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# GEPHOTO

Grade(s): High School Algebra & Geometry



Driving Question: How can mathematics enhance our photography skills?

Summary: In this project, students will explore geometric concepts of transformations as well as algebraic concepts of lines to enhance their photography skills. Students will examine how their photos are impacted by the use of geometric skills. As a final product, students will create a photo essay around a chosen topic, highlighting how their use of geometric and algebraic properties enhanced their photos.

## Content Standards:

- Lines: types, graphing equations
- Geometric transformations
- Properties of angles

## Mathematical Habit of Mind:

- Search for Patterns

## Success Skills:

- Creativity
- Risk-taking

# LAUNCH

## Engaging Hook

Ask students to bring a photo to class that they really like. The photo can be one they have taken or found on the internet. Do not give any more description other than “a photo you like.” In small groups of four to six, ask students to share why they chose the photo. Direct students to create “categories” of features that highlight why photos were chosen. If possible, post photos on a bulletin board in the room to serve as an “anchor” for the project.

Then, engage students in a digital breakout room. Include clues with geometric skills or photography components to engage student background knowledge or foreshadow upcoming topics.

## Driving Question

How can mathematics enhance our photography skills?

## Project Overview

Load a digital copy of the Project Overview sheet on the school’s learning management system. Provide students time to explore the Project Overview sheet before gathering “need to know” questions.

## Need to Knows

Use Mentimeter. Students individually access Mentimeter, then write two “need to know” questions.

# MILESTONE 1

## Anticipated "Need to Know"

How do lines impact a photo?

### Content Standard, Mathematical Habit of Mind, & Success Skill

- Lines: types, graphing, equations
- Properties of angles
- Search for Patterns
- Creativity
- Risk-taking



## Inquiry Activities:

### Card Sort and Angle Exploration

- In partners, ask students to sort cards into categories of their choosing. Students should create headings for sorted cards on sticky notes.
  - Cards include vocabulary words, pictures, graphs, and equations of the following types of lines and angles:
    - Parallel, perpendicular, vertical, horizontal, diagonal
    - Alternate interior angles, vertical, congruent, transversal corresponding angles, congruent, transversal
- Exploration into angle properties of parallel lines:
  - Have students physically cut angles and lay them on top of corresponding angles.
  - Ask them to prove that two lines are parallel using postulates and theorems as previously explored.

### Guided Research

- Direct students to explore how lines impact photography through guided research.
  - Guided research instructions can be found at <https://qrs.ly/56ensfy>.

### Photo Essay Examples and Storyboard

- Share examples of photo essays. Have students examine professional photos for the types of lines used.
- Provide physical and digital options for students to storyboard their photo essay (final product). Ask students to consider the following:
  - What is the theme or message of your photo essay?
  - What kinds of photos do you need to take?
  - When/where will you take these photos?
  - Do you need props? Permission from people? Additional equipment like lights, filters, or backdrops?

## Formative Assessment

### Card sort

Desmos Graphing Calculator photo analysis activity

### Reflection

In my photography so far, I have been most effective at . . .

One thing I will do differently next time I take photos is . . .







## Photography Outing

- Go on a walk or field trip to a location where students can take photos that have lines in them. For example:
  - A park or garden with benches, trellises, brickwork, bridges, or walking paths, etc.
  - A city street with lots of buildings, lamp posts, streets, sidewalks, trees, benches, billboards, etc.
- Challenge pairs of students to take pictures of each type of line studied in the guided research.
- Have students create anchor charts of their photos, printing out images and highlighting the types of lines in each photo.

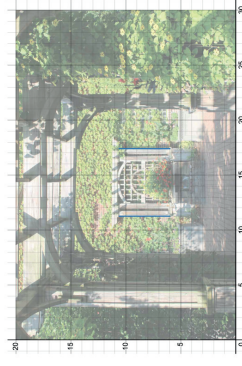
## Desmos Graphing Calculator Activity

- Guide students to analyze lines in their photos using Desmos Graphing Calculator.
  - Analysis investigation instructions can be found at <https://qrs.ly/56ensfy>.
  - A student example of analysis can be found at <https://qrs.ly/56ensfy>.

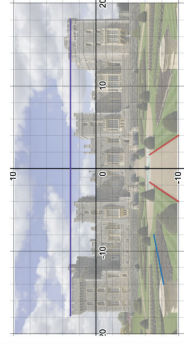
## Revisit “Need to Knows”

- Discuss which questions were answered and which questions have yet to be explored. Add new questions as they arise.

Vertical Lines (Blue):  
 The vertical lines add strength to the photo, making the structure in the center appear strong and permanent.  
 The vertical lines have equations of approximately  $x = 11.2$  (left) and  $x = 17.4$  (right).



- The blue line of  $y = -1.5x - 4$  is an example of leading and converging lines. They draw your attention to the castle and move your view up the path to get there.
- Notice the lines are not parallel, so eventually they will converge.
- This line gives the photo a feeling of perspective and dimension, because without them it could look very two dimensional.



Photos (above right): Students explore lines by taking photos through an iron fence.

Photos (above left): Anchor charts of vertical and diagonal lines taken on photography walk.

Photo (left): Student work from Desmos Graphing Calculator activity.

## MILESTONE 2

|  |  |  |
|--|--|--|
| <p><b>Anticipated “Need to Know”</b></p> <p>How do transformations impact a photo?</p> <p><b>Content Standard, Mathematical Habit of Mind, &amp; Success Skill</b></p> <ul style="list-style-type: none"> <li>• Geometric transformations</li> <li>• Search for Patterns</li> <li>• Creativity</li> <li>• Risk-taking</li> </ul> | <p><b>Inquiry Activities:</b></p> <p>Jigsaw</p> <ul style="list-style-type: none"> <li>• Partner students randomly. Have students collaboratively jigsaw learning about the four types of geometric transformations (translation, rotation, reflection, dilation).</li> <li>• Student partners should create a poster of their learning to share with the class.</li> </ul> <p>Expert</p> <ul style="list-style-type: none"> <li>• Invite a photographer to share about their work. Ask the photographer to share about their use of lines and geometric transformations.</li> <li>• Have students prepare questions ahead of time, perhaps exploring the photographer’s portfolio of work.</li> <li>• Write thank-you cards after the presentation.</li> </ul> <p>Photography Outing</p> <ul style="list-style-type: none"> <li>• Go on a walk or field trip to a location where students can take photos that have geometric transformations.</li> <li>• Challenge partners to take pictures of each type of transformation.</li> <li>• Create a class Google Slideshow of photos representing each geometric transformation.</li> </ul> <p>Desmos Transformations Activity</p> <ul style="list-style-type: none"> <li>• Guide students to analyze geometric transformations in their photos using Desmos.             <ul style="list-style-type: none"> <li>◦ Analysis investigation instructions can be found at <a href="https://qrs.ly/56ensfy">https://qrs.ly/56ensfy</a>.</li> </ul> </li> <li>• Scaffold the critique opportunity of Good, Better, Best with random groups of three to four.</li> </ul> <p>Revisit “Need to Knows”</p> <ul style="list-style-type: none"> <li>• Discuss which questions were answered and which questions have yet to be explored. Add new questions as they arise.</li> </ul> | <p><b>Formative Assessment</b></p> <p>GeoGebra analysis of geometric transformations</p>   |
|  |  | <p><b>Reflection</b></p> <p>Exit ticket:</p> <p>Rank the four types of transformations from easiest (1) to hardest (4) in terms of describing the transformation mathematically. Explain your ranking. Next, rank the four types of transformations using the same scale in terms of capturing the transformation visually in photographs. Explain this new ranking.</p> |

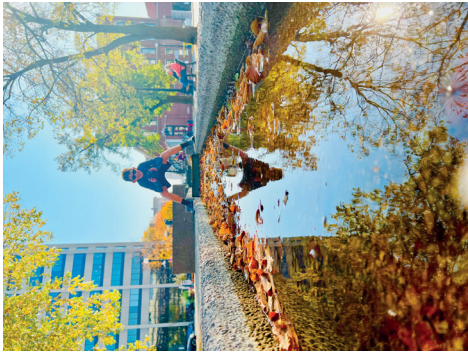




Photo (far left): A student poses for a photo of a reflection.

Photo (left): Student takes photos of geometric transformations.



## MILESTONE 3

|   |  |   |
|---|--|---|
| <p><b>Anticipated “Need to Know”</b></p> <p>How can I create an impactful photo essay using my knowledge of mathematics?</p>  | <p><b>Inquiry Activities:</b></p> <p><b>Photo Editing</b></p> <ul style="list-style-type: none"> <li>Engage in playful exploration of programs that allow students to edit photos such as Lightroom (Adobe) or Pixlr.</li> <li>Create an “expert” board where students sign up to help their peers in different aspects of photo editing, such as exposure, saturation, hue, vibrance, clarity, feather, temperature, vignette, tint, masking, and so on.</li> </ul> <p><b>Photo Essay Creation</b></p> <ul style="list-style-type: none"> <li>Co-create a rubric with students, determining descriptors of categories.</li> <li>Manage students as they edit photos, research information for captions, and use either Desmos Graphing Calculator, GeoGebra, or both to analyze the mathematics in their photos.</li> </ul> | <p><b>Formative Assessment</b></p> <p>Photo essay draft, including captions and mathematical work</p>   |
| <p><b>Content Standard, Mathematical Habit of Mind, &amp; Success Skill</b></p> <ul style="list-style-type: none"> <li>Line: types, graphing, equations</li> <li>Properties of angles</li> <li>Geometric transformations</li> <li>Search for Patterns</li> <li>Creativity</li> <li>Risk-taking</li> </ul> |  | <p><b>Reflection</b></p> <p>Individual conferences:</p> <p>How have your ideas changed from initial brainstorm to prototyping to finished product? Why did these ideas change? Were the changes better or due to constraints?</p> |
|   | <p>Photo (left): A student examines his photo as he prepares his photo essay.</p> <p>Photo (right): A student gathers a photo of lines for her photo essay.</p>  |   |



## PROJECT CONCLUSION

### Critique

I Learned . . . I Liked . . . I Wonder . . .  
 An example protocol can be found at <https://qrs.ly/56ensfy>.

### Revision

Revision based off critique protocol feedback

### Final Product

#### Photo Essay

- Displayed photos are edited using online software.

#### Captions

- Captions provide further research or insight into the creative mind.

#### Mathematical Photos

- Photos and written explanations show the mathematics of lines and geometric transformations using GeoGebra or Desmos Graphing Calculator.
- An example final product can be found at <https://qrs.ly/56ensfy>.

### Culminating Experience

Photo essay exhibit at local arts center

### Reflection

One of the goals of this project was to connect mathematics with the creative endeavor of photography. Using one of the three quotes that follow, reflect on how you grew as a mathematician and a creative person.

Quote 1: "The comfort zone is the great enemy to creativity." ~Dan Stevens

Quote 2: "Creativity is just connecting things." ~Steve Jobs

Quote 3: "Creativity is the greatest rebellion in existence." ~Osho



The weathering of this gravestone is so extensive a date cannot be read. This limestone grave marker contains a significant amount of calcite which is impacted by acid rain along with the normal weathering due to rain and wind. It also shows signs of age as moss and lichen cover the majority of its surface.

To make this photo dramatic, I angled my camera, exaggerating the diagonal lines at the base of the gravestone. The parallel lines on the gravestone continue to add movement, drawing the viewer's eyes from the top left to the bottom right, giving a sense of movement in an otherwise still photo.

Photos (above): An example photo essay.

Source: *Desmos, PBC.*

Weathered Gravestone Change Image  
 Center: (5, 4) Width: 10 Height: 8.7  
 Angle: 0 rad Opacity: .5

$y = -25x + 4.3 \{ 2 < x < 8.9 \}$   
 $y = -25x + 3.8 \{ 1.9 < x < 8.8 \}$   
 $y = -25x + 3.43 \{ 1.8 < x < 8.7 \}$   
 $y = 6.5 \{ 0 < x < 2.5 \}$

By exploring the math on Desmos, I found the equations of three parallel lines from the base of the gravestone (in blue). I also found the equation of a horizontal line that matches the horizon in the photo (in green).