LITTLE BIG FUTURES

Fire detection with the Internet of Things (IoT)

A MATHS LESSON - EXPLORING POLYGONS THROUGH THE 'ART GALLERY PROBLEM'

The Internet of Things (IoT) connects the unconnected.

The IoT is improving fire detection, helping to save lives through more intelligent, efficient systems.

‘Smart’ fire detectors can now communicate with other detectors, alert the fire service and warn people at risk of fire.

This resource requires students to explore the optimal placing of connected fire detectors in a range of different buildings.

Learning outcomes

- explore the properties of convex and concave polygons
- develop strategies to solve problems
- look for patterns and relationships in unfamiliar settings

Resources

- PowerPoint presentation (projector or other display needed)
- access to Cisco IoT videos on YouTube
- student worksheet
- squared paper for student work
- pencils, rulers

CISCO STEM LEARNING

Lesson activities

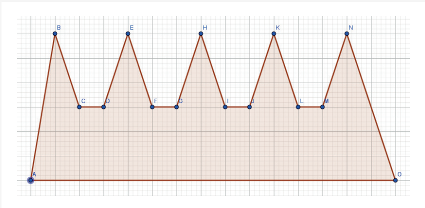
(1 hour duration; may be extended if appropriate)

	Activity	Resources
Activity 1 **(5 mins)**	Choose one (or more) of the eight Cisco 'Internet of Everything' commercials – these cover different themes. Explain that previously unconnected devices are being connected to bring about huge changes in how the world works. This is the basis of the 'internet of things'. Discuss how the Internet of Things could be used in fire prevention, detection and in alarm systems.	Streaming videos: General introduction to the 'Internet of Everything' Cycling accident Basketball Bananas Rock concert New year's eve power DIY store Cats and milk
Activity 2 **(15 mins)**	Use the presentation to introduce the task. Students are to play the role of fire safety company employees. Their task is to find the most efficient placement of fire detectors in a variety of rooms. This type of problem is known as the 'art gallery problem'. For each room students have to decide where to place fire detectors so that the entire room is covered, using the smallest number of detectors. Some rules: ▪ detectors can only be placed at the vertex (corner) of each room ▪ detectors can sense infrared heat at all distances, through 360° ▪ detectors cannot sense infrared through walls The presentation (slides 7-9) contains four examples to consider as a whole class. Slide 7: two detectors are required. You may want to highlight that the two cameras can be placed in a number of different vertices correctly. Slide 8: again two detectors, despite there being fewer vertices in this example. You may wish to discuss gradient using this example. If a camera is placed at vertex A, can it see vertex E? Why/why not? Slide 9: two examples of convex polygons. For all rooms of this type only one camera will ever be required.	PowerPoint presentation (More details of the art gallery problem: http://wild.maths.org/art-gallery-problem)

Activity 3
(15 mins)

In groups, or individually students can now work through the worksheet containing 11 examples.

Slide 13 contains a further challenge:



"The fire detector company think this room required 5 cameras- do you agree?

How many distinct ways can the cameras be placed?"

There are many different combinations of 5 detectors, for example (A, D, G, J, M) or (A, E, H, K, O). How many can students find?

Slide 14 contains a 40 sided shape, as seen in student worksheet 2. You may wish to ask students to create their own designs for others to attempt?

Student worksheet 1

Answers:

1 1
1 2
2 1

2 2
2 3
5

Student worksheet 2

Squared paper for students

Activity 4
(15 mins)

For the remaining part of the lesson (slide 15 onwards), students will investigate the maximum number of fire detectors requires for a given number of vertices.

"Can you design a room with nine vertices that requires more? What is the maximum number detectors needed?"

Divide students into groups ask them to consider a different number of vertices (10, 11, 12+ … vertices). Ask each group to design a room that requires the most detectors possible for their given number.

Bring the results together as a class. The maximum number of detectors required should be as below:

Vertices	Detectors
9	3
10	3
11	3
12	4
13	4
14	4
15	5
16	5
17	5
18	6

Follow up and discuss if groups suggest a different number of detectors than in the table.

Using the table, can students see a pattern?

Squared paper for students

Activity 5 (5 mins)	Explain to students that the number of detectors required is connected to the number of vertices. If there are n vertices, the number of detectors required is: $\left\lfloor \frac{n}{3} \right\rfloor$ The floor function rounds down to the nearest integer. Discuss with students whether this fits with their own maximum suggestions.	The proof of this upper bound requires splitting the original shape into triangles, more detail can be found here: https://plus.maths.org/content/art-gallery-problem

Additional notes

Slide 14 contains a 40 sided shape, as seen in student worksheet 2.

You may want to use this as a homework activity. The activity can be extended by using plans of your school grounds or from local buildings and ask students to investigate where they would place fire detectors.