



Lesson Focus

Computer graphics dominates young people's lives. Their worldview is heavily influenced by pixels. This lesson uses age appropriate experiences to explain the difference between bitmap (raster) and vector graphics. The lesson covers how information is lost when it is digitized, and how computer graphics techniques can both enhance images, and provide vehicles for corrupting them. It also introduces some ideas on how to efficiently schedule a task.

Age Levels

Recommended for ages 8 – 10

Also appropriate for lower Middle School (e.g. age 11).

Objectives

Introduce students to:

- ✦ The difference between bitmap and vector graphics.
 - ✦ How scale influences the detail you see in an image.
 - ✦ How the graphics coordinate system differs from the Cartesian.
 - ✦ How scheduling a task makes it efficient.
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Anticipated Learner Outcomes

Students will demonstrate/explain how:

- ✦ Images are represented as pixels, or points in a bitmap.
 - ✦ How vector graphics are increasingly being used to maintain detail integrity.
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Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

<https://www.youtube.com/watch?v=MoCSwF0n-io>

<https://www.youtube.com/watch?v=fy9Pby0Gzsc>

Recommended Reading

<http://techterms.com/definition/vectorgraphic>

<http://www.bbc.co.uk/schools/gcsebitesize/dida/graphics/bitmapvectorrev1.shtml>

Optional Writing Activity

When bitmap (raster) images are enlarged, they get fuzzy. Computer Scientists say they lose information. In your own words explain what this means. What information is being lost?

Graphics: Bits and Points

For Teachers: Teacher Resources

◆ Lesson Objectives

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◆ Materials

- ✦ Access to the Internet to watch the most appropriate video for your class.
- ✦ A brick wall upon which students can draw with colored chalk, and lay down tape. Alternatively, a smooth wall upon which a butcher block paper mural can be posted. (Many schools have rolls)
- ✦ Large sticks of colored chalk, in as many colors as possible.
- ✦ Post-Its, (2 X 2 inch preferred).
- ✦ Painters' tape in ½ inch width.
- ✦ Graph paper in two sizes, preferably 4 X 4 squares per inch (10 X 10 cm), and 10 X 10 per inch (25 X 25 cm).
- ✦ Colored pencils, rulers.

◆ Procedure

This activity assumes you have a class of approximately 20 students. If you have less than 15 or more than 24, adapt these activities as needed. In Session Two, approximately 2/3 of your students will be drawing on each of two murals, while the final 1/3 will be supervising their work. Estimate that the mural can be no higher than your tallest student can reach, and that the murals need to be wide enough to accommodate students working side by side. The size of your mural is also dependent upon whether you are drawing directly on a brick wall, or on a grid on butcher-block paper. Standard bricks are approximately 8" X 4". The worksheet grid assumes this, giving each student a 40 X 40 inch (5 X 10 brick drawing space).

In Session One, students will design individual contributions to a 'bitmap' mural. In the second session they will construct the bitmap mural from the design, and create a 'vector' mural directly on a wall. The goal is to display two works of art that tell the whole school about the difference between bitmap (raster) and vector graphics. Ideally the murals should be constructed at the end of a long hallway, one side of a gym, or on an external wall that can be viewed both from a distance and close up. Given the time constraints of this activity, it is recommended that you do not consider making this permanent artwork, which take considerable planning and time. Perhaps think of this activity as a draft of a potentially larger project that introduces steAm (science, technology, engineering, Art, and math) to your school as a whole.

If your walls are brick, consider using chalk, which can be easily erased, but be sure to get permission first! If you can't chalk directly on the wall, you will need to do some preplanning by preparing a large area of butcher block paper with a grid made of painters'

tape so that the tape grid can be gently removed. Alternatively, draw a grid with a pencil. You can adjust the size of the mural according to the space you have, but the width should be approximately twice the height. It is estimated that this preparation will take an hour or two depending on how many people help. You will not have time to prepare the butcher-block paper during the first session.

Choose a theme that allows students to place drawings above and below each other. For example people on a street won't work well, but monsters in space will. Create a sample or two of potential critters, or objects in your scene.

Computer-based activities have intentionally been left out of these lessons because of anticipated resource constraints, and teacher expertise. If you, a colleague, parent, or community member has expertise with graphic arts tools such as Photoshop, please consider having them help you construct an on-computer experience for your students, which covers the same concepts. The Scratch (Scratch.mit.edu) environment has a wonderful graphics editing tool, using Scratch blocks, that allows students to directly explore the difference without learning how to code. If you do include a computer-based activity, please make sure it actively engages students as participants, not as observers of a demonstration.

Session 1:

1. Have your students watch one or both of the videos listed above in Internet Connections, at the start of the session (or assign it for homework before the session).
2. Have a discussion about bitmaps and vector graphics. Ask students to talk a little about the differences. Ask which one loses information and which one keeps it. If you have a school logo, have them locate different sized images of it (on a letter head, a banner, a T-shirt etc). Discuss how vector graphics are increasingly used to create icons and logos because they can be printed or displayed in any size.
3. Distribute Worksheet 1, and explain that as a class you will create a 'bitmap' mural of a fish tank (or other two-dimensional scene). Brainstorm the theme of your mural. Ask them to color in the squares on their worksheet to create a bitmap figure. Limit them to three colors.
4. Explain what a 'bounding box' is. They may know it as the 'hit box' from video games. This is the rectangle that minimizes white space. Demonstrate how to cut out the box, using the rule that each side of their drawing is on one edge of the bounding box. Have them mark the bounding box of their image with a pencil and a ruler, and after your approval, cut out the bounding box.
5. Place their images on a table or floor space to plan out where their contribution will go on the mural. As a group, make some decisions about how the background will be filled in - will you leave it blank (showing the background color), or will you create a background image or theme.
6. Have each student identify her position on the large mural. The computer graphics coordinate system starts in the upper left corner. Each student should create a label (on a Post-It) with her name and starting position. The starting position is where the upper left corner of their bounding box is positioned.

If your students have encountered graph coordinates in their math classes: hold up a piece of graph paper on which you've drawn a traditional Cartesian axis. Ask them to show where the origin is (lower right corner). Now show Worksheet 1, which has a computer graphics coordinate system. Demonstrate how the origin is

in the upper left corner, and that x positions increase from left to right, and y positions increase from top to bottom.

If your students have not encountered coordinate systems (Common Core Grade 5), simply show them how to count from the corner. For example position $x=3$, $y=4$, can be written as "3 across, 4 down".

7. As a group, you will also have to plan who will simultaneously work on the 'bitmap' mural. This is a scheduling problem in which your students should actively participate - to assign drawing times so they won't have to climb over each other. Schedule three groups that will each have 15 minutes to draw their contribution. (You will need a final 15 minutes for setup and clean up.) Have each student write down which group they are in, and keep a master schedule as well. Collect all the drawings and Post-Its.

Session 2:

Given the schedule developed in Session 1, each group of students will flow through three activities:

1. Bitmap Mural Drawing: where each member of the group adds their drawing to mural.
2. Vector mural drawing: where each member of the group contributes lines to create one image to the mural, and color in any closed regions.
3. Production supervising: where each member is assigned to either the Bitmap or Vector mural and confirms that the rules are being followed.

Bitmap Drawing: Mark off the upper left corner of the mural on the wall or butcher-block paper. This mural is straightforward. Students will locate the upper left corner of their own contribution relative to the upper left corner of the mural. Have a production supervisor confirm their correct positions, and transfer the drawing to the mural.

Vector Drawing: Mark off the upper left corner of the mural. Using painters' tape, each member of the 'Vector' group should add as many lines to the mural as they can, in a 5 minutes time period. The remaining minutes should be used to color in any closed regions (e.g. polygons). Encourage cooperative behavior by suggesting or insisting that later groups not color over earlier groups, and earlier groups leave space for later ones.

Production Supervising: Is an opportunity for students to think through what the rules are, and provide support for their peers. Encourage gentle support rather than authoritative criticism.

Once the murals are complete, have the students compare the images up close, and at a distance, and discuss how the two techniques create different effects.

◆ Time Needed

- ✦ 2 sessions, 1 hour each, maximum. If your students are typically cooperative during group activities, this can be accomplished in a single two-hour session.

Graphics: Bits and Points

Student Resource:

In this lesson you are going to learn about the difference between *bitmap* and *vector* graphics. Bitmap graphics are everywhere there is a computer screen, from your smart phone to the gigantic images that appear in Times Square New York. Vector graphics are increasingly used to create print materials because as you increase size, the quality of the picture doesn't change. You will also see that a *graphics buffer* knows how to construct an image by using a *coordinate system*. You are also going to learn about how *scheduling* a task can accomplish a lot of work in a small amount of time.

Until very recently, almost all of the images you saw on a computer were made by loading an image made up of *pixels*, or *points of light*, into computer memory. This is called *raster graphics*, and was based on the way old television technology worked. When you take a picture with a phone or digital camera you are producing an image made up of millions of pixels. The pixels are stored in memory starting with the one in the upper left corner, then the one to the right of that one, until the right edge is reached. Then the next row of pixels is loaded.

Even with modern computers, loading pixels takes time. Computer scientists study how to make things faster and take up less space, and often use math to help them. Vector graphics was invented to produce a picture in less time. Rather than keep track of all the points in a line or curve, vector graphics uses *vectors*. A vector is just a point in space. To keep it simple, we will stay in 2D (two dimensions). We need two numbers to keep track of a point: we need the horizontal position and the vertical position. (How many numbers do you think we need for 3D?).

To determine where a point is, we need a coordinate system. In math class you may have learned about Cartesian coordinates. Computer graphics is based on a different coordinate system, where the upper left corner is the *origin*, or starting position. You count positions across to the right just like in the Cartesian system, but to find a position in the vertical, you count down from the top, rather than up from the bottom.

Vector graphics are stored as a collection of instructions to draw lines and curves, with specific colors, based on the fewest number of points. Lines require two points - a start and an end. A rectangles and ellipse (egg shaped thing) also requires only two points. Other kinds of curves are a bit more complicated, but still need much less computer memory than bitmaps.

In this activity, you are going to create a bitmap mural where the points are large rectangles of color. Very old video games called 'low res' used this kind of bitmap images. You are also going to create a vector mural using lines.

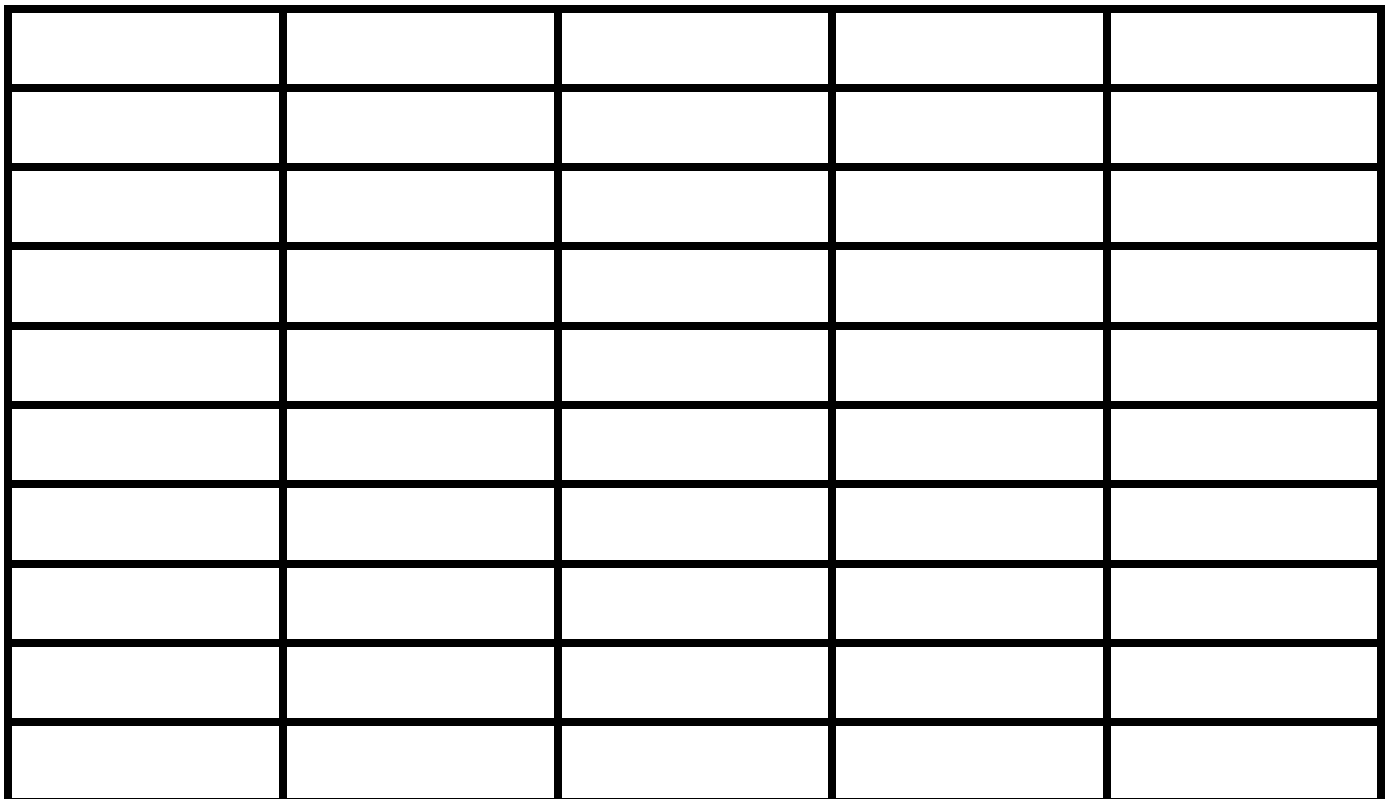
This activity will require you to schedule who in your group will do what, and when. Modern computers do a lot of scheduling to create images, videos, and animation. Although the type of scheduling computers do is very different from the actual schedule you will learn to do, you will get an idea of how complicated computer graphics is.

Graphics: Bits and Points

Student Worksheet 1: A Bitmap Drawing

Using this grid, create a drawing to contribute to your class mural.

1. Using a pencil, draw along the edges of the blocks that will be part of your contribution. Erase or start over if you need to.
2. When you have a drawing you like, use at most three colors to fill in the bricks.
3. Follow the directions your teacher gives you to cut out a bounding box.
4. As a group, lay out your bounding boxes to create a draft of the mural.
5. Fill out a Post-It with your name, your position on the mural, and your group.



Graphics: Bits and Points

Student Worksheet 2: A Vector Drawing

Now that you are familiar with the coordinates of bitmap, let's see how a vector drawing happens. A vector drawing is made up entirely of lines and curves that can be colored in (filled) when a region is closed. A square can be filled. A rectangle with one side missing cannot. Although vector drawings contain lines, curves and points, in this activity you will use painters' tape to draw lines. Whenever there is a closed region, it can be filled with color.

Your teacher will show you the boundaries of the drawing.

In groups assigned by your teacher, spend five minutes putting lines on the vector mural:

1. Distribute about a yard (meter) of tape to everyone in the group.
2. Start a timer and spend 5 minutes using your tape to draw lines within the drawing boundaries.
3. If you use up your tape, get more.
4. When the timer stops, distribute chalk to everyone in the group and spend at most 10 minutes coloring any closed regions. You may find all kinds of interesting polygons.

Hints:

- ✦ Think a bit about what you want to add to the mural with your tape.
- ✦ Cooperate within your group and help each other create something interesting.
- ✦ Cooperate with other groups by not covering what they've done, and leave room for the next group.
- ✦ Consider leaving some open regions for the next group.
- ✦ Consider creating closed regions from regions left by the previous group.

Graphics: Bits and Points

For Teachers:

Alignment to Curriculum Frameworks

Note: All lesson plans in this series are aligned to the Computer Science Teachers Association K-12 Computer Science Standards, and if applicable also the U.S. Common Core State Standards for Mathematics, the U.S. National Council of Teachers of Mathematics' Principles and Standards for School Mathematics, the International Technology Education Association's Standards for Technological Literacy, the U.S. National Science Education Standards and the U.S. Next Generation Science Standards.

◆ National Science Education Standards Grades K-4 (ages 4-9)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Understanding about science and technology

◆ National Science Education Standards Grades 5-8 (ages 10-14)

CONTENT STANDARD E: Science and Technology

As a result of activities, all students should develop

- ✦ Understandings about science and technology

◆ Next Generation Science Standards & Practices Grades 6-8 (ages 11-14)

Practice 2: Generating and Using Models

- ✦ Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

◆ Next Generation Science Standards & Practices Gr.9-12 (ages 14-18)

Practice 2: Generating and Using Models

- ✦ Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.

◆ Principles and Standards for School Mathematics Gr. 3-5 (ages 8-10)

Geometry Standard

- ✦ make and use coordinate systems to specify locations and to describe paths

◆ Principles and Standards for School Mathematics Gr. 6-8 (ages 11 - 14)

Geometry Standard

- ✦ use coordinate geometry to represent and examine the properties of geometric shapes

◆ Principles and Standards for School Mathematics (all ages)

Problem Solving Standards

- ✦ Solve problems that arise in mathematics and other contexts

Connections

- ✦ Recognize and apply mathematics in contexts outside of mathematics

Representations

- ✦ Use representations to model and interpret physical, social, and mathematical phenomena

Graphics: Bits and Points

For Teachers: Alignment to Curriculum Frameworks

◆Common Core State Standards for School Mathematics Gr. 3-5 (ages 8-10)

Geometry Standard

- Graph points on the coordinate plane to solve real-world and mathematical problems.
 - ✦ CCSS.MATH.CONTENT.5.G.A.2 Represent real world and mathematical problems by graphing points in the first quadrant of the coordinate plane, and interpret coordinate values of points in the context of the situation.

◆Common Core State Practices & Standards for School Mathematics (all ages)

- ✦ CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.
- ✦ CCSS.MATH.PRACTICE.MP4 Model with mathematics.

◆ Standards for Technological Literacy - all ages

Nature of Technology

- ✦ Standard 2: Students will develop an understanding of the core concepts of technology

The Designed World

- ✦ Standard 17: Students will develop an understanding of and be able to select and use information and communication technologies

◆CSTA K-12 Computer Science Standards Grades 3-6 (ages 8-11)

5.1 Level 1: Computer Science and Me (L1)

- ✦ Computational Thinking (CT)
 3. Demonstrate how a string of bits can be used to represent alphanumeric information.
- ✦ Collaboration (CL)
 1. Identify ways that teamwork and collaboration can support problem solving and innovation.