Olin College of Engineering

Teacher's Guide for **Math and Plants**

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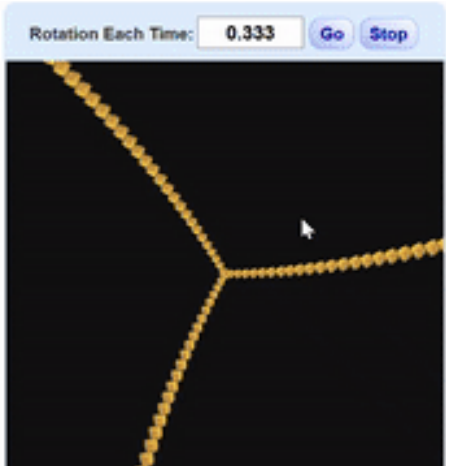


Workshop Description

Struggle to get your students excited about math? Why not use the beauty of classical art, nature, and visualization to teach math! We have three lovely workshops, the first on the golden ratio in sunflowers and plants, a second on the golden spiral in classical art and architecture, a third on graphing your own art based on simple shapes/lines.

This teacher's guide covers the first workshop, where we teach the golden ratio and fibonacci sequence through "being the sunflower." Students will participate in an interactive website where they control how a sunflower grows its seeds in a spiral to maximize their closeness. From there, the workshop goes into what the golden ratio means, what makes it special, how you can make it with the fibonacci sequence, and how it can be visualized as the golden spiral.

Workshop Requirements

- **Runs about 45-60 minutes** depending on class size and student engagement
- **Required or suggested materials**
  - Computer
  - Internet
- **Suggested ages/grades:** Early High school
- **Prerequisite Knowledge (suggested):**
  - Familiarity with fractions and ratios

Learning Goals

- Be able to discuss the golden ratio, the Fibonacci sequence, and the golden spiral and their relations to each other

- Understand the relation of ratios and above concepts to plants and the natural world
    - primarily sunflower seed formation
- Understand the idea of math as a model and approximation tool to understand more complicated concepts
- Cultivate passion for and understanding of connections between disciplines and ways science and math can work together

Workshop Materials

Workshop Slides

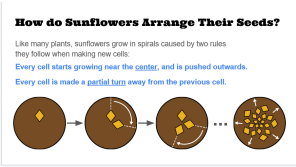
Workshop Outline (copy and edit to work for your students, if an outline of the workshop would be helpful)

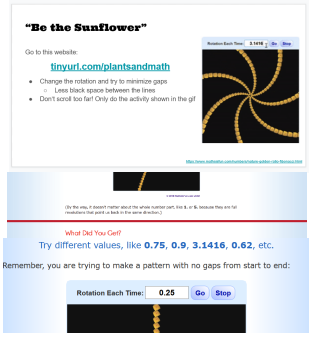
Sunflower Interactive Website (used for the activity around slides 9-10)

Sunflower Gallery Share-out (make a copy and share the new URL with your students to use during the activity around slides 9-10)

Suggested Notes and Tips for Running

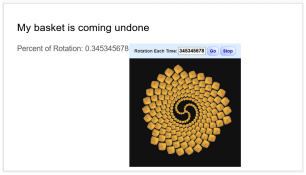
In advance, please make copies of the workshop slides and gallery share-out slides and test the interactive website.

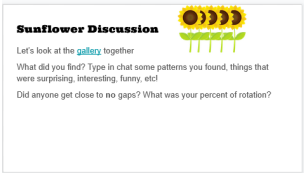


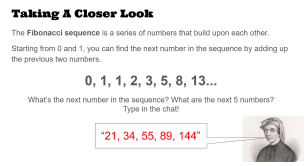


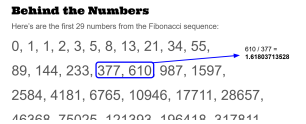
- **Slides 1-4:** Basic introductory information; edit as appropriate for your audience.
- **Slide 5 ("favorite plant")**: Icebreaker where we ask about favorite plants. As teachers we used the chat to add our favorite plants and talked a bit about them to give a chance to respond and warm up.
- **Slide 6-8 (".. Arrange Their Seeds"):** Background and introduction to sunflowers. The important part here is to talk about seeds being packed together as close as possible and seeds being grown in a spiral (slide 7), as this will help set up the interactive activity. It was also helpful to mention that the picture is of a dried sunflower to help visualize the seeds easier.
- **Slide 9:** Share link to gallery but don't go into depth on it yet.
- **Slide 10 ("Be the Sunflower"):** Share link to interactive activity and be clear not to scroll down past the activity at the beginning of the page (I added a red line to a screenshot of the website to show the point not to scroll past.) If you scroll past the red line, there's dense mathematical explanations and it gives away the answer of the golden ratio.
    - Slide 11 has the abbreviated notes written on it.
    - Exit out of the slide show and go to the website.

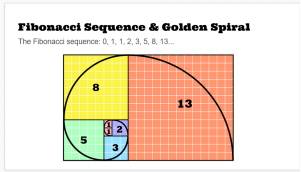
- Experiment with .5, .25, and .33 rotation in live time and explain how that corresponds with the picture and way the seeds lay out.
  - ex. “here you can see that .25 corresponds to 25% or quarters, where a seed is placed and then rotates a quarter of the screen, then places another seed, and so on.”
    - Show how to copy or save the image.
    - Go over to the gallery slideshow and put in the image on a slide, label it with a name (pictured on the left “my basket is coming undone” was put in the gallery slideshow by a participant).
    - Prompt them to play with the website and put in their images to the slide deck, we said to use as many slides as you want, and added pictures at the same time as them.
    - We gave students 10 minutes and said to try to get the closest packed seeds as possible. If they are stuck, ask them to experiment with whole numbers, fractions (like .5), complicated decimals, and approximations of known irrational numbers (which should give better results).
    - After the time, encourage people to share the slides they created- focus on packing seeds closely and what components of the decimal kids used let them get closer to that goal. (Note: be sure that you made a copy of the share-out slides and shared the new URL with your class so that they are all editing the same document.)
    - **Slide 15 (Taking a Closer Look)**: Explain Fibonacci sequence and show the pattern by adding the first few numbers.
    - Advancing the slide to show the numbers coming in “1” then “2” then “3” then “5, 8, 13.”
  - Ask for the next five numbers in chat and either annotate the slide or verbally confirm.
    - Once you have the next five, advance the slide for the red text to display the numbers.
    - **Slide 16 (Behind the Numbers):** Ask students to pick two numbers next to each other and divide the right by the left.
    - Advance the slide to show an example “610/377 = 1.618037135”
    - Tell them to use the chat (or call out) to share their answers. (Note: It should work out that their results are close to the golden ratio, especially as they choose larger pairs of numbers.)
    - Once a few minutes have passed, advance the slide to show the “answer” of the golden ratio.
    - Make sure to explain the pattern: as the Fibonacci numbers get larger in value, the ratio between consecutive Fibonacci numbers approaches the golden ratio.
    - **Slide 17 (Fibonacci Sequence & Golden Spiral):** This slide has a golden spiral graphic that displays a square with a value of the fibonacci sequence, with slide transitions to bring in new values. It’s good to say “This is a visual representation of the golden ratio and fibonacci sequence.”
    - The most important transition is the last one that places the golden spiral. Explain how this is made by the ratio of the fibonacci numbers, their ratio
    - **Slide 18 (The Golden Spiral):** first image- “we created this sunflower in the activity”, advance slide, “Here’s a picture of an actual sunflower”, advance slide, “we can see that the golden spiral fits this image of the sunflower.”











➢ **Slide 19 (pictured on left):** Be clear that this spiral doesn't show up exactly, but like most math, is a good approximation to help explain patterns. Talk about the other examples in nature and how evolution brought them to this point.

➢ **Slide 20:** Finish up and ask them how it went!

Enrichment Information

A fun potential extension for this workshop would be for students to cut out golden spirals or use transparency sheets and explore an outdoor environment nearby to see if there's other plants or things in nature that fit this pattern. Or they could search the internet for plant images and make graphics with the spiral.

Please use these materials and tailor them to your students!

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