



AGE : 13 - 14

Fractals and Nature

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Activity n°2

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Educator's guide



Introduction

Fractals are the converging point of STE(A)M. They bridge the gap between science and metaphysics which make them extensively rich in scope and simply fabulous subjects for learning. They are described as the never-ending patterns. They are ubiquitous, and arguably, they are the design of nature and life. It was the Polish-born mathematician, Benoit Mandelbrot, who coined the word “fractal” to accommodate shapes in nature that fall outside the standard recognised forms. Broccoli is a popularly cited example. If you look closely at the arrangements of its florets, you will find that each one is a smaller representation of the entire broccoli head. Math and different branches of science – physics, chemistry and biology all offer explanations at varying levels of these intricate arrangements. A student ushered to the “mathgic” of fractals will never view STE(A)M with the same lens of disinterest again.

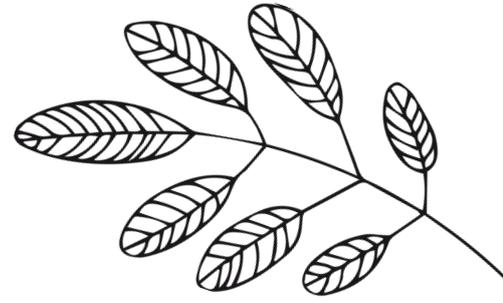
Permaculture design puts a premium to the significance of fractals in the design process. Observation, an integral part of the permaculture methodology, ushers the designer to the reality that there is no straight line in the natural world, that even the horizon is a curve. Understanding the patterns in nature is not only imperative, but more so, it ascertains the adaptation of permaculture ethics and principles in every project. Once a student recognises the resemblance of the fractals in our human veins with those we see from a river delta, his critical thinking skill will naturally trigger his creativity. Students who learn holistically will be capable of designing 21st century products that safeguard our rivers and oceans.

Calendar

The research, field trips and challenges can be carried out all year round. If outside/nature classes will be experimented on, good weather, of course, had to be considered.



Duration



Lecture Outdoor/Classroom learning:
Fractals in Math, Art, Science: >2 hours /discipline
Permaculture Design -chapter on patters: >2 hours

Tasks:

Task 1: Nature walk report: 1 hour

Task 2: technology related. 15 minutes search from each student. 2 hours for the preparation of the presentation

Task 3: Edge effect project: Preparation with teachers 1.5 -2.5 hours (divided between educators)+ 2 hours on-site visits + 2 hours preparation + 20 minutes presentation each

Field trip:

Forest/park visit: 2 hours

Important note:

In Belgium and possibly in other European countries, there are no particular lessons dedicated to fractals for students of 10-14 years of age. For countries with an ICT curriculum, fractals may be dealt with in passing. However, in other countries like the USA and India, the Geometry of fractals is introduced to at an early age, and the lessons are designed according to the students learning capacity.

Gamification method(s)/technique(s)

Riddles and silent walk during the field trip will rouse a sense of interest from the students in this activity. The artwork activities entailed in the Edge project are also guaranteed to bring the fun. Experimental outside classroom teaching can be fun for both students and teachers.

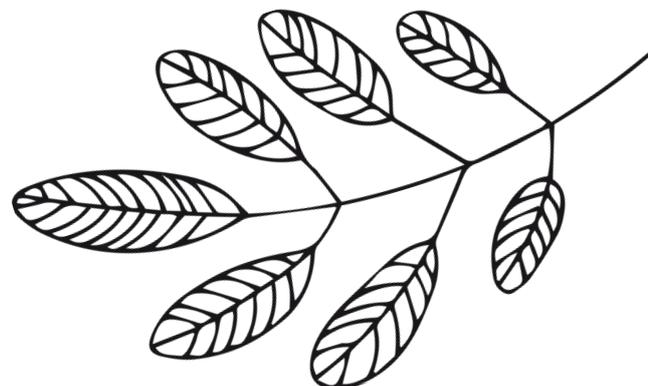
Preparation

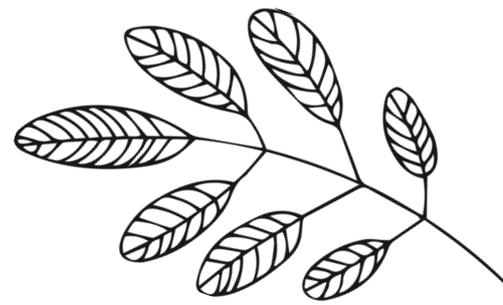
A prerequisite to this activity is the in-depth knowledge, and conscientious comprehension of the educator on Permaculture design and a short Permaculture Design Course is highly recommended. In the subject of fractals, two critical elements of Permaculture are addressed: Patterns and Edge Effect. For the sake of simplicity, the project presented here will focus on the edge effects.

The internet is a fountain of information and ideas that will help the teachers in teaching this topic and adapting it to the aptitude of the child and for the students to expand their interest in the subject.

Challenges that will lead to the completion of the tasks

The field trip will open an array of challenges that the educators can eventually scale up to further the learning. During the field trip, the first challenge for the student is self-control during the quiet walk. Then the riddles they have to solve that will provide clues to the lessons in fractals are not only good builders of excitement but are challenges in themselves. The educators are encouraged to keep the lessons in fractals as riveting as possible. They may consider holding classes outside of the classroom to give a sense of open space to the students. The success of the student in this game is measured by his outputs or actual applications from the projects. The possibilities for fun and learning are only limited to how far the educator would want to take the fractals to.





Tips for successful facilitation, supervision and organizing:

It is important to be sensitive to the students' learning concerns (e.g. learning disability) when implementing this activity. This activity is an opportunity for educators from different disciplines to work together. Math, science and art teachers will benefit most if they join forces. The framework here is a suggestive idea that can be modified and stretched to adapt to the learning environment in the school and the aptitude of the students.

Before the concept of fractals is introduced in the classroom, it would be good to stimulate the imagination of the students by starting with the field trip jointly organised by the three educators. At this point, the students must already be familiar with “thoughtful observation” as a prerequisite in permaculture. It will be their most potent invisible tool for the field trip.

To provide a hint on the purpose of the hike: Sing “Let It Go” with the students. It is song in the famous movie “Frozen” that introduced fractals in its lyrics (My soul is spiraling in frozen fractals all around). The song was harnessed by many teachers to break fractals in the classroom.

The most important tip is the openness of the educators to the experiences in this activity and the learning they themselves can derive from it.

Debriefing outcomes and obtained competences:

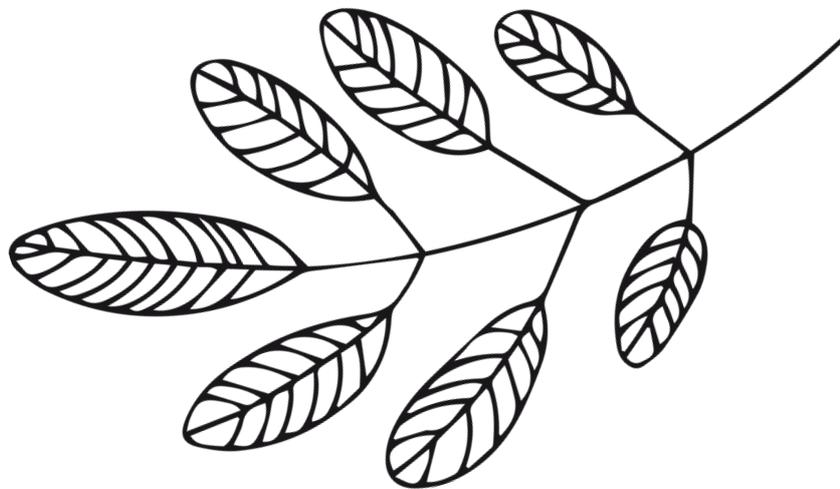
3STE(A)M Learning objectives:

At the end of this activity, the students should be able to:

1. Have an understanding of fractals and a notion of the Mandelbrot set
2. Appreciate the beauty of natural geometry and be able to site actual applications of fractals
3. Have a notion on how they can apply the edge effect in gardening
4. Attain a recognition of the richness in cultural exchange and the enriching impact of multiple viewpoints
5. Demonstrate a deepened appreciation of nature or the world they live in

Methods applied:

Deep learning, field observation with analysis, documentation, presentation and problem-solving.



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Students' worksheet



Related STE(A)M theory:

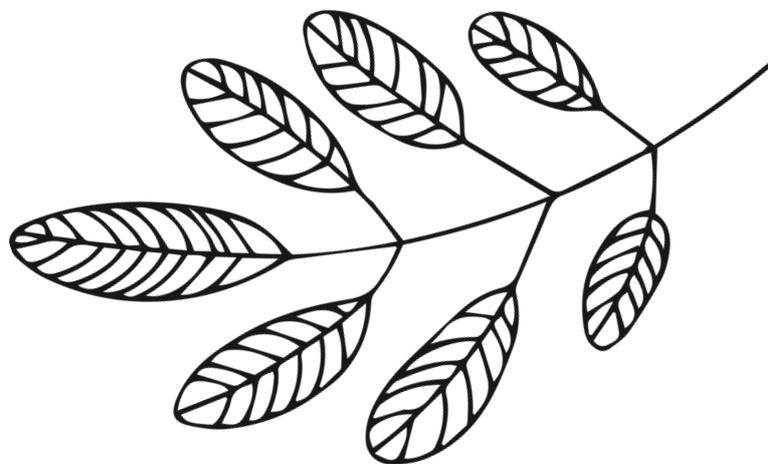
- Mathematics
- Arts
- Science(s)

Key Words

Fractals, Mandelbrot set, Mandelbrot, Fingerprint of God, Permaculture Edge effect, Permaculture and fractals, fractals for STE(A)M, fractals for kids

Developed skills:

- Heightened ecological awareness
- Development of the student's ethical standards
- Critical & creative problem solving
- Research skills
- Sensitivity to the world around them (culturally and ecologically)
- Self-expression



Necessary Equipment and Materials:

Students: A4 paper, materials for presentation, computer and internet connection

Media and Resources

Real resource persons

Internet sources for fractals:

<https://www.youtube.com/watch?v=WFtTdf3l6Ug>

<https://educationonline.ku.edu/articles/teaching-kids-patterns-in-nature>

<https://thekidshouldseethis.com/post/fractals-nature-universe-bbc-ideas>

Internet sources for permaculture:

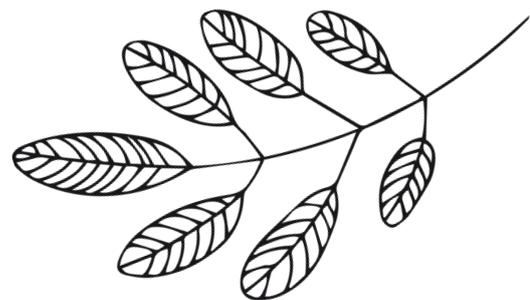
<https://www.visionarypermaculture.com/notes>

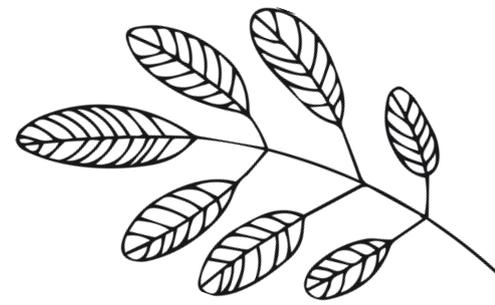
<https://www.permaculturenews.org>

Tasks

Lesson in Permaculture Design: chapter on Patterns (if not yet given or if already done, a refresher will be useful). Outdoor classroom would be fun- one hour.

Lesson in Permaculture Design: The Edge effect. Outdoor classroom is an option. An excellent reference can be found here:
<http://www.holocene.net/dissertation.htm#2> >1 hour.





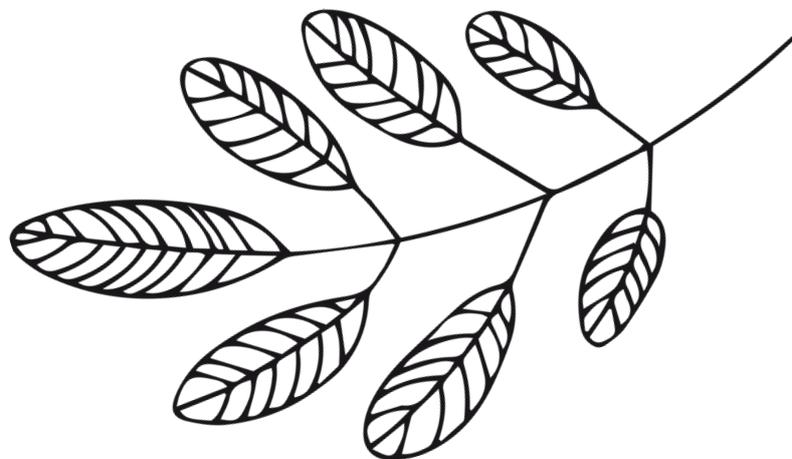
Tasks

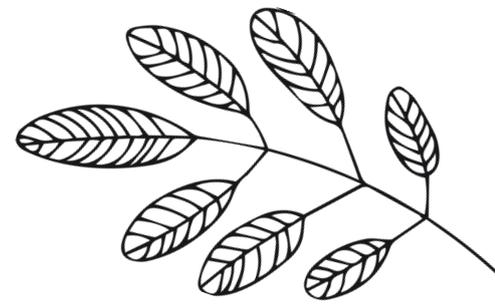
Field Trip with Art, Math & Science Educators: At least two hours of a forest walk. If there is no forest close by, botanical or other nature parks are possible options. The park visit should precede the lessons on fractals.

- The forest walk will start with fifteen minutes (or more) of a quiet walk. No communication in any form between teachers and students and between students during this time and all electronic gadgets switched off.
- Instruct the students to observe the sensations in their body, their thoughts without engaging in them. Dare them to find out what “being one with nature” means to them. You can mention the names of successful people, such as Steve Jobs, who do “weird” things like this.
- If during the fifteen minutes there are dissidents among them, let them be. The educators should simply set the example.
- After the fifteen minutes, thank them. Give clear instructions that the objective of the trip is to observe the shapes, forms and patterns they see around. They are to make mental notes of their findings.
- During the start of the talking walk, each educator can trail alternately along 3 or 4 students to offer them a space to express. Observation is the key so prejudgements about the student or their reactions should not be entertained. The idea of the silent walk is to prepare the group for heightened sensations during the walk. It is an excellent exercise to sharpen the minds.
- After an hour of walk, the educators will introduce the riddle game. (Educator can prepare the riddle themselves or see Annex 1 for examples).

Tasks

- The students will now be grouped in 3's and regrouped every 30 minutes. The more people they have been with, the better. A riddle is given to the group every time they regroup.
- To stimulate interactions, the group members should be encouraged to talk among them about what captures their attention.
- It will be useful to end the trip with lunch in a cafeteria or school canteen (if free for schools). The teachers can organise with canteen staff for a meal with broccoli or cauliflower (fractal examples). The final puzzling question that will lead the students to internet search will be: "If God or the creator has a fingerprint, how do you think it will look like? That will be the pick up point of the fractal lessons.





Tasks

Lesson in Fractals: >1 hour per discipline. Math, Art and Science. Relating the experience to the lessons in permaculture will yield a more diverse perspective from students.

Task 1: Discussion of what was observed in nature during the walk. >1,5 hour.

- Give each student an A3 sheet of white paper.
- Instruct them to draw or sketch on the sheet as many elements they have seen in the natural world (human-made structures are not included at this point) from the forest/park walk. They are likely to draw trees, leaves, birds, insects, etc. Tip: Educator can invite the student to pay attention to the absence of pure straight lines. The geometry of nature is not defined by straight lines but by waves, turnings and curves.
- Let them check each other's work and search from the others what is missing in their sheet.
- Using a different colour of pencil, they must add the elements their classmates found that they missed out. The purpose of this is not to compete against each other but to share information. Encourage to identify patterns in each other's drawings.

Task 2: Fractals in the internet. Students to work in groups of 5. The goal is to search for the most exciting short videos (3-5 minutes) on fractals that they can find. They will share their findings in class with a quick rationalisation on why they chose that video and a summary of what they learned about fractals from it.

External Lecturer: Deep Learning on Edge effect and fractals

Invite experts: a permaculture farmer/ experts in other fields that apply the permaculture discipline for 1-2 hours presentation. If not available in your area, set up a live video presentation with experts from other countries. Encourage cross-sectional interactions.

Tasks

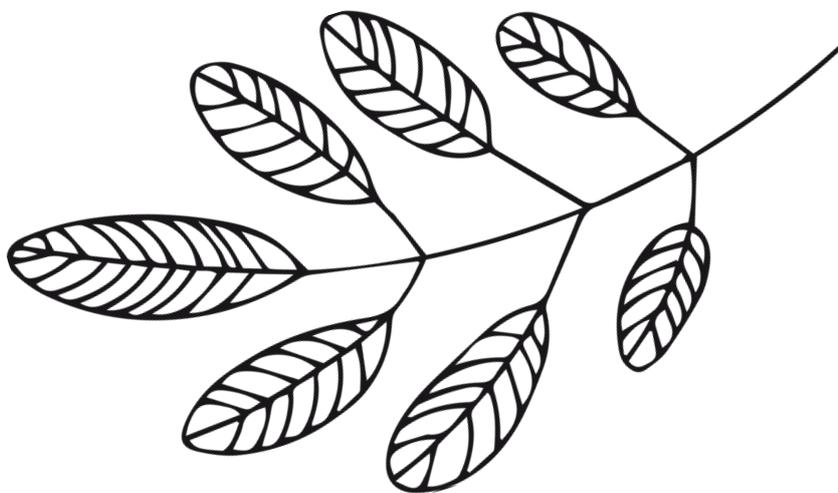
Task 3: The Edge Effect Project.

Group the students in 5.

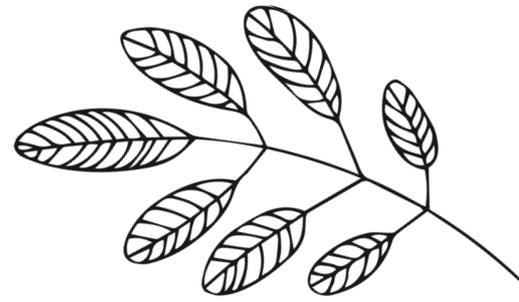
The edge effect challenge: A graphic illustration of real-life edge effect.

Potential subjects: edge effect in cultural exchange, edge of woodland, edge in urban planning, edge of water and woodland systems, etc. Joint project of educators from the three disciplines.

- Each group must submit a subject for investigation of edge effect.
- They should be able to consult all three educators for guidance.
- Each educator assists the groups in understanding the Edge Effect based on the discipline they teach. For example, the math educator may explain how fractals are used in the subject they intend to investigate. Since these are 12-14 y.o. students introduction of mathematical formulas might be complicated, so it will be enough to explain the applications by citing examples how fractals are used in film making, in understanding climate change mathematically, and the fractals in their chosen topic.
- The Art teacher can guide in the illustration and artistic presentation of their report.
- The science teacher explains the biology or physics in the subject chosen.
- The research can be done by interviews, site visits or internet research. The first two options will be more exciting.
- All 3 SMA educators must be present during the presentation so the presentation can happen within the Math, Science or Art class.



Project's partners



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