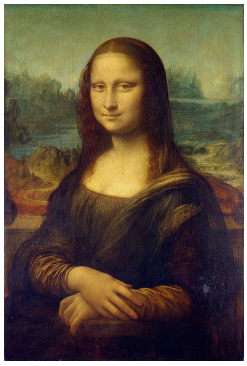
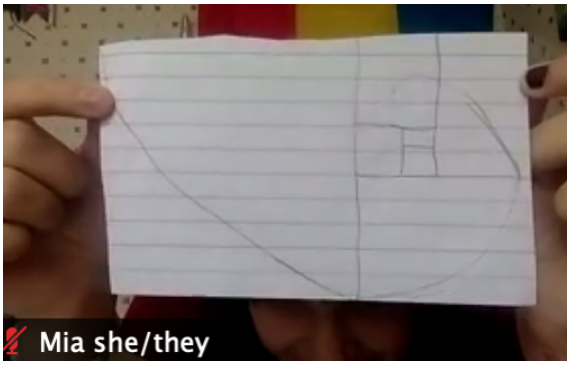
Olin College of Engineering

Teacher's Guide for **Math in Art and Architecture**

Riley Zito (Olin '22), Mason Grabowski (Olin '22), Brent Usui (Olin '23), Annie Tor (Olin '22)





Mona Lisa, Leonardo da Vinci, Public domain, via Wikimedia Commons; *Pyramids of the Giza Necropolis*, KennyOMG, CC BY-SA 4.0 <https://creativecommons.org/licenses/by-sa/4.0>, via Wikimedia Commons

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.

What does the Mona Lisa have in common with the Pyramids of Giza? Is it its age? Its color? What if the answer was… math????

Come learn about how math ties together our favorite pieces of art and architecture (including the Mona Lisa and the Pyramids)! We'll dive into the mysteries of how artists, architects, and designers across time and place have used math in their works, and we'll explore how we might use math to inform our creativity by making some art of our own. Anyone interested in art, history, design, or anything in between is encouraged to participate!

This teachers' guide covers the second workshop in the Math and Beauty series-- the relationship between math, art, and architecture. Instructors are encouraged to run the first workshop in the series (Math and Plants) before introducing this workshop to help students build foundational knowledge of the golden ratio and the Fibonacci sequence, but this workshop can also be delivered as a free-standing session.

Workshop Requirements

- **Runs about 45-60 minutes** depending on class size and student engagement
- **Required or suggested materials**
  - Pen/Pencil

- Paper (tracing paper is preferred, but a sheet of normal paper is also fine)
- A ruler
- Scissors
- If remote: computer and internet access

➢ **Suggested ages/grades:** 9th grade and up

➢ **Prerequisite Knowledge:**

- Basic operations (addition, subtraction, division, multiplication)
- Basic understanding of ratios

Learning Goals

➢ Key topics students will learn about:

- the golden ratio and the golden spiral
- the Fibonacci sequence

➢ Students will also practice basic math skills, including:

- pattern recognition
- division
- using ratios
- using a ruler

➢ Moreover, students will practice:

- math visualization
- applying creativity
- appreciating math and its complexity

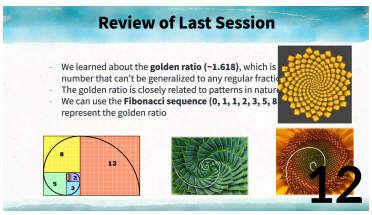
Suggested Notes and Tips for Running

The workshop includes an introductory art interpretation warm-up activity, a review (or introduction) of the math behind the golden spiral, an overview of how and why the golden spiral shows up in nature and in art and architecture, a spiral-drawing activity, and an optional art-making activity.

Link to full slide deck. Reference the speaker notes included for more details on how to deliver the workshop.

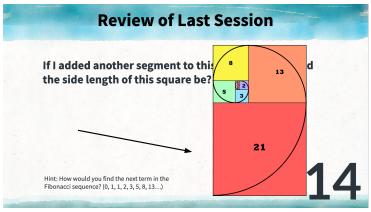
➢ **Slides 1-3: An introduction to the workshop and the instructors**-- edit to fit your classroom and your team. Give students a few minutes to gather the supplies needed for this workshop.

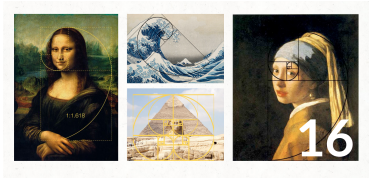
➢ **Slides 4-11: A warm-up activity to get students thinking about art and beauty.** The building and the works of art used in the original workshop belong to the Museum of Fine Arts in Boston, but we encourage you to change the museum (and pieces of art) to whatever your students might have access to. You don't need to spend too long on this activity-- we just want to pique students' interest and get them curious about how math and art might fit together.

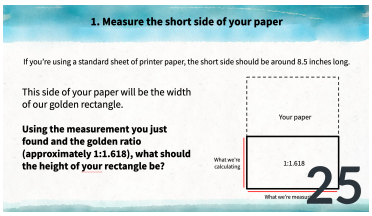


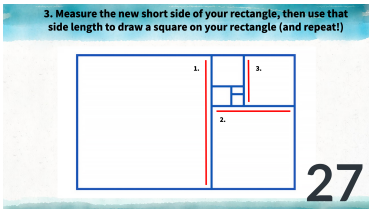
➢ **Slides 12-14: Here is the bulk of the hard math concepts used in the workshop.**

- If students have already gone through the Math and Plants workshop, this may be delivered as a quick review, but if these concepts are new to students, you might need to spend more time explaining the Fibonacci sequence and the golden ratio.









- There is a small point of interaction built into this section on Slide 14 (see speaker notes), which you can employ or skip at your discretion.
- Before you move on, ask some questions to ensure that students understand how the Fibonacci sequence works and how it can be built into the golden ratio and the golden spiral. (for example: how would you find the next number in the Fibonacci sequence? How does the Fibonacci sequence relate to the golden ratio? etc)
- If needed, you can borrow some slides from the Math and Plants workshop to further explain these concepts.

➢ **Slides 15-16: Some interesting examples of how the golden ratio comes up in nature and the manmade environment.** We suggest you mention that use of the golden ratio spans time and place (eg, the *Mona Lisa* was painted in 1500s Italy whereas *The Great Wave off Kanagawa* was carved in 1800s Japan but both seem to employ the golden spiral in their composition).

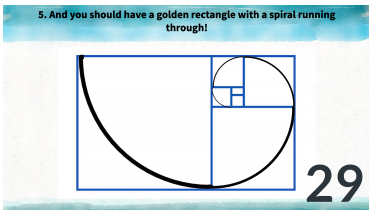
➢ **Slides 17-22: Revisit the pieces we saw at the beginning of the presentation** and explore how the golden spiral is or is not found in each of them. Mention that the golden spiral is not necessary for something to be perceived as beautiful-- it's just a very interesting pattern that seems to come up a lot in beautiful things.

- **At the end of this section, run this spiral fitting activity with your students**, where they can try their hand at exploring how the golden spiral fits into pieces of art and architecture. To do this, you can either share your screen and collaborate with your students on one document, or you can let students create copies of the document to play with on their own. Students will guess and test how the golden spiral factors into the composition of the images on the document by resizing, rotating, and moving the golden spiral until it seems to fit well. There are multiple ways the golden spiral can work, so be prepared to see a range of answers!

➢ **Slide 23:** By this point, students are probably quite curious as to why the golden ratio comes up so often in things that are visually pleasing. This is a hypothesis.

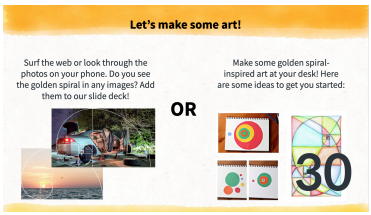
➢ **Slides 24-29: Students will now draw their very own golden spiral to reference and use in their own art-making.**

- Before drawing the spiral with your students, this is a good time to pause to answer any questions they might have about the golden ratio, the golden spiral, or the Fibonacci sequence.
- Also, make sure students have access to all the materials listed at the top of the presentation. The advantage to using tracing paper is that students will be able to look through their golden spiral to better visualize how it might fit into different images.
- If delivering this workshop virtually, see if you can share two camera angles in your meeting-- one of your face, and another of your spiral as you draw it (no worries if you can't get this set up, just remember to hold up your paper to the camera often). Use a dark pen or marker. This portion of the workshop will take up the most amount of time, so to shorten it you might pre-cut golden Rectangles for your students or prepare a template.
- This activity first asks students to calculate the dimensions for and then cut out a golden Rectangle of their own (Slides 24-25). Next,



students will draw guidelines for their golden spiral (Slide 27). When drawing the guidelines for the golden spiral, you will first draw the largest square and build inward toward the center of the spiral. Detailed instructions can be found in the speaker notes. Lastly, students will draw a line through the corners of the guidelines they just drew to form a golden spiral. It may be helpful to draw the golden spiral segment-by-segment, confirming with students in between segments.

- Make sure to practice this part of the workshop ahead of time to avoid making confusing mistakes on camera.



- **Slide 30: If time permits, students can make some of their own art.** This activity can be adjusted to fit whatever resources your students have on hand. Some ideas:
  - Students can surf the web or look through photos on their computers/phones and try to identify the golden spiral in any images. To help students do spiral fitting on their images or images they find online, you can make a copy of this open-ended spiral fitting share-out slide deck and then share the new URL with your students:
  - Students can create some original golden spiral-inspired art. Check out the images on Slide 30 for some inspiration on what these pieces might look like.
  - Students can head outside or look around at their immediate surroundings and capture some images that fit the golden ratio. Encourage students to explore a variety of elements (plants, trees, flowers, buildings, roads, furniture, etc).
  - Invite students to add the images they found or created to a shared slide deck to form a student-generated math and art digital gallery. If the classroom is quiet, put on some music :)
- **Slide 31: Invite students to reflect on their experience during the workshop.**
- **Slides 32-33: If additional content is needed to fill time, give a sneak peek of the next workshop** (in this case, Line Art).

Enrichment Information

For a more geometry-focused workshop, the golden spiral can be folded instead of measured out. This method relies on the angle bisector theorem, which you can prove to students if you wish. Watch this video for more information on how to do this (can also be found on slides 34-35 in the presentation):
https://www.youtube.com/watch?time_continue=195&v=0aAucyCgPCM&feature=emb_title

Please use these materials and tailor them to your students!

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