LIVING STEM

AGE : 10 - 14

The Golden ratio, the bees and Permaculture Design

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Activity n°2

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Educator's guide

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Introduction

The Fibonacci number or sequence is a mathematical idea with a very extensive scope. It's relevance as a teaching tool in problem solving, its logarithmic applications in information technology, its essence in visual arts - architecture, paintings, designs, and even in poetry contribute to a growing number of Fibonacci followers and fans, ushering renewed interests in mathematics, extending to younger generations in some parts of the world.

In Permaculture, we cannot over emphasize the vital role of "Observation" as an integral part of its systems thinking approach to design. The role of natural patterns observed in nature is of great relevance. It is from these observed patterns that the elements within a system (natural or structural) are enhanced to optimise the effectiveness of the design. This is why the Fibonacci sequence and golden ratio observed in nature weighs a great deal in permaculture design.

Calendar

The research, field trips and challenges can be carried out all year round. However, careful planning must be observed as the schedule will impact on some activities in the Part 2 of this activity

Important note

In Belgium and possibly in other European countries, the Fibonacci series is introduced only to students following advanced Geometry classes therefore not for ages below 16 years. However, in other countries like the USA and India, the Fibonacci concept is introduced to as early as 10 year-old students classified as "gifted and talented students". The advantage of using Fibonacci to fascinate students with mathematics at young age can help augment the interest of the students to this discipline. Furthermore, artists being instinctive pattern creators demonstrate the golden ratio in most of their works. Integrating mathematics to art brings forth a completely different perspective of these disciplines to the students.

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Duration

Classroom learning:
Fibonacci introduction/refresher: 30 minutes to 1 hour
Fibonacci sequence and the Male Bee: 1,5 to 3 hours (depending on how much the educator intends to expand on this topic)
Permaculture Design -chapter on patterns: 1-2 hours

Tasks:
Task P1.1: Homework, apiary visit preparation- 30 minutes to 1 hour
Task P1.2: hours counted as field trip
Task P1.3: Presentation- 2 hours preparation and 20 minutes presentation
Task P2.1: Binder Fibonacci art- 1 hour indoor activity
Task P2.2: Search for location - 30 minutes x 7 days, Permit/permission- depends on the location
Task P2.3: Observation- 15 to 20 minutes x 21 days (flexible and scalable)
Task P2.4: Design layout - 2 hours indoor + 1 hour on site
Task P2.5: Garden plot prep: gathering of materials- X hours, onsite work depends on the size of the plot
Task P2.6: Seeding and planting: Purchase or search for seeds takes X time, actual seeding 30 minutes; transplanting - 30 minutes x 8 people
Task P2.7: Filming - 5 minutes per task, 2 hours to mount the entire film +1 hour editing
Task P2.8: 30 to 45 minutes per visit X the number of planned organised visits. For the apiary visit, this has to be checked with the local apiary. Bee farms or apiaries are normally open all-year long, though with limited opening days during winter.

Field trip:
Visit to the apiary: 2 hours

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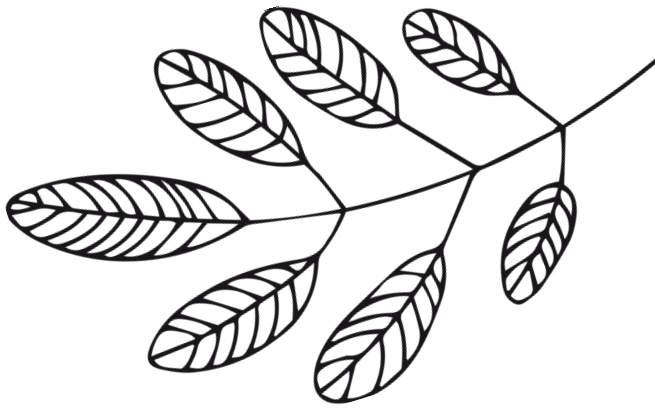
Preparation

The educator needs to have proper knowledge of the Fibonacci numbers. The internet is an easy resource as it offers immense materials on Fibonacci sequence and related subjects. There are also international networks of teachers who exchange lesson plans and other materials according to the age group or aptitude levels of the students. Also accessible through the internet are downloadable lesson plans. (example: https://www.mensaforkids.org/teach/lesson-plans/fabulous-fibonacci/). The educator should have in-depth and conscientious background of permaculture to teach the "course patterns in permaculture". He/she should be able to interconnect with ease the mathematics in nature as espoused by the Fibonacci series and the golden ratio. A basic Permaculture Design Course (is highly recommended although not obligatory). Materials available from the internet.

Challenges that will lead to the completion of the main task:

All parts of this activity are loaded with challenges. The challenges will be met with fascination because the educator will be introducing STEAM in the "out of the box" way with a mathematical concept that is outside of the current curriculum reach. It will be a milestone for the students to work on their own permaculture design and create it. The realisation of this will be the ultimate reward for the students.



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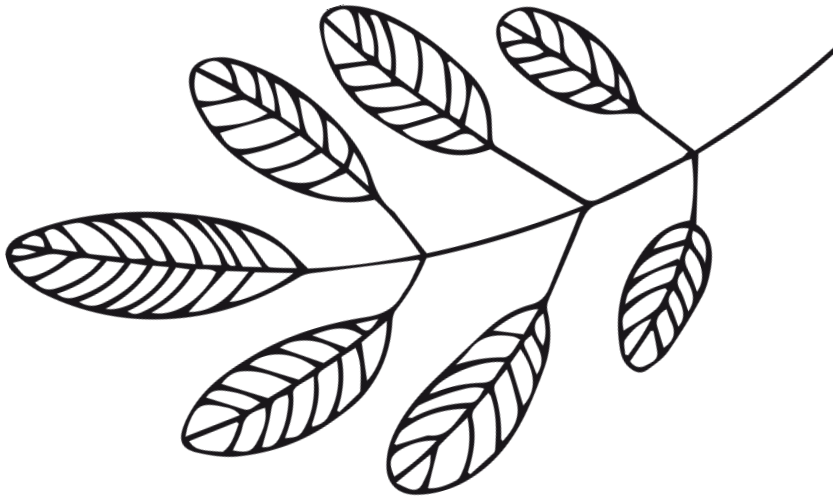
Tips for successful facilitation, supervision and organizing:

- This activity involves different parts.
- Determine the learning aptitude as well as the learning concerns (e.g. case of learning disability) of the student and scale the activities accordingly.
- Plan out the activities in consideration of your region and climate and schedule properly to make them enjoyable instead of straining for the students.
- Define the goals and challenges clearly of each part to stimulate the creative sides of the students.
- Cite inspirations from Fibonacci and other related materials to keep the students motivated (examples: legend of Fibonacci being bullied as kid but succeeded, how he found his mathematical sequence by communing with nature, the painting of Mona Lisa & the golden ration shows how Da Vincci subscribed instinctively to the golden ratio..)
- One vital permaculture inspired approach that is perhaps already practiced by the educator and will be of utmost use for the success of this activity is to apply "thoughtful observation". This is not only confined to observation of each student in order to be able respond to each adaptively but also observation of the general process of the activity.



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PART 1: Focus on Fibonacci & the male bee

Gamification methods

P1.1.
The students will derive a lot of fun learning from bees and their world as they are tasked to map out the importance of bees in the ecosystem. The students will also be applying the Fibonacci golden ratio in creating artworks. The realisation of a garden bed using the spiral pattern or the Fibonacci numbers can be both challenging and amusing.

Tasks and Challenges

P1.2.

- **Classroom learning 1:** One to two hours of class lessons on the Male Bee or Ancestry of Drone are a prerequisite for this activity. (See Annex 2 for simplified overview). There is an open source in the internet for this with free lesson plans for teachers.
- During the lesson the educator will ask the students what they know about the bees. Their collective input will be noted down by the educator for future comparison to their input after the visit to the apiary.

Task 1: as part of a homework. Every student will list down what they expect to learn from the visit. They can prepare questions to ask the apiary guide.

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Tasks and Challenges

Field Trip : Visit to the local apiary
Group students in 3's or 5's depending on the size of the class.

Task 2: Note down as much lesson learned. The challenge here to ensure attentiveness is that from what they learn, they will make a presentation in class of the new knowledge acquired.

At the end of the visit, the students would have learned, among others:

- to relate what they learn about drones and the female bee from the Fibonacci series lessons the community structure of a beehive and the efficient production line that allows the bees to store honey
- how honey is produced through a different kind of leadership system & collaboration
- the reproduction system of the bees
- the significant roles of the bees in the ecosystem and how responsible apiaries are managed
- and many other vital as well as trivial realities that are helpful for the student to be creative in their thinking.

Task 3: Presentation. They can choose their own topic but information will be based on their analysis and perception of the acquired knowledge from the apiary visit. They have to come up with proposals on what every person can contribute to protect the bees. Self-reflection and research encouraged.

- **Classroom Learning 2: Permaculture and Patterns**

Tip: Prior to tackling the subject on permaculture, the educator opens the floor for brainstorming. The question is to find the relevance of bee colonies to permaculture design and to relate what they learned in this module with what they already know at this point about permaculture.

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Debriefing outcomes & obtained competences:

P1.3.
STE(A)M Learning objectives:
At the end of this activity, the students should be able to:

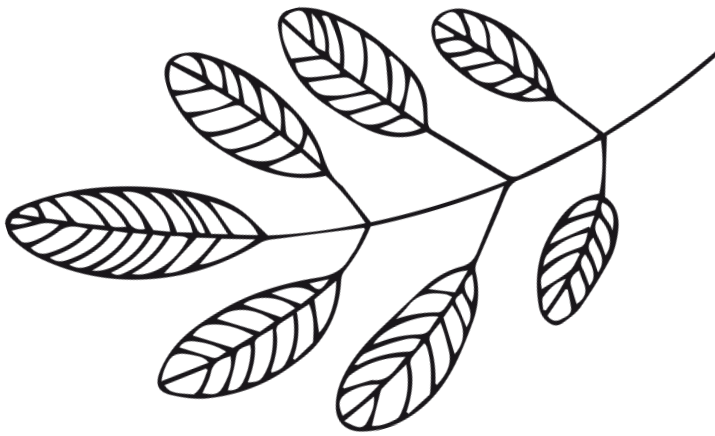
1. Compute the Fibonacci generation sequence and explain its relevance to the daily life
2. Relate the Fibonacci generation sequence to the biological existence of the bees
3. Attain a deep insight on self-responsibility in preserving the bees & our environment
4. For advance levels: Connect the Fibonacci reproductive sequence to permaculture design

Methods applied: Field observation with analysis, documentation, presentation and problem solving.

Related STE(A)M theory:

P1.4

- Mathematics
- Science: Biology
- Eco sociology



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Educational Objective(s)

P1.5 Developped skills

- Development of the student's ethical standards and ecological awareness
- Critical problem solving
- Research skills
- Sensitivity and responsibility to others
- Self-expression

Necessary Equipment and Materials:

P1.6 Students: notebook and pen, materials for presentation

Key words

P1.7.

Fibonacci male bee ancestry, Fibonacci series in bees, bees and Fibonacci, the golden ratio, golden ratio in nature, golden ratio in art, golden ratio in vegetables, spirals, the golden spiral, spiral and harmony, beauty and golden ratio, Permaculture and patterns, Permaculture design, patterns in permaculture, patterns in nature, Fibonacci sequence/series/numbers, Mathematics in nature.

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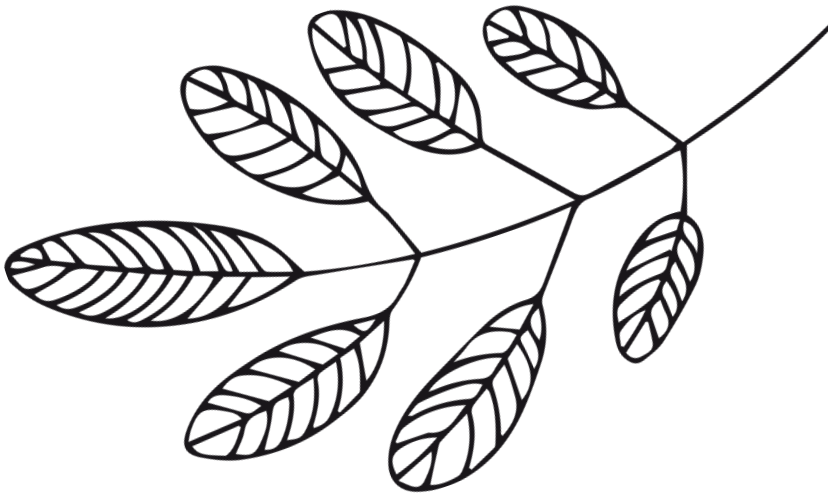
Media and Resources

P1.8

- Camera through phone, tablet or using a real camera (Instructions to use this was left out intentionally to allow the students' own creativity & initiative to take photos of the apiary visit for their presentation).

- Internet sources:
  http://www.dave-cushman.net/bee/fibonacci.html
  https://wild.maths.org/fibonacci-and-bees
  https://www.mensaforkids.org/teach/lesson-plans/fabulous-fibonacci/



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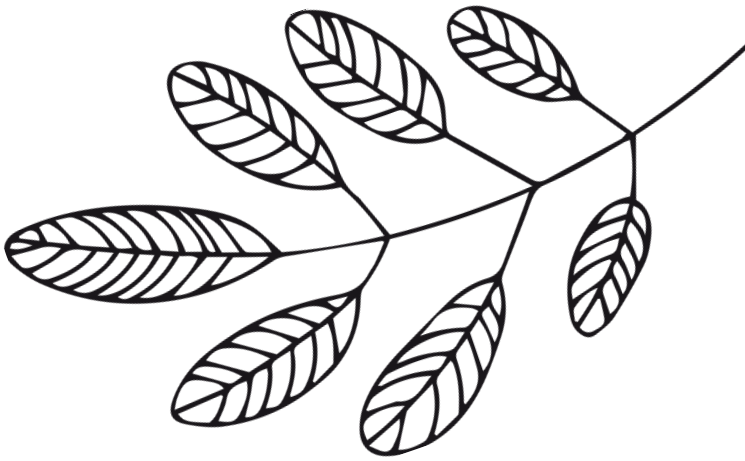
Part 2: Permaculture and the Golden Ratio Gamification methods

P2.1

The gamification techniques are integrated in the different tasks and challenges for which the rewards are the outcome of their work. As the students review and apply the Fibonacci sequence from the simple artwork of a binder through the use of recycled materials, they will progress into a bigger challenge of applying permaculture design with the Fibonacci number. The fun part is in their independence in applying their instinct and design skills and the many outdoor activities within a group. The visits of external guests will also be a unique experience that they will savour.



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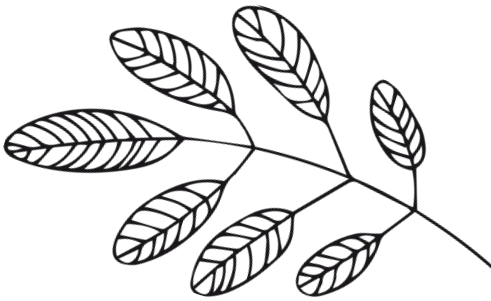
Tasks and Challenges



P2.2
Designing a garden with the Fibonacci sequence
Group students in 8's from Task P2.3

Student Directions that the educator provides:

Challenge: Creating your first Fibonacci art

Task P2.1 Fibonacci Art
• Design your office binder. Pick one where you can glue stuff on it.
• Using recycled materials of 6 different colours, such as printed parts of used plastic bags, coloured plastic bags, fabric from old coloured jeans, or old clothes, any old materials you can glue and cut.

• Create your Fibonacci Art by cutting out 6 circles of different colours from your recycled materials.

• Build up own sequence by starting with 2 circles with X cm radius and compete the sequence from there... choose your initial radius and create your own series. (Hint: if you start with 1cm radius, next circle is also 1cm and then next is 2cm and the next is 3cm...

• Glue the circles to the front of your binder in any pattern you like.
• There you have your Fibonacci Permaculture Garden Binder (FPG Binder)!

Challenge: Designing a permaculture garden with Fibonacci sequence
Task P2.2: Find your location.
Search for an abandoned or unkept area in your garden, in your school yard, neighbour's garden, local farm (organic or not), a public lot that you imagine to convert into a garden plot.
Obtain permission or permit (if in a public area). The observation starts during the search of your location. TIP: Start small. Ensure accessibility (to you and to water supply).

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Tasks and Challenges

Task P2.3: Visit the location several times. Observe.
What is the orientation of the lot (facing North? South?...) to determine, wind and sun direction.
What kind of vegetation is present?
What type of soil is there?
Passages of people or animals (domestic or wild)?
If you're visiting at a certain season, ask around what the situation is like in that area during the other seasons. Is there flooding risk, etc.
Journal all observations. File in your FPG Binder

Task 2.3. Designing your garden

Based on the objective/s you set for your design (example productivity and aesthetic, resilience to the surrounding, etc), the elements observed in your location, decide on the pattern you will apply.

To lay out your design pattern, you can use cut out circles or squares or simply draw on a large grid/graphing paper. If using cut out papers to create your zones, make sure to consider larger circle or square cut outs to obtain a bigger perspective on your design. Important: Your design lay out should be in proportion it to the garden plot you are designing.

Always thoughtfully consider: the sowing season, sun exposure needs and water demand of each plant; also the full size of the plant when grown up, and of course their best-friend-plants.
Once the plants are decided, you can start filling in your zones by writing down their
.
Mark the positions of the plants on the circles and write down their names.
You have a temporary design. Temporary because your pattern could still change.
Remain flexible.

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Tasks and Challenges

Note: Do not rush growth in your garden plot by forcing plants out of season. If this project is started in autumn or winter, you might want to prepare your garden plot by cutting the grass and covering it with thick piles of newspapers and cartons and then covering the cartons with dried haystacks from your local organic farmer or mowed grass. It is ideal to start the planting in spring although some vegetables can be sowed in winter. Check your choices of plants -vegetables/flowers.

Task 2.4 Prepare your garden plot

Prepare your soil. Do some research on permaculture or organic gardening soil preparations.

Soil preparation tips (depending on your area/country):

Autumn-winter- early spring: cover with cardboards or thick newspaper piles, then mowed grass or dried organic straw.

Late spring- late summer: apply no-dig technique. No-dig technique is layering of cartons, straws and top healthy soil on an unworked garden bed or plot. This allows you to start immediately with your planting. Different techniques are available in the internet.

Task 2.5 Seeding and Planting

Tip: If you start in spring, ask around your neighbourhood for seeds or seedlings. If none available, procure your seeds.

Based on your location and your prepared garden bed/plot, decide instinctively, if you plant directly or to start with seedlings.

Task 2.6 Let your garden grow!

Film the highlights of every phase of your project from Task 3.2 onwards.

Task 2.7 Organize visits

Invite other groups to visit your garden plot and exchange experiences.

Invite teachers and other classes to visit when your gardens are starting to take form or ready for harvesting. Be prepared to explain the do's and don'ts that you learned from experience.

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Debriefing outcomes and obtained competences:

STE(A)M Learning objectives:
At the end of this activity part 2, the students should be able to:

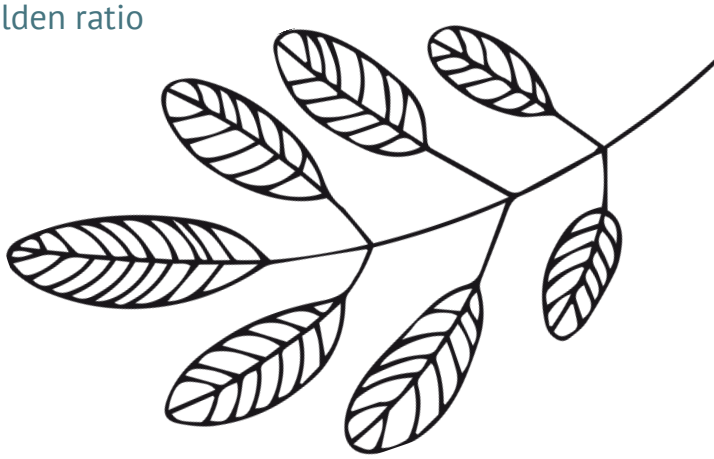
1. Be familiar and comfortable with the Fibonacci numbers
2. Have an appreciation of the patterns they see in their environment & have a notion of their impact
3. Understand the golden ratio and its significance in the natural world
4. Apply mathematical and scientific skills in designing and creating a garden plot.

Methods applied:
Field observation with analysis, documentation, presentation, problem solving, designing.

Related STEAM theory

P2.4

- Science: Biology
- Technology: use of gadgets and apps as well as relationship of Fibonacci to the IT world
- Engineering: designing a garden plot
- Art: visual art
- Mathematics: Fibonacci series and the golden ratio



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Developped Skills

P2.5

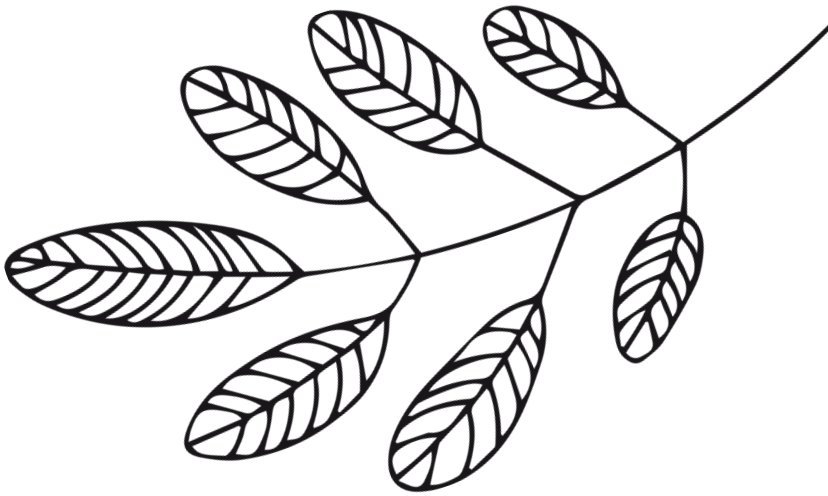
- Self-reliance
- Development of the student's ethical standards and ecological awareness
- Critical & creative problem solving
- Creative ability
- Leadership
- Research skills
- Sensitivity and responsibility to others and to their environment
- Self-expression

Necessary Materials

P2.6

Part 1: Notebook and pen, materials for presentation

Part 2: Living Stem Cards, Binder, pieces of recycled colours materials, ruler, scissors, glue, graphing or grid paper, coloured pencils, coloured papers (optional), cartons, straw, soil or compost, seeds and/or seedlings, watering tool (sprinkler). Phone, tablet or real camera for the filming.



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Key words/phases

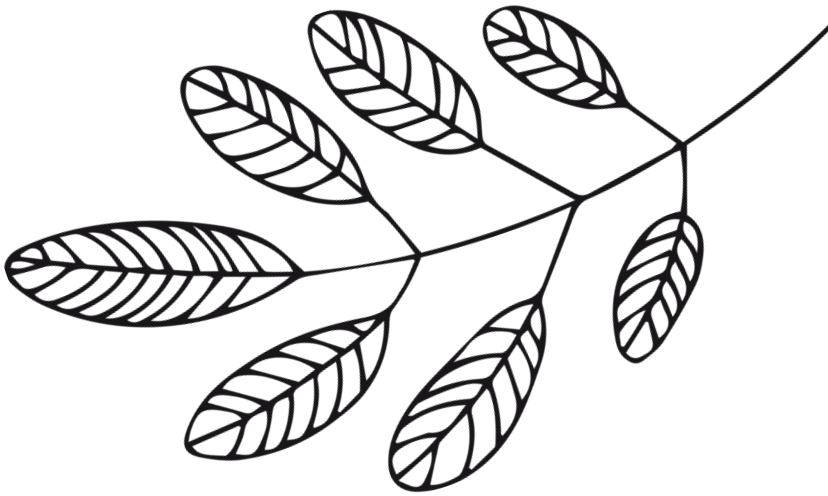
P2.7

Fibonacci and the golden ratio, Permaculture design, Patterns in permaculture, patterns in nature, Fibonacci sequence/series/numbers, Mathematics in nature, Art in nature, Fibonacci art in architecture, golden ratio in vegetables, plants and animals, golden ratio

Media and Resources

P2.8

1. Internet access
2. Books on permaculture and Fibonacci
3. Internet sources:
https://www.mensaforkids.org/teach/lesson-plans/fabulous-fibonacci/
https://www.visionarypermaculture.com/notes



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