Fibonacci's Sunflowers

Suggested Grade Level: 6-8

Time: 1-2 45-minute class periods

Subject: Math, Ratios and Proportional Relationships, Integers, Rational Numbers and Irrational Numbers, English Language Arts, Science, Plant Structure and Function, Environment, Biological Evolution and Trait Selection, Art, Analyzing and Interpreting Artwork, Music, Musical Structure, Agriculture, Sunflowers

Overview: This engaging, cross-curricular lesson connects math, science, English language arts, visual arts, music, and agriculture by exploring the sunflower's natural patterns and the Fibonacci sequence. Students observe sunflower structures, discover how the Fibonacci sequence and Golden Ratio appear in nature, and use context clues and word roots to understand technical vocabulary. Optional activities extend the lesson by exploring the Golden Ratio, Mozart and the Fibonacci sequence, and Vincent van Gogh's sunflower series.

Objectives:

1. Identify observable features of sunflower heads and leaves.
2. Explain how sunflower seeds grow.
3. Break down the arrangement of sunflower seeds and spirals to illustrate how Fibonacci numbers appear in natural growth patterns.
4. Evaluate Fibonacci numbers and the Golden Ratio in nature, music, art, and famous structures.

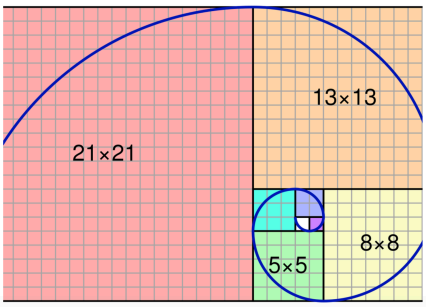
Background Information:

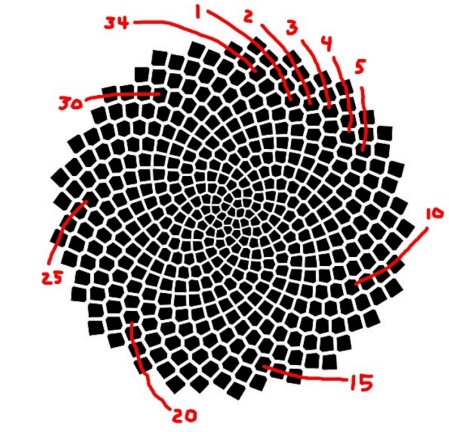
Sunflowers have rays (petals) and disk flowers (seeds). The sunflower heads may have 1,000-2,000 seeds. Sunflowers follow the sun from east to west. They reset to the east again at night, catching the sun in the morning. After a sunflower has finished flowering, it stops rotating, and the head droops. This drooping prevents the birds from eating the developed seeds. Sunflower production has increased rapidly throughout history. First, in the early 1800s, Russian immigrants brought seeds that produced bigger blooms. Then, in 1946, Canada developed a seed-crushing machine, which led to an increase in the cultivation of oil-type seeds in the US. In the 1970s, more Americans became more interested in sunflower oil because it is a low-cholesterol alternative to animal fats (Myers).

Sunflower seeds can be added to breads, cookies, and other products, and they can also be eaten separately as a snack. They are a good source of thiamine, riboflavin, niacin, and other vitamins. They also contain minerals and antioxidants. One ounce of cooked or roasted sunflower seeds provides 49 percent of the daily recommended serving of vitamin E, the highest amount among oils or nuts, compared to the same serving size (McCulloch). Sunflower seeds are squeezed and crushed to extract the oil used for frying and cooking. This oil is heart-healthy and can benefit individuals with asthma due to its anti-inflammatory properties. The vitamin E found in sunflower oil is beneficial for hair growth and health, as well as for the skin. Some studies suggest that it could slow the progression of Alzheimer's (WebMD).

The Fibonacci (fee-buh-naa-chee) sequence was founded by Leonardo Bonacci, also known as Leonardo Bigollow Pisano, or Leonardo of Pisa. He lived between 1170 and 1250 in Italy. During this time, it was common to identify someone more accurately by adding their place of origin to their name, as seen in examples like Leonardo of Pisa or Leonardo da Vinci, a native of Vinci. Fibonacci was a nickname derived from "fils de Bonacci," which roughly translates to "son of Bonacci."

The Fibonacci sequence is the series of numbers: 0,1, 1, 2, 3, 5, 8, 13, 21, 34, etc. This sequence is created by adding the two previous numbers and continues indefinitely (0 + 1 = 1, 1 + 1 = 2, 1 + 2 = 3, and so on). A spiral evolves when you make a square with the widths in the sequence (Math).





You can find this sequence in many items in nature, such as sunflower seeds and pinecone spirals. Most flowers have petals that are a number in the Fibonacci sequence: a lily has three petals, a buttercup has five petals; a marigold has 13 petals; and a black-eyed susan has 21 petals. The sequence, also called the Golden Spiral, allows for the maximum number of seeds on a sunflower head. A sunflower grows in opposing spirals, with 55 spirals in one direction and 34 in the other. The sunflower's center has 21 spirals, and the very middle 13 spirals. These are all sequential Fibonacci numbers (MoMath). The ratio of its rotation's diameter to the next is 1.618. The ratio between the margin of a leaf and its veins is also 1.618.

The Fibonacci sequence is also related to the Golden Ratio. The Golden Ratio is an irrational, non-terminating number, like pi, but it is even more critical. It is found in nature, the solar system, the human body, music, and famous structures. In the Fibonacci sequence, if a number greater than two is divided by its preceding number, the dividend is 1.618. The Golden Ratio can help create a photo or picture pleasing to the human eye by drawing attention to the essential elements: some examples include The Great Pyramid of Giza, Notre Dame, The Vitruvian Man, The Last Supper, and The Parthenon (Go Figure Ratio).

The Golden Angle—about 137.5°—is formed when a circle is divided so that the ratio of the larger arc to the smaller arc matches the Golden Ratio. In sunflowers, this angle helps create the distinctive alignment of seeds in the flower head. Because the Golden Angle is an irrational number, no two seeds are positioned at exactly the same angle from the center. This constant shift in angle causes the seeds to spread out evenly, forming the spiraling pattern we see in sunflower heads (Go Figure Angle).

Kansas Connections:
According to Kansas Farm Food Connection, "… Kansas is the sunflower state because our weather is perfectly suited for them. The plant is native to North America and grows well in many locations throughout the continent. Kansas is special, however, because the flower can be found in every county… The plant can thrive in the different soils, clays, and sands that cover much of Kansas' ground." Sunflowers are a big part of our state's identity, and for good reason. Before European settlers cultivated sunflowers, Native tribes grew them for food, coffee, medicine, and dye. These hardy flowers soak up the sun, thrive in dry weather, and grow in a wide range of soil types. This makes them desirable in areas that often face drought conditions, such as the western half of Kansas. Sunflowers have been a crucial asset and point of pride to many Kansans for much of our history. The Kansas Legislature named sunflowers the state's official flower in 1903, 42 years after Kansas' induction into the United States. Interestingly, every version of the Kansas state flag has included a sunflower! Kansas is fourth overall in the United States for sunflower production after North Dakota, South Dakota, and Minnesota (Kansas).

Materials:
Engagement:
- Real sunflower heads with leaves around them (enough for each group of three to four students to have one head).

Activity:
- Tape measures
- Meter sticks
- Calculators

- Optional items for examination: pinecones, pineapple, various real flowers and plants, pictures of the Last Supper, the Parthenon, a snail, a shell, ants, bees, and other pictures that show the Golden Ratio.

Optional Math Activity:

- Various measuring tools
- Optional: dolls, teddy bears, stuffed animals, etc.

Optional Fine Art Activity:

- Poster board or thick paper
- Multimedia paper
- Scissors

Instructional Format:

1. Review background information.
2. Conduct engagement activity.
3. Lead a class discussion.
4. Complete the activity.
5. Optional: Complete an additional math, music, or fine arts activity.
6. Optional: Complete the assessment.

Engagement:

Instruct your students to observe the provided items and any other objects in the room. Divide the class into groups of 3 to 4 students. Provide each group with a sunflower head. Ask students to observe the patterns and numbers of items they find on the sunflower, including petals and leaves. As the students see patterns, they should report them to you to put on the board. Take the time to work on this part and encourage the students to explore designs and focus on numbers. Ask each group if they see the same things reported before putting them on the board. As students start to see the patterns and numbers, be sure they understand the sequence of spirals and the Fibonacci numbers: 1, 1, 2, 3, 5, 8, 13, 21, etc. Have them figure out how the following numbers can be found without counting spirals, seeds, or leaves.

Procedures

Discussion:

1. Watch Scientific American: The Mind-Blowing Mathematics of Sunflowers – Instant Egghead #59 https://www.youtube.com/watch?v=z9d1mxgZ0ag
2. Ask students to discuss how the sunflower head grows the seeds within their groups. Students should again examine their sunflower heads and look for the spirals, patterns, and Fibonacci numbers.

Activity:

1. Have the groups select different Fibonacci numbers greater than two. Each group will divide its number by the number before it in the sequence. Groups can work together on a single piece of paper to complete the long division and check each other's work. Then, ask each group to report their answer; they will find the

Golden Ratio to be approximately 1.618. Explain that this is called the Golden Ratio. It is essential in nature, as well as in art, music, photography, and architecture. It is also found in their bodies.

2. Watch Jeffrey Chasnov: The Growth of a Sunflower (Lecture 19) Fibonacci Numbers and the Golden Ratio https://www.youtube.com/watch?v=Q44Xgxfl3f0.
3. Have students return to the sunflower and provide time to further investigate the spirals and growth of the sunflower. Ask them to use their meter sticks to measure and make more observations about the petals, leaves, spirals, and growth patterns (They can take notes of their observations for comparison in class discussion or submission for participation).
4. If other objects/pictures are provided, allow groups time to look for the Fibonacci sequence and the Golden ratio.
5. Introduce the Career Information by saying, “Did you know there are scientists who study sunflowers and other crops to improve how they grow, resist disease, and feed people more efficiently? They’re called agricultural crop researchers.” Ask your students, “What kinds of patterns or measurements might a crop researcher look for in sunflowers?”

Additional Activity: Math

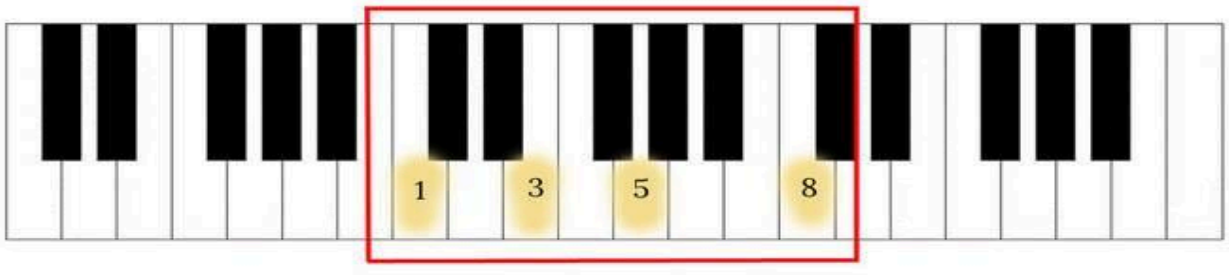
1. Provide each group of students with measuring tools.
2. Have the groups measure each other and use the Golden Ratio worksheet to record their measurements. Ensure groups are comfortable with each other measuring them, or provide a doll or teddy bear to those who are not comfortable.

Additional Activity: Music

1. Ask students to list numbers they know from music. Place these numbers on the board in numerical order as they are stated. Here are a few examples:

- An octave on the piano consists of 13 notes. Eight are white keys, and five are black keys.
- A scale comprises eight notes, of which the third and fifth notes create the foundation of a basic chord.
- On a scale, the dominant note is the fifth note, the eighth of all 13 notes that make up the octave.

2. As the numbers 3, 5, 8, & 13 appear on the board, ask the students to divide the numbers next to each other. (Eight divided by 13 equals 0.61538... the approximate Golden Ratio)
3. Define the Golden Ratio for the students and ask them to share where else they see these numbers in the Fibonacci sequence and the Golden Ratio. Continue with a discussion of Mozart and how he used the Fibonacci sequence and the Golden Rule. Where else is it found in music?



Additional Activity: Fine Art

1. Prepare a large drawing/painting or print-out of one of Van Gogh's sunflower series vases beforehand. Ensure the vase is large enough to display your students' cut-out sunflower paintings. You can display this project on a large poster board, thick paper, or other suitable materials.
2. Introduce Van Gogh's sunflower series to the class. Explain that Van Gogh was known for his sunflower paintings. Show the class some of his sunflower paintings, which can be found on the Van Gogh Museum website: https://www.vangoghmuseum.nl/en.
3. Explain to your students that they will be creating their own sunflowers. Explain that their sunflowers should reflect the Fibonacci sequence and be in the style of Van Gogh (post-impressionism).
4. While your students are creating, walk around the room and count to ensure that all sunflowers follow the Fibonacci sequence.
5. Have your students cut out their sunflowers and put their names on the back.
6. Glue them all above the vase for display.

Vocabulary:

- **Integer:** a whole number and its opposite
- **Rational number**: a number that can be made by dividing two integers
- **Irrational number**: a real number that can NOT be made by dividing two integers. It is a number that cannot be written as a fraction.*
- **Fibonacci sequence**: a set of numbers that starts with a one or a zero, followed by a one, and continues based on the rule that each number equals the sum of the preceding two numbers.
- **Golden Ratio**: the Golden Ratio is a ratio of 1 to 1.618, also known as the Golden Number. The 1:1.618 might also be expressed using the Greek letter phi.
- **Golden Angle**: the smaller of the two angles created by sectioning the circumference of a circle according to the golden ratio

Kansas Standards:

Next Generation Science Standards
From Molecules to Organisms: Structures and Processes
MS-LS1-5. Construct a scientific explanation based on evidence for how environmental and genetic factors influence the growth of organisms.
MS-LS1-7. Develop a model to describe how food is rearranged through chemical reactions forming new molecules that support growth and/or release energy as this matter moves through an organism.
Biological Evolution: Unity and Diversity
MS-LS4-4. Construct an explanation based on evidence that describes how genetic variations of traits in a population increase some individuals' probability of surviving and reproducing in a specific environment.

Mathematics
6th Grade
Ratios and Proportional Relationships
6.RP.3c. Use ratio reasoning to convert measurement units; manipulate and transform units appropriately when multiplying or dividing quantities.
8th Grade
The Number System
8.NS.1. Know that numbers that are not rational are called irrational. Understand informally that every number has a decimal expansion; for rational numbers show that the decimal expansion repeats eventually, and convert a decimal expansion which repeats eventually into a rational number.

Language Arts
6th Grade
Reading: Informational
Language in Reading: Informational
RI.6.11 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on sixth grade reading and content.
Speaking and Listening
Comprehension and Collaboration
SL.6.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on sixth grade topics, texts and issues, building on others' ideas and expressing their own clearly.
7th Grade
Reading: Informational
Language in Reading: Informational
RI.7.11 Determine or clarify the meaning of unknown and multiple-meaning words and phrases based on seventh grade reading and content.
Speaking and Listening
Comprehension and Collaboration
SL.7.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on seventh grade topics, texts, and issues, building on others' ideas and expressing their own clearly.
8th Grade
Reading: Informational

Language in Reading: Informational
RI.8.11 Determine or clarify the meaning of unknown and multiple-meaning words or phrases based on eighth grade reading and content.
Speaking and Listening
Comprehension and Collaboration
SL.8.1 Engage effectively in a range of collaborative discussions (one-on-one, in groups and teacher-led) with diverse partners on eighth grade topics, texts and issues, building on others' ideas and expressing their own clearly.

Visual Arts
6th Grade
(Cr1.1.6) Combine concepts collaboratively to generate innovative ideas for creating art.
(Re7.2.6) Analyze ways that visual components and cultural associations suggested by images influence ideas, emotions, and actions
(Re8.1.6) Interpret art by distinguishing between relevant and non-relevant contextual information and analyzing subject matter, characteristics of form and structure, and use of media to identify ideas and mood conveyed.
(Cn11.1.6) Analyze how art reflects changing times, traditions, resources, and cultural uses.
7th Grade
(Cr1.2.7) Develop criteria to guide making a work of art or design to meet an identified goal.
8th Grade
(Cn10.1.8) Make art collaboratively to reflect on and reinforce positive aspects of group identity.
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Music
Gr 6-8
Process Component Cr.3: Evaluate and refine selected musical ideas to create musical work(s) that meet appropriate criteria.
Cr.3.8.a Evaluate their own work by selecting and applying criteria including appropriate application of compositional techniques, style, form, and use of sound sources.
Process Component Pr.2: Analyze the structure and context of varied musical works and their implications for performance.
Pr.2.8.c Identity how cultural and historical context inform performances and result in different musical effects.

National Agricultural Literacy Outcomes:
Food, Health, and Lifestyle
- Identify sources of agricultural products that provide food, fuel, clothing, shelter, medical, and other non-food products for their community, state, and/or nation (T3 6-8 i.)
- Identify the careers in food production, processing, and nutrition that are
- essential for a healthy food supply (T3 6-8 j.)

Culture, Society, Economy, and Geography
- Consider the economic value of agriculture in America (T5 6-8 a)
- Highlight the interaction and significance of state historical and current agricultural events on governmental and economic developments (e.g., the building of railroads, the taxation of goods, etc.) (T5 6-8 f)

Supporting Resources:

Kids Connection Magazine Stately Sunflowers
cdn.agclassroom.org/ks/resource/connection/sunflower.pdf

Sunflower Fun Facts cdn.agclassroom.org/ks/ksresource/sunflower-fun.pdf

Sunflower Growth Cycle cdn.agclassroom.org/ks/ksresource/sunflower-growth.pdf

Sunflower Plant Part Labelling cdn.agclassroom.org/ks/ksresource/sunflower-plant.pdf

Career Information: Agricultural Crop Researcher
An agricultural crop researcher (scientist) conducts a study on improving crops through genetics, plant protection, irrigation, storage, farm machinery innovation, marketing, and resource management. In 2022, the average salary in the United States was $65,687, ranging from $44,000 to $121,000. A bachelor's degree is expected for entry-level positions.

Assessment:

- Exit slip: Write five numbers from the Fibonacci sequence.
- Draw a picture that shows the golden ratio found in real life and label it correctly.
- Write a paragraph about how sunflowers follow the sequence.

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Name: _____ Date: _____

The Golden Ratio and Fibonacci Numbers

Work with a partner. Use a measuring tape and record each measurement in millimeters. After each pair of measurements, divide the first number by the second and write the ratio.

1. **Full Body Length**
   a. Measure from the top of your head to your toes: _____
   b. Measure from your belly button to your toes: _____
   c. Divide: a ÷ b = _____
2. **Arm Length**
   a. Measure from your shoulder to the tip of your index finger: _____
   b. Measure from your elbow to your wrist: _____
   c. Divide: a ÷ b = _____
3. **Head Proportions**
   a. Measure from the top of your head to your shoulder: _____
   b. Measure from the top of your head to your chin: _____
   c. Divide: a ÷ b = _____
4. **Upper Body Proportions**
   a. Measure from the top of your head to your belly button: _____
   b. Measure from the top of your head to your shoulder: _____
   c. Divide: a ÷ b = _____
5. **Lower Body Proportions**
   a. Measure from your belly button to your knee: _____
   b. Measure from your knee to the bottom of your foot: _____
   c. Divide: a ÷ b = _____
6. **Face Proportions**
   a. Measure the length of your face (hairline to chin): _____
   b. Measure the width of your face (cheekbone to cheekbone): _____
   c. Divide: a ÷ b = _____
7. **Write all 6 final ratios from each section below.**

   _____ _____ _____ _____ _____ _____

8. **Reflection**

   Are your ratios close to 1.618, the Golden Ratio? Explain why some measurements might be close while others are not.

   _____

   _____.