YARD4ALL

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Guide to develop science concepts on school yard

Content

Introduction

Underlying all activity in Yard4all project 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) will be involved in all activities inherent to permaculture (i.e. making beds, planning, sowing, replanting, mowing, weeding, composting etc.). Coordinated with these activities, children will engage in systematic register of observations and experiences, by drawing. 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.

In addition, there's an 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 scientific discussion for all children. The aim of supporting inclusive education is present and the peer-to-peer models developed in the project (IO2) will, ideally, constitute a guideline for practice.

This document is elaborated as a framework for pilots to be carried out by the teams of each partner and/or associated schools of the project Yard4All. It is intended to establish a common ground for these pilots, by providing ideas and practical clues for implementation of science and drawing activities in the permaculture school garden. Teachers are invited to, and helped with, register their observations about the various activities in a "teachers diary", during implementation. These diaries will be the backbone of our exchange of practices.

Communities of practice will be established to share and discuss experiences between teachers in the partner and associated schools. The experiences collected during the implementation will in turn feed into the process of refinement of this framework, that will result in the "Guide for developing science concepts in the school garden" (IO5).

The framework is constructed around "Units of inquiry" (UI) which in turn are organized around the cycle horticultural activities. However, these UI are not meant to be separate entities or meant to be used in sequence.

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 the science curriculum. In order to support schools in establishing the permaculture gardens we have, in the scope of the project (IO5), elaborated a "Draft 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)*

Considerable body of literature exists that indicate that purposefully drawing functions in various ways to facilitate young children's acquisition of science concepts; it serves as tools for assessment, 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 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 an open door into the mind and affect 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. These artifacts are also great opportunities 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). Learning more about what the boundary conditions for learning by drawing are, including those for children with SEN, is a central preoccupation in this project. This framework is a contribution to develop and implement activities that will stimulate the use of drawing for learning science for all children.

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.). Drawing also contributes to the development of attitudes and skills that are important for the citizens of the 21st: Drawing nurtures and builds confidence about learning, encourages persistence and risk taking (Adams, 2009). Additionally, drawing helps children acquire the skills of analysis, interpretation expression and communication, among many others. In fact, it develops a wide range of skills, from physical to emotional.

The purpose 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 purpose (observational drawing, imaginative drawings and designs). All these somehow relate to how the drawing is made. However, to understand drawing as a medium for learning, it is more helpful to ask **what the drawing is for**, rather than how is the drawing made (Adams, 2017). In this way the focus will also shift from the appearance of the drawing, to <u>what the pupil learns</u> through drawing (Adams, 2017).

Adams (2017), defines four main categories of drawing that emerge from reflecting on what the drawing is for, that we will use in this document (Adams, 2017).

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.

Box 1: 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

General 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. From that experience emerge a set of practical 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. Ideal duration of a session is 1:30, to allow time for arriving, settling down, complete the activities in the garden, draw, discuss and wrap 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:

(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 (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.).

Preparing activities in the Garden:

- Keep the objectives/activities for each session simple.
- Prepare the frames for the day activities (group size, who does what, etc.) so these preoccupations do 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 out 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 rain water 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!!!

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.

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 I - 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).

Planning: A general sequence

Table II - 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 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.

Drawing types – 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:

Observation drawing - supports the children in slowing down, and really 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.

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. It allows children's ideas to become visible and facilitate discussions and negotiation for finding out good solutions.

Imagination drawing – Harnesses children's creativity. It can make visible connections with the memories and knowledge of children – and allow insight into their 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).

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
- Graphite pencils with different degrees of hardness (from 2B to 8B)
- Soft pastel
- Wax crayons
- Charcoal
- Markers (varied thickness)
- Inks and brushes
- Erasers

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.

Box 3: The teacher's diary – planting carrots and cabbage

Claudia Carolino, teacher, Sintra, Portugal

Group 9 (age 9-10) – Sintra 28th November 2020



Today was planting day for this group. We planted 10 carrots and 20 cabbages.

We started the session at the garden by weeding and mulching. Then we picked up the materials for planting: seedlings and planting tools. Then we started the planting activity in groups of four.

While planting, the pupils inquired about the placing and distance between seedlings. Discussions arose and there were different opinions as to what would be adequate. Because of that the seedling were planted in different patterns. After planting, all groups drew the map of the bed showing the placing of the plants, with figure text.

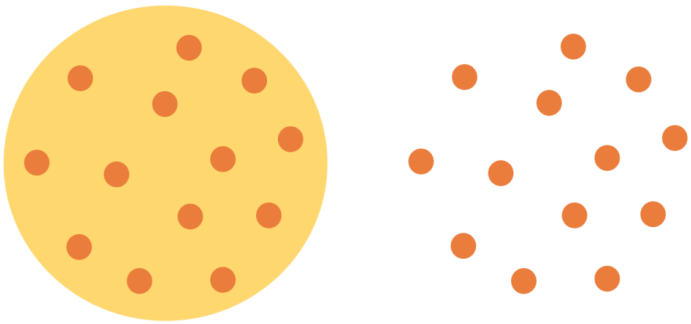
I understood that next time we should have the discussion before the actual planting, so that I can plan better. I had thought about it, but with everything happening in the garden, I forgot.

Many enjoyed drawing the map of the planted seedlings while others were more interested in crumpling the soil with the fingers…

While the pupils were planting, I told them to be aware and not to press the soil while making the planting holes, or while placing the small plant on the ground. I showed them how the soil was humid and easily became compact. I showed how it became almost like modeling paste. The pupils asked why, and I told them it was because it contained much clay.

After the session in the garden I contacted the class teacher and reported the pupil's interest for the soil and its properties. We agreed we will have an experimental in-classroom activity, about soils. She does the planning and organizes support materials. I will prepare experiments to observe and explore permeability, color, smell, and structure of soils. We agreed on the 14th of December for this activity.

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

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 that children can be involved in, at different levels.

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, erosion. These offer opportunities for learning among other things, concepts of ecology, geology, climate, weather ….

Children can also be involved in the conception and building of tables and benches (fig. xx). In that case curricular areas of technology and design can be explored through, for example carpentry. This may give an excellent opportunity to introduce ideas of circular economy and the importance of considering sustainable development, as well.

Drawing

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

Figure 1. Planning the garden: children draw a possible design after observing patterns of waterflow in the terrain, after rainfall.

Exploring ideas:

the water cycle; sediment transport; erosion; soil properties; gravity; volumes and flows; sustainable building

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.), learning opportunities regarding soil structure and composition and understanding of ecological concepts (recycling of nutrients; trophic chains; water cycle; carbon cycle among others).

Figure 2. 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 different groups get the task to document a special 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 we cover with straw or other material?
- How to prevent soil compaction?

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
- Microorganisms 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.

Competencies:

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

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 cantina).


Figure 3. Children feed the vermicompostor with kitchen debris.

Time of the year: 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 pag.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

Competencies:

Observation; hypotheses testing through experimentation, scientific methods, argumentation

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 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 learning of concepts, competences and attitudes.

Figure 4. 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?

Competencies:

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?

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 5. 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

Competencies*:*

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.

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 out. 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.

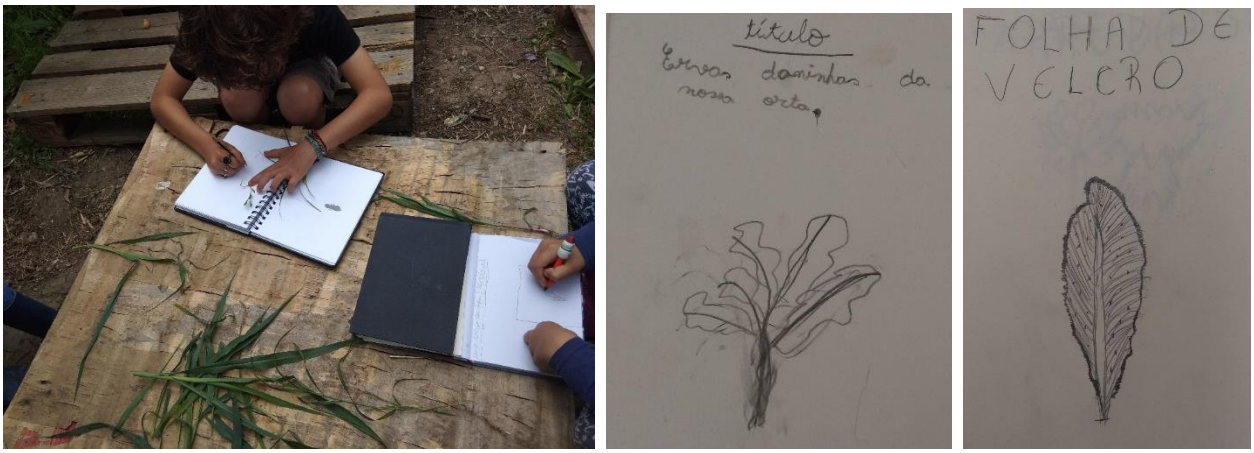


Figure 6. Children drawing weeds (left), drawing of a whole weed no one knew the name of…(middle) and a close-up of a leaf that was hairy and prickly and got the name of "the Velcro plant" (right).

Time of the year: All year

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.

Competencies:

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.

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.

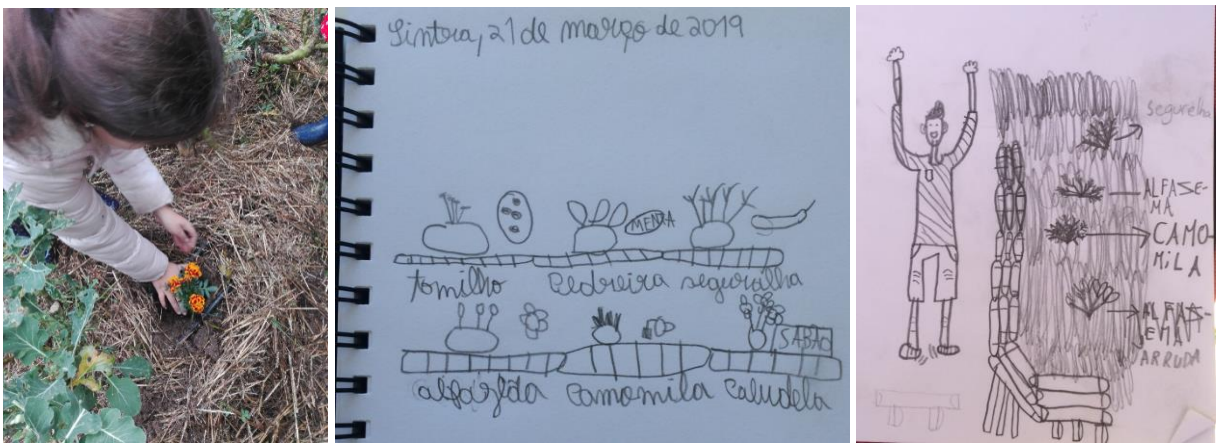


Figure 7. Child planting tonic carnation for repelling snails and slugs (left), and two different renderings of the bed of aromatics planted for attracting pollinators (middle and right).

Time of the year: all year

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 particular 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

Competencies:

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?

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 cantina for example)

Figure 8. 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 all 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
- How do the different organs look like and what is their function for the plant (storage organs, production organs).

Competencies:

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?).

References

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

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.

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.]* Oslo: Universitetsforlaget.

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

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

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