



Vector Graphics Use Functions

TryEngineering

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Lesson Focus

For a half century computing technology has played an increasing role in how we create visual imagery. Vector graphics was the original method for rendering images on a display screen. It fell out of favor in the 1990s as increasing memory size allowed raster, or bitmap images, to be stored. Within the last decade there has been a resurgence of vector graphics to efficiently support graphic displays as large as billboards and as small as postage stamps. Vector graphics are dependent upon functions. This lesson introduces vector graphics and functions through a collaborative design activity.

Age Levels

Intended for 14 - 18 (US High School grades 9 - 12)

Can be used in upper Middle School (e.g. 8th grade)

Objectives

Introduce students to:

- ✦ how vector graphics technology works, and contrasts with raster graphics.
 - ✦ how smooth scaling occurs.
 - ✦ the role that functions play in vector graphics.
 - ✦ how modern mapping software is implemented as vector graphics.
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Anticipated Learner Outcomes

Students will:

- ✦ describe the difference between vector and raster graphics.
 - ✦ create a vector image by hand and write the related functions.
 - ✦ draw an personal logo using a set of functions.
 - ✦ explain how mapping software is more flexible with vector graphics.
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Alignment to Curriculum Frameworks

See attached curriculum alignment sheet.

Internet Connections

- ✦ <https://youtu.be/MoCSwF0n-io>
 - ✦ <https://youtu.be/fy9Pby0Gzsc>
 - ✦ <https://youtu.be/XI0rf2r-dx8>
 - ✦ <http://www.printfreegraphpaper.com/>
 - ✦ http://appleinsider.com/articles/12/08/03/inside_apples_new_vector_based_maps_in_ios_6
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Recommended Reading

- ✦ <http://www.britannica.com/topic/vector-graphics>
 - ✦ <http://www.britannica.com/topic/raster-graphics>
 - ✦ https://en.wikipedia.org/wiki/Vector_graphics
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- ✦ <http://www.finewoodworking.com/workshop/tip/a-precise-method-for-drawing-an-ellipse.aspx>
 - ✦ https://en.wikipedia.org/wiki/Computer_graphics
 - ✦ https://en.wikipedia.org/wiki/Comparison_of_vector_graphics_editors
 - ✦ https://en.wikipedia.org/wiki/Scalable_Vector_Graphics
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Optional Writing Activity

- ✦ Take a position on the following statement and back it up with at least two references from the Internet: "Although vector graphics has seen a resurgence in use, it will be replaced by raster graphics in the next generation of software."

Vector Graphics Use Functions

For Teachers: Teacher Resources

◆Lesson Objectives

Introduce students to:

- ✦ how vector graphics technology works, and contrasts with raster graphics.
- ✦ how smooth scaling occurs.
- ✦ the role that functions play in vector graphics.
- ✦ how modern mapping software is implemented as vector graphics.

◆Materials

- ✦ Access to the Internet to watch the videos listed under 'Internet Connections'.
- ✦ Colored pencils
- ✦ Cartesian graph paper in two distinct sizes, such as 1/2 inch and 1/4 inch, or 5mm and 2mm. One sheet per student. You can print your own either English or metric: <http://www.printfreegraphpaper.com/>
- ✦ Straight edge or rulers.
- ✦ (Optional) push-pins, string and grommet to draw ellipses. (See: <http://www.finewoodworking.com/workshop/tip/a-precise-method-for-drawing-an-ellipse.aspx>)
- ✦ (Optional) Access to software that supports vector graphics drawing. Google Drive Draw is available free via a web browser.

◆Procedure

This lesson provides paper and pencil activities to explore vector graphics. Although there is a plethora of computer tools available, the physical act of drawing on graph paper, and recording the process as a sequence of steps provides a rich understanding of the efficiency and power of vector graphics. There are three activities in this lesson:

1. **Drawing** a personal logo using vector graphics, and recording the functions that created the drawing.
2. **Recreating** a drawing by following the directions of a recorded sequence of functions to create a larger scaled drawing.
3. **Using software** to create a vector drawing.

The recommended approach is to do Activities 1 and 2, combined in a single one-hour session, and then create the same logo using software (Activity 3) in the second hour. If you do not have adequate access to drawing software, do Activity 1 in the first hour and Activity 2 in the second session.

The first task is to create a simple icon on the graph paper with the smaller sized squares. You will need to know the number of squares in the width and height of the larger-dimensioned graph paper, and must restrict the drawing to that number of squares on the smaller paper. Otherwise, redrawing to the larger dimension may exceed the paper size.

Things can go awry with these activities. It is suggested that you create a logo for yourself, record the functions it uses, and then recreate the logo yourself. Make sure your recording is accurate so that in the event that things go wrong for your students, you at least have a demonstration of what can happen. If your class sessions can extend beyond two hours, allow your students to fix any inaccuracies, or send them home with

homework. If your time is limited to two hours, and students have inaccuracies, just move on and work with their inaccurate instructions. The object lesson in that case is that humans are more tolerant than computers.

If you have the resources, provide your students with the opportunity to use a vector drawing tool to create a more sophisticated version of their logo. Google Drive Draw is recommended. As your class works, emphasize how they don't have to actually record the functions, the interface does this for them.

Session 1:

Activity 1:

1. Choose one of the videos under 'Internet Connections' to show your students. As briefly as possible, review the differences between raster and vector graphics. Emphasize that raster graphics requires recording every pixel in the image. When the image size is increased, each pixel is represented by a larger group of pixels, and the quality of the image is decreased. Because vector graphics is based on a sequence of functions, the size of the image doesn't impact the quality of the image. Vector graphics functions draw lines from point to point. The larger the image, the further apart those points are, however the function still draws from point to point.
2. Review the student resource sheet with the class, and explain the rules of drawing with vector graphics. At a minimum, demonstrate how to draw a line and a rectangle. If you and your students are up to it, demonstrate how to draw ellipses, either by first drawing a rectangle and drawing the ellipse within, or by using the pushpin and string method described in the recommended reading resources. Take care to keep things simple if you will only have an hour to draw and record steps, and recreate the drawing. The focus is on how easy it is to scale when you have vector functions.
3. Give each student one sheet with small squares, and one sheet with large squares. Tell them that one square on the small sheet equals one square, on the large sheet. The logo drawing they create on the sheet with small squares will be transferred to the sheet with larger squares. They will therefore have to limit the size of their drawing on sheet with larger squares to the number of squares across and down the sheet with larger squares. See the student resource page for full instructions. To save them some time you should consider telling them exactly what size area on the sheet with small squares they should use. For example, the sheet with large squares is 20 X 50 squares, and the sheet with small squares is 40 X 100, then they should mark off an area on the sheet with small squares that 20 X 50, marking the upper left corner of this area as (0,0.)
4. Distribute Worksheet 1 and challenge your students to create a simple logo for themselves, using the basic drawing functions on the resource sheet. Remind them that their drawing will be enlarged to the second sheet, and to keep it simple. Time the activity if necessary. As they draw, they should record their actions as function statement. An example is given on the Student Resource Sheet. Remind them to note the position of the start of any drawing. Note that in computer graphics position (0, 0) is at the top left of the screen.

Activity 2:

As students complete their logo (or when half the teaching session is complete), give them the second piece of graph paper and instruct them to draw their logo based on their coordinate instructions. Do not allow them to look at their initial drawing. This activity illustrates how the computer follows the vector instructions. If the sequence of

instructions the student records were not accurate (and it probably won't be) the second drawing will come out differently than expected. Allow students to 'debug' their instructions or have a good chuckle over how things can go wrong. This happens all the time in computer programming.

Activity 3:

Provide your students with a vector drawing tool such as Google Drive Draw. Instruct them to enhance their logo using whatever functionality is available. Have them save their work, and then ask them to figure out how to use the interface to double the size of their drawing without having to redraw.

◆Time Needed

- ★ 2 sessions, at most 1 hour each. If this is done in a single, two-hour session, only do Activities 1 and 2. If you have more time, you can do the project in a sequence of days, giving more attention to the details of the initial drawing.

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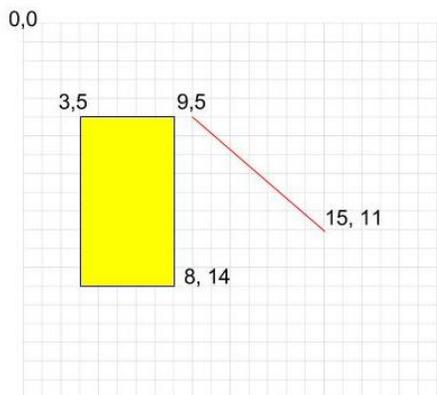
Student Resource:

Overview of Vector Graphics

Creating a drawing with vector graphics involves using *functions* to determine the placement, size, and shape of objects on the screen. You will be drawing with lines and rectangles, and perhaps curves and ellipses. To illustrate how easy it is to change the size of the drawing, you will design a logo for yourself on graph paper with small squares, record the steps you took, then redraw it on graph paper with larger squares. You may also have an opportunity to use a software drawing tool to enhance your logo with a full compliment of graphics functions.

Plotting Vector Functions

A *function* is a tool in mathematics that allows you to calculate a result based on initial values. Functions are essential for vector graphics because everything that is drawn is the result of the initial values specified. A graphics function uses a collection of points to draw a shape. Lines and rectangles require two points as shown here. The function also requires a line color, and if the shape is closed, it requires a fill color.



The list of functions that create this drawing are:

Rectangle (3,5,8,14, blue, yellow)
Line(9,5,15,11, red)

Vector Graphics Functions

Vector drawing software has a huge number of functions. Only three are described here. The function is recorded with the minimum amount of information needed to draw it. Both rectangles and lines need two points and some color information. Each point is made up of two numbers, an 'x' coordinate that plots the distance horizontally, and a 'y' coordinate, that plots the distance vertically, from the upper left corner of the drawing region. Ellipses use the same sequence of numbers as rectangles. Think of the ellipse as being drawn inside a rectangle.

Rectangle(upper-leftX, upperleftY, line color, fill color)

Ellipse(upper-leftX, upperleftY, line color, fill color)

Line(leftX, leftY, rightX, rightY, line color)

Vector Graphics Use Functions

Student Worksheet 1: Text

◆Activity 1

Your teacher will give you two pieces of graph paper, one with large squares and one with smaller squares. How many squares are there in the width and height of the sheet with the larger squares? Write those numbers down here:

Number of squares across the large graph paper (width): _____

Number of squares down the large graph paper (height): _____

Transfer these numbers to the smaller size graph paper. Only draw within these boundaries. Position (0,0) is the upper left corner of your drawing space, not the upper left corner of the graph paper. (They may be the same, depending on your boundaries.) Using the functions on your student resource page, design a logo for yourself. Do **not** write down the points on the graph paper. As you draw, record the points by writing the functions below on the worksheet. Sequence matters. Functions drawn first will appear below those drawn later. (That's kind of obvious in hand drawings, but sometimes gets lost when using drawing software.) Given the time constraints, keep it simple. List your steps here, take care to keep them in order, and double check the points you write down. Remember to count from the upper left corner. This is not the same as the coordinate system you see in a math class.

Vector Graphics Use Functions

Student Worksheet 2: Text

◆Activity 2

Put away your drawing, (hide it from view, or give it to your teacher). Using the sequence of functions on Worksheet 1, draw your logo on the graph paper with the larger squares. If you got the points and colors right, you will have a larger version of your drawing. But if your sequence, points, or colors are not accurate, things will go wrong along the way. Your teaching may or may not let you go back to your original drawing. If you can, 'debug' or fix your sequence of functions on Worksheet 1 and keep going.

◆Activity 3 (Optional)

Using vector drawing software is much easier than drawing by hand. However, a lot of computer artists first hand sketch what they want to do. It takes practice to know how to use many drawing functions. Your teacher will give you basic instructions on the tool selected for your use.

Start by recreating your logo with the drawing tool. Enhance it with functions beyond the three defined above. Notice that you don't have to worry about points because the software keeps track of that for you. Make sure to save your work.

Your teacher will ask you to stop drawing at some point and ask you to double the size of your drawing. Your software should have a way for you to select everything that is drawn, and enlarge the entire picture. With your classmates, figure out how to do this.

You may be able to load drawing software on your mobile device. Can you figure out whether or not it supports vector graphics? Have fun creating graphics based on functions!

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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 9-12 (ages 14-18)

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 Gr.9-12 (ages 14-18)

Practice 5: Using Mathematics and Computational Thinking

- ✦ Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
- ✦ Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations

Practice 6: Constructing Explanations and Designing Solutions

- ✦ Apply scientific ideas, principles, and/or evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects.

◆ Principles and Standards for School Mathematics (ages 14 - 18)

Functions

- ✦ model real-world phenomena with a variety of functions
- ✦ translate among tabular, symbolic, and graphical representations of functions

◆ 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

◆ Common Core State Standards for School Mathematics Gr. 9-12 (ages 14-18)

Mathematics | High School—Functions

f-If - Interpreting functions

- Analyze functions using different representations.
 - ✦ CCSS.Math.Content.HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases.

Vector Graphics Use Functions

For Teachers:

Alignment to Curriculum Frameworks

◆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.
- ✦ CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.

◆ 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 9-12 (ages 14-18)

5.3 Level 3: Applying Concepts and Creating Real-World Solutions (L3)

5.3.A Computer Science in the Modern World (MW)

- ✦ Computational Thinking (CT)
 3. Use predefined functions and parameters, classes and methods to divide a complex problem into simpler parts
- ✦ Computing Practice and Programming (CPP)
 12. Describe how mathematical and statistical functions, sets, and logic are used in computation.

5.3.B Computer Science Concepts and Practices (CP)

- ✦ Computing Practice and Programming (CPP)
 1. Use advanced tools to create digital artifacts (e.g., web design, animation, video, multimedia).