational drawing, imaginative drawings and designs), all these somehow relate to how the drawing is made or what the drawing is about (refer to the product). However, to understand drawing as a medium for learning, it is more helpful to ask **what the drawing is for**, rather than how the drawing is made (Adams, 2017). In this way, the focus will also shift from the appearance of the drawing, to what the pupil learns through drawing (focus on the process) (Adams, 2017).

Adams (2017), defines four main categories of drawing that emerge from reflecting on what the drawing is for. These are useful to have in mind as a theoretical framework for conceiving activities that involve learner generated drawings. Depending on the purpose of drawing, prompts and materials have to be selected accordingly (for more see Part 2 for recommendations and Part 3, for examples from the Yard4all project).

Perception: drawing as perception helps organize sensations, feelings, ideas and thoughts. It is made primarily for the benefit of the person drawing. It may enable them to explore and to develop observation and interpretative skills to question and understand the world. Other people may not understand these drawings but that doesn't matter.

Communication: drawing as communication is the drawing that helps the process of making ideas, observations, thoughts or feelings understandable by others.

Invention: Drawing as invention assists the creative manipulation and development of thought. This is where you cannot think the thought until it is made visible and accessible – and therefore amenable to change and manipulation

Action: this type of drawing forms a bridge between the realm of the imagination and implementation. The intention is not just to focus on the content of ideas and proposals – but also to put them into test and see how to put them into effect.

Implementation of science inquiry by drawing

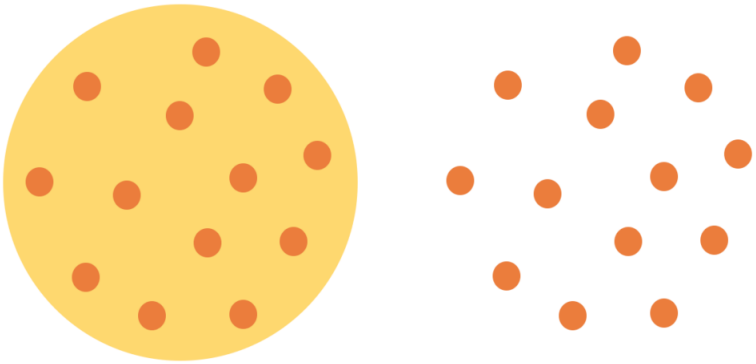
Science inquiry can be understood in several ways. If we use an integrated understanding inquiry can be described like this:

"*Inquiry is a multifaceted activity that involves making observations; posing questions, examining books and other sources of information to see what is already known; planning investigations; reviewing what is already known in light of experimental evidence: using tools to gather, analyze and interpret data: proposing answers, explanations and predictions; and communicating the results. Inquiry requires identification of assumptions, use of critical and logical thinking, and consideration of alternative explanations*"

(Carlson, Hemphrey and Reinhardt, 2003, p 23).

One way to draw on the potential of the children's own initiative and interests is to plan instruction with an inquiry-based learning approach in mind. This approach to learning emphasizes the student's role in the learning process. Pupils are encouraged to explore the material, ask questions, and share ideas and learn by doing. This allows them to build knowledge through exploration, experience, and discussion. Drawing, alone or cooperatively, lends itself well to this way of working.

PART I – Units of inquiry



"Orange dots of knowledge, on the left surround by the orange circle of experience. When knowledge is scaffolded by experience, it is made real, owned by the learner, who can then make connections and use the knowledge in meaningful ways."

Paula Briggs, 2020

UI 1 - Planning the garden in your school yard

Description of the activity

Planning the construction of a garden, and associated working areas, is a design project in which children can be involved.

Choosing the location for the establishment of the garden involves studying, analyzing, and evaluating abiotic factors: exposure to sun, rain and wind, conditions regarding the soil and slope of the terrain, natural water drainage and erosion. This offers opportunities for inquiry and learning concepts of ecology, geology, climate and weather, among other things.

Children can also be involved in the conception and building of tables and benches and or building and decoration of boxes for planting (fig. 1.1.). In that case curricular areas of technology and design and arts and crafts can be explored. If this activity takes uses recycled materials, it may be an excellent

opportunity to introduce ideas of circular economy and the importance of considering sustainable development, as well.

Figure 1 - Children decorated the planting boxes and made plans for establishing the school garden (Scoala Gimnaziala nr.28 Bucharest)

Drawing activities

Opportunities for drawing include planning sketches of the garden (fig. 1.2.); drawing plans of the watering system, dynamic renderings of natural waterflow, concept drawings of weather factors etc. This also includes the opportunity to learn about the art of constructing/drawing maps which include mathematics/geometry skills as well as more artistic skills related to colors, patterns, pictograms.

Exploring ideas

The water cycle; sediment transport; erosion; soil properties; gravity; volumes and flows; sustainable building; perimeter and area.

Figure 2. Planning the garden: children draw an adequate design after observing patterns of waterflow in the terrain, after Rainfall (Agrupamento de Escolas D. Carlos I, Sintra)

UI 2 - Preparing the planting beds

Description of the activity

At the beginning of each season, the soil may need to be aerated and/or enriched with compost, and the straw cover may need tending and reconstruction. The purpose of this operation is to create better conditions for plant growth: compact soil hinders healthy root development and nutrition must be balanced for optimal plant growth. The coverage of planting beds is important for water balance and retention, avoiding erosion and to reduce competition by weeds.

This operation creates the opportunity for physical work (digging, mixing of the soil, carrying the compost etc.), inquiry and learning opportunities regarding soil structure and composition and understanding of ecological concepts (recycling of nutrients; trophic chains; water cycle; carbon cycle among others).



Figure 3. Digging (right), mulching (middle) and the beds ready for planting (left).

Time of the year

At the onset of the garden or when necessary for example after harvest, before new planting

Practical activities

- Remove the soil cover;
- add compost;
- mix the compost with the soil;
- cover with straw again.

Drawing activities

- Draw what you have done/ draw how you have done it so we all can remember later/when we need to do this next year (it can be a cooperative endeavor where groups get the task to document a particular activity).
- Record the sequence of activities needed for making a bed – make a cartoon story
- Drawing a cross-section of the bed when it is finished
- Drawing landscape architecture maps and garden plans – year to year

Lines of inquiry

- What are the soil properties and composition?
- Compost: what is it and why do we add it?
- Why mix and aerate the soil?
- Why do we cover the soil with straw or other material?
- How and why prevent soil compaction/erosion.

Science concepts

- Compaction of soil affects water absorption and hold, root penetration, sufficient oxygen and microbiological activity.
- Mulching protects the soil microbiota and prevents erosion.
- Microorganism species living in the soil are important for the ability to fight plant diseases and degrade pollutants.
- Microorganisms in the soil are responsible for carbon and nitrogen cycling.

Competences

Practical skills; Cooperation; Observation of different kinds of microscopic species; observation of soil structure.

UI 3 - Compost production and care

Description of the activity

The production of compost to enrich the soil is one of the inherent activities in permaculture. Producing compost involves many activities that may include the community (collection of waste products at home or the school canteen).

Compost care involves monitorization and the control of environmental factors like sunlight, humidity and shade. Indicators of humidity used are the presence or absence of certain living creatures. This provides rich opportunities to learn about animals, their needs and how they live.


Figure 4. Children feed the vermicompostor with kitchen debris.

Time of the year

All the year round

Practical activities

- Collect food waste; cut materials in adequate small pieces and add dry material (3 times a week).
- Turn the compost weekly and rebuild the layers (see pp. 4-8 of Organic garden maintenance manual).
- Check the humidity level of compost – can include datalogging of temperature, humidity, pH, nutrients

- Check visiting animals: flies and mosquitoes indicate too much humidity; woodlouse, roly-polies and ants indicate not enough humidity.

Drawing activities

- Draw the worms found in the compost; draw the worms moving;
- Draw what you think happens to the food rests in the compost;
- Make and instruction guide for compost care (cooperative drawing);
- Draw the organisms you find in the compost; draw these organisms moving;
- Draw the vermicompostor microecosystem.

Lines of inquiry

- What happens to the food debris we add to the compost?
- What do worms need to thrive?
- How do worms move?
- Why do different organisms indicate different levels of humidity in the compost?

Science concepts

- Nutrient recycling, decomposition and decomposers
- Different organisms need different conditions to thrive
- All organisms thrive in an optimal level of humidity, light, nutrients and temperature.
- Animal movement – form and function

Competences

Observation; hypotheses testing through experimentation, scientific methods, argumentation

Exploring ideas

To follow the" life" of your compost, mount a window into the compost to be able to observe how the compost changes over time. Then you can observe over time the soil structure and the lifecycle of the animals that live in the compost.

UI 4 - Sowing and production of seedlings

Description of the activity

Sowing is normally done indoors, in small containers, and serves the purpose of producing robust healthy seedlings and small plants to sow outside. Sowing must be done well in advance and can be a project for the pupils themselves and can be planned in cooperation with their families.

Although the practical activity in itself is simple, it opens up for the development of many areas of the science curriculum and of the child's inquiry learning of concepts, competences and attitudes. Sowing and production of seedlings lends itself well to run experiments where environmental variables can be manipulated (fair testing for example). In this context elements of scientific research like generation of hypothesis an experimental design can be practiced, and issues of sampling, replication, collection and recording of data can be discussed

Figure 5. Sowing in trays and in recycled drink packaging

Practical activities

- recycling containers for sowing (for example from packages), making containers with newspaper paper (origami)
- sowing
- watering and tending the seedlings until ready to plant
- controlling and registering environment variables regularly

Drawing

The drawing activity follows the dynamics of the process of seed germination: Each student tends to one (or more) seed and draws it regularly in small papers

of equal size (for example post-its…): these drawings are displayed on a big board so that everyone can follow the growth of all plants. In the end the drawings can be used to construct a flipbook. Here any drawing activity that allows for depicting the passage of time is adequate.

Lines of inquiry

- Seeds need daily care to grow into healthy seedlings that can grow into plants
- What happens when we sow a seed?
- What do seeds need to germinate and grow healthy?

Science concepts

- A seed contains a new plant (Epicotyl, hypocotyl, radicle, cotyledon, etc.)
- Seeds need certain conditions to grow and not all seeds need the same conditions
- Different seeds require different times to germinate and grow
- Some seeds may not germinate
- When is the seedling ready to plant?

Competences

Research skills (systematic observation and systematic recording of results); communication skills (Creating the presentation table – writing, labeling); organization and self-management skills (keeping the seed alive and thriving; remembering care and recording of own seed); care and responsibility for living things.

Exploring ideas

This is an opportunity to analyze and represent germination rates and growth curves in different ways: You can use fractions, percentages, or different types of charts and graphs.
Research the origins of a favorite plant.
Which plants are native to the country?

UI 5 - Planting in the garden

Description of the activity

Planting seedlings in the garden beds according to permaculture principles requires planning and reflection about what species to plant where in the bed according to plant needs. It also requires investigating appropriate consociations (confer with "Guide for the establishment of a permaculture garden in schools" for information on consociations), and conditions for growth. It is therefore a planning activity as much as a practical task, opening for the development of specific science competences.

Planting should be coordinated with previous seeding activity – the pupils plant the seedlings they have been growing and caring for.

Figure 6. Children waiting to plant their seedlings (left), making the planting hole with a tool manufactured from a cane (middle) and a close-up of a newly planted lettuce (right).

Time of the year

Varies depending on country – for example, Portugal has two planting seasons.

Practical activities

- Making tools for digging planting holes;
- Crafting and use of mini greenhouses;
- Planning appropriate placing of rows on planting beds;
- Calculating appropriate distance between plants according to plant needs for sun and water and according to plant growth;
- Planning and planting according to consociation principles;

- Can also include systematic documentation of activity, and abiotic and biotic factors changing from year to year.

Drawing activities

- Draw the map of the bed representing the planted plants, representing consociation.
- Draw the map of the bed representing the planted plants, representing space between plants.
- Draw a seedling of your favorite plants (later can be compared with the grown plant).
- Record in a cartoon storyboard the sequence of activities needed for planting.

Lines of inquiry

- What are appropriate materials for planting tools?
- What are appropriate materials for making mini-greenhouses?
- How do greenhouses alter growing conditions (temperature and humidity)?
- Which plants may grow better inside (or outside) greenhouses?
- Plants need light, water, nutrients and space: Do all plants need the same conditions (of light, water, nutrients, space…)?
- How fast do plants grow: do all plants grow at the same speed?

Science concepts

Plant growth; Conditions for plant growth (temperature, light and humidity); Plant anatomy - Root types, leaf and stem types; What are the functions of the different parts of the plant?; Flowering and fructification.

Competences

Observation; measuring distances and areas; estimating and predicting based on information; planning; decision-making; problem solving.

Exploring ideas

Analyse the type of soil (sand and clay components of soil); Explore ways of measuring plant growth and evaluate best ways of doing that (root growth, leaf growth, stem growth…). Compute growth rates for different plants. Compare across countries – how does the same plant grow in different countries.

UI 6 - Weeds and weeding

Description of the activity

Weeding is a part of the routine activities of maintaining the garden. Even though mulching reduces weeding growth, some weeds will always make their way through. Weeding involves detailed observation of plants, to pull out only the non-desired plants and reduce competition.

Weeds have a variety of shapes, flowers and adaptations that are different from the cropping plants. This represents an opportunity to further explore characteristics of plants – shapes of flowers, adaptations to spreading and so on.

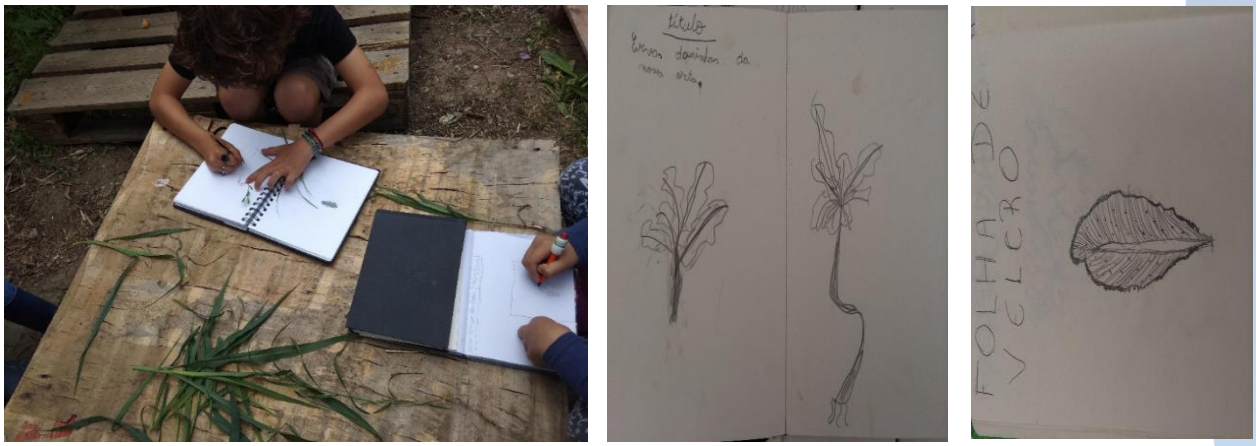


Figure 6. Children drawing weeds (left), drawing of a whole weed no one knew the name of…(middle) and a close-up of a leaf that was hairy and prickly and got the name of "the Velcro plant" (right).

Time of the year

All the year round.

Practical activities

- Pull out all the plants that we don´t want in our garden;
- Leave the pulled plants covering the soil (for mulching and nutrient recycling);
- Registration of weeds in a catalogue.

Drawing activities

Observation drawing of weeds: Each pupil draws one weed showing the details that allow to recognize that particular plant to produce a catalogue of the weeds of the garden; Each pupil draws one detail (the leaf, the flower or another part of the plant) and in the end they "construct" the whole plant in a big poster by gluing their pieces.

Lines of inquiry

Do we want all plants in our garden or only the ones we planted?
How can we decide which ones to pull out (the weeds)?
Where do the plants we did not plant come from?
Why must we remove the weeds?
What can we do with the plants we pull out, that may benefit our own garden?

Science concepts

plants compete for available light, nutrients, water and space;
decomposing plants return nutrients back to the soil;
there are many seeds in the soil that we did not put there.

Competences

Observation, comparing, distinguishing and classifying according to criteria; making connections of shape and function.

Exploring ideas

Analyse the volume of the soil, count and investigate types of seeds available. Compare with soil samples from other locations – for example a forest or a corn field.

UI 7 - Plant protection and attracting pollinators

Description of the activity

Several things must be done in the permaculture garden to keep plants free from herbivore damage and to attract pollinators. Examples are initiatives to trap snails or to attract insects. Some are part of the design of the garden, like building a pond, while others will be a part of the maintenance activities.

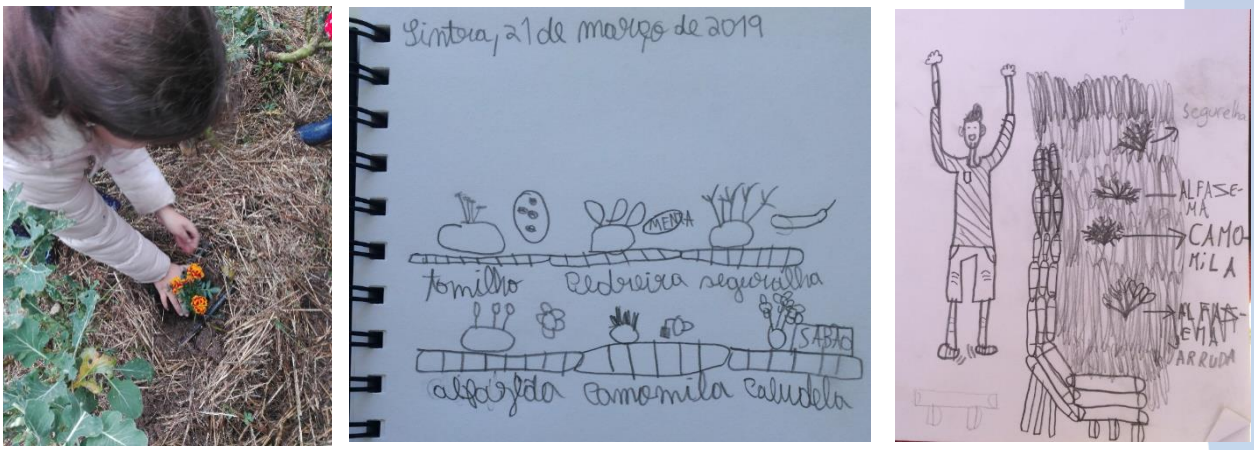


Figure 8. Child planting tonic carnation for repelling snails and slugs (left), and two different renderings of the bed of aromatics planted for attracting pollinators (middle and right).

Time of the year

All the year round.

Practical activities

- Planting aromatics to attract insects;
- Planting repelling plants to keep snails away;
- Constructing and setting up beer traps for snails and slugs;
- Checking plants for damage due to insects or other animals;
- Observation of visiting insects and other animals.

Drawing activities

Observation drawing of insects and other organisms, showing the details that allow recognition of that organism; Drawing insect damage on plants. Drawing insects observed through the binocular loupe. Pupils project insect hotels, slug traps and other traps, by drawing their ideas for such installations.

Lines of inquiry

- What is eating our plants?
- What are the animals we see in our garden?
- Which insects do the aromatic plants attract?
- Exploring habitats of the visiting animals.

Science concepts

Recognition, comparison and classification of living beings; characterization of the habitat of living beings.

Competences

Observation; hypotheses testing through experimentation, scientific methods, argumentation.

Exploring ideas

Investigating why beer traps attract snail and comparing with other substances. What is the importance of the pond for the vegetable garden?

UI 8 - Harvest

Description of the activity

Plants are ready for harvest at different times of the year. At the same time, what we harvest from some plants might be different to others: we only harvest the leaves from cabbage, while we are going to harvest the flowers of broccoli and leeks. Carrots and chives are harvested by removing all plant from the earth. The pupils will be involved in the harvesting process and in handling the harvest till it reaches the consumer (home, market or school canteen for example).

Figure 9. Harvesting green peas and examining the fruit (left), harvested vegetables (middle) and drawing the details of freshly harvested leek (right).

Time of the year

Depending on the plant and the vegetative cycle (for example, leek is ready 5 months after planting and beet 2 months).

Practical activities

- Harvesting leaves (ex: cabbage, chard), flowers (ex: broccoli, cauliflower) or fruits (ex: tomato, green peas, beans);
- Harvesting whole plants (ex: leek, carrots, beets, lettuce);
- Counting and weighing the harvest;
- Packing the harvested vegetables in boxes of equal value/weight.

Drawing activities

After harvesting it is possible to draw the whole plant: observation drawings of the plant, and of the different plant parts.

Lines of inquiry

- When do we harvest each plant in our garden?
- How long does it take to grow?
- Why do we sometimes harvest the whole plant and sometimes just some parts?
- When we harvest some plants are we planting new ones in that free place?

Science concepts

Different plants have different life cycles;
Different plants have different patterns of growth;
The anatomy of plants including roots, leaves, flowers and fruits varies widely;
Form and function of plant organs are interconnected (storage organs, production organs).

Competences

Observation skills; measurement of harvest; planning harvest and packing of vegetables; decision-making about what is ready to harvest.

Exploring ideas

Explore why do we choose to eat different parts of the plants. Explore ideas around which part of plants we eat most of (we consume mainly fruits and roots? Or do we?).

PART II - Practical and methodological recommendations

The core ideas for the elaboration of this guide are a result of the experience collected by the team through pilot projects/activities developed at AEDCI with the cooperation of the team at NTNU. These core ideas were piloted in several schools throughout Europe and the guide refined incorporating the experiences from the practice. From these collected experiences emerge a set of practical and methodological conditions that we think apply to all and are beneficial for the learning activities.

General conditions

Children groups should not exceed 15 children.

The time allocated for the activities should not be shorter than one hour. The ideal duration of a session is 1:30, to allow time for arriving, settling down, completing the activities in the garden, drawing, discussing and wrapping up, in a relaxed atmosphere that is beneficial for learning.

Ideally two teachers work together with the children (at least at the pilot phase) to ensure proper documentation of the learning session for further development (see section "Reporting learning and connections" below).

The support of school administration is essential to allocate time and resources to the project, that will ensure implementation conditions.

If the educators conducting the work with the children at the garden are not the class teachers, coordinated involvement of class teachers will potentiate learning and the overall benefits for the children (see section "Reporting learning and connections" below).

Physical conditions

In this section, we present elements of the infrastructure that can facilitate and the expand the opportunities for exploring science concepts and for inquiry-based learning. This is not an extensive list, but results from the practice and piloting during this project. It is important to note that whilst opening possibilities, these infrastructure elements are not determinant of the success of the work.

(confer with page 8 of the "Guide for the establishment of a permaculture garden in schools" for more detail)

The existence of spaces near the garden where children can sit together, talk, draw, extend their observations, and interact in a relaxed and comfortable way (garden tables, chairs including tools and equipment adequate for children with SEN…). These spaces should be sufficiently near the garden, so children can move back and forth between spaces, for example, while making observations and drawing.

Shelter from weather conditions will greatly improve the possibilities to work outside while drawing and investigating (shade, protections from rain etc.).

A locked space in close connection with the garden, with electricity connection, to store equipment for science inquiry and materials (drawing material, stereomicroscopes etc.).

Shed for tools and other garden equipment is also beneficial as it facilitates children's organizational autonomy.

Tips for success - Plan and plan to "drop the plan"

Keep the objectives/activities for each session simple.

Prepare the frames for the day activities (group size, who does what, etc.) so these preoccupations don't take over and steal the attention from what is happening.

In an outside setting the teacher is worried about security, distractions and about controlling factors (that are not a challenge in classrooms). Try to keep your mind relaxed about this, and prepare by thinking "what's the worst that can happen?"

Think of strategies to limit risk, conflict and children disengagement.

Have in mind strategies to promote cooperative learning and peer interaction

Keep an attitude as an observer and coach rather than leader.

Pay attention – keep focused on the wholeness of the learning experience and its potential.

- Plan thoroughly and - most importantly – prepare <u>to drop your plan</u>!

Planning is important because structured instruction at the garden has proven to benefit learning. However, experience has shown that children-initiated open activities can be equally rich opportunities for learning, if not richer.

In children-initiated projects, pupils spontaneously and independently engage in cooperation, exploration, research, planning, designing, applying of knowledge and problem solving. So, opportunities for the emergence of these kind of projects should be given (see BOX 2. The water dam project).

Box 2: The water dam project:

"We want to collect the rainwater for watering the garden"

Claúdia Carolino, teacher working with a group of primary school children in Sintra, Portugal

This inquiry emerged from a spontaneous activity of a group of pupils, the teacher tells:

We arrived at the garden after a heavy rainfall – and some 4th grade pupils noticed that the water had dug a path adjacent to the garden. A group of pupils, I will call it group A, was thrilled by what was going on and observed how the water had carved out the path and how stones had accumulated in a lower place. They called me to come and look at what was going on. Right there, one pupil forwarded the idea that it would be a good plan to build a small dam to receive the run-off water and use it to irrigate. This group of students quickly started to take action and it seemed to me that I was not needed there – so I left to do a routine task with students who did not seem to show much interest in the construction of the dam.

After half an hour, the pupils had already started the construction of the dam and were discussing strategies to proceed and reevaluating the construction. At the end of the session I asked the group how they intended to continue construction in the next class and which materials they needed. They discussed the objectives and the necessary materials, outlining some strategies to overcome a main difficulty: how to excavate such a hard and compact soil.

In the following session, group A continued the project they had started and another group B, enthusiastic about the advances of their colleagues, started a project to irrigate the spiral of aromatic plants by using the rainwater. Group B decided to use adobe to cement an irrigation structure invented from 5-liter plastic bottles - and in the next session the whole group had already investigated the proportions of water and clay soil in order to obtain adobe. This idea and investigation was worked on in class with the class teacher.

In both groups, A and B, there were one or two students who energized the rest of the group. However, it was very interesting to see that all students in each group, gave ideas, discussed the best solutions, quickly and effectively experimenting and reassessing the best way to move forward - always working as a team, with enthusiasm and the creative participation of all. They generated and tested ideas and automatically presented more effective solutions for each difficulty encountered.

I was amazed because they consulted and explained me ideas, without ever questioning their skills, autonomy and leadership of the project, that was theirs alone. Never before, in my 30 years, of teaching have I been able to observe such a rhythm of work, initiative, cooperation and enthusiasm!!!

A general sequence for a session in the garden

Table I - A generalized model for a two hour "work and learn" session in the garden. This sequence can be used with modifications according to objectives and time allocated to the activity.

Moments	The purpose	What to do?	Time needed
Checking-in	Settling down - The children are unsettled because there are many areas of interest	- Change to appropriate shoes and clothing; - provide relaxing free time for running, eating or chatting...	15 min.
What will we do today? Planning the session with pupils	Organizing the activities for the day with the participation of the pupils and incorporating their suggestions	- All meet – routine tasks and task of the day are proposed. - Allow time for sharing ideas, expectations, wishes, questions, worries… - Distribution of tasks.	15 min.
Activities: what is my goal for today?	Gardening maintenance. Creating learning opportunities.	- Establishment of small groups (2-4) - Routine tasks (1) - Activity of the day (2) - Drawing activities (3) - Possibilities for peer interaction and support(4)	15 min. (routine) 20 min. (activity) 30 min. (drawing)
What have we done today? Reflection and evaluation	Participated evaluation of the day	- Discussion and reflection (5). - Plans for the next time. - Tasks in between sessions if any.	15 min.
Checking-out	Closing the session	- Tidying up - Washing and changing - Going back to class	10 min.

Activities:

(1) Examples of routine activities: Compost maintenance; general cleaning of the garden from garbage; watering; mending the water system; inspection and maintenance of mulching...
(2) Examples of specific activities: planting, weeding, mulching, seeding, harvesting.
(3) Examples of drawing: registering observations, documenting processes, planning for new activities, projects or ideas. Expand to documenting of sensations and feelings. (think, the purposes of drawing: drawing to understand; drawing to communicate; drawing to invent; drawing to act)
(4) peer-to-peer support models (IO2) to function as inspiration and guidelines for this
(5) Discussing and reflecting – drawings can be used as prompts for reflections and problem solving, regarding the topics of learning and social interactions and events.

Planning with an inquiry-based learning mindset

Inquiry based learning can be implemented in the garden in several ways (based on Turner et al., 2011):
Observing over time (Examples: Seed development, Plants growing, temperature in your garden)
Identifying and Classifying (Examples: Identifying and classifying weed, insects, birds
Pattern seeking (Examples: Seek for systematic patterns in your garden: which type of soil fits best for different plants, are some plants or vegetables preferring dry or wet places, sun or shadow?
Research (Examples: Study historic meteorology data for your garden, search for recommendations for suitable vegetables, fruits or plant fitting your garden's topography or location
Fair testing (Examples: Keep as many as possible plant/vegetable parameters constant and systematically change one parameter at a time – to explore, for example, the effect of much or little water to one specific plant growing in the same flowerbed getting exact the same amount of sun and nutrition. Compare the growth of the same plant in different countries.

When designing inquiry-based science tasks, it is important to keep in mind how you will design the inquiry. How open or closed should the tasks be? Are the pupils going to just follow a recipe (few degrees of freedom) or are they designing most of the tasks themselves as a complete project: making the hypotheses, design sampling methods, collecting data, and discussing the results related to literature or others results. The aim of optimal inquiry-based science teaching is to train the pupils to manage more degrees of freedom as they grow up and get trained, ending up as capable to manage all degrees of freedom in some way when leaving school.

Table II - A simplified model for growing degrees of freedom in inquiry learning (Knain & Kolstø, 2011)

Degrees of freedom	Problem	Method	Results
0	Given by teacher	Given by teacher	Given by teacher
1	Given by teacher	Given by teacher	Done by pupil

2	Given by teacher	Done by pupil	Done by pupil
3	Done by pupil	Done by pupil	Done by pupil

For more reading about inquiry and models for degrees of freedom, see Fradd, Lee, Sutman, and Saxton (2001).

Challenges posed to working inquiry based (IBL) are well described in literature. As a result of the investigations in PRIMAS project are described three group of obstacles that might hinder IBL: "technical problems, political problems and cultural problems" (Primas, 2013). Examples would be factors including pluralism in teacher's background, roles and practice, as well as pluralism in the environment around the teachers including school system, textbooks, curriculum, assessment/exam system and parent's roles. All these factors can create obstacles that hinder optimal IBL.

Based on our experience and literature, it is recommended that teachers carefully implement and plan a high degree of frames and scaffolding around inquiry-based activities from the very beginning (Knain and Kolstø,2011; 2019; Bjønnes and Knain, 2018 and Bjønnes and Kolstø, 2015). Scaffolding can be toned down gradually as the students get more trained and skilled in this way of working with science.

Clear frames are helpful in the beginning. On the other hand, it is important for the students to have some degree of freedom and autonomy, and the possibility to make their own choices, use individual skills and knowledge and to feel ownerships to their projects (see Box 2). However, this has to be trained and combined with the teacher's supervision and the role as a wise mentor, asking questions more than giving final answers. One way of doing this is to systematically alternate between giving the students' freedom and structure as the project keeps going.

Planning drawing activities

The drawing activities are more successful if the children have a place where they can sit and draw comfortably and quietly.

The drawing can be initiated by a prompt that contains a challenge and allows room for own observations and objectives.
Allow time for conversation about the object/subject before engaging in drawing – verbalization of the child's own observations, objectives and desires will benefit the process.

Some children will need more scaffolding and encouragement during drawing – the teacher must be observant to be able to coach all students during the drawing and eventually coach or provide opportunities for/ model peer-coaching.
To be successful, drawing activities require time and tranquility for both teacher and pupils.

Ways of drawing are "different learning tools"

Depending on the objectives of the drawing activity, different prompts and different modalities of drawing will be adequate. Here we mention a few in broad lines:

Warm up drawing exercises – these drawing exercises do not necessarily target scientific content. They are simple drawing tasks that should be accessible to all learners and designed for purposes of creating a concentrated and relaxed moment. It is a good tool to support the pupils in the transition from the classroom environment to the outside, where so many stimuli compete for the attention of the children. Warm up drawings can also be used to prepare pupils for more challenging drawing tasks like observation and cooperative drawing.

Observation drawing - supports the children in slowing down, observe carefully, and in learning how to record what they actually see, rather than what they think something looks like. Through noticing the details, the children's understandings deepen, and further questions are provoked.

Series drawing – help document processes and support children's understanding of sequences of events. This type of drawing is very useful to review learned procedures and to share knowledge about experiences. Series of drawings are also useful to support learning of, and inquiry into, natural phenomena and concepts that include a temporal component (for example are life cycles,

germination and growth, wilting, changes in weather, to name a few). Figure xii

Drawing for planning – Support thinking and reflecting on how things can look like, be constructed or done. This type of drawing helps children organize their thoughts in problem solving tasks and to communicate their vision. It allows children's ideas to become visible and facilitate discussions and negotiation for finding out good solutions.

Imagination drawing – Harnesses children's creativity and can make visible connections with the memories and knowledge of children. It also supports the child in the generation of new connections and ideas tapping on intuitive knowledge. Imagination drawing can also allow insight into children's affect and experiences.

Collaborative drawing - this is a type of drawing where children collaborate towards the final drawing. The process of collaborative drawing opens for negotiations of meaning and representation, developing cooperative learning and giving room for direct peer support (IO2). When well directed it is one of the more inclusive practices of drawing promotes competences of cooperation, perspective, shared ownership and shared responsibility (see cases in Apendix 1 and 2) Figure XIII

Material for drawing

- Drawing book for each child to keep: ideally A4 with hardcover normal binding (not spiral), plain paper appropriate for drawing (100- 130 g);
- Bigger paper formats for cooperative drawings and other projects;
- A variety of papers (variety of weights and grains and colours);
- Graphite pencils with different degrees of hardness (from 2B to 8B);
- Soft pastel;
- Wax crayons;
-
- Charcoal;
- Markers (varied thickness);
- Inks and brushes;
- Erasers;
- Finger paint.

Note: This list is by no means exhaustive, but rather indicative of choice of

materials that will allow a lot of the purposed work; materials can be adapted depending on the availability of materials in the school and the purpose of the drawings. For example, it can be nice to use recycled material to create drawings or wall murals (old newspapers, magazines, organic material from the garden, etc.)

Documenting learning and connections – the teacher's diary

Ideally two teachers work together with the children (at least at the pilot phase) to ensure rich documentation of the learning sessions for further development. The documentation should include field notes and a short reflection including plans for the future, and is best elaborated right after the session, before "busy life" takes over (see Box 3 for an example). If working together this reflection can be done in a quick debriefing right after the session, while all ideas are fresh. Documentation can also include photographs of the activities, of the drawings and short films or sound recordings. In that case authorization from the parents must be collected so that the material can be used in the scope of the project.

If the educators conducting the work with the children at the garden are not the class teachers, coordinated involvement of class teachers will potentiate learning and the overall benefits for the children. In the example provided in Box 3., you can read the notes from the teacher working in the garden, and how she brought the information about the pupil's interests and questions generated in the garden session, to the class teacher. This immediately resulted in a plan for further exploration of the science content, in the classroom. This generates possibilities for authentic learning (Donovan, Bransfrod & Pelegrino, 1999) also in the classroom.

The teacher's diary is important for the development of the learning sessions in the garden and therefore improving the pupil's learning and increases the potential of the garden as a learning arena. The documentation also serves an extremely important element for the communication of project results and in creating impact in the school and wider community.

APPENDIX I: Exploring science in the permaculture garden - examples in practice

This section is a compilation of examples of practice developed in the various schools piloting the activities proposed in this guide. These examples are intentionally edited to a minimum and not standardized or reduced to lesson plans. The purpose is to show the varied ways in which educators have supported themselves in this guide, how they worked with the children, how they reflected and documented their work and a taste of the results, Hopefully, this will inspire and be helpful for other educators starting to use this guide in their practice

Planning the garden (UI 1)

Kelenvölgyi Elementary School, 1st class (Budapest, Hungary)

The teacher diary

Today we started planning our bed with the first-grade children.

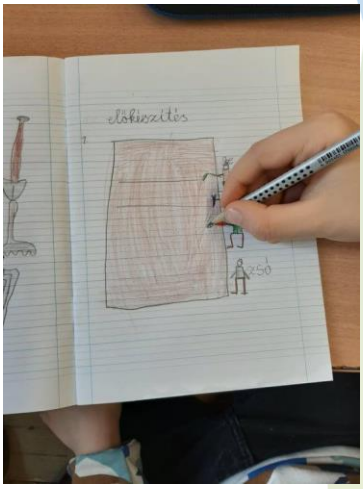
First, we learned about the concept of bedding. Many of children live in a house with a garden, so some have already shared their experiences with their peers. I found this very useful as learning from peers is extremely important in children's lives.

We planned to prepare the location of the plants. We discussed what activities will be needed in the future to prepare the soil. We agreed with the students that we would need more tools. We also need to prepare them for the next session.

The children documented everything in their drawing diary about the garden. We also agreed with the small group of students that we would draw everything and every steps from design to implementation. The changes will also be recorded in drawings.

In the school yard, the children immediately began to press their hands and fingers into the soil. I have seen that doing activities will be much preferable in this age group than planning. I realized that I need to plan more activities for the next session.

The children really enjoyed the planning process with drawing, they were happy to draw how we will prepare and implant our beds. They have also skillfully drawn the tools we will need during implementation.



In connection with the planning, we also discussed with the children that we could grow seedlings in the early spring period. We have also started preparations for this. In the spirit of recycling, we will collect boxes of yoghurt, sour cream, and other dairy products, into which we can sow seeds later.

Planning the yard

Schedule	Goals	Activities	Duration
Check-in, introduction	Venue, clarifying goals of the activity, name of the yard Tündérkert (Fairy garden). Concept of a flowerbed	Take on weather suitable clothing „Warm up" with games.	15 minutes
Presenting the flowerbeds Discussing earlier experiences	Selection of the class' bed How we can use the bed? What could we product/plant in it? Listening and discussing children's ideas, planning together.	Ideas, listening and discussing earlier experiences. Answering raised questions and sharing the tasks.	15 minutes
Presenting the Diary, Planning the preparation and distribution of bed	Presentation on how to use drawing diary, planning with drawings accordingly to the children's age. Creating learning opportunities.	Developing routine activities (assign responsible ones, clarifying their tasks) Loosen up the soil, talking about the equipment, documenting the planting process with drawings. Preparing flowerbed's plan, preparing a drawing of imagination.	10 minutes 20-25 minutes
Reflexion and evaluation	Evaluation of the activity together with the students.	Planning the next activity. Discussing each other's drawings and plans.	15 minutes
Checkout	Closing the activity	Tidying and cleaning up, dressing up.	5-10 minutes

Preparing the beds (UI 2)

Kelenvölgyi Elementary School, 1st class (Budapest, Hungary)

The teacher diary

The kids were very much looking forward to work in the garden. Before the session, they agreed, who would like to work with which tool.

We started the garden work by getting to know the tools (spade, hoe, rake). There were small children who hadn't yet held garden tools in their hands. We discussed which tool to use for what and how we could use them safely (without accidents).

I was pleased to notice that the students helped each other often during the garden work, and that they shared experiences with each other. During the session, I made the children aware of why it is important to hack the soil well and to take out the roots of any weeds. Soil structure was observed before and after hacking. We also discussed in which condition the water can get to the roots of plants more efficiently. My little students were also able to summarize their observations at the end of the session.

It happened several times that the children started digging holes during the hacking of the soil. I showed them how they can level the soil, so they can prepare the beds for the seeds of the plants more efficiently. However, this did not always go smoothly.

We also prepared the plastic boxes for sowing in the classroom, which we collected in the last few weeks. The children filled these little boxes with soil.

They liked to record the tasks they performed together during the drawing based on their observations and experiences.

Preparing the bed

Chronology	Target	Activities	Time
Check-in, introduction	Venue, clarifying goals of the activity, School yard – classroom	Check-in, introduction	15 minutes
Discussion of previous experiences	Preparing the soil of the bed. Presenting the tools, how to use them without an accident. Listening to children's ideas, discussing together, planning together.	Ideas, listening and discussing earlier experiences. Answering raised questions and sharing the tasks.	15 minutes
Preparing the soil of the bed Documenting the activities with drawing	Presenting techniques to loosen the soil, how to implement it and practice. Preparing the soil and documenting it by drawing. Drawing after observation, as an implemented method.	Routine activities (preparation of the tools, allocation, sorting, tidying up). Detailed documentation of soil loosening, weeding, using the tools, documentation by drawing.	10 minutes 20-25 minutes

	Creating learning opportunities.	Preparing the in door ortugue, preparing plastic boxes, soil and seeds in the classroom.	
Reflection and evaluation	Joint evaluation of the session with the children.	Planning together the next lesson. Discussing each other's drawings and plans.	15 minutes
Checkout	Closing the activity	Tidying and cleaning up, dressing up.	5-10 minutes

Starting a new compost (UI 3)

Agrupamento de Escolas Dom Carlos I, (Sintra Portugal)

We started this activity by picking up the composting waste from the school canteen.
As the vermicomposting bathtub was already full of composting waste that we had brought from home, we decided that we would start cold composting on the floor. First, we had to decide where to place it. A student suggested best would be to stay close to the bathtub and all composting would be in the same area. We discussed whether the place had the necessary conditions for composting and everyone agreed that had shade and space as needed.
We drew a rectangle on the floor and I asked the students to divide it into 3 equal parts. Since we didn't have a tape measure, I asked them how we were going to solve this problem.
There was a girl who immediately remembered that we could see how many steps the length of the rectangle was, and 12 steps were counted.
I explained to them that unlike vermicomposting, in this case we had to have the space divided into 3 equal parts to start using only one for the waste.
They discussed among themselves how they were going to do it and agreed that a mathematical operation was needed. Some children realized that they had to divide the total by 3 and others had more difficulties. I suggested to them to sit and record the calculations to be made in the field diary.
The students helped each other to understand the calculations and found a result. With this result, they measured in steps each of the 3 parts and placed sticks dividing each part.

They started the cold composter putting compost residues in one of the three parts. I asked the students why we would need 3 parts and we could discuss and understand why.

That day I talked to the class teacher to continue the calculations and convert the feet in to cm measurement. With these mathematical calculations they can determine the perimeter and area of the rectangle as well as of each of the three parts.

How I planned?

I planned to do a pile of cold compost. I checked: - Do I have a space where I could place a rectangle with1.30m/ 0.50m; that is in the shade and easily accessible

How I conducted the activity?

I informed the students about the need of having a rectangle to place the pile compost.
I explained why it's necessary to divide the rectangle in 3 parts.
We discussed why it's necessary to have a shaded place and they found out the best place would be near the vermicomposting.
We had to solve the problem how to divide a rectangle in 3 equal parts and they decided to use the foot as a unit of measurement.
Calculations were made in order to find the measure corresponding to one third of the total length of the rectangle.
I suggested that students register this calculation and draw the composter we started.

How I support my activity?

I supported the planning and practice of my activity on Draft guide (framework for science inquiry by drawing in permaculture gardens) (page 19)
Below is the summary of what has been explored with this activity and what we will explore in the near future while building and maintaining the compost.

<u>Practical activities</u>: Collect food waste; Turn the compost weekly and rebuild the layers; Check the humidity level of compost; Check visiting animals: flies and mosquitoes indicate to much humidity; woodlouse, roly-polies and ants indicate not enough humidity.

Drawing activities: Draw the worms found in the compost; draw the worms moving; Draw what you think happens to the food rests in the compost; Make and instruction guide for compost care (cooperative drawing).
Lines of inquiry: - What happens to the food debris we add to the compost?–- What worms need to thrive?–- How worms move?–- Why do different organisms indicate different levels of humidity in the compost?
Science concepts: - all organisms need humidity, light, food and temperature; - Animal movement
Competences: Observation; hypotheses testing through experimentation, argumentation, mathematical calculations.

Compost production (UI 3) – recycling home debris

(Scoala Gimnaziala nr.28 Bucharest)

The teacher's diary

The production of compost to enrich the soil is one of the inherent activities in permaculture. Composting is a process that aims to turn organic matter into valuable material.
The students collected the organic remains from their own households and from the school orchard. And under the supervision of the biology teacher (and other members of the project team) the students made vermicomposting.
For the production and care of compost, we used Organic Garden Maintenance Manual (IO5) that was given to us during the training sessions.

Sowing (UI 4) – setting the stage for inquiry learning

Kelenvölgyi Elementary School, 1st class (Budapest, Hungary)

Part 1. Sowing

The teacher diary


We sowed the seeds with the children today. We also planted seeds in pre-prepared boxes in the garden bed and in the classroom. I showed the children how to make a groove into which the seeds are thrown.

Everyone helped to sow the seeds. They covered the seeds with earth enthusiastically. In some places to much soil was put over the seeds. I opened their eyes to the fact, that the plant can come up to the light more slowly in this case.

We marked, in which groove we sowed which seeds. We sowed Hungarian and Portuguese wheat, parsley, beetroot and spinach seeds in our bed. The same seeds were also sown in boxes placed in the classroom. The children made holes with their fingers into the soil putted in the box and then threw the seeds in it.

The seeds sown both in the boxes and in the beds were watered. We agreed to observe where the plants germinate earlier. We discussed the conditions of the germination. Nevertheless, there were children who said, the plants germinate outdoors sooner, despite the fact, that there are still frosts at night.

I agreed with the children that we are going to compare their assumptions with their observations in the future. We are going to record all this also in form of drawing also.

We made a schedule: when and who water the sawing.

My lesson Plan

Sowing

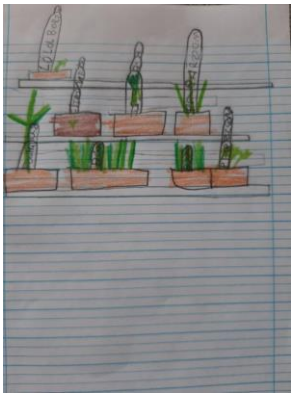
Timing	Goal	Activity	Duration
Check-in	Venue, clarifying the goal of the activity, Tündérkert (Fairy Garden), classroom	Getting dress according to the weather, playful „warming-up"	15 minutes
Discussing previous experiences	Get to know the seeds. Discuss about the conditions of germination (water, temperature) and the weather in the beginning of spring. Listening to the ideas of children, discussing of them, planning together.	Listening to and discussing ideas, previous experiences. Answering of questions, distribution of tasks.	15 minutes
Sowing (into beds – into prepared boxes) Recording by drawing of activities	Making furrows, throwing seeds, covering. Marking the lines of seeding-crops Throw the seeds into the boxes prepared in the classroom, marking. Recording the sowing through using the tool of drawing based on observation. Creating learning possibilities.	Routine activities (preparing tools, distribution, organizing, tidying up) Recording the sowing through drawing.	10 minutes 20-25 minutes
Reflexion and evaluation	Evaluation of the activities with the children.	Planning of the next occasion. Talking about drawing and plans of each other.	15 minutes
Check-out	Closing of the lesson	Packing up, washing themselves, clothing.	5-10 minutes

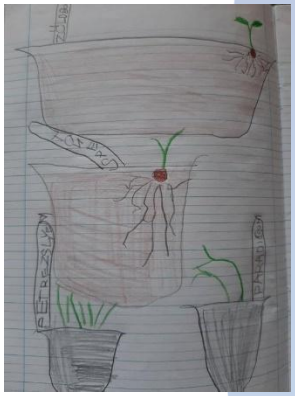
Part 1 - Follow and care of the seedling – (10th to 24th march)

Teacher diary

We have monitored the development of small plants continuously since the day of the sowing.

We discussed these experiences with the children at the closing occasions. After that, they documented, or rather drew their experiences in the drawing journals.



According to the expectation of the majority of pupils, seeds sown in the open field have not yet germinated. The seeds sown in the classroom have germinated and are now small plants. The first two weeks were very spectacular, as the change was visible almost in every 2-3 hours. This engrossed and piqued the interest of the children in an extraordinary way.

Unfortunately, some seeds did not germinate, so we will try again the sowing later. There were also small plants, which perished in the weekend. They probably got too much water. We talked with the kids about that, too. It was also found that care should not be overdone.

I think, documenting in the form of a drawing is a good method, because beside the opportunity to develop several competencies in this project, the drawing is really close to the age group 6-7.

We will continue the observing and caring of the plants in the coming weeks and months in any case.

Part 2 - Follow and care of the sowing

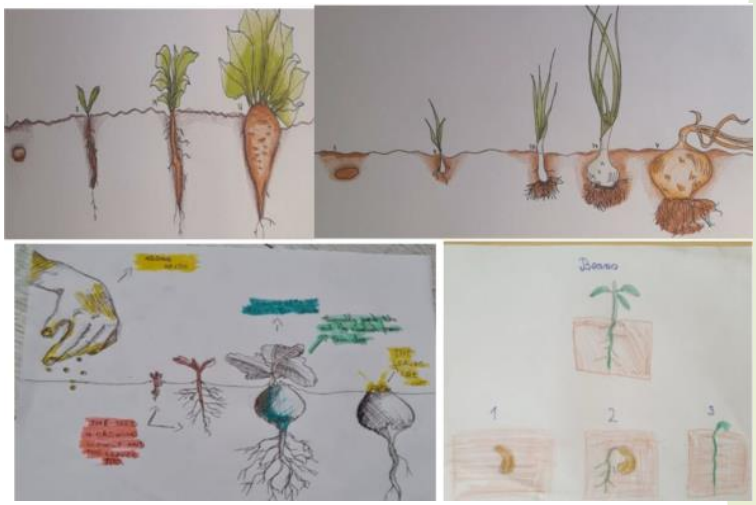
Timing	Goal	Activity	Duration
Check-in	Venue, clarifying the goal of the activity, Tündérkert (Fairy Garden), classroom	Getting dress according to the weather, playful „warming-up"	15 minutes
Discussing previous experiences	Discuss about the conditions of germination (water, temperature) and the weather in the beginning of spring. Listening to the ideas of children, discussing of them, planning together.	Listening to the experiences of the sowing, discussing. Answering of questions. Experiences of plant care tasks.	15 minutes
Caring of plants, observing of changes Recording of activities through drawing	Recording of plants growing through drawing, mainly by using the tool of drawing based on observing.. Creating learning possibilities.	Routine activities (preparing tools, distributing, organizing, tidying up...) Recording of plants growing through drawing. Comparing of experiences – sowing into the garden beds, and into the boxes in the classroom.	10 minutes 20-25 minutes
Reflexion and evaluation	Evaluation of the activities with the children.	Planning of the next occasion. Viewing and discussing the drawing of each other's.	15 minutes
Check-out	Closing of the lesson	Packing up, washing themselves, clothing.	5-10 minutes

Seeding and care of seedlings (UI 4)

Scoala Gimnaziala nr.28 Bucharest)

The teacher diary

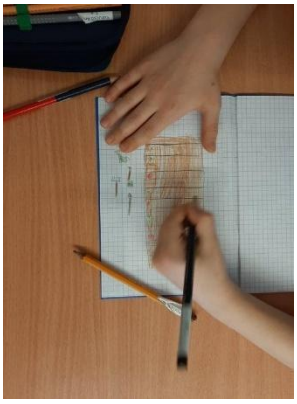
The students (age 9-10) planted some seed with the help of the teacher. And the other students (age 12-14) were asked to plant themselves some seeds at home (under Covid-19 lock down).
The students sowed the seeds of some vegetables in recyclable materials, observed the stages of germination, provided the environmental factors necessary for germination, growth and development of plants (temperature, humidity, light) and took photos.
Running the experiment of the germination of the beans seed in transparent containers allowed to follow the formation of the vegetative organs: root, stem, leaves (in the plantlet phase). These observations were also explored by drawing other species (drawing from imagination).

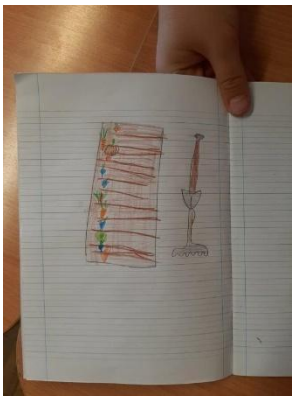


Planting (UI 5) – the planning process for planting

Kelenvölgyi Elementary School, 1st class (Budapest, Hungary)

The teacher diary






In today's session, we planned how to plant the plants in our beds. We discussed with the kids what plants we would sow and how to place them.

There was also talk about when it would be worth to prepare the soil for planting. We have agreed that we will be preparing the soil for the next session.

As we planned in the previous (November) session, we kept on collecting the plastic boxes needed for indoor planting. The need for recycling and re-usage of plastic was discussed again.

During the planning of the bed, the children enthusiastically drew their plants to be sown.

Next time, I need to get the seeds, so we can study the descriptions of the plants and to learn the process when we sow, and how shall we take care of the seedlings.

I noticed that the kids would have already started working on the plants. I convinced them that the steps could not be missed because if we did not prepare the soil properly, our plants would not be able to develop properly.

Planning the yard–- planting planning

Chronology	Target	Activities	Time
Check-in, introduction	Venue, clarifying goals of the activity, name of the yard	Check-in, introduction	Venue, clarifying goals of the activity, name of the yard
Discussion of previous experiences	Planning the plants to be planted in the bed. Listening to children's ideas, discussing together, planning together.	Ideas, listening and discussing earlier experiences. Answering raised questions and sharing the tasks.	15 minutes
Planning with drawing Planning the preparation and distribution of the bed	Using a drawing diary is an age-appropriate method for planning with children. Creating learning opportunities.	Routine activities (preparation of the tools, allocation, sorting, tidying up). Detailed documentation of soil loosening, weeding, discussion about the tools & planning and our drawings for this process. Making a drawing of the bed. Planning to use recycled bottles for planting.	10 minutes 20-25 minutes
Reflection and evaluation	Joint evaluation of the session with the children.	Planning together the next lesson. Discussing each othe''s drawings and plans.	15 minutes
Checkout	Closing the activity	Tidying and cleaning up, dressing up.	5-10 minutes

Planning the garden in our school (UI 1) – measuring and planning for consociation

Scoala Gimnaziala nr.28 Bucharest)

The teacher diary

The children's mission is to know and get acquainted with the garden area, to make measurements and to draw on paper a contour of the garden.

Students draw the map of the bed (raised furrows) according to the compatibility between plants, the soil pH. Moreover, they had to bear in mind the distance between plants, plant protection and pollinators. Some students drew the garden plan using coloured pencils; others made the map of the garden using the computer. Most of the students made the garden plans in accordance with the requirements listed above.

Planting green beans (UI 5) – elements of engagement

Agrupamento de Escolas Dom Carlos I, (Sintra Portugal)

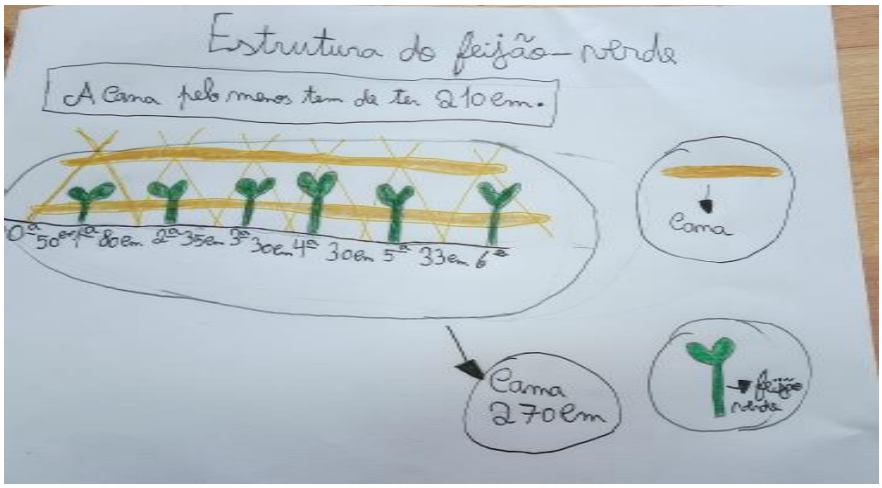
The teacher diary

I have a 5th grade group with 6 girls and 3 boys, where most of the students have special educational needs (SEN).
After they arrived, we talked about the proposed tasks to be carried out that day, weeding and planting green beans and beets. The girls were enthusiastic, but the boys did not participate in the conversation, maintaining an attitude that was detached from the conversation we were having.

The tools to start working were distributed to both groups and the beds where they should plant indicated. The girls immediately started their task although showing some level of disorganization. The boys disappeared and even if i called them back, they did not come. I decided to start working myself expecting them to imitate me. However, this technique did not work because the boys ignored me and disappeared again.
I went to see where they had gone and found that they were neither together nor doing anything. I asked one of them where did go and what did he want to do but he didn't answer.
The other two boys also wandered without seeming to have any goal.
I called them back, and intuitively I realized that they need to have very short tasks. As soon as they picked up some weed, I said that we could start planting the green beans. These small plants are very beautiful, and this seemed to have influence them. We considered the appropriate distances between each plant and in a short time the 6 plants were planted.

What caught my attention was that these boys showed such a detached and scattered gaze ... without presence.

Meanwhile the girls have also finished planting 12 green beans. After washing their hands, they sat down at the table to draw.
During the individual conversation about the drawings of each one I was very surprised when I saw the drawing of one of the boys.
The design was meticulous and precise, and the drawing had been done with dedication. I was surprised because this contrasted deeply with the behavior he had shown earlier, of the disinterested attitude and the lack of enthusiasm.



How I conducted the activity?

Before planting the green beans, I informed the students about the light and humidity needs of this plant being very similar to those of the strawberry. in consociation in this planting bed.
We also discussed how fast the green beans and the strawberries grow and whether the growth of green beans would affect the strawberries' need for light and space.
We concluded that the speed of growth and the height reached by the green beans would not harm the strawberry.
I suggested to the students to register the activity by drawing. Some drew the plants, and some drew the map of the bed representing the planted plants.
During the time that each one drew, I asked little questions about the records they made regarding the space left between the plants, the depth to which they had been planted, shape, size, ribs, color, etc. depending on the situation of each drawing.

How I planned?

I planned to plant 6 plants of green beans in a planting bed where there was already planted 12 plants of strawberries.
I checked in the permaculture guide: - green beans and strawberries are companion plants and both can be in consociation in the same planting bed; - green beans and strawberries have the same need for sun and water; - strawberries usually reaches 10 to 30 cm in height and green beans 2 or 2.5 m high; spacing between strawberries plants can be 20 to 35 cm and green beans 60 to 70 cm.

I supported the planning and practice of my activity on the "Draft guide for science inquiry by drawing in permaculture gardens" (page XX). Using the elements as explained in the unit of inquiry about Planting. I present below a summary of my concretization of the UI planting what has been explored with this activity.

Practical activities: - Calculating appropriate distance between plants according to plant needs for sun and water and according to plant growth; - Planning and planting according to consociation principles;

Drawing activities: Draw the map of the bed representing the planted plants, representing space between plants. Draw the plant

Lines of inquiry: Plants need light, water, nutrients and space: - How fast plants grow: do all plants grow at the same speed?

Science concepts: - Plant growth - Plant anatomy

Competences: observation; measuring distances and areas; estimating and predicting based on information; planning; decision-making;

Exploring ideas: ; Explore ways of measuring plant growth and evaluate best ways of doing that (root growth, leaf growth, stem growth…).

Planting outside (UI 5)

Scoala Gimnaziala nr.28 Bucharest)

The teacher diary

In April we planted onion and garlic bulbs, potato tubers, the seeds of some vegetables (carrots, peas, radish, beetroot, baby spinach, pumpkin, sunflower, beans). We also took in consideration plant's compatibility.
The students were delighted to see how those seeds look like. The planting was done later due to unfortunate wheatear conditions. The beds were covered with mulch (made from straws).
In May we also planted the students' seedlings (peppers, cucumbers, tomatoes, strawberries) and some herbs, such as thyme, lovage, parsley, celery and mint). Also, we planted pollinating plants: tagetes, petunias, common/ garden sage, homestead purple (verbena).

Planting seedlings in the garden beds according to permaculture principles requires planning and reflection on what species to plant and where those plant species should be put in the bed according to plant needs and consociations.

The Harvest (UI 8) – Vegetable Festival celebration

Scoala Gimnaziala nr.28 Bucharest)

The teacher diary

The project of creating a vegetable garden abiding by the principles of permaculture has a positive impact on many students, who eagerly want to participate in the activities. Also, some parents announced their participation, their role being the procurement of materials (seeds, tools for analysing soil p H, humidity, soil temperature) as well as in carrying out activities with students (dissemination of information, making questionnaires, round table talks, etc.).

Harvest (UI 8) – Learning about roots and fruits and stems

Agrupamento de escolas de Alfornelos (Portugal)

Main Objetive: Learn science concepts through drawing;

Activities:

. Prepare the garden;

. Observe the garden;

. Learn science concepts

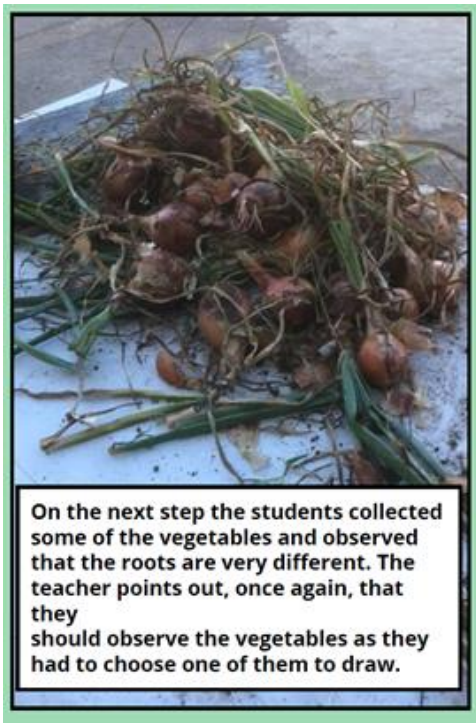
. Drawing;

. Students' drawings

This pilot was implemented in our school unit with (SEN) students under the survision of the teacher. However in some of the tasks the students were also helped by a peer suporter, an older student (CEF course). The teacher gave them some clear and easy instructions while explaining how to do the tasks.

Observing the garden

The teacher called the students' attention to the different kind of roots and the way they were planted and how they grow.



On the next step the students collected some of the vegetables and observed that the roots are very different. The teacher points out, once again, that they
should observe the vegetables as they had to choose one of them to draw.

The students chose a vegetable and the teacher gave them some pencils to draw and also coloured ones to paint the drawings.
The teacher told them that they must be very attentive to the details of the vegetables they have chosen before starting to draw.

So as to help the students while they were drawing
they could, look and observe the vegetable or, in case of need, use the mobile phone to see the vegetables they were drawing.

Harvesting carrots (UI 8) - Cooperative drawing

Agrupamento de Escolas Dom Carlos I, (Sintra Portugal)

The teacher diary

Today we collected carrots, and the students made their records in a cooperative drawing.

"Each one has their own thought about carrots"
"It was very interesting to see the carrot in different shape"
"the drawings were getting improved by the participation of all of us"
" I liked how the draw appears after we all draw. It's a kind of surprise"

(impressions were collected in a conversation after the activity).



I divided the students into two groups and in each group were two students with Special Educational needs (SEN).
The students drew the carrot for 2 minutes and then changed places by turning until they reached the original place of each one. When each student came to place that considered "their drawing" most of them accepted the modifications made by each colleague however some had difficulty dealing with the traces made by the SEN students. The SEN students who participated had a good mastery of trace but differences between them were visible. In the end we were able to talk and integrate a more open view about the registration made together by the whole group. Each drawing is actually a work and an expression of the carrot integrating the view of the whole group.

I asked to each student how did they feel about this challenge and most of them liked it and had fun with it (see impressions above). „
Some expressed that they did not like the experience because they felt that their drawing was ruined by the others. They would like to do their own drawing.

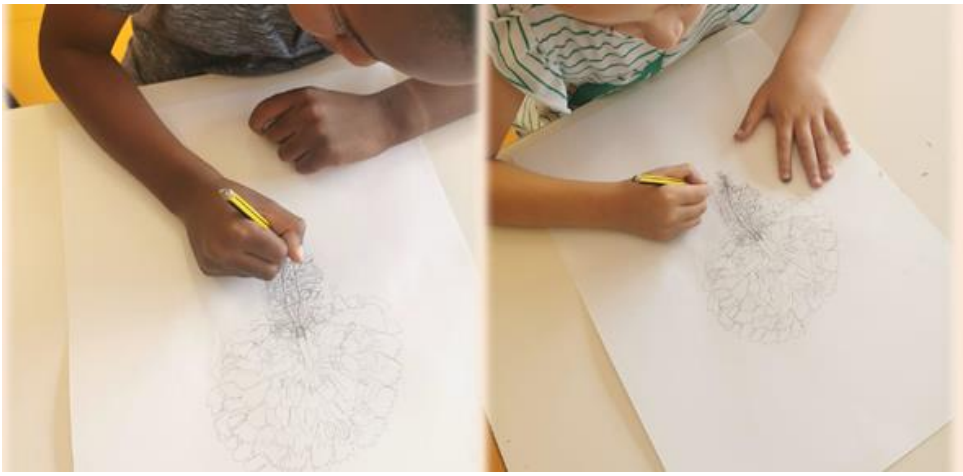
I decide that next week i will propose a different experience in an attempt to mitigate conflict that arose this time and promote cooperative learning: 1) observe and tell the observation to each other working in pairs; 2) do an individual carrot draw; 3) discuss about the result referring to features of the colleague's drawing on the side; 4) do a cooperative draw of the same carrot.

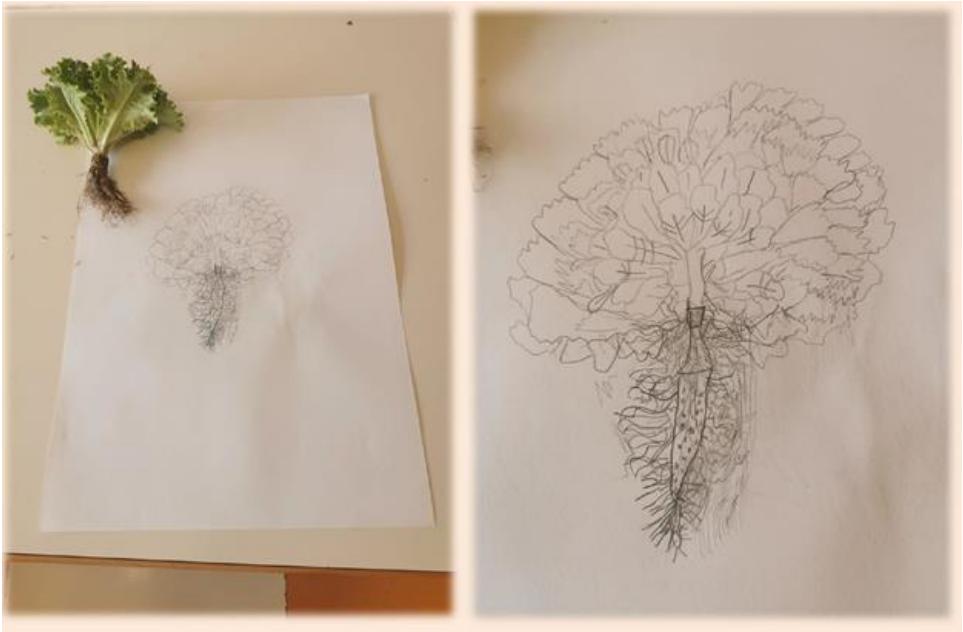
APPENDIX II. Yard4All - inspiring moments

The lettuce - learning and cooperating through drawing

Agrupamento de Escolas de Alfornelos (Portugal)

In this activity the children observed the vegetable and they drew the lettuce, one by one adding some more details. First, they drew some lines and after they started enriching the drawing in terms of shadows. For this activity the children used some special pencils with different grades.
This drawing technique is based on observation and promotes cooperation and creativity as it is done in Several steps because the participants contribute with their own perception on what they are seeing and observing.





This work was done by a class of 1st year, from EB1 Santos Matos. The children are 6 or 7 years old. It was a small experiment on Cooperative Drawing with small children.

Poetry written by student of class VIII B.

Scoala Gimnaziala nr.28 Bucharest

The veggie yard
Rows and rows all rose in line
like pawns aligned!
Smallish seedlings
just like siblings,
stand in yards
playing cards.

And the springtime sun shining bright
fondles them, bringing them light
And the chlorophyll –'till noon
They will all be fed, very soon.

Greenish Lettuce do I see already?
Is it *Lactuca sativa*, fully grown and ready?
Near *Pisum sativum* still standing?
Just a minor misunderstanding.
Have you guessed it how
do I understand it now?
Ha, I am at ease!
I know those are just peas!

Look! In the furrow
Look, how they burrow
the chives full of sorrow
Not getting another tomorrow
Because they all will soon be gone over morrow!
An onion is now the chive
And look how they all thrive
The little prick, it sprouts!
Big pods, yet watery -no one doubts.

But I still don't get it why it's called -horseradish
A family it makes with the radish.
However, there's no horse, just a name.

but their heads are all the same.
Not big and round,
But in the ground!
There bloomed some nests, as well, maybe new
Abundant bundles of sorrel, maybe a few
And the patience dock
grew on the block
Healthily and stealthily

And in the yard, what can I say, ah, just a word or two.
All for you.
The trophy went to the hedges
Looking sleek,
and shabby-chic
gulping down veggies for ages!

"Vegetable King" student in class VC

REFERENCES

Adams, E. (2009). Power drawing: active learning (p. 32). *ArtForms, Education* Leeds The Campaign for Drawing.
Adams, E. (2014). Drawing attention to Drawing. *The public art think tank*.
Adams, E. (2017). Thinking Drawing. *International Journal of Art & Design Education, 36*(3), 244-252. doi:10.1111/jade.12153
Areljung, S., Due, K., Ottander, C., Skoog, M., & Sundberg, B. (2021). Why and how teachers make use of drawing activities in early childhood science education. *International Journal of Science Education*, 43(13), 2127–2147.)
Bell, D. V. (2016). Twenty-first century education: Transformative education for sustainability and responsible citizenship. *Journal of Teacher Education for Sustainability, 18*(1), 48-56.
Binder, M. J. (2017). In Conversation with Bob Steele. In M. J. Binder & S. Kind (Eds.), Drawing as Language: Celebrating the Work of Bob Steele (pp. 1-12). Rotterdam: SensePublishers.
Bjønness, B., & Knain, E. (2018). A science teacher's complex beliefs about nature of scientific. Nordic Studies in Science Education, 14(1), 54-67.
Bjønness, B., & Kolstø, S. D. (2015). Scaffolding open inquiry: How a teacher provides students with structure and space. Nordic Studies in Science Education, 11(3), 223-237.
AccessArt (2020). - Briggs, P. - Knowledge Organisers for Art in Primary Schools.Let's Think Before We Leap.
https://www.accessart.org.uk/knowledge-organisers-for-art-in-primary-schools/
Carlson, Hemphrey and Reinhardt (2003). Weaving science inquiry and continous assessment: Using formative assessment to improve learning. Thousand Oakes: Corwin press.
Chang, N. (2012). What are the roles that children's drawings play in inquiry of science concepts? *Early Child Development and Care, 182*(5), 621-637. doi:10.1080/03004430.2011.569542
Donovan, S., Bransford, J., & Pellegrino. (1999). How People Learn: Bridging Research and Practice. Washington, DC: National Academy of Sciences.
Fiorella, L., & Mayer, R. E. (2015). *Learning as a generative activity*: Cambridge University Press.
Fradd, S. H., Lee, O., Sutman, F. X., & Saxton, M. K. (2001). Promoting science literacy with English language learners through instructional materials development: A case study. *Bilingual Research Journal, 25*(4), 479-501.
Hathaway, M. D. (2016). Agroecology and permaculture: addressing key ecological problems by rethinking and redesigning agricultural systems. *Journal of Environmental Studies and Sciences, 6*(2), 239-250.
Knain, E. & Kolstø, S. D. (2011). Elever som forskere i naturfag. [Pupils as researchers in science.] 2. Utg. Oslo: Universitetsforlaget.
Knain, E. & Kolstø, S. D. (2019). Elever som forskere i naturfag. [Pupils as researchers in science. 2nd edition] 2. Utg. Oslo: Universitetsforlaget.

Lin, L., Lee, C. H., Kalyuga, S., Wang, Y., Guan, S., & Wu, H. (2017). The Effect of Learner-Generated Drawing and Imagination in Comprehending a Science Text. *The Journal of Experimental Education, 85*(1), 142-154. doi:10.1080/00220973.2016.1143796

McGinnis, J. R., & Kahn, S. (2014). Special needs and talents in science learning. *Handbook of research on science education,* 2, 223-245.

Primas (2011). The PRIMAS project: Promoting inquiry-based learning (IBL) in mathematics and science education across Europe. Primas guide for professional development providers. Deliverable D.4.1. Version 1, March 31st 2011. https://primas-project.eu/wp-content/uploads/sites/323/2017/10/PRIMAS_Guide-for-Professional-Development-Providers-IBL_110510.pdf

Turner, J., Keogh, B., Naylor, S. & Lawrence, L. (2011). *It's not fair. A guide to developing children's ideas through primary science enquiry*. Milgate House Education & The Association for Science Education. UK.

Tytler, R., Prain, V., Aranda, G., Ferguson, J., & Gorur, R. (2020). Drawing to reason and learn in science. Journal of Research in Science Teaching, 57(2), 209-231. doi:https://doi.org/10.1002/tea.21590

UNESCO-IBE. (2022). Twenty-first century skills. http://www.ibe.unesco.org/en/glossary-curriculum-terminology/t/twenty-first-century-skills. Bureau international d'education, Unesco, 1995-2022.

Wilson, R. E., & Bradbury, L. U. (2016). The pedagogical potential of drawing and writing in a primary science multimodal unit. *International Journal of Science Education, 38*(17), 2621-2641. doi:10.1080/09500693.2016.1255369

Project Partners: