‘Hidden Figures’ movie lesson

Overview

In this lesson, students discuss *Hidden Figures* and what it might have meant that Katherine Johnson had to “make new mathematics” where “there is no formula”. They then play a game about communicating mathematical ideas across barriers that may force them to “see beyond the numbers” and come up with new mathematics. Finally, they reflect on their experiences dealing with mathematical frustrations, and the ways that Katherine Johnson’s experiences as a ‘black’ woman might have helped prepare her to be a pioneer in her field.

Lesson Resources Needed

- *Hidden Figures* trailers: http://www.foxmovies.com/movies/hidden-figures (particularly the second trailer, “Give or Take”)
- Folders or books to put up between students to make a barrier to hide each other’s work during the “Mission Control” game
- Either tangram or pattern block pieces or graphs and graph paper, depending on which version of the “Mission Control” game you want students to play

Lesson Launch

Play one or more trailers from the movie, *Hidden Figures*. Help students understand what role the women at NASA were hired to do (carry out the sort of calculations that calculators and computers now do, based on others’ instructions), how hard that work was, and how it was different from what the ‘white’ male engineers were expected to do (apply mathematical ideas in new ways to problems that no one had solved before). Make sure students are aware that Katherine Johnson, and other women at NASA at the time, went beyond the expectations to “invent the math” and be problem solvers.

Explain to the students they are going to play a game that will encourage them to think about math in new ways, apply some problem-solving, and work on a version of the problem that Katherine Johnson went on to work on at NASA: how to communicate with the astronauts in space when some part of your communication has failed, and you need them to understand the geometry or rocket trajectory to return home to Earth again.

Mission Control Games

(Originally published in *Powerful Problem Solving*, Heinemann 2013)

Geometry Version

Format .....Students working in pairs or groups of four.

Materials .....Folders or books to serve as dividers, pattern blocks or tangrams.

Step 1.....Determine which blocks will be used for Game 1.

Suggestion.....Start with two each of two different polygons.

Step 2.....Using the folders or books to block others' views, one student in the group (or pair) constructs a pattern using the specified number of blocks.

Step 3.....Set the scenario explaining that the person making the pattern using the specified number of blocks is Mission Control and all others participating are Space Ship Crew Members. The Space Ship Crew Members are on a mission and have encountered problems—they have only one-way communication with Mission Control! To find their way home, they must follow Mission Control's orders exactly to rebuild their panel of controls.

Step 4.....Remind all students that there is only one-way communication, which means only Mission Control may speak!

Step 5.....Looking at the "panel" of shapes, Mission Control carefully describes the position of the shapes using as precise vocabulary as possible to assist the crew in constructing the panel, which will enable them to return to Earth.

Step 6.....As Mission Control speaks, the Crew Members listen and construct the panel using Mission Control's description.

Step 7.....All students compare their control panel to that of Mission Control. If it is exactly the same, they return to Earth. If it is not exactly the same, they are lost in space!

Step .....Discuss what was difficult and what strategies students invented to help solve this novel problem. How are they getting better at the task? Play again to let people put their new strategies into action.

Suggestion.....Make a list of useful words (available for everyone to see) to assist in subsequent games.

Step 9.....As skill in describing the configurations improves, add more blocks to the panel until of the different polygons have been used.

Algebra/Coordinate Geometry Version

Format .....Students working in pairs or groups of four.

Materials.....Folders or books to serve as dividers, graphs and graph paper.

Step 1.....Using the folders or books to block others' views, give one student in each pair, or 2 students in each group, a graph to study. Depending on what you are studying, students might get:

- Linear functions
- Quadratic functions
- A graph of a circle or other shape using coordinate geometry

Step 2.....Set the scenario explaining that the person with the graph is Mission Control and all others participating are Space Ship Crew Members. The Space Ship Crew Members are on a mission and have encountered problems—they have only one-way communication

with Mission Control! To find their way home, they must follow Mission Control's orders exactly to plot the trajectory of their space ship.

Step 4.....Remind all students that there is only one-way communication, which means only Mission Control may speak!

Step 5.....Looking at the graph, Mission Control carefully describes the graph using as precise vocabulary as possible to assist the crew in plotting the trajectory, which will enable them to return to Earth.

Step 6.....As Mission Control speaks, the Crew Members listen and plot the graph using Mission Control's description.

Step 7.....All students compare their graph to that of Mission Control. If it is the same, they return to Earth. If it is not the same, they are lost in space!

Step 8.....Discuss what was difficult and what strategies students invented to help solve this novel problem. How are they getting better at the task? Play again to let people put their new strategies into action.

Suggestion.....Make a list of useful words (available for everyone to see) to assist in subsequent games.

Step 9.....As skill in describing the graphs improves, add specific constraints to Mission Control about what they can and cannot tell their astronauts. For example:

- Students can only give the coordinates of points with positive x-coordinates -- the rest of the trajectory has to be figured out through other kinds of clues
- Students can only give the exact coordinates of one point – the rest of the trajectory has to be figured out through other kinds of clues*
- For students of calculus, you can force them to use the math Katherine Johnson was using by telling them they can only give a starting point on the curve and then information about the slope or derivative!

**In the Hidden Figures movie, Katherine Johnson suggests using Euler's method to plot the trajectories. What students are doing as they try to describe a graph with the constraint of knowing only one point is related to Euler's method. Euler's method is a way to plot a curve given only the starting point and knowing the rate of change (local slope) at each point on the curve. The curve can be approximated using lots of tiny linear functions to get to the next point – a method your students might use as they tell a friend, "Start at (0, 0). Go up 1 and over 1. Now, go up 3 and over 1. Then up 5 and over 1." If students use this method, point out the connection to Katherine Johnson's work.*

Lesson Debrief

Hear from students what it was like trying to use mathematics they were familiar with (shapes, graphs) to solve a new problem: communicating with someone who couldn't see what you saw and couldn't ask you any questions. Listen to students describe what was hard or easy, what made them think in new ways, and what it was like to have to use math to do something they'd never thought about before.

Ask students to connect their experiences with this game to other aspects of their lives: have they had to use communication skills like this before? Cope with frustrations? How did their previous experiences help them have success today?

Connect this back to Katherine Johnson by asking, “How might the women in *Hidden Figures* have drawn on their life experiences to help them make mathematical and engineering and computing breakthroughs?”

Students might consider:

- They knew how to cope with frustration and set-backs.
- They knew how to look at problems (computers taking over their jobs, Russia winning the space race, not knowing a formula) as opportunities (the computers will need programmers, the urgency around Russia means that there will be more leeway in allowing us to contribute, there are mathematical techniques that are specifically designed for calculating without a formula such as Euler’s method).
- They learned to be confident in their own thinking, and check their own work, knowing that they could only rely on themselves and each other.
- They learned to be precise and attend to details, and to look for patterns and shortcuts that they could justify and explain, knowing that their work had to be fast and perfect for them to be accepted and keep their jobs.
- They learned to explain their thinking clearly and succinctly knowing that they had to fight to be listened to.

As students share, encourage them to focus on what they may have learned from the movie, book, and/or articles about these specific women, and what they can draw on from their own life experiences. Notice places where participants might be over-generalizing or stereotyping in their assumptions. You might ask, “What did you notice about the character’s life that makes you wonder how that impacted her?”

If students have had experience at school talking about their various identities (both visible and hidden, e.g. race and gender, disabilities, immigration status, nationality, religion, etc.) they might also consider questions like these, publicly or in private reflection: How do your identities impact how you in math class? How have your other identities shape you as a doer of mathematics? Is it important to you to see people like you who are mathematicians or scientists or engineers?

If exploring the various identities of professional mathematicians, past and present, and how their experiences shaped them as mathematical thinkers, is of interest to you and your students, you might also check out The Mathematician Project. Math teacher Annie Perkins and her students started it and have created a four-part blog series here:

http://www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School/Blog/The-Mathematician-Project/

http://www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School/Blog/How-to-Enact-the-Mathematician-Project/

http://www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School/Blog/What-I-Learned-about-My-Students/

http://www.nctm.org/Publications/Mathematics-Teaching-in-Middle-School/Blog/Extensions-of-the-Mathematician-Project/

More Resources

- Excerpt from *Hidden Figures* (the book): http://nautil.us/issue/43/heroes/the-woman-the-mercury-astronauts-couldnt-do-without
- Katherine Johnson's first paper (with her name on it!) about calculating aspects of orbit: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19980227091.pdf (I think this paper is about figuring out how to launch a rocket so that it passes over what the movie calls the "go/no-go" point. In the "Give or Take" trailer she assumes that the capsule is over a certain point and calculates that it will therefore land in the Bahamas. This paper shows that once you work backwards to find the right point for the rocket's re-entry that will get it to land in the right spot in the ocean, how to work backwards further to figure out where to point the rocket at launch to get it to pass over the "go/no-go" point.)
- Paper by Katherine tJohnson about how astronauts can navigate by stars and do calculations by hand to re-set their trajectory: https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19680002053.pdf (One problem they had to solve: making sure the by-hand calculations didn't take so long that by the time you were done calculating you were past the point to turn!)
- For teachers, from NCTM, a book on identities and math class: https://www.nctm.org/store/Products/(eBook)-The-Impact-of-Identity-in-K-8-Mathematics-Learning-and-Teaching--Rethinking-Equity-Based-Practices-(PDF-Downloads)/