Culturally Responsive STEM Lesson Plan

NATIONAL MAGLAB
Research Experiences FOR TEACHERS

Food for Thought: An Examination of Grocery Gaps in Communities (Grades 6-8)

Lesson Objectives

- Students will examine the proximity of grocery stores in their local community
- Students will explore radius of circles and area of circles as a way to observe data about grocery store availability in their community or neighboring communities (both urban and rural)
- Students will think critically about issues of food access and regional equity
- Students will investigate applications of Voronoi Diagrams through the use of a Desmos (https://www.desmos.com/) created activity and use Voronoi Diagrams to propose solutions
- Students will have extension options to further analyze texts or resources that address low access and low-income grocery gaps (also referred to as food deserts) as a result of systemic practices over time

California CCSS Mathematics Standards

7.G.B Solve real-life and mathematical problems involving angle measure, area, surface area, and volume.

7.G.B.4 Know the formulas for the area and circumference of a circle and use them to solve problems; give an informal derivation of the relationship between the circumference and area of a circle.

7.G.B.6 Solve real-world and mathematical problems involving area, volume and surface area of two- and three-dimensional objects composed of triangles, quadrilaterals, polygons, cubes, and right prisms.

Next Generation Science Standards

HSETS1-1 – Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities.

NGSS Crosscutting Concept: Systems and system models. Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.

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STEM Rationale for Lesson:

This is an exploratory lesson that could be used within a unit on circles, or during a project-based learning unit about food access in a middle school, integrated math, and/or science classroom. The lesson is designed to help students visualize the area of a circle within context, such as over a map of a city and the area covered within a certain radius. Students will be introduced to a higher-level math concept called a Voronoi Diagram, allowing them to see real-life applications of geometry and mathematics that can be used to pose solutions to issues of food access in our society. Voronoi Diagrams have many applications in the fields of math and science. This lesson also provides ample opportunity to review measures of center when analyzing data about food deserts and making comparisons of the number of grocery stores someone has access to from a certain base point or the average distance to the nearest grocery option.

Culturally Responsive Connection

This lesson allows students to explore issues of food access within their local community and reflect on their own personal experiences with food and how their family obtains food. Students will also compare their data to other communities. By design, the lesson is intended to get students asking questions about food access and grocery gaps - why don't residents have equal access to healthy food? Students will examine existing disparities between communities and discuss why the term "grocery gap" is preferable to the commonly used term of "food desert" based on the fact that such gaps are not a naturally occurring phenomenon (as the term desert implies) but rather, a result of inequitable, systemic practices over time.

Students will be able to equally access the activities by reflecting on and sharing from personal experience. The lesson will also provide various case studies for students to explore that represent different communities impacted by food access inequities. We will draw from lived experiences and also provide opportunities to share stories of others, recognizing that the challenge of affordable access to food impacts some communities and groups more than others. We will also discuss the grocery gap that developed overnight and continues to impact the community of Buffalo after the mass shooting at a Tops Grocery Store in May of 2022.

At the end of the lesson, students are asked to apply their understanding of the mathematics explored to suggest an ideal location for a new community in need of another grocery store.

A note about language: During the planning of this lesson, I came to learn that the term "food desert" could be more accurately described as a "grocery gap," "food apartheid," or "food oppression." This is due to the fact that a desert is a naturally occurring phenomenon whereas the problems explored in this lesson are not. A "grocery gap" does not imply that this problem is naturally occurring. For more information visit the Food Empowerment Project website: *"Food Empowerment Project (F.E.P.) recognizes the problem with the term food desert, defined by the USDA as mostly being about proximity to food providers, rather than considering other factors such as racism, cost of living, people being time poor and cash poor, cultural appropriateness of available foods, the ability of people to grow their own foods, etc. F.E.P. considers terms like food apartheid and food oppression to be more accurate."*

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Materials Needed:

Provided by Teacher:

1. Access to student computers or chromebooks
2. Access to slides (Appendix C)
3. Copies of a local map (area surrounding school)
4. Rulers or tape measures (1 per group)
5. Compass (1 per group)
6. Notebooks or scratch paper
7. Student handout (Appendix A)
8. Copies of article (Appendix B)

Activate Prior Knowledge:

1. Students should be familiar with parts of a circle (radius, circumference, diameter) as well as the importance of pi in relationships between parts of a circle (area formula of a circle).
2. Students should be able to measure and describe distances.
3. Students should have practice plotting points on a coordinate plane and identifying (x,y) coordinates.
4. Students should be able to read and interpret a map and its scale.

Lesson Introduction:

The lesson will start with conversations about food traditions, favorite foods, and where we get our food. The purpose of this introduction is to build community within the group and help everyone find their individual connection to the topic of food. By discussing our own connections to food, students will be able to see the relevance and importance of the lesson goals. Students will do a short movement activity where they stand on the side of the room for the statement that best represents how they feel when it comes to various questions about food, as well as reflect overall on one question.

Lesson Activity:

1. **Map Exploration:** Students will work in groups to complete an investigation using maps of their local community. They will work together to draw a one-mile radius around the school and then identify all of the grocery stores or markets within this one-mile radius. They will reflect on whether or not all of these options are actually accessible to them (are there physical barriers such as freeways, rivers, or buildings that prevent them from actually accessing these stores?) (see Appendix A for student handout and Appendix C for student facing slides)

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2. **Voronoi Diagrams:** Students will work on computers using a program called Desmos. The activity is designed as a progression of steps that will introduce students to a modeling tool called a Voronoi Diagram. The Voronoi Diagram is a mathematical way for students to more deeply explore the concept of food access and how placement of a new store could be determined by looking at the gaps and proximity to existing stores. Please see the teacher notes attached for more information about the desmos activity. *Note: This activity was created by Desmos and "inspired by a session at TMC18 led by Dave Sabol centered around using maps in math classes, and literally dozens of Desmos Fellows and Employees helped influence and shape this activity during Fellows Weekend 2019."* (see Teacher Notes)

3. **Reading:** Students will take 10-15 minutes to read and discuss a short text about applications of Voronoi Diagrams, called "How Voronoi Diagrams help us understand our world." (see Appendix B)

Lesson Assessment

1. This lesson is an exploratory lesson and does not have an explicit assessment that goes with it. However, there are multiple opportunities for formative assessment and feedback embedded within the Desmos slides. Teachers are encouraged to use the Desmos slides as a way to promote class discussion and learning around these topics. The slides are not meant to be a summative assessment of student learning on these exploratory topics. Should a teacher choose to, they could create a short assessment within a unit on circles within the context of the lesson themes explored. This could involve giving students a new community map with a given scale and having students draw a one mile radius around a focus point, identifying food options, and reflecting on the situation or making comparative claims to a different community. Additionally, students could be assessed on their proposed solutions to food deserts in surrounding communities.

Lesson Extensions

1. There are many opportunities for further exploration and extension within this topic. Many articles, news clips, and podcasts discuss the topic of grocery gaps in communities. Here are a few resources that could be developed into further investigations for students looking for extension connections.

a. News Connection: Students can discuss what happened at a Tops supermarket in Buffalo, NY in 2022. An article from NPR titled: *"The Buffalo shooting is a reminder that millions don't live near a grocery store"* discusses the overnight food desert the community faced after a tragic mass shooting closed the store for a long term investigation.

b. Midnight at the Oasis Slow Reveal Graph: This presentation by Corey Jones invites more wonderings about food deserts and inequities across the United States. It is a wonderful follow up (or pre-activity) to this lesson.

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c. GeoGuessr Game: This is an online, interactive game where students are placed somewhere in the world, shown a picture, and challenged to identify where they are on a map. There are variations and levels, but it can be a great "hook" or way to get students engaged in sense making with maps and scale.
d. USDA Food Access Research Atlas: This online resource uses census data with maps to allow for exploration.
e. Voronoi Diagrams Continued: Students who want more information about Vornoi diagrams can explore this video set about patterns in dinosaur skin.
f. Raised Garden: Students could move toward solutions and explore urban gardening. This website is just one example of a curriculum designed for a small classroom raised garden.
g. Text Sets: Students interested in the topics could read article sets on Newsela or other sites, such as "Solving the nation's food dessert problems yields unexpected results" or www.foodispower.org.
h. Learning for Justice: This website has many resources related to food access, exploring one's local community, as well as causes and consequences of food deserts.
i. Google MyMaps: Students can create an interactive map with what they've learned!

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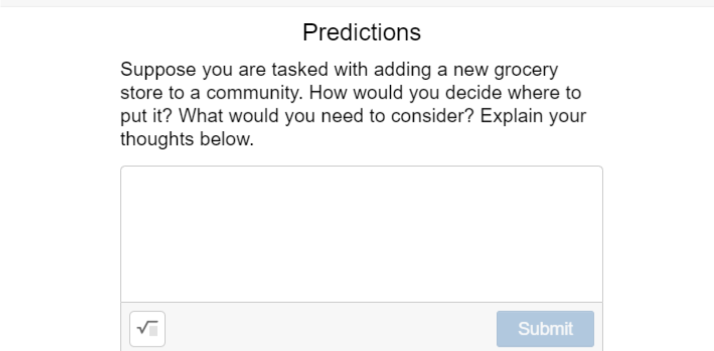
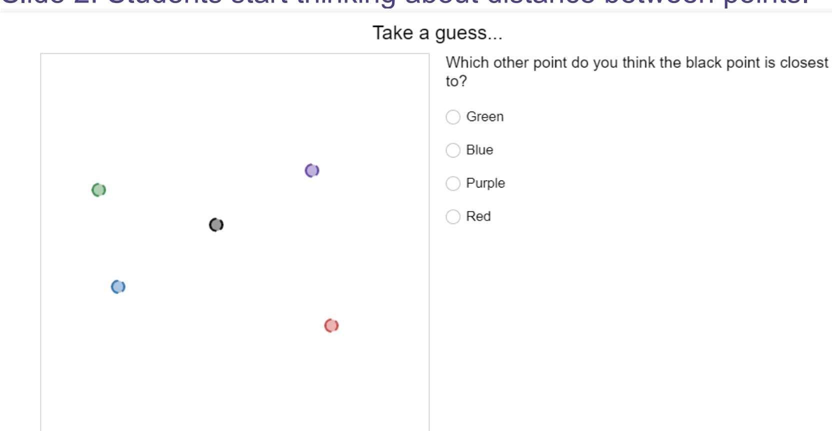
Teacher Notes
Voronoi Diagrams - Desmos Activity

Note: This activity was originally created by Desmos and modified by me. Desmos notes that it was "inspired by a session at TMC18 led by Dave Sabol centered around using maps in math classes, and literally dozens of Desmos Fellows and Employees helped influence and shape this activity during Fellows Weekend 2019." All credit for the original creation of this Desmos activity should go to Dave Sabol and team.

Slide 1: Students are asked to reflect about how decisions about grocery stores are made.



Slide 2: Students start thinking about distance between points.



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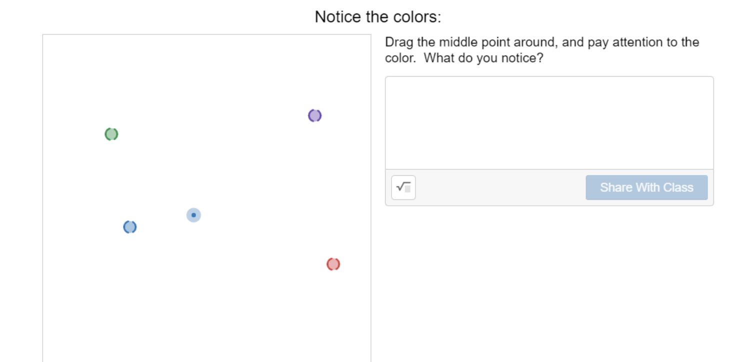
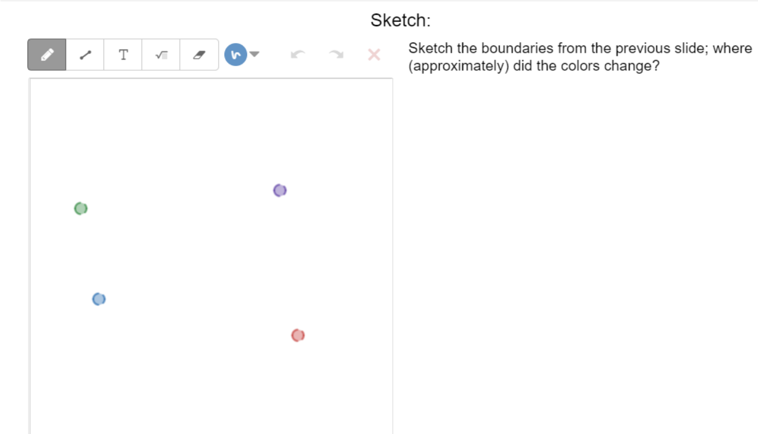
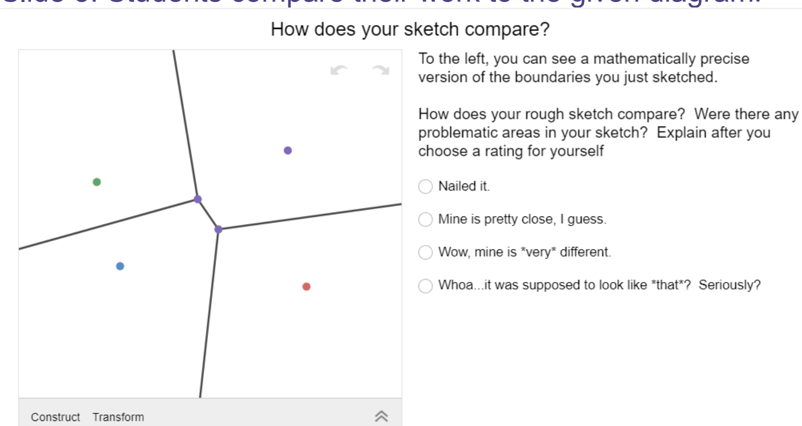
Slide 3: Students can now move the black point, and notice how it changes color depending on its proximity to other points.



Slide 4: Students sketch the approximate boundaries from the previous slide; they can move back and forth as needed to sketch.



Slide 5: Students compare their work to the given diagram.



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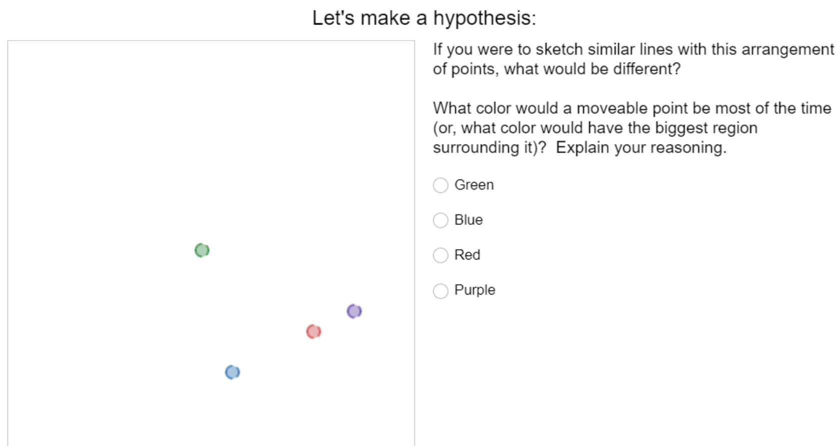
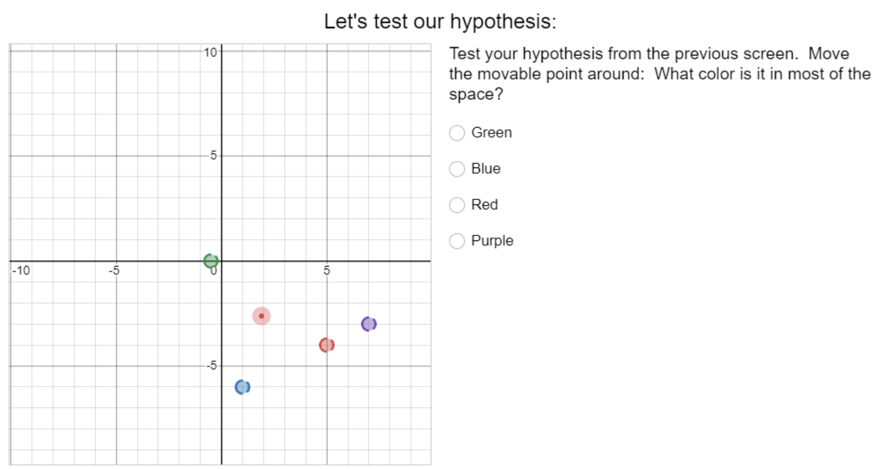
Slide 6: Students hypothesize about the next set of colored dots:



Slide 7: Students test their hypotheses:



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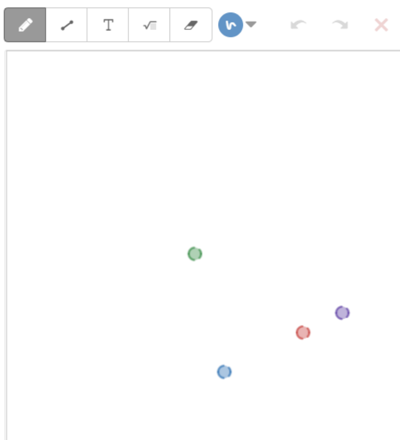
Slide 8: Students sketch their results:

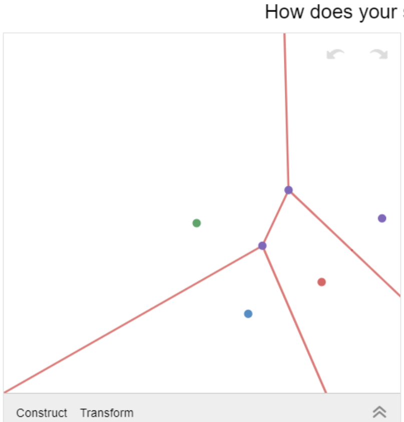
Now, let's sketch our results:



Sketch the boundaries from the previous slide; where (approximately) did the colors change?

Slide 9: Students check their results and compare them to their first round. Most will improve!

How does your sketch compare?



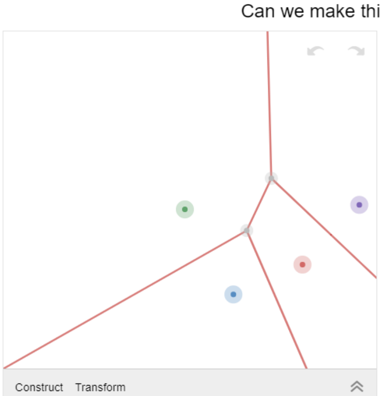
Now that you've estimated the boundaries, let's again look at a mathematically precise version; how does your sketch compare to the first one you did?

This time, use the explanation box to give your best description or definition for what each of those four regions of the space represent in this diagram.

- Better than last time!
- About the same as the first one.
- Not great! This one was even tougher!

Slide 10: Students are now asked to consider if they can make the boundaries of the regions in the next set of dots more equitable.

Can we make this more equitable?



Move the green, red, blue, and purple points so that the four regions are more equally spaced.

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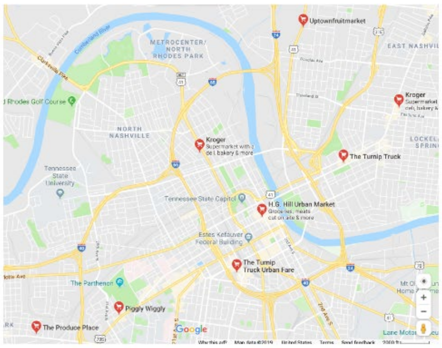
Slide 11: Students start thinking about maps and making the connection between the dots activity and the context they will be exploring today.

Let's make a connection...



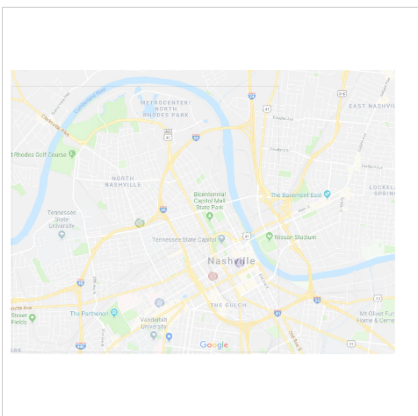
What do you notice about this map of Nashville that has the locations of grocery stores indicated with map pins?

How is it related to the images we've been working with on the last few slides?

Share With Class

Slide 12: Students tie together the math and the map and are introduced to the idea of a food desert.

Tying together the math and the map



The mathematical images in this lesson are called Voronoi Diagrams. They show which areas of a plane surface are closest to certain important points.

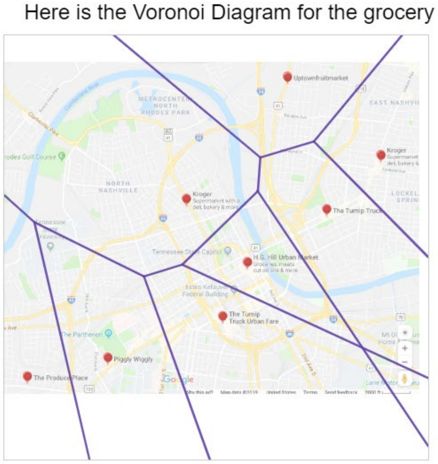
Food Deserts are areas of a city that are under-served by grocery stores, and they typically are found in lower-income parts of a city (such as North Nashville on our map). Food deserts cause greater inequity in our cities.

Mathematicians use Voronoi Diagrams to analyze societal issues like Food Deserts and recommend solutions.

Move to the next slide when you are ready.

Slide 13: Students start to think about how residents access food, and which stores serve greater regions.

Here is the Voronoi Diagram for the grocery stores in the map of North & East Nashville.



Which store serves a larger section of the city than any of the others? In the explanation box, brainstorm about how residents of North Nashville might have to acquire their food, particularly if they don't own a vehicle.

- The Produce Place
- Piggly Wiggly
- Kroger (Approximate Center of Map)
- The Turnip Truck Urban Fare
- H.G. Hill Urban Market
- Uptown Fruit Market
- The Turnip Truck
- Kroger (Eastern Edge of Map)

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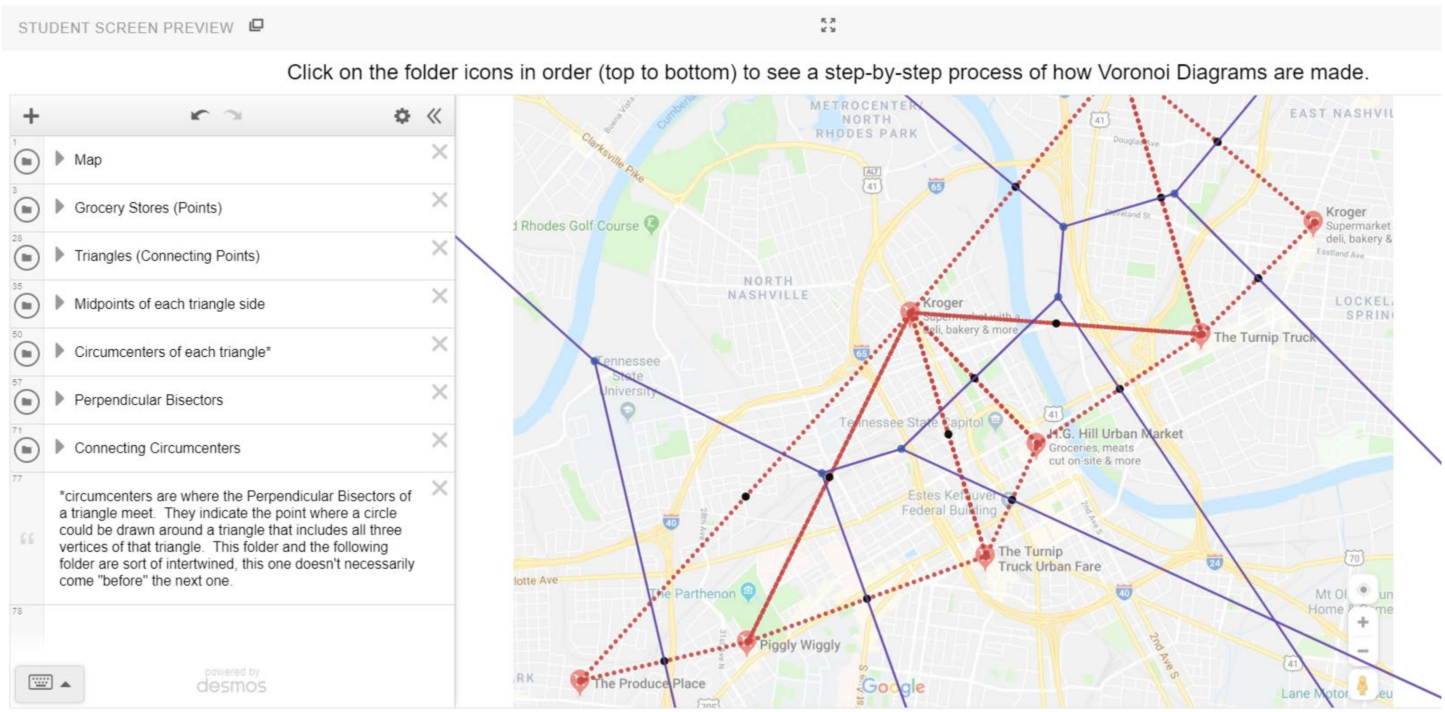
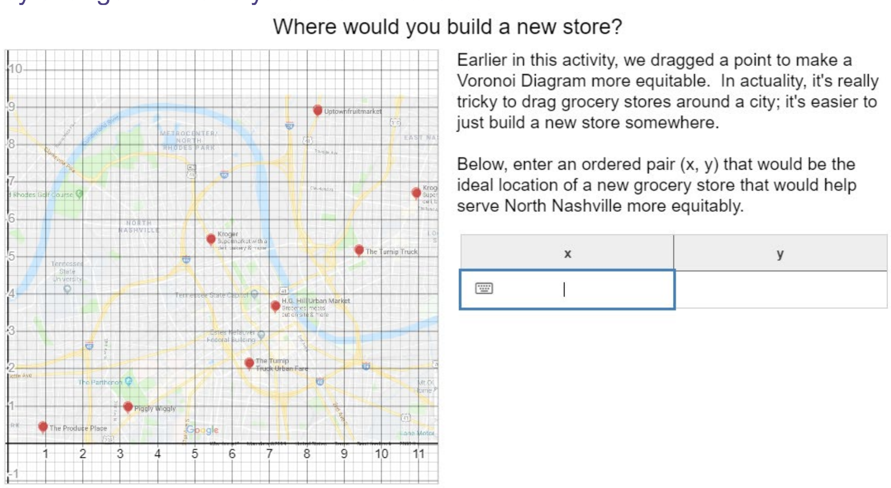
Slide 14: Students can go through a step by step process to see how a Voronoi Diagram is made. This content is beyond the scope of a grade 6-8 math class, but is intended to show students the mathematical process between the dots and the boundaries in a Voronoi Diagram. Students can see a preview of how various geometric processes can be applied to a real life situation to help solve real life problems.



Slide 15: Students make an initial guess as to where to put a new store, by plotting an (x,y) coordinate pair on the map. Prior to having students work on this slide, the teacher can review (x,y) coordinates. This is a good way for students to practice the coordinate plane in context, noticing how horizontal and vertical placement changes in relation to the origin as they change the x and y values in the table.



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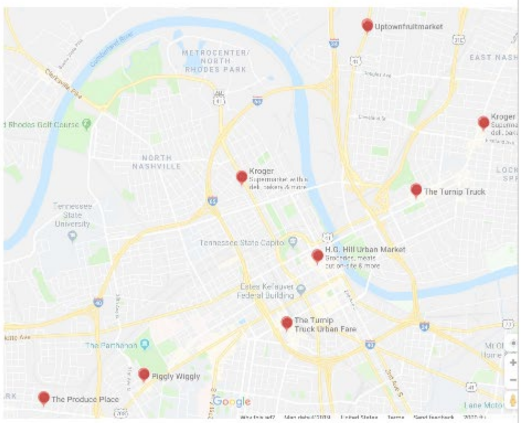
Slide 16: Students points are plotted (all from class) and the teacher can use this slide as a discussion point to compare ideas (all points will be overlayed). This is a good time to discuss other barriers to food access such as the river in this community, bridges, freeways, public transportation routes, etc.

See your results:



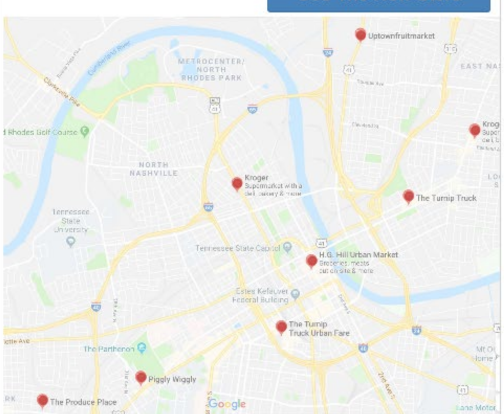
Here is your result (in black).

Let's look at an overlay of all of the locations this class chose to put the new store and discuss where we were similar in our placements and where we disagreed. (See teacher screen).

Slide 17: Students see a potential developer location. Note that the location varies by student - not every student will be seeing the “answer” in the form of the most equitable solution. It is just a possible placement, left for students to reflect on.

Uh oh...we have some competition!

See The New Store



A new developer has beaten you to the punch and purchased land to build a new grocery store in Nashville.

Click the "See The New Store" button on the graph once to see the location (in purple). Explain whether or not you think their location will make things more or less equitable for the under-served residents of North Nashville.

- ◯ The new store location makes things more equitable
- ◯ The new store location makes things less equitable

Slide 18: Students flip the thought process around, this time using given borders of the Voronoi Diagram to predict where the locations of the dots (or grocery stores) would be to create these boundaries.

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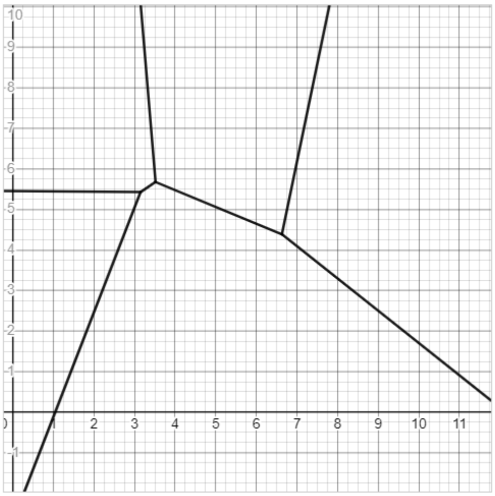
Let's try and think about Voronoi Diagrams from a different angle...



Here you see a Voronoi Diagram that represents the boundaries for the locations of grocery stores in a neighborhood of South St. Louis, MO.

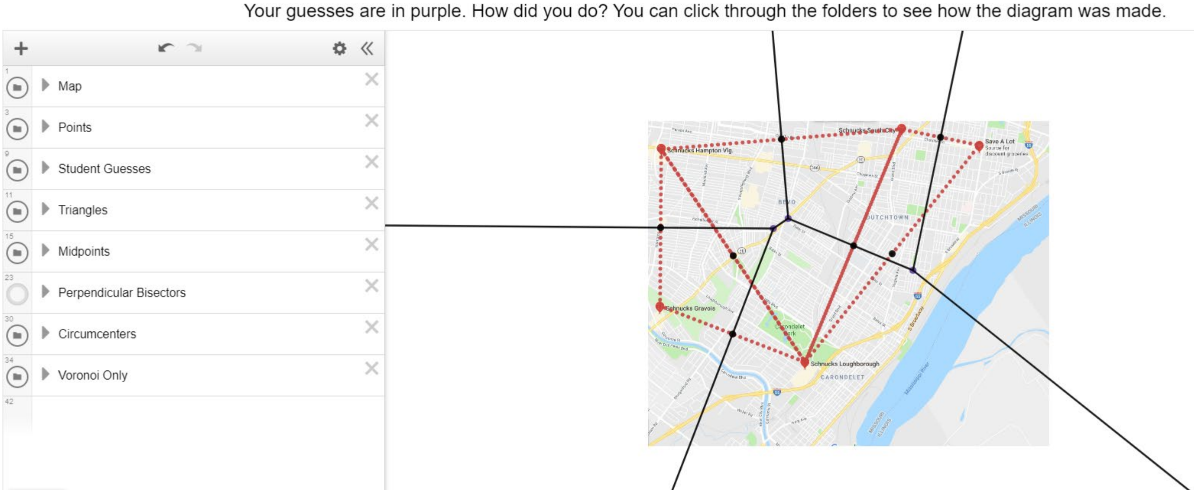
In the table below, input the ordered pairs that you feel are the likeliest locations of the grocery stores based on the lines for the Voronoi Diagram. There are 5 of them (one for each area of the map).

Progress to the next slide to see your selections overlaid on an actual map of St. Louis.

x	y

Slide 19: Students see the solution explained.

Your guesses are in purple. How did you do? You can click through the folders to see how the diagram was made.



Slide 20: Students reflect on the lesson activities.

End of Desmos Slides

Appendix A

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Food For Thought: Student Handout
Lesson Activity: Map Exploration

Your task: Investigate all of the markets or grocery options within a 1 mile radius of our school using the tools and city map provided.

To determine the 1 mile **radius**, we will need to use the scale given on the map, a ruler, and a compass (if you do not have a compass, use a piece of string to help you construct the circle).
Note: To identify grocery options, you may need to reference google maps.

Let's begin!

1. Look for a scale on your map. For example, your map may have a scale where every 1.5 cm = 1 mile. Sometimes the scale is shown as a bar with a given length. Write or draw that scale here: __________
2. Identify the location of the school on your map. Circle the location.
3. Use your ruler to mark a distance 1 mile from the school. Remember to use the correct scale provided on the map.
4. Use a compass (or if needed, a piece of string) to construct a circle with a one mile radius around the school.

Within a 1 mile radius…

5. Identify any grocery stores or markets that you know of, or can see on the map. Put a star for each of these locations.
6. Use Google Maps to get a closer look. Are there any markets or grocery stores that you missed?
7. What area does this circle cover? Calculate the area and note it here. _____________
8. Is it possible for someone living in this urban area to walk in this area? What natural barriers exist? (rivers, mountains, etc) What other barriers exist? (buildings, train tracks, etc)

Now choose a new urban location and repeat the process. You can choose your home address, or another address on the map in San Diego. If you aren't sure where to start, here are a few urban areas you can try and compare. Choose a location different from someone around you.

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Hillcrest (92103 zip code)
Skyline (92114 zip code)
Downtown (92101 zip code)
Lemon Grove (91945 zip code)

Within a 10 mile radius…

9. We are going to try a similar activity, but this time I want you to choose a rural location and draw a circle around that location with a 10 mile radius. Then again, use Google Maps to get a closer look. Are there any markets or grocery stores that you missed?
10. What area does this circle cover? Calculate the area and note it here. ___________
11. Is it possible for someone living in this urban area to walk in this area? What natural barriers exist? (rivers, mountains, etc) What other barriers exist? (road access, buildings, train tracks, etc)

If you aren't sure where to start, here are a few rural areas you can try and compare. Choose a location different from someone around you.

Jamul (91978 zip code)
Campo (91906 zip code)

Reflect

The US Department of Agriculture (USDA) defines food deserts as low-income census tracts with low access to healthy food, meaning residence **more than 1 mile away from a grocery store or supermarket in urban areas (or 10 or 20 miles in rural areas)**.

12. What did you notice from your map exploration?

13. What does this exploration make you wonder?

14. Why do you think the radius of 1 mile (urban areas) or 10-20 miles (rural areas) is significant? What might prevent someone living in these areas from being able to access food in either of

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these areas?

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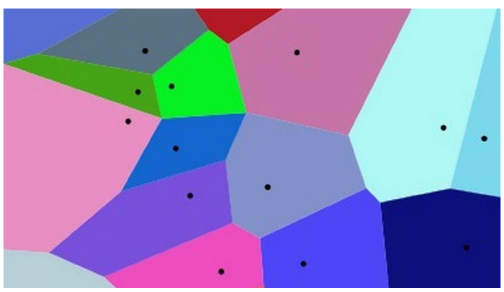
Appendix B: Article from Irish Times

Science

How Voronoi diagrams help us understand our world

Proximity diagrams have applications in most areas of science and engineering



A Voronoi diagram: In mining, they can aid estimation of mineral resources based on exploratory drill holes.

Peter Lynch

Mon Jan 23 2017 - 15:25

We frequently need to find the nearest hospital, surgery or supermarket. A map divided into cells, each cell covering the region closest to a particular centre, can assist us in our quest. Such a map is called a Voronoi diagram, named after Georgy Voronoi, a mathematician born in Ukraine in 1868. He is remembered today mostly for this diagram, also known as a Voronoi tessellation, decomposition or partition.

Another practical problem is to choose a location for a new service, such as a school, which is as far as possible from existing schools while still serving the maximum number of families. A Voronoi diagram can be used to find the largest empty circle amid a collection of points, giving the ideal location for the new school. Of course, numerous parameters other than distance must be considered, but access time is often the critical factor.

In mathematical terms, we are given a finite set of points in the plane and, for each point, the corresponding Voronoi cell consists of all the locations closer to it than to any of the other points. The cells are all convex polygons; that is, they have boundaries made up of straight line segments and all corners have internal angles less than 180 degrees.

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Voronoi diagrams are easily constructed and, with computer software, can be depicted as colourful charts, indicating the region associated with each service point or site. For any location, the nearest service can immediately be read off the diagram (see the accompanying figure). Proximity diagrams were used by many mathematicians, back to Descartes in the mid-17th century, but their theory was developed by Voronoi, who in 1908 defined and studied diagrams of this type in the general context of n-dimensional space, with n being the number of dimensions.

Biological structures

Voronoi diagrams have applications in almost all areas of science and engineering. Biological structures can be described using them. In aviation, they are used to identify the nearest airport in case of diversions. In mining, they can aid estimation of overall mineral resources based on exploratory drill holes. In epidemiology, they can help in identifying the source of infections.

One of the first applications of a Voronoi diagram was by Dr John Snow, a prominent London physician. Cholera, which became widespread in the 19th century, has killed tens of millions of people. Before the cholera bacterium was isolated, overcrowding, bad diet, poor sanitation and noxious miasma emanating from rotting organic matter were all suspected. Snow believed that cholera was caused by infected drinking water.

A serious cholera outbreak in 1854 killed 500 people in five days. Snow gathered statistics on the number of victims and locations of outbreaks. He divided inner London into neighbourhoods, each having a separate water supply. He plotted his data on a chart, effectively constructing a Voronoi diagram. This revealed that almost all fatalities were in houses supplied by a single pump in Broad Street, Soho. When the pump handle was removed, death rates were greatly diminished and the epidemic quickly died out. An engineering survey later showed that a poorly constructed drain was contaminating the pump water.

There are numerous other applications of Voronoi diagrams. These include network analysis, computer graphics, medical diagnostics, astrophysics, hydrology, robotics and computational fluid dynamics. It is surprising how the simple concept of tessellating a region in terms of distance to a given set of points can be so powerful.

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The National MagLab is funded by the **National Science Foundation** (DMR-1644779) and the **State of Florida**

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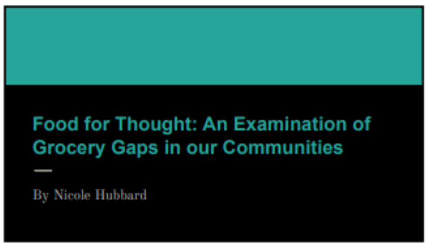
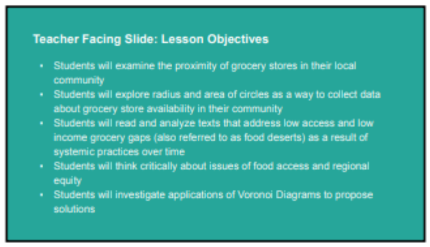
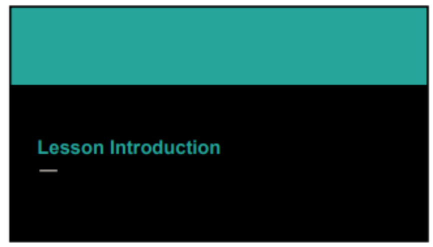
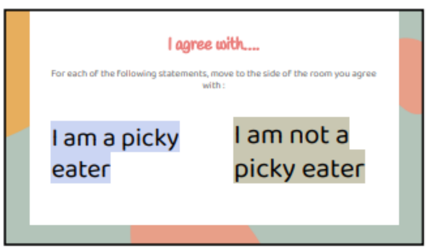
Source: The Irish Times
https://www.irishtimes.com/news/science/how-voronoi-diagrams-help-us-understand-our-world-1.2947681

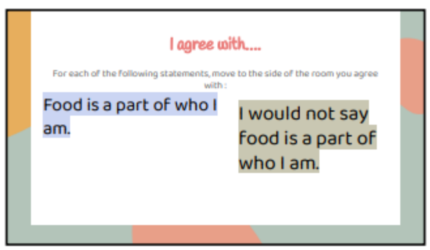
Appendix C: Student facing slides

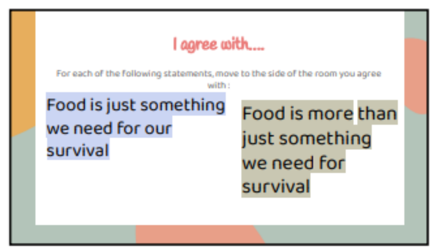


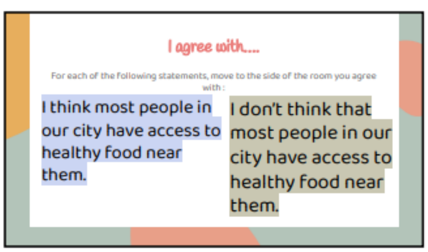


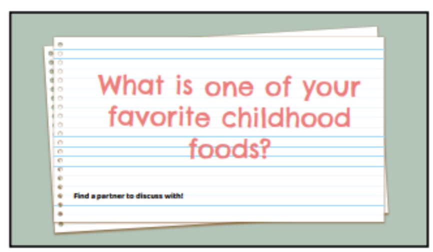












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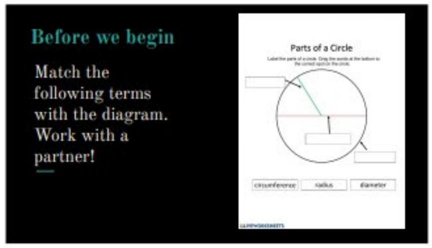

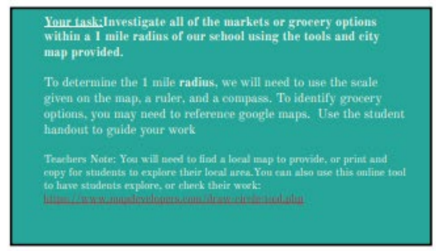

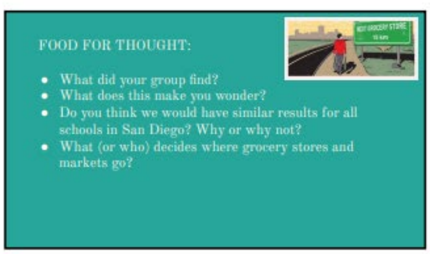

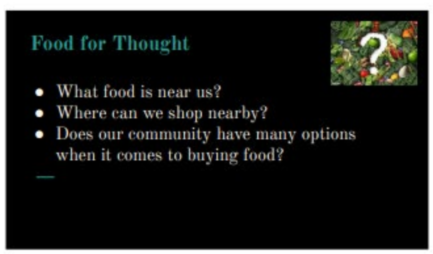

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