Drones (Unmanned Aerial Vehicles)

S.T.E.M. Curriculum

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Abstract

This course explores a wide variety of subjects through the lens of understanding and developing a particularly useful, popular, and fun technology. Students will start by learning how unmanned aerial vehicles—drones—are used for a wide variety of purposes, including scientific endeavors, business, and even therapy. They will learn about the basic parts of a drone, learning about its mechanics and engineering. Interacting with real drones and comparing them to flying organisms, such as bats, birds, and even dinosaurs, students will then learn the basic principles of aerodynamics. Students will then explore other types of unmanned vehicles, including submersibles, and consider legal and ethical questions around this type of technology. Other subjects explored in this course include computer programming and coding, communication, aerial mapping, basic business principles, geometry, and design. Finally, students will apply what they've learned and think about how they would use aerial unmanned vehicles! Students will gain skills in all four STEM areas: science, technology, engineering, and mathematics.

Budget: Approximately $500 (can easily be reduced by borrowing or substituting materials, or expanded by ordering more supplies per class)

Grade Level: Adaptable

Additional Notes: The order of these lessons can be easily changed depending on outdoor weather (some classes center on indoor activities, while others are outdoors) or on other class needs

Lesson 1: What is a Drone?

Suggested Time: 60 minutes

Can be extended to 120 minutes or a two-part lesson if necessary. Review the Optional Multimedia Resources for additional experiments and other material. Mathematical exercises can also be added for high school students.

Overview

Students will learn about the basic parts of a flying drone (or unmanned aerial vehicle) and examine some case studies of uses in conservation, business, and therapy.

Vocabulary

- Unmanned Aerial Vehicle (UAV)
- Conservation Drone
- Model Aircrafts
- Autopilot
- Payload
- Software
- Waypoints
- Interface

Objectives

- Students will learn about unmanned vehicles and their basic engineering.
- Students will explore the many uses being developed for drones in fields such as science, business, and security.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- PS2.A. Forces of Motion.
- LS2.A-D. Interdependent Relationships, Cycle of Matter and Energy Transfer, Ecosystem Dynamics, and Energy in Chemical Processes and Everyday Life.
- LS4.A-C. Evidence of Common Ancestry and Diversity, Natural Selection, and Adaptation.
- ETS1.A-C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Project Materials

- Computer with live internet for class demonstrations
- Borrowed or purchased durable drone such as this one: http://www.amazon.com/Syma-Channel-2-4G-Quad-Copter/dp/B00906PKQ4/ref=sr_1_4?s=toys-and-games&ie=UTF8&qid=1393490917&sr=1-4&keywords=drone
- iPod nano or similar tiny camera
- Lightweight strap, string, or trustworthy adhesive

Multimedia Resources

- "A Drone's-Eye View of Conservation" by Lian Pin Koh. *TED Talks*. Video (13.31) provided and also available at http://www.ted.com/talks/lian_pin_koh_a_drone_s_eye_view_of_conservation.html
- "Pictures: Drones Take on Hurricanes, Environment Work." *National Geographic*. Slide Show http://news.nationalgeographic.com/news/2012/09/pictures/120921-hurricane-drones-nasa-usgs-environment-science/#/news-drones-control-station_59342_600x450.jpg
- "Amazon Testing Delivery By Drone." USAToday. Article and video (2.12) http://www.usatoday.com/story/tech/2013/12/01/amazon-bezos-drone-delivery/3799021/
- "Netflix Mocks Amazon With Video for DVD Delivery Drone." *Wired*. Video (1.12) http://www.wired.com/business/2014/02/netflix-heats-amazon-rivalry-dvd-delivery-drone-video/
- "Drone Club for Kids is Really, Really Awesome." *Popular Science*. Article and videos http://www.popsci.com/technology/article/2013-09/drone-club-kids-autism-makes-awesome-videos

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Set up and practice with the drone. Make sure you know how to calibrate it—set it on a flat surface and wait for it to self-calibrate before flying.

The Lesson

Part 1: Conservation Drones (20 mins)

1. Show "A Drone's-Eye View of Conservation" by Lian Pin Koh. Afterwards, review what Koh said about the important components of a drone. Have the class review the specific tasks conducted by the conservation drone in this example (including mapping orangutan nests, looking for fires, and retrieving motion-activated camera equipment).
2. What are some other potential conservation-related uses for drones?
3. Show the National Geographic slide show, "Pictures: Drones Take on Hurricanes, Environment Work."

Part 2: Drones in Business (5 mins)

1. Show the "Amazon Testing Delivery Drone" video. Then show Netflix's spoof video making fun of Amazon. This will make everyone laugh!
2. The spoof video makes some important points. What are some obstacles to using drones to deliver packages? How would Amazon have to adjust its current business model?

Part 3: Drones in Therapy (10 mins)

1. Show excerpts from the videos in "Drone Club for Kids is Really, Really Awesome" and discuss the use of drones for engagement therapy.

Part 3: Fly a Drone! (25 mins)

1. Go outside with the students and fly the drone! Make sure to let it self-calibrate first so that it flies properly.
2. Attach various small objects to it to demonstrate how much weight it can carry.
3. Attach the iPod Nano or other very small camera and record footage.

Lesson 2: The Aerodynamics of Wings

Suggested Time: 60 minutes

Can be extended to 120 minutes or a two-part lesson if necessary. If lesson is extended, consider adding a model-building exercise to Part 2 of the lesson. Mathematical exercises can also be added for high school students.

Overview

Students will learn about aerodynamics by looking at shapes and forms found in nature. They will learn the differences between monoplanes and biplanes and compare engineered flight models with those found among flying organisms like birds, bats, and dinosaurs. They will explore mathematical concepts to understand how wings create lift.

Vocabulary

- Aerodynamics
- Wings
- Biplanes
- Monoplane
- Fixed-wing aircraft
- *Microraptor gui*
- Wright Brothers
- Planform
- Dihedral Angle
- Aspect ratio
- Stability
- Velocity
- Drag
- Parasitic drag
- Lift
- Chord

Objectives

- Students will learn about the differences between monoplane and biplane designs in aviation.
- Students will learn how wing shape and design correlates with evolutionary adaptations in nature and compare this with evolutionary adaptations in engineering.
- By comparing engineered flight designs with existing designs in nature, students will learn about the mechanics of aviation and aerodynamics.
- Students will explore mathematical concepts including drag, velocity, and aspect ratio.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- PS2.A. Forces of Motion.
- LS2.A-D. Interdependent Relationships, Cycle of Matter and Energy Transfer, Ecosystem Dynamics, and Energy in Chemical Processes and Everyday Life.
- LS4.A-C. Evidence of Common Ancestry and Diversity, Natural Selection, and Adaptation.
- ETS1.A-C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Michigan Math GLCE Standards

- G.SR.07. Draw and Construct Geometric Objects.
- N.FL.07. Understand and Solve Problems Involving Rates, Ratios, and Proportions.

Required Project Materials

- Access to a computer lab with live internet connection

Multimedia Resources

- "How do Planes Fly?" Canadian Museum of Nature. Interactive gallery animation. http://www.nature.ca/discover/exb/hwdbrdsfly/index_e.cfm
- "Super Pitts Stunt Biplane at Point Mugu." Youtube video (3.11) http://youtu.be/DzhCOy5M8ck
- "Photo in the News: Dino Species Flew Like a Biplane." National Geographic News. http://news.nationalgeographic.com/news/2005/10/1018_051018_biplane_dino.html
- "Dinosaur Flew 'Like a Biplane.'" Nature News. http://www.nature.com/news/2005/051017/full/news051017-1.html
- "Paleontologists in a Flap over Four-Winged Dinosaurs." http://www.abc.net.au/science/articles/2003/01/23/767860.htm
- "Wing Geometry". NASA Kids. https://www.grc.nasa.gov/www/k-12/airplane/geom.html.

Optional Multimedia Resources

- "Biplanes, Triplanes, and Edwardian Era Aircraft." Youtube video (29.32) http://youtu.be/Iv8wJhbWseI (good for showing specific plane models)
- Many other stunt biplane videos available on Youtube
- "Dinosaur Flew Like Biplane?" Scientific American (60 second audio podcast) http://www.scientificamerican.com/podcast/episode/51192681-e7f2-99df-37e5080ce0a83a04/

Before the Lesson/ Background Information

- Print out copies of the National Geographic and Nature News articles (provided) about *Microraptor gui,* the dinosaur that flew like a biplane.
- Print out the NASA "Airplane Geometry handout" (provided) for use during class.

The Lesson

Part 1: Comparing Wings (30 mins)

1. With the class watch the interactive gallery animation, "How do Birds Fly?" Then announce to the group that species fly differently, and have different wing shapes, based on how they've adapted to their environments. Some are specialized for gliding, some only use flight to get away from predators, and some even use their wings to swim.
2. Separate the students into groups of two to four at a computer lab. Each group will conduct research on a different winged animal. Assign or allow groups to choose from the following animals (you can add more to this list if necessary):
    - Flying squirrel
    - Bat
    - Albatross
    - Hummingbird
    - Swallow
    - Goose
    - Flying Fish
    - Cormorant
    - Pelican
    - Chicken
    - Eagle
    - Penguin
    - Ostrich
3. Each group will research their animal and work to find out the following questions:
    - Can the animal fly? If so:
        - Does it fly on a regular basis, or for specific reasons?
        - How does it fly?
        - How fast can it fly?
        - How far can it fly?
        - What is its wing shape? How does the shape affect the way the animal flies?
        - How does the animal obtain "liftoff"?
    - If the animal can't fly:
        - Why does it have wings?
        - What does it use its wings for?
        - What is its wing shape?
    - What is the animal's habitat (in other words, where does it live)?
    - What does the animal eat and how does it obtain food?
4. Have each group put together a sketch of their animal with a diagram of its wings and the different kinds of feathers or parts. They should also diagram the geometry of the wings, using the "Wing Geometry" handout for comparison.
5. Have each group present to the rest of the class for one to two minutes about their animal.
6. Discuss with the class what they learned about different types of flight and wing structures found in nature.

Part 2: Lecture and Discussion (30 mins)

1. Discuss different types of biplanes and the history of aviation. Note that the biplane was the first plane invented by the Wright Brothers.
2. Discuss the advantages and disadvantages of biplanes. Cover important concepts like stability, velocity, drag, lift, and aerodynamics.
3. Show stunt biplane video and any other optional videos.
4. Have the students read, and then discuss, the articles about *Microraptor gui,* the dinosaur that flew like a biplane. Draw out the following points:
    - Why do scientists think *Microraptor gui* flew like a biplane?
    - How does this compare with how modern species fly?
    - What advantages would this dinosaur have had over other flyers?
    - What is a competing theory about how *Microraptor gui* flew?
    - What can *Microraptor gui* tell us about how biplanes fly?
    - Are biplanes still useful today? Why or why not?
    - Why did the monoplane model become dominant?

Lesson 3: Animals and Machines that Hover

Suggested Time: 60 minutes

Overview

Students will explore the earliest form of rotorcraft, a child's toy called the "bamboo dragonfly", by building their own. They will compare and contrast fixed-wing aircraft with rotary-wing aircraft, learning how to explore and apply basic principles of aviation mechanics.

Vocabulary

- Aviation
- Fixed-wing aircraft
- Rotorcraft or rotary wing aircraft
- Helicopter
- Rotor
- Propellor
- Tail Rotor
- Multicoptor
- Bamboo dragonfly
- Dragonfly
- Hummingbird
- Hover
- Hovercraft

Objectives

- Students will conduct a fun in-class experiment to discover the most ideal shape and configuration of rotors.
- Students will learn how engineered technologies are often modeled after wildlife and forms of motion found in nature.
- Students will learn how some wings (and blades) are specialized to hover, fly backwards, and perform other tasks that other winged creatures (and machines) cannot do.

Next Generation Science Standards

- MS-PS-1, MS-PS-4. Developing and Using Models.
- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- PS2.A. Forces of Motion.
- LS2.A-D. Interdependent Relationships, Cycle of Matter and Energy Transfer, Ecosystem Dynamics, and Energy in Chemical Processes and Everyday Life.
- LS4.A-C. Evidence of Common Ancestry and Diversity, Natural Selection, and Adaptation.
- ETS1.A, B, and C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Project Materials

- Thick card stock or cardboard (different materials if possible)
- Bamboo or other wooden skewers
- Wrapping paper or paint to decorate
- Craft glue

Multimedia Resources

- "Dragonfly Wings in Slow Motion." *Smarter Every Day*. Youtube video (5.59) http://youtu.be/oxrLYv0QXa4
- "Hummingbird Aerodynamics." *Smarter Every Day*. Youtube video (5.38) http://youtu.be/1VA8v1btKdQ

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Look up examples of the "bamboo dragonfly"

The Lesson

Part 1: Introduction (10 mins)

1. Tell the students that while drones take many shapes, including winged aircraft and gliders, many new drones are equipped with rotors, like helicopters. Work with the class to identify the special uses for rotor crafts and what advantages they have over other types of flying machines for certain tasks.

Part 2: Exploring the History of Rotors in Aviation (35 mins)

1. Tell the class that they will be conducting an experiment in which they will replicate the invention of the first ever "rotor", a Chinese toy called the "bamboo dragonfly", which emerged about 400 BCE. This and several other Chinese inventions, including the kite, contributed to the study of aerodynamics and gave many inventors ideas for the development of modern aviation technology, including helicopters.
2. First, have each student write out a problem statement related to the exploration of what people might have learned from this child's toy. Then they will write out a methodology for how to build and test the toy. The students will need to figure out how to construct it from the materials provided; however, the instructors may guide the students through the exercise. The instructions for building a bamboo dragonfly are as follows:
   - Cut out the shape of a blade in the card stock (have the students think about what shape of blade to use).
   - Make a hole in the middle of the blade with the pointy end of the skewer.
   - Glue the end of the skewer to the blade.
   - Decorate the "bamboo dragonfly".

3. Have the students test their bamboo dragonflies for how well they hover and how long they stay in the air. To fly them, they have to spin them quickly between the palms of their hands and release them in the air. They should try different shapes of blades. Which blade shapes work the best?
4. Have the students graph and describe the "results" of their experiments.
5. The final section will be the "significance". Have students write out why bamboo dragonflies might have been important to later developments in aviation.
6. Have each group exchange their experiment write-ups. They should then compare results, and share with the class any suggestions for improving the other group's write-up, methods, and interpretation of results.

Part 3: Animals that Hover (15 mins)

1. Show the *Smarter Every Day* videos. Remind the students that engineering models are often inspired by animals, and that studying how animals move can lead to innovations in technology. What are some other inspiring animals?
2. Ask the students to compare dragonflies and hummingbirds, both of which can hover, with helicopters. How are they the same? How are they different?

Lesson 4: Submersibles and Fluid Dynamics

Suggested Time: 60 minutes

Can be extended to 120 minutes or a two-part lesson if necessary. Review the Optional Multimedia Resources for additional experiments and other material. Mathematical exercises can also be added for high school students.

Overview

Students will learn about the science of fluid dynamics and how it relates to aerodynamics. They will study the basic engineering of submersible technologies and sketch their own design for how they might build one.

Vocabulary

- Fluid Dynamics
- Flow
- Air
- Water
- Volume
- Buoyancy

Objectives

- Students will understand that aerodynamics is a subfield of fluid dynamics, and that scientists study the flow and motion of fluids in order to engineer dynamic machines.
- Students will explore how buoyancy works by testing different shapes with a plasticine ball.
- Students will learn about future shapes for unmanned underwater vehicles and experiment with their own shapes.
- Students will learn from a youth who designed his own submarine and create designs of their own.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- PS2.A. Forces of Motion.
- LS2.A-D. Interdependent Relationships, Cycle of Matter and Energy Transfer, Ecosystem Dynamics, and Energy in Chemical Processes and Everyday Life.
- LS4.A-C. Evidence of Common Ancestry and Diversity, Natural Selection, and Adaptation.
- ETS1.A-C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Michigan Math GLCE Standards

- G.SR.07. Draw and Construct Geometric Objects.
- N.FL.07. Understand and Solve Problems Involving Rates, Ratios, and Proportions.

Required Project Materials

- Computer with live internet connection for class demonstrations
- Paper towels

Experiment 1 (Buoyancy):

- Plasticine balls
- Containers of water

Experiment 2 (Flow):

- Rubber placemats
- Scissors
- Large pans or trays of water, or an aquarium

Multimedia Resources

- "The Weird and Wonderful World of Fluids." *Wired*. Article and videos http://www.wired.com/wiredscience/2011/06/weird-world-of-fluids/
- "Kid Makes His Own Submarine Out of Scrap and Stays Underwater for 30 Minutes." *Wonderful Engineering*. Article and video (3.02) http://wonderfulengineering.com/kid-makes-his-own-submarine-out-of-scrap-and-stays-underwater-for-30-minutes/
- "Futuristic Unmanned Submarines Could Move Like Stingrays." *Mashable*. Article and video (1.14) http://mashable.com/2013/12/03/submarine-stingray/
- "Why Do Wings Help you Fly?" *TED Education*. Video (2.50) http://ed.ted.com/featured/QGAvaMwM

Optional Multimedia Resources

- "Fluids in Motion: Fun Science Experiments." *LiveScience*. http://www.livescience.com/42579-fluids-science-experiments.html
- "Sharks and Rays: Stingrays." *National Geographic*. http://video.nationalgeographic.com/video/animals/fish-animals/sharks-and-rays/stingray/

Before the Lesson/ Background Information

- Review "Fluids in Motion: Fun Science Experiments" for possible additional experiments.

The Lesson

Part 1: Introduction (10 mins)

1. With the class go through "The Weird and Wonderful World of Fluids" as a slideshow and also watch the videos as desired. Let the students know that air is a fluid and that aerodynamics is actually a subfield of fluid dynamics. Work with the class to understand why it's important for engineers to study fluid dynamics.
2. Discuss the shapes of fish and aquatic mammals. How are they similar to flying animals? (Hint: don't they look an awful lot like wings?)

Part 2: Buoyancy Experiment (20 mins)

1. Show and discuss "Kid Makes His Own Submarine Out of Scrap and Stays Underwater for 30 Minutes." Using the picture of the youth's submarine, work with the class to identify the functions of its parts. What are the most important features of a submarine? (These can include buoyancy, watertight conditions, safety features, etc.)
2. Separate the class into groups of about four students. Each group should immerse the plasticine ball in the water and record the results. Then have the groups form the ball into different shapes, including disks and bowls, and observe if and how quickly a particular shape sinks. Why does this take place?

Part 3: Flow Experiment (30 mins)

1. Show and discuss "Futuristic Unmanned Submarines Could Move Like Stingrays." What are some uses for unmanned submarines?
2. In groups, have the students cut shapes from the rubber mat. They should make some that look like stingrays, and some made in other shapes. Can they replicate how a stingray moves and observe the way they move in water? How does this compare with other shapes?
3. Have the groups design their own submersible. Each group will need to come up with:
    - A statement of purpose describing the purpose of the submersible
    - A list of features (such as safety alarm, camera, etc.)
    - A sketched design of what the submersible would look like, complete with labels and rudimentary measurements
4. Each group will present their creation before the rest of the class for one to two minutes.
5. Discuss with the class what they learned about how different shapes affect fluid dynamics.
6. Show the TED Education video, "Why Do Wings Help you Fly?" Remind the class that the science of fluid dynamics is ongoing, that there are competing theories about how flying animals and machines work, and that there is much more to be discovered!

Lesson 5: Legal and Ethical Issues in Drone Use

Suggested Time: 60 mins

Overview

Students will critically examine and discuss legal and ethical concerns related to the use of unmanned aerial vehicles (UAVs) in certain industries including business, media, and law enforcement. They will weigh both sides and construct arguments in favor of, and opposition to, use of drones in certain contexts, then work in groups to come up with their own solutions and compromises.

Vocabulary

- Constitutional rights
- Civil liberties
- Privacy concerns
- Surveillance
- Law Enforcement
- Media
- Journalism
- Airspace
- Federal Aviation Administration (FAA)
- Regulations

Objectives

- Students will engage in critical and collaborative thinking exercises around complicated technologies.
- Students will develop their own solutions, taking into account the social and political implications of engineered technologies.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- ETS1.A, B, and C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Materials

- Computer lab with live access to the internet (optional)
- Printed articles for discussion guidance

Multimedia Resources

- "Unmanned Aircraft Systems." *Federal Aviation Administration*. http://www.faa.gov/about/initiatives/uas/

Optional Multimedia Resources

- "FAA Halts Man's Drone Photography Business Over Regulations." *The Blaze*. Article and videos at http://www.theblaze.com/stories/2013/03/15/faa-halts-mans-drone-photography-business-over-regulations/
- "Drones Present a Challenge to FAA." The Buffalo News. Article http://www.buffalonews.com/business/drones-present-a-challenge-to-faa-20140211
- "Domestic Drones." American Civil Liberties Union (ACLU). https://www.aclu.org/blog/tag/domestic-drones
- "Drones at Work Worldwide, but U.S. Still Lacks Laws." Voice of America. Article and video http://www.voanews.com/content/drones-at-work-worldwide-but-us-still-lacks-laws/1859180.html
- "Lawmakers May Restrict Drone Aircraft for Privacy's Sake." The Seattle Times. Article http://www.voanews.com/content/drones-at-work-worldwide-but-us-still-lacks-laws/1859180.html
- "Surveillance Drones." Electronic Frontier Foundation (EFF). https://www.eff.org/issues/surveillance-drones
- "Privacy Issues Hover Over Police Drone Use." The Washington Post. http://www.washingtonpost.com/wp-dyn/content/article/2011/01/22/AR2011012204026.html?sid=ST2011012300293

Before the Lesson/ Background Information

- Print out up-to-date news articles about FAA and state regulations on drones, pressing legal and ethical issues, and court cases. Make sure and provide balanced views. Some example articles are provided under "Optional Multimedia Resources". View videos to determine which ones to show in class.

The Lesson

Part 1: Researching and Debating the Issues (30 mins)

1. Show videos from "FAA Halts Man's Drone Photography Business Over Regulations" and other videos, if desired, and briefly discuss the main points of the articles.
2. Split the students up into four teams and pass around the articles for guidance. Each team will research, discuss, and present on the legal and ethical concerns associated with the use of drones in the following domestic contexts:
    - Use of drones in law enforcement
    - Drones and business: safety issues, such as collisions and crashes, and the need to share airspace with other vehicles
    - Drones in security, surveillance, and media journalism: invasion of privacy and concerns related to constitutional rights
    - Drones in business and industry: drones and other robots replacing humans in

certain types of employment, e.g., delivery services

3. Each group should work to:
   - Identify the advantages of using drones in the particular context
   - Identify the disadvantages of using drones in the particular context, focusing on ethical and legal concerns
   - Set up arguments for and against use of drones
   - Work toward a compromise by outlining solutions, such as rules and regulations, or physical modifications to drone technology, that would address concerns and ensure fairness

Part 2: Presentations and Class Discussion (30 mins)

1. Each group should pick two representatives. One will present a one-minute argument in favor of using drones in this context. The other will present the opposing one-minute argument. Then the two representatives, or the rest of the group, will present the solutions they discussed. Finally, they will take questions and lead discussion on the topic with the rest of the class.
2. In total, each group's presentation and discussion should take about 5 minutes.
3. Hold final discussion with the students and seek individual comments.

Lesson 6: Drone Demonstration

Suggested Time: 60 minutes

Overview

Students will go on a field trip to fly a drone with a professional drone designer. They will tour his or her workspace, examine the parts of a drone, learn about the software used to code a drone, view component parts and attachments, and assist with flying a professional drone outside.

Vocabulary

- Aerial Unmanned System
- Conservation Drone
- Model Aircraft
- Autopilot
- Payload
- Software
- Waypoints
- Interface

Objectives

- Students will learn about unmanned vehicles and have a chance to interact with their component parts under the guidance of a professional drone designer.
- Students will explore the many uses being developed for drones in fields such as science, business, and security.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- PS2.A. Forces of Motion.
- ETS1.A-C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Project Materials

- None

Multimedia Resources

- None

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Contact a local drone company, such as Harry Arnold's Detroit Drones (http://www.detroitdrone.com) to arrange field trip. If possible, arrange a tour of the workshop where drones are made as well as an outdoor demonstration.

The Lesson

Field Trip (60 mins including travel time)

1. Ask the students to list questions prior to the field trip.
2. The drone maker should explain the component parts of the drone and demonstrate how drones are coded in open-source language.

Part 2: Drones in Business (5 mins)

1. Show the "Amazon Testing Delivery Drone" video. Then show Netflix's spoof video making fun of Amazon. This will make everyone laugh!
2. The spoof video makes some important points. What are some obstacles to using drones to deliver packages? How would Amazon have to adjust its current business model?

Part 3: Drones in Therapy (10 mins)

1. Show excerpts from the videos in "Drone Club for Kids is Really, Really Awesome" and discuss the use of drones for engagement therapy.

Part 3: Fly a Drone! (25 mins)

1. Go outside with the students and fly the drone! Make sure to let it self-calibrate first so that it flies properly.
2. Attach various small objects to it to demonstrate how much weight it can carry.
3. Attach the iPod Nano or other very small camera and record footage.

Part 2: Lecture and Discussion (30 mins)

1. Discuss different types of biplanes and the history of aviation. Note that the biplane was the first plane invented by the Wright Brothers.
2. Discuss the advantages and disadvantages of biplanes. Cover important concepts like stability, velocity, drag, lift, and aerodynamics.
3. Show stunt biplane video and any other optional videos.
4. Have the students read, and then discuss, the articles about *Microraptor gui,* the dinosaur that flew like a biplane. Draw out the following points:
    - Why do scientists think *Microraptor gui* flew like a biplane?
    - How does this compare with how modern species fly?
    - What advantages would this dinosaur have had over other flyers?
    - What is a competing theory about how *Microraptor gui* flew?
    - What can *Microraptor gui* tell us about how biplanes fly?
    - Are biplanes still useful today? Why or why not?
    - Why did the monoplane model become dominant?

Lesson 7: Coding and Communicating with Drones

Suggested Time: 60 mins

Can be extended to 120 minutes or a two-part lesson if necessary. Materials for class extension are provided in the "Optional Multimedia" section. These optional materials are most appropriate for high school and upper middle school students.

Overview

Students will learn basic concepts used in computer programming, then move on to learning their own code by practicing using HTML and CSS via the interactive project tutorials provided by Code Academy.

Vocabulary

- HTML/CSS
- HTML5
- Javascript
- Coffeescript
- Recursion
- Procedures
- Overloading
- Conditional branching
- Loops
- Command lines

Objectives

- Students will learn advanced computer science concepts by playing an accessible game.
- Students will learn some of the basic language used to program drones, including HTML/CSS, HTML5, Javascript, and potentially Coffeescript.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- ETS1.A, B, and C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Materials

- Computer lab and class computer with live access to the internet

Multimedia Resources

- "Write Your First Computer Program" (2.01) available at http://learn.code.org/hoc/1

Optional Multimedia Resources

- Coffeescript tutorial and installation instructions for game development http://www.alexanderocias.com/tutorials/coffeescript_game_dev.html and "The Game", coded with HTML5 and Coffeescript http://splash.abc.net.au/web/zoom
- "Writing Your First AR Drone Plus NodeJS Program." Hacking Drones. http://drones.johnback.us/blog/2013/01/28/writing-your-first-ar-drone-plus-nodejs-program/

Before the Lesson/ Background Information

- Make sure computers are available and have a live connection to the internet.

The Lesson

Part 1: Learning Programming Concepts (20-30 mins)

1. Together with the class, watch the inspirational introduction about why coding is important on code.org (1.01).
2. Click on the "Start" button. Together, watch the video called "Write Your First Computer Program" (2.01) available at http://learn.code.org/hoc/1.
3. Once the video is over, a Blockly program will appear that allows the user to control an Angry Bird interface! Allow the students to explore this Blockly program on their own or in groups. Have them complete as many levels as they can. As they complete each level, they should click the button that says "show code". This will show the actual code they wrote by moving blocks! (Again, this can be done on one computer with the class if you prefer).
4. The mistakes in this game are fun. Do some intentionally if they don't happen naturally!

Part 2: Enroll in Code Academy (30-40 mins)*

1. In the computer lab, have students sign up for Code Academy. The site is free, but they will need to link their Google or Facebook accounts, or create a login account. (You can also have them work in groups of two).
2. Once they enroll, they can begin working on simple coding projects to learn basic HTML and CSS, such as creating a virtual solar system, animating their own names, or building a website. Let them explore these lessons on their own.
3. Once they have completed these tutorials, they can move on to other languages. Javascript is one of the languages that is used to code commands for drones.
4. Allow a few minutes at the end of class for discussion. What would the students program their drones to do?

***Option for a second class session on drone coding: if your class has advanced through Javascript and you have access to an AR drone, the class can start learning how to code it by installing Coffeescript (a variety of Javascript) according to the instructions provided under "Optional Multimedia". Have them play "The Game" to see what Coffeescript can do! Then they can follow the instructions provided in "Writing Your First AR Drone Plus NodeJS Program" to begin Drone programming.**

Lesson 8: Building and Flying an Unmanned Aerial Vehicle (a Kite)

Suggested Time: 60 minutes

Can be extended to 120 minutes or a two-part lesson if necessary.

Overview

Students will practice building an older version of an unmanned aerial vehicle: a kite! They will learn about the history of the kite, as well as its contributions to the field of aerodynamics, and build and fly their own.

Vocabulary

- Aerial Unmanned System
- Kite
- Model Aircraft
- Autopilot
- Payload
- Software
- Waypoints
- Interface

Objectives

- Students will learn about unmanned vehicles and their basic engineering.
- Students will explore the mechanics of flight by building their own kite, then imagining how they would equip it with the same abilities as a drone (autopilot or navigation, a payload or object to carry, and a means of interacting with the kite's activities).

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- PS2.A. Forces of Motion.
- ETS1.A-C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Project Materials

- 13-gallon (49-liter) plastic trash bag (white bags are best for decorating)
- Two wooden dowels or straight sticks, one about 24 inches (60.96 cm) long, the other about 20 inches (50 cm) long (this can vary, or you can experiment with various lengths and widths)
- Scissors
- String or fishing line
- Ruler

- Clear packing tape
- Ribbon and permanent markers for additional decoration

Multimedia Resources

- *Kites for Everyone: How to Make and Fly Them*. Margaret Greger. Available at Amazon http://amzn.com/0486452956

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Set up and practice with the drone. Make sure you know how to calibrate it—set it on a flat surface and wait for it to self-calibrate before flying.

The Lesson

Introduction: the History and Function of Kites (10 mins)

1. Use *Kites for Everyone: How to Make and Fly Them* to discuss the history and many functions of kites.
2. Summarize the many types of kites.
3. Separate the students into groups for kite-building.

Part 1: Building Kites (25 mins)*

1. Cut open the trash bag to form a flat plastic sheet.
2. Measure six inches (15.24 cm) down on the long stick and make a mark. Lay the short stick at the mark and form a "t" or cross shape. Tie the sticks together and use some tape if necessary.
3. Put the sticks down on the trash bag and use your ruler to draw a line around the frame from the top stick to the side and then down to the bottom point. Use your ruler to continue the outline on the other side of the t-shape. It should look like a diamond. Cut your diamond two inches (5 cm) wider than your diamond pattern.
4. Lay the sticks on the plastic diamond shape and fold the edges over the stick frame and tape it down. Turn the kite over and decorate it using your markers.
5. Cut a piece of string 20 inches (50-cm) long. Poke holes in the top and bottom of the kite and tie the string in a knot in the top and bottom holes (if necessary, use some tape to keep it secure). Then tie on the rest of your string to the middle of the string.
6. Tape the ribbon to the bottom of the kite to create a tail for your kite.
7. On a windy day, take your kite outside and start running, holding tightly onto the kite string. Keep your kite away from power lines and trees.

Part 2: Flying Kites (20 mins)

1. If it's a windy day, the students can take their kites outside and fly them! Alternatively, save the kites for a windy day and engage in more discussion.

Part 3: Discussion (5 mins)

1. Have the students brainstorm how they would equip a kite with the same abilities as a drone (autopilot or navigation, a payload or object to carry, and a means of viewing the kite's activities either after or during the flight). For example, they could attach a programmed GPS to the kite, or a camera.

***Supplies and project instructions adapted from *National Geographic Kids*.**

Part 2: Lecture and Discussion (30 mins)

1. Discuss different types of biplanes and the history of aviation. Note that the biplane was the first plane invented by the Wright Brothers.
2. Discuss the advantages and disadvantages of biplanes. Cover important concepts like stability, velocity, drag, lift, and aerodynamics.
3. Show stunt biplane video and any other optional videos.
4. Have the students read, and then discuss, the articles about *Microraptor gui,* the dinosaur that flew like a biplane. Draw out the following points:
    - Why do scientists think *Microraptor gui* flew like a biplane?
    - How does this compare with how modern species fly?
    - What advantages would this dinosaur have had over other flyers?
    - What is a competing theory about how *Microraptor gui* flew?
    - What can *Microraptor gui* tell us about how biplanes fly?
    - Are biplanes still useful today? Why or why not?
    - Why did the monoplane model become dominant?

Lesson 9: Building and Flying an Unmanned Balloon

Suggested Time: 60 minutes

Can be extended to 120 minutes or a two-part lesson if necessary. Mathematical exercises specific to mapping can also be added for high school and upper middle school students.

Overview

Students will practice aerial mapping, and building and flying a balloon with a camera attached. They will then practice knitting images into their very own maps.

Vocabulary

- Aerial Unmanned System
- Balloon
- Aerial Photography
- Mapknitter
- Mapping
- Topography

Objectives

- Students will learn about unmanned vehicles and their basic engineering.
- Students will explore the mechanics of flight by building their own balloon, then using it to map a small area.
- Students will produce a map with the images gathered by the balloon.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- PS2.A. Forces of Motion.
- ETS1.A-C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Project Materials

- Public Lab Balloon Mapping Kit, available at http://store.publiclab.org/collections/mapping/products/balloon-mapping-kit
- 2 liter soda or juice bottle
- A camera that can do continuous shooting
- Helium source
- Access to a computer lab with an online connection, to use MapKnitter

Multimedia Resources

- "Barataria Bay Mapping Project." http://publiclab.org/wiki/barataria-bay-mapping-project
- Images and maps from Balloon Mapping of BP Oil Spill. http://www.flickr.com/photos/tags/gulfoilmap/
- "Map Knitter." http://mapknitter.org

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Review the Public Laboratory website and balloon mapping materials so that you have some familiarity with the hardware and software.

The Lesson

Introduction: Using Homemade Balloons to Make Maps (10 mins)

1. Explore how useful balloon mapping can be by going through the Public Laboratory projects as a slideshow, discussing projects in the Gulf Coast such as the Barataria Bay Mapping Project and the maps of the 2010 BP Oil Spill.

Part 1: Building a Balloon (30 mins)

1. Have the class work as a team, following the instructions provided with the kit to build the balloon.
2. Equip the balloon with the camera.
3. If it's a calm day, send the balloon up with the camera and take aerial photographs!

Part 2: Knitting Maps (20 mins)

1. Assemble the images onto class computers.
2. Allow the students to explore and learn how to use MapKnitter.

Lesson 10: Build Your Own Business

Suggested Time: 60 mins

Overview

Students will work in groups to develop business plans centering on the use of drones, either in the form of unmanned aerial vehicles (UAVs) or unmanned underwater vehicles (UUVs). They will determine a mission statement, a procedure for implementing the business, a design of their drone, and a list of ethical and legal concerns and how to address them.

Vocabulary

- Business Plan
- Pitch
- Marketing
- Mission Statement/ Statement of Purpose
- UAV
- UUV

Objectives

- Students will engage in critical and collaborative thinking exercises around complicated technologies.
- Students will work together in groups to develop rudimentary business plans and technological designs.

Next Generation Science Standards

- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- MS-LS1-2. Structure and Function.
- ETS1.A, B, and C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.

Required Materials

- Computer lab with live access to the internet (optional)
- Presentation materials, such as a trifold board (optional)

Multimedia Resources

- None

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Determine whether there will be a visual component to the class presentations. If so, the students will either need a substantial amount of time to compose a visual presentation in the computer lab, or a second class session to put together a poster presentation or powerpoint.

The Lesson

Part 1: Designing a Business Plan (20 mins)

3. Split the students up into groups of up to six individuals each. Have each group develop the following components of a business plan:
    - Mission statement
    - Procedure for launching business
    - Drawn design (engineering blueprint) of drone
    - Consumer need to be fulfilled/ specific use of drone
    - List of legal and ethical issues and how to address them
4. Each group project should seek to:
    - Follow a nonprofit or business model
    - Conduct research on a scientific problem, or produce a service or a product
    - Use a drone (UAV or UUV) as a central component of the business plan

Part 2: Presentations and Class Discussion (20 mins)

1. Each group will present their business design to the rest of the class. Each member of the group should participate in the presentation in some way.
2. After the presentation, the group will field questions from the rest of the class and from the instructors.
3. In total, each group's presentation and discussion should take up to 5 minutes, depending on the number of groups.
4. Hold final discussion with the students and seek individual comments.

Part 3: Drone Flying! (20 mins)

5. Rate each group's design and presentation. The winning group(s) will have a hand in operating the drone! Make sure you save a few minutes at the end of class for drone fun.

Optional Lesson: Engineering Paper Airplanes!

Suggested Time: 60 minutes

Overview

Students will build paper airplanes in class, first individually, then deal with more complicated ones in groups. They will then test them for functionality and rate them on design features.

Vocabulary

- Engineering
- Machine
- Design
- Aerodynamics
- Graphics

Objectives

- Through both individual and group work, students will practice designing paper airplanes according to provided templates.
- Students will learn about how the shape of an object is important to consider in the field of aerodynamics.
- Students will design their own paper airplanes!

Next Generation Science Standards

- MS-PS-1, MS-PS-4. Developing and Using Models.
- MS-PS1-3. Obtaining, Evaluating, and Communicating Information.
- ETS1.A, B, and C. Defining and Delimiting Engineering Problems, Developing Possible Solutions, and Optimizing the Design Solution.
- PS2.A. Forces and Motion

Required Project Materials

- Paper Airplane Designs, provided and also available at http://www.funpaperairplanes.com/plane_downloads.html.
- Colorful construction paper
- Markers or stickers for decorating

Multimedia Resources

- None

Optional Multimedia Resources

- None

Before the Lesson/ Background Information

- Print out enough simple paper airplane designs for each student to have them. Put them, shuffled, in a box or tray.
- Print out the more complicated airplane instructions, one for each student group.

The Lesson

Part 1: Individual Design (20 mins)

1. Have each student randomly draw a design from the box or tray of airplane designs.
2. Pass out the instructions and have the students construct their own planes. They can construct more if they want to!
3. Have them test out their flyers and determine which shape flies the fastest and farthest.

Part 2: Group Design (20 mins)

1. Separate the students into groups. Assign a more complicated paper airplane design. Have them work together to construct the paper airplane, then decorate it.
2. Determine which airplane(s) has the most functional design. Evaluate them for graphic design as well.
3. Have the students evaluate each other's work.

Part 3: Individual Design II (20 mins)

1. Have each student design his or her own paper airplane.
2. Which one flies the best? What about graphic design?
3. Ask the students to discuss which aerodynamic shapes flew the fastest, which flew the farthest, and if any had any special capabilities or flew differently.