Sensor Solutions

Educator Notes

Learning Objectives

Students will

- Describe elements of a basic sensor.
- Identify sensors used in everyday life and their importance.
- Describe the importance and use of sensors on aircraft.
- Design a sensor to solve a problem.

Challenge Overview

In this activity, students will gain a better understanding of the types of sensors installed on drones, how the sensors work, any advantages or limitations of the sensors, and how a drone's sensors can provide benefits to society while improving safety features for sharing the airspace with other aircraft. Students will imagine innovative solutions to real-world problems facing their local communities and demonstrate how those problems could be solved by designing a sensor.

Safety

- Students should be aware of their surroundings and move carefully throughout the room when viewing other teams' work.
- Before using sharp instruments, discuss safety issues surrounding proper use.
- When students are blindfolded, they need to remain seated.

Challenge Preparation

- Read the Educator Notes and Student Handout to become familiar with the activity.
- Read the NASA Context sheet at the end of the Educator Notes for helpful background information about NASA's work with sensors and advanced air mobility (AAM).
- If placing students into groups, have the groups prearranged.
- Have a variety of miscellaneous materials available for the final project or allow time for students to bring materials from home.
- Print Research Links and copies of one or more of these mazes to use with the Engage activity:
  - STEM maze "S": A-MAZE-ING WOMEN OF STEM: SCIENCE www.nasa.gov/sites/default/files/atoms/files/pdf-womenstemmaze-science9.pdf
  - STEM maze "T": A-MAZE-ING WOMEN OF STEM: TECHNOLOGY www.nasa.gov/sites/default/files/atoms/files/womenstemmaze-tech3.pdf
  - STEM maze "E": A-MAZE-ING WOMEN OF STEM: ENGINEERING www.nasa.gov/sites/default/files/atoms/files/edu_womenstemmaze-eng.pdf
  - STEM maze "M": A-MAZE-ING WOMEN OF STEM: MATHEMATICS www.nasa.gov/sites/default/files/atoms/files/womenstemmaze-math3.pdf

Grades 6 to 9

Suggested Pacing

120 to 150 minutes

Materials

- ☐ Blindfold or something else to cover students' eyes so they cannot see
- ☐ Research Links printed out
- ☐ STEM mazes printed out
- ☐ Pencils
- ☐ Computers with internet access
- ☐ Simple sensors (e.g., smoke detector, thermometer, ultraviolet (UV) beads)
- ☐ Materials to showcase student ideas (will differ for each student)

National STEM Standards

- ISTE 1.1.c, 1.3.a, 1.3.c, 1.3.d, 1.4.a, 1.5.a, 1.5.c, 1.6.a, 1.6.c, 1.6.d, 1.7.a, 1.7.c, 1.7.d
- NGSS MS-PS4-3
- PS4.C

An idea for a future air taxi hovers over a municipal vertiport in this NASA illustration.

Facilitate the Challenge

Engage

Begin the activity by playing a paper-based game. Model the game with students first so they will have a chance to experience the game and ask questions, then pair students and have them play the game together. By playing the game, students will learn that sensors provide information about a nearby area but do not actually provide information about where to go.

In this game, the sensor (the person who is **not** blindfolded) provides the drone (the person who **is** blindfolded) information about the maze through feedback (sound or tap) when the drone approaches a wall. Through trial and error, the drone (blindfolded student) will try to navigate the NASA STEM maze using a writing utensil. Students acting as drones should not see the mazes before the activity begins.

- Two students will work together as a team. The student who is blindfolded will be the uncrewed drone, and the student who is not blindfolded will be the sensor.
  - The job of the blindfolded drone is to navigate the maze with a writing utensil.
  - The job of the sensor is to tell the drone when it bumps into a wall, is about to hit the wall, or is going in the wrong direction. This will be done by saying one word or by making a sound; for example, the sensor can say "no" or "beep" or even gently tap for haptic feedback. The sensor **cannot** tell the drone which way to go; for example, the sensor may not say "left" or "forward." When the student pretending to be the drone hears the keyword or sound or feels the tap, they will know to stop and go in a different direction. Teams should decide what the word or sound will be prior to starting the game.
- When the educator models this for the class, the educator should be the drone, and the students should be the sensor.
- Once students are paired, have each pair decide
  - Who will be the drone the first time through the maze
  - What word or sound or tap the sensor will use to direct the drone
- Remind students to keep the maze facedown on the desk.
- Have the drones sit down and put on their blindfolds. For safety reasons, the blindfolded person must remain seated at all times. Have each sensor place a writing utensil in the drone's hand.
- When all the students are paired and ready, have each sensor turn the maze over and position the other student's hand (drone), holding the writing utensil, at the beginning of the maze.
- Have everyone begin at the same time.
  - When the educator starts the game, the drones will move their writing utensils in whichever direction they think they should be going to get through the maze.
  - Sensors will use the single word or sound or tap that was decided on prior to starting to let the drones know when they are going in the wrong direction or when they are going to hit the wall of the maze.
- Give students a time limit of about 2 to 3 minutes. When time is up, have students turn their mazes facedown.
- Ask team members to switch roles.
  - Have the new drone sit down and put on the blindfold.
  - Have the new sensor place the writing utensil in the drone's hand. For safety reasons, the blindfolded person must remain seated at all times.
- When everyone in the room is ready, have sensors turn the maze over and position the drone's hand, holding the writing utensil, where the previous drone left off in the maze.
- Have everyone begin at the same time to try to navigate through the maze.
- After another 2 to 3 minutes, have the drones put down the writing utensils and take off the blindfolds.
- Identify which team was able to get farthest through the maze (or fastest).
- Discuss the following questions with the whole group:
  - How difficult was this activity? What was most difficult?
  - Would it have been easier to tell the drone where to go versus where not to go?
  - Were there any strategies you used to make it easier? What were they?
- Have students work in pairs or teams to answer these questions from their own experiences and knowledge:
  - What is a sensor?

- What everyday things have sensors in them?
- How can sensors make your life easier?
- Are there ways sensors can make life more difficult?

- Discuss the questions with the whole group. Do not correct answers; accept all responses and let students know they will revisit their answers later in the activity. After learning more about sensors, students will come back to these questions to see if their answers have changed.

Explore

- Share with students the video "How UAS Impacts the Future." https://youtu.be/FfC4G45-CbQ
- Ask students the following questions to get them thinking about sensors.
  - How do uncrewed drones work without bumping into things?
  - How would uncrewed drones locate fires?
  - If drones are uncrewed, how can they make deliveries?
  - What type of sensors or equipment would delivery drones need to have on board in order to complete their task(s)?
  - What are some other ways you imagine drones helping in the future?
    - Students may not be able to answer this yet, depending on their exposure to drones. Revisit this question toward the end of the activity to see if they have more to add to their answers.
- Have students explore the website "NASA Home & City." https://homeandcity.nasa.gov/
  - Remind students to click on each "Learn More" icon, watch the short videos, and then scroll down to click "Read more in *Spinoff*."
  - While they are exploring, have students create a graphic organizer that will
    - Identify five to eight objects containing sensors.
    - Note which type of sensor each object contains.
    - Explain how that sensor has been used by NASA. For example, there is a temperature sensor in the precision coffee maker that was adapted from technology used in NASA's Mobile Autonomous eXplorer (MAX) 5A unmanned ground vehicles. https://homeandcity.nasa.gov/nasa/kitchen/151/precision-coffee-maker
- Have students share some of the items they put on their graphic organizers and discuss what the objects are, the types of sensors they contain, and how the sensor is helpful.
- Share with students examples of simple sensors or instances of sensors in the classroom. Examples could include a smoke detector, lights activated by a motion sensor, or an infrared sensor on a TV.
- Have students do a general internet search on "small electronic sensors." This will give students a broader view of the types of sensors that exist. Limit searching to just a few minutes, then have students share what they have learned.
- Have students revisit their answers to these questions from the Engage phase:
  - What everyday things have sensors in them?
  - How can sensors make your life easier?
  - Are there ways sensors can make life more difficult?
- Ask students if any of their answers need to be adjusted. Encourage natural discussion through curiosity.

Explain

In this phase, students will conduct research on the future of airspace and the types of sensors used on drones.

- Share with students the video "What is AAM?" https://youtu.be/Vu1VWEvgd24
- Have students watch the video a second time. Be sure they have paper and a writing utensil to take notes.
  - Have students write down the types of sensors, or the type of equipment using sensors, that they recognize in the video. If students are unsure, they can list what types of sensors they think might be on the aircraft or should be on the aircraft.
- After the video, discuss the following questions:
  - How would you describe advanced air mobility (AAM)?
  - How can drones be used in the future?
  - What sensors or equipment will the drones need when uncrewed?
  - What sensors or equipment did you recognize in the video?

- Next, students will use the Research Links assigned by the educator to research drones and the types and functions of sensors (or equipment with sensors) used by drones.
  - Remind students that they do not need to read or view all the research materials listed, only those that have been assigned.
  - Students may work in groups or jigsaw this activity.
  - As an accommodation, students who read at a lower level can watch the videos or be paired with students who read at a higher level.
  - Remind all students that the materials may need to be read or watched more than once for better comprehension.
- Information should be organized into a graphic organizer.
  - What is the name of the sensor, program, or equipment?
  - What purpose does it serve?
  - How does it work?
- Some of the articles on the Research Links list may be long or written above grade level. Teach students how to skim through articles by using the "Find" function (Control + F) to pinpoint the term they are looking for.
- When students have completed their research, have them regroup and share what they learned.
- Revisit this Explore phase question: "What are some other ways you imagine drones helping in the future?" Ask students if they can think of more ideas now that they have done some research.

Elaborate

Ask students to imagine innovative solutions to real problems, small or large, facing their local community. Maybe they face this problem in their own lives, or maybe they know of others facing this problem. Ask students to show how they could solve this problem by designing a sensor, either using household materials or electronics kits. Electronics kits that integrate both simple and more complex sensors can be found online at a range of prices.

- Have students work individually or in teams to brainstorm and design a plan that considers these questions:
  - What is the problem?
  - What is the solution to the problem?
  - How will the sensor help solve the problem?
  - What is the type of sensor?
  - How does the sensor work?
  - Where else could this sensor be used?
    - Can it be used in an aircraft, vehicle, or on its own? Remind students that inventions or products are often just as helpful, or even more helpful, in other applications later on. NASA spinoffs are good examples of this.
  - Who or what will benefit from it?
- After students create a plan for their problem-solving sensor, have them share their ideas with the whole group or with another team and get feedback on their design. Have them use the feedback to make improvements.

Evaluate

Have students share their ideas in one of the following ways. Remind them to also include a written description of their sensor and the role it plays in solving the problem (250 words or less). Students may showcase their work through virtual, online, or "in real life" presentations, gallery walks, or displays.

- Build and test the actual sensor.
- Film a short (1-minute) video or commercial about the sensor and the role it plays in solving the problem.
- Illustrate a comic book describing the sensor and the role it plays in solving the problem.
- Draw or paint a detailed picture of the sensor and the role it plays in solving the problem.
- Build or 3D-print a model of the sensor.
- Write an essay or story about the sensor design and the role it plays in solving the problem.
- Write and sing a song (with descriptive lyrics) about the sensor and the role it plays in solving the problem.
- Create digital artwork of a sensor.

- Create an artistic representation of a sensor design and the role it plays in solving the problem.
- Develop an entertaining presentation about a sensor and the role it plays in solving the problem.
- Create a mock patent of a sensor design, including detailed descriptions on how to make it.

Assessment

5E Step	Novice (0)	Apprentice (1)	Journeyperson (2)	Expert (3)	Level of student knowledge (Score)
Engage	Student does not identify any prior knowledge or connections to previous learning experiences	Student identifies irrelevant or inaccurate prior knowledge or connections to previous learning experiences	Student identifies one example of relevant and accurate prior knowledge or connection to previous learning experiences	Student identifies two or more examples of relevant and accurate prior knowledge or connections to previous learning experiences	
Explore	Student does not participate in a brainstorming discussion	Student participates in brainstorming discussion (e.g., asks questions) but does not contribute possible hypotheses, solutions, or tests	Student contributes at least one possible hypothesis, solution, or test to brainstorming	Student contributes at least one possible hypothesis, solution, or test to brainstorming and an alternative or improvement to another student's idea	
Explain	Student does not provide an explanation of observations	Student provides an explanation of observations that is inaccurate or incomplete or lacks evidence	Student provides an accurate, complete explanation of observations based on evidence	Student provides an accurate, complete explanation of observations based on evidence and supplements their reasoning with either evidence or evidence-based explanations from others	
Elaborate	Student does not draw reasonable conclusions based on evidence	Student draws reasonable conclusions but does not utilize scientific terminology or evidence	Student draws reasonable conclusions utilizing scientific terminology and evidence	Student draws reasonable conclusions utilizing scientific terminology as well as evidence and can make reasonable predictions based on those conclusions	
Evaluate	Student does not demonstrate understanding of concept or can only repeat provided definitions	Student demonstrates an understanding of concept by providing definitions or explanations in their own words, drawings, models, etc.	Student demonstrates an understanding of concept by applying it to new questions or by analyzing new evidence	Student demonstrates an understanding of concept by explaining how evidence caused their knowledge to progress over time or by proposing new ways to use their new knowledge (such as followup experiments)	
				Total	

Reference

Rover Races Activity. https://www.nasa.gov/stem-ed-resources/rover-races-activity.html

Extensions

- How Would You Measure the Moon? https://www.nasa.gov/centers/glenn/stem/make-it-nasa/content-modules/
- For higher level students or technology classes, students can develop a survey for the community before creating the sensor. The survey can be used to guide the students in creating the best sensors to help benefit the community.
- After presentations have been shared, students can choose the sensors that would best benefit the community. If time permits, students can modify the chosen sensor to help benefit the community.
- Encourage students to find problems in different regions of the world that could be solved by sensors. For example, the Himalayas may need a sensor for detecting avalanches. Hawaii has volcanic activity and tsunamis. Other countries are rich in agriculture. Sensors could monitor cow hormone levels to tell farmers the best time to milk the cow. Place students in groups to research sensors and their possible uses in other geographical areas.

NASA Context

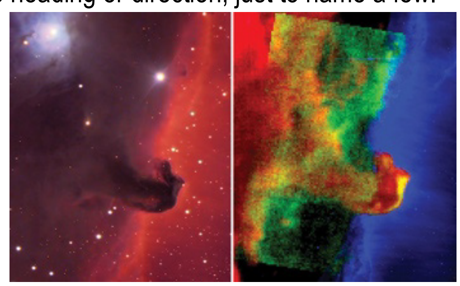
What Are Sensors?

Humans gather information about the world around them through their sensory organs—eyes, ears, nose, tongue, and skin. The technology we create, such as robots and unmanned aerial vehicles (UAVs, commonly referred to as "drones") uses sensors in much the same way. Anything that has a consistent reaction (sometimes called an *output)* to a given situation (also called a *stimulus* or *input*) can function as a sensor. For example, the chemical that makes a red cabbage red is an excellent pH sensor, as it reliably turns varying shades of red or blue in response to how acidic or alkaline the liquid it is in happens to be. Many sensors act as *transducers*, which is defined as anything that converts energy from one form to another. For example, a computer mouse turns the mechanical energy of being moved around into electrical energy that the computer can process. A sensor is *digital* if it can only be on or off, like a traditional light switch; a sensor is *analog* if it can be partway on, like a volume dial. Just as eyes and ears sense light or sound but not both, no single sensor can detect everything. A simple string with some bells attached makes for an excellent motion detector, for example. If you taped that do-it-yourself sensor to a door, you would definitely know when someone opened it. However, that sensor would not tell you who had opened the door.

Though advances in machine learning are helping drones perceive the world in more human-like ways, these sensors have historically been very specialized. Instead of pointing a camera at an object and having the computer attached to it determine "that is a lemon," a very basic robot might have one sensor to detect the color yellow, a second sensor to detect the smell of the chemical limonene, and a third sensor to make sure the object in question is the right size and shape. As the complexity of a task increases, the number, variety, and complexity of the sensors must also increase. Flight is a very complex task, so a drone might have an altimeter to measure height off the ground, a barometer to detect local weather conditions, and a compass to detect the heading or direction, just to name a few.

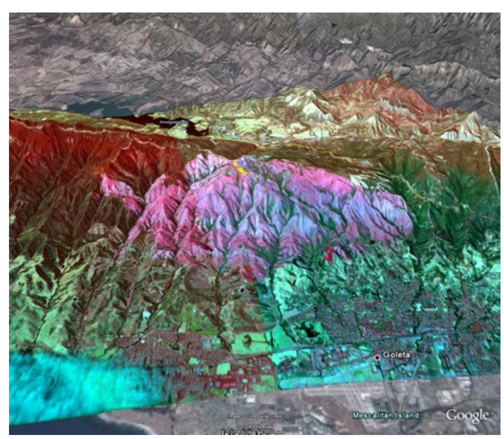
Sensors at NASA

At NASA, physics and engineering concepts are used to develop sensors with a variety of uses and applications. The Stratospheric Observatory for Infrared Astronomy (SOFIA) is a special aircraft with a special telescope and onboard instruments that allow humans to see things in space that our eyes cannot see. SOFIA is designed to observe the infrared universe. Many objects in space emit almost all their energy at infrared wavelengths and are often invisible when observed with visible light.



Images of the Horsehead Nebula taken by NASA's SOFIA aircraft. Visible image (left) and infrared image (right). The dust that forms the Horsehead blocks visible light but glows brightly in the infrared. (NASA/Dylan O'Donnell (left); NASA/SOFIA/J. Bally et al. (right))

NASA's Ikhana drone participated in the Western States Fire Missions from 2007 to 2009. Through these flights, Ikhana demonstrated improved wildfire imaging and mapping capabilities. NASA Ames Research Center at Moffett Field, California, developed Ikhana's sophisticated sensor and real-time data communications equipment, the Autonomous Modular Sensor (AMS). During the Fire Missions, the AMS was capable of peering through thick smoke and haze to record hot spots and the progression of wildfires over a lengthy period. The data gathered was overlaid on Google Earth maps and downlinked in near-real-time to the Interagency Fire Center in Boise, Idaho. In the image below right, yellow depicts active fire areas to assist incident commanders in allocating firefighting resources.



(Left) With its sensor pod under its left wing, NASA's Ikhana drone flies over California during the Western States Fire Mission. (NASA/Jim Ross)
(Right) This image of the American River Complex was taken by Ikhana's onboard Autonomous Modular System wildfire scanner in 2008.
This image provides information about the fire, vegetation type, and burned areas. (Google)

Future Airspace

A new future for air transportation is in the works at NASA. This new future, where both people and packages will take to the air, is called Advanced Air Mobility, or AAM. NASA's vision for AAM is to develop a safe, accessible, automated, and affordable air transportation system that allows passengers and cargo to travel on demand in innovative aircraft—across town, between neighboring cities, or to other locations typically accessed by car.

The future of aviation will depend on sensors to navigate the airspace. Compared with traditional airplanes and helicopters, the aircraft that will fly in this new airspace are typically smaller in size, and many of these aircraft are self-flying, or autonomous. There are many potential benefits and challenges of new sensing technology, and NASA wants to ensure the market is sustainable, secure, and safe. These drones will be used as air taxis and package delivery vehicles, provide emergency response, perform rescue missions and medical drops, conduct aerial photography, and much more.

Mapping and monitoring are two areas where NASA and other AAM researchers are working to develop new and more sophisticated systems. The presence of people, buildings, and other obstacles at low altitudes makes it unrealistic to continuously track or control these aircraft using radar or satellite technology. Instead, these small aircraft will use onboard sensors to monitor flight conditions to ensure safety. It will also be important to map the sky at 400 feet and below. Creating a digital 3D roadmap of the sky will improve navigation software and make it safer to fly. Safety will also be enhanced by programs such as Safeguard, which was created using NASA-developed technology. Safeguard can keep drones from traveling outside their scheduled flight paths by setting up a geofence—an invisible fence around a specific area.

Research Links

Articles

Advanced Air Mobility for Healthcare (reading level: medium)
https://www.nasa.gov/centers/armstrong/features/aam-for-healthcare.html

Volcano-Observing Drone Flights Open Door to Routine Hazard Monitoring (reading level: difficult)
https://www.nasa.gov/feature/ames/volcano-observing-drone-flights-open-door-to-routine-hazard-monitoring

Building Future Air Taxis To See Through the Fog (reading level: medium)
https://www.nasa.gov/feature/ames/building-future-air-taxis-to-see-through-the-fog

Flights Help 'Teach' Drones To Navigate the World (reading level: medium)
https://www.nasa.gov/image-feature/ames/flights-help-teach-drones-to-navigate-the-world

Advanced Air Mobility for Emergencies (reading level: medium)
https://www.nasa.gov/centers/armstrong/features/aam-for-emergencies.html

Chemical Sensors (reading level: medium). https://www1.grc.nasa.gov/research-and-engineering/chemical-sensors/

High Altitude UAV for Monitoring Meteorological Parameters (reading level: medium)
https://technology.nasa.gov/patent/LAR-TOPS-281

Eagle Eyes in Treacherous Skies (reading level: medium). https://spinoff.nasa.gov/eagle-eyes-in-treacherous-skies

Sensors Detect Icing Conditions To Help Protect Airplanes (reading level: medium)
https://www.nasa.gov/content/sensors-detect-icing-conditions-to-help-protect-airplanes

NASA, Industry Complete Third Phase of UAS Flight Testing (reading level: difficult)
https://www.nasa.gov/centers/armstrong/features/detect_and_avoid.html

Wildfire Workshop Accelerates NASA Firefighting Solutions (reading level: difficult)
https://www.nasa.gov/aeroresearch/wildfire-workshop-accelerates-nasa-firefighting-solutions

NASA Begins Air Taxi Flight Testing With Joby (reading level: medium)
https://www.nasa.gov/press-release/nasa-begins-air-taxi-flight-testing-with-joby

Videos

Detect and Avoid (video). https://youtu.be/XTrX88rZ9NM

Fiber Optics Sensing System: A New Technology for Measurement (video). https://youtu.be/_CdULw4-j_o

It's Raining Drones! NASA Drops 100 Drones Tiny Enough To Fit in Your Hand (video). https://youtu.be/nS_iO8uNBMA

NASA's Safeguard System: An Assured Safety Net Technology for UAS (video). https://youtu.be/0Kc01cV7vCU

NASA's Research Efforts and Management of Unmanned Aircraft Systems (video). https://youtu.be/7IJfez-ZuRM

Orion and Ikhana UAS (video). https://youtu.be/ihAlsdZgtZE

Flight Test Series Provides a UAS Road Map (video). https://youtu.be/cF2S81xmGr0

NASA's Drone Traffic Management System Completes Final Tests (video). https://youtu.be/jIs_fWFjUA4

NASA Supports Advanced Air Mobility Development and Testing (video). https://youtu.be/iBsgqNFM_XU

The LA–8, NASA's New eVTOL Testbed (video). https://youtu.be/-Z_r6GgK7M4

NASA's Advanced Air Mobility Playbook: Automation (video). https://youtu.be/bXY5sxT3J0Y

NASA's Advanced Air Mobility Playbook: Emergency Response (video). https://youtu.be/iVKN8p2EIU4

NASA's Advanced Air Mobility Playbook: Healthcare (video). https://youtu.be/oGdiLPOYgcY

NASA's Advanced Air Mobility Playbook: Vertiports (video). https://youtu.be/JDZUhHvo4bg

Sensor Solutions

Your Challenge

In this activity, you will gain a better understanding of the types of sensors installed on drones, how the sensors work, any advantages and limitations of the sensors, and how a drone's sensors can provide benefits to society while improving safety features for sharing the airspace with other aircraft. You will imagine innovative solutions to real-world problems facing your local communities and demonstrate how those problems could be solved by designing a sensor.

Engage

To begin learning more about sensors and drones, you will participate in a short activity where you and a teammate will pretend to be a sensor or a drone. The idea of the game is to show how sensors provide information about a nearby area without actually providing information about where to go.

In this game, the sensor (the person who is **not** blindfolded) gives the drone (the person who **is** blindfolded) information about the maze through feedback (sound or tap) when the drone approaches a wall. Through trial and error, the drone (blindfolded student) will try to navigate the STEM maze (provided by the instructor) using a writing utensil. The student acting as a drone should not see the mazes before the activity.

- Two students will work together as a team. The student who is blindfolded will be the uncrewed drone, and the student who is not blindfolded will be the sensor.
  - The job of the blindfolded drone is to navigate the maze with a writing utensil.
  - The job of the sensor is to tell the drone when it bumps into a wall, is about to hit the wall, or is going in the wrong direction. This will be done by saying one word or by making a sound; for example, the sensor can say "no" or "beep" or even gently tap the drone. The sensor **cannot** tell the drone which way to go; for example, the sensor may not say "left" or "forward." When the student pretending to be the drone hears the keyword or sound or feels the tap, they will know to stop and go in a different direction.
- Your instructor will first demonstrate how the game works. Be sure to pay attention and ask questions.
- When you are paired into teams, decide
  - Who will be the drone the first time through the maze
  - What word or sound or tap the sensor will use to direct the drone
- Keep the maze facedown on the desk. Do not look at the maze before beginning the activity.
- The drone will sit down and put on the blindfold. For safety reasons, the blindfolded person will always remain seated. The sensor will put the writing utensil into the drone's hand.
- When everyone in the room is ready to play, your instructor will tell the sensors to turn the maze over and position the drone's hand, holding the writing utensil, at the beginning of the maze.
- The instructor will give a signal for everyone to begin.

Local governments prepare their transportation plans to include this new form of air travel known as advanced air mobility (AAM).

In the future, AAM could be used in healthcare operations in the form of air taxi ambulances or medical supply delivery.

Career Corner

We Want You! Many new opportunities await our next generation of explorers. Unmanned aerial vehicles (UAVs), also called drones, will impact the way we work, commute, and live. Imagine how awesome it would be to take a ride on a drone to a friend's house, or get your favorite midnight snack delivered to your home!

What kind of new career opportunities await you, and how can you prepare? As NASA's groundbreaking technologies are rapidly changing our world today, so are the careers that will be necessary to build the technical breakthroughs of tomorrow.

Learn more: https://www.youtube.com/watch?v=FfC4G45-CbQ

  - When the instructor starts the game, the students pretending to be drones will move their writing utensils in whichever direction they think they should be going to get through the maze.
  - Sensors will use the single word or sound or tap that was decided on prior to starting to let the drones know when they are going in the wrong direction or when they are going to hit the wall of the maze.
- The instructor will allow a time limit of about 2 to 3 minutes. When time is up, turn the maze facedown.
- Teammates will now switch roles. The drone becomes the sensor, and the sensor becomes the drone.
  - Drones will sit down and put on the blindfolds. For safety reasons, the blindfolded students will always remain seated.
  - Sensors will place the writing utensil in the drone's hand.
- When everyone in the room is ready, the students acting as the sensor will turn the maze over and position the drone's hand, holding the writing utensil where the previous drone left off in the maze.
- At the instructor's signal, everyone will begin at the same time to try and navigate their drones through the maze.
- After another 2 to 3 minutes, the instructor will signal the end of the game. All drones must drop their writing utensils and remove their blindfolds.
- Your instructor will identify which team was able to get farthest through the maze (or fastest).
- Be prepared to discuss the following questions with the whole group:
  - How difficult was the activity? What was most difficult?
  - Would it have been easier to tell the drone where to go versus where not to go?
  - Were there any strategies you used to make it easier ? What were they?
- From your own experiences and knowledge, answer these questions, then be prepared to discuss them with the whole group:
  - What is a sensor?
  - What everyday things have a sensor in them?
  - How can sensors make your life easier?
  - Are there ways sensors can make life more difficult?

Explore

- Watch the video "How UAS Impacts the Future." https://youtu.be/FfC4G45-CbQ
- Answer the following questions:
  - How do uncrewed drones work without bumping into things?
  - How would uncrewed drones locate fires?
  - If drones are uncrewed, how can they make deliveries?
  - What type of sensors or equipment would delivery drones need to have on board in order to complete their task(s)?
  - What are some other ways you imagine drones helping in the future? (You can come back and visit this question again toward the end of the activity to see if you have more to add to your answers.)
- Explore the website "NASA Home & City." https://homeandcity.nasa.gov/.
- While you are exploring, create a graphic organizer that will
  - Identify five to eight objects containing sensors.
  - Note which type of sensor each object contains.
  - Explain how that sensor has been used by NASA. For example, there is a temperature sensor in the precision coffee maker that was adapted from technology used in NASA's Mobile Autonomous eXplorer (MAX) 5A unmanned ground vehicles
  - Be sure to click on the "Learn More" icons, watch the short videos, and scroll down to click "Read more in *Spinoff.*"
- With the whole group, share some of the items you put on your graphic organizer and discuss what the objects are, the types of sensors that they contain, and how the sensor is helpful.
- To get more ideas of types of sensors, do a general internet search on "small electronic sensors." List the sensors that you found.
- At this point, revisit these three questions from the Engage phase. Check to see if any of your answers need to be adjusted.
  - What everyday things have sensors in them?
  - How can sensors make your life easier?
  - Are there ways sensors can make life more difficult?

Explain

In this phase, you will research the future of airspace and the types of sensors used on drones.

- Watch the video "What is AAM?" https://youtu.be/Vu1VWEvgd24
- Watch the video again. Be sure you have paper and a writing utensil to take notes.
  - Write down the types of sensors or the type of equipment using sensors that you recognize in the video. If you are unsure, list what types of sensors you think might be on the aircraft or should be on the aircraft.
- After the video, answer the following questions and be ready to discuss them with the whole group:
  - How would you describe advanced air mobility (AAM)?
  - How can drones be used in the future?
  - What sensors or equipment will the drones need when uncrewed?
  - What sensors or equipment did you recognize in the video?
- Your teacher will assign research links to each group to research drones and the types and functions of sensors (or equipment with sensors) used by drones. You do not have to read or view all the material on the Research Links sheet, only those your teacher has assigned to you. You can share the information you learn at the end of this phase.
  - You may need to read or watch materials more than once for better comprehension.
- Information should be organized into a graphic organizer. Include the following:
  - What is the name of the sensor, program, or equipment?
  - What purpose does it serve?
  - How does it work?
- Some articles may be long or written above your grade level. They do not all have to be read from beginning to end. Find the section of the article that has information on sensors or equipment containing sensors (e.g., radar or infrared).
- Regroup and share what you learned with the whole group.
- Revisit this Explore phase question: "What are some other ways you imagine drones helping in the future?" Can you think of more ideas now that you have done some research?

Elaborate

Imagine innovative solutions to real problems, small or large, facing your local community. Maybe you face this problem in your own life, or maybe you know of others facing this problem. Show us how you could solve this problem by designing a sensor, either using household materials or electronics kits. Electronics kits that integrate both simple and more complex sensors can be found online at a range of prices.

- Brainstorm and design a plan.
  - What is the problem?
  - What is the solution to the problem?
  - How will the sensor help solve the problem?
  - What is the type of sensor?
  - How does the sensor work?
  - Where else could this sensor be used?
    - Can it be used in an aircraft, vehicle, or on its own? Remind students that inventions or products are often just as helpful, or even more helpful, in other applications later on. NASA spinoffs are good examples of this.
  - Who or what will benefit from it?
- After you create a plan for your problem-solving sensor, share your ideas with the whole group or with another team and get feedback on your design. Use the feedback to make improvements.

✓ Evaluate

Share your ideas in one of the following ways. Include a written description of your sensor and the role it plays in solving the problem. Your description should not be longer than 250 words. You can showcase your work through virtual, online, or "in real life" presentations, gallery walks, or displays.

- Build and test the actual sensor.
- Film a short (1 minute) video or commercial about your sensor and the role it plays in solving the problem.
- Illustrate a comic book describing your sensor and the role it plays in solving the problem.
- Draw or paint a detailed picture of your sensor and the role it plays in solving the problem.
- Build or 3D-print a model of your sensor.
- Write an essay or story about your sensor design and the role it plays in solving the problem.
- Write and sing a song (with descriptive lyrics) about your sensor and the role it plays in solving the problem.
- Create a digital artwork of your sensor.
- Create an artistic representation of your sensor idea and the role it plays in solving the problem.
- Develop an entertaining presentation about your sensor and the role it plays in solving the problem.
- Create a mock patent of your sensor design, including detailed descriptions on how to make it.