Introduction to Drones- Flying and Coding Skills for the 21st Century Middle School Learner

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Abstract

Introduction to Drones- *Flying and Coding Skills for the 21st Century Middle School Learner* is a unit that explores the basics of flight, introduces drones in the classroom and real world settings, and explores coding in a three-dimensional space. Next Generation Science Standards (NGSS), International Society for Technology in Education standards (ISTE), and Pennsylvania STEELS (Science, Technology & Engineering, Environmental Literacy & Sustainability) are used as the focus of these lessons. Drones are an emerging tool in many careers, and will continue to be as new technology creates even better sensors and cameras, as well as making them cheaper to produce for the consumer and hobbyist. Coupled with advances in AI to help bring some automation to using drones, they will continue to be of use far into the future. The skills our students will learn throughout this course will introduce them to these concepts and give them confidence in using technology. Given the hands-on learning they experience it should lead them to have above average understandings that are easily transferable if they choose to go forward with drones, robotics, and coding in the future. The ultimate outcome is to motivate students towards careers in STEM and to increase student engagement.

Keywords

Drone, Drones, Education, STEM, Coding, technology, classroom, school, students, robots, robotics, middle school, STEAM, science, flying, flight, UAV

Unit Content

Teaching in an urban school district can sometimes make one feel that our students are at a disadvantage compared to their peers in wealthier areas. One of our responsibilities as educators is to mitigate that gap. Giving our students any edge in their education that can help translate into being more equipped and better prepared for their lives post academia is a main focus for all educators. In this unit you will understand the importance of the integration of drones in your curriculum and in the students' lives in general. Additionally, you will have some guidance on getting funding for drones in your classroom, the history of drones, the science behind flight, and current uses and careers for drones. All of this content is included in order for you, the teacher, to be able to create your own lessons to fit in your specific classroom.

In this curriculum unit, teachers will introduce students to the basics of flight, controlling a drone remotely, creating and presenting a poster on a career that uses drones, coding a drone, and engineering a pick up and deliver mechanism simulation. This unit was designed for middle school students (grades 6-8) in which the teacher instructs them for 45 minute periods. The unit is designed in such a way that it could be adapted to fit in any classroom setting. Additional information has been included to give teachers multiple options to include drones in any classroom setting and expand this unit with the content any teacher wishes to explore in their subject area.

"We live in a world where technology is changing so quickly that career counseling, planning, and educational choices must be based on forecasts of job availability. Technology is progressing in every industry, including aviation, making it essential that we prepare our young people for future careers in this arena" (NSTA Reports!, 2016, p. 8). Drones are used for so many tasks in various fields that our students will interact with one day. From agriculture, construction, mapping and surveying, manufacturing, infrastructure, inspections, and search and rescue just to name the major ones. The proposed engineering challenge in this unit is based on pick up and delivery or search and rescue as students will create a delivery system for our drones to model how larger drones could be used in real world applications. "The potential of drone delivery to become a delivery solution in the big city is currently among the most intensely discussed emerging technologies, likely to expand mobility into the third dimension of low-level airspace" (Sapry, Azuwalri, & Ahmad, 2022, p. 319). Throughout the unit there are opportunities to discuss other uses and careers involving drone piloting. The video capabilities of the DJI drones (https://store.dji.com/product/tello?vid=38421) , or the color recognition sensors in the CoDrone EDU (https://www.robolink.com/products/codrone-edu) are easily used to model how drones can help with agriculture. The video capabilities on the DJI drone makes the mapping, construction monitoring, infrastructure inspection careers an easy model in the classroom too. You could focus on any one of these options for your classroom. The hope is that this background knowledge and the ideas presented in the curriculum can give teachers the confidence they need to add drones as a tool in their classrooms. As such I wanted to present a few ideas in this portion. Additional career options, including the arts, are presented in the form of posters and included in the resources section. See under the "works cited" portion: "CAREERS: DRONES."

This paper and curriculum was written with the help and guidance of the University of Pennsylvania TIP (Teacher's Institute of Philadelphia) program. Their mission states: "Beginning with the idea that intellectually engaged teachers produce better results in the classroom, the Teachers Institute of Philadelphia (TIP) enables public school teachers to expand their knowledge base through university-level study and research. TIP aims to bring new content to classroom teaching, increase expectations for student achievement and raise teacher morale in the public schools." Teachers Institute of Philadelphia. (n.d.). I was a fellow in the seminar *The Science, Engineering, and Operation of Drones* where I

was given the opportunity to learn drone history, fundamentals about different parts of drones and how they operate, and some coding and controller skills with a practice drone. The culminating part of that class was to present what we learned and a curriculum to use in our classroom. I will present some of the items I learned, why they are important, and how this new learning helps fill a gap for the benefit of students.

Drone Types, History, and Flight Basics

A drone is any uncrewed aircraft, while another term when using drones is UAV which is an unmanned aerial vehicle. The history actually starts with balloons in the late 1700's. Amazing to think of how far technological advances have come from then to now. In the final years of the 1800's Nikola Tesla created remote controlled boats which were the first radio controlled crafts. After this the next breakthroughs were mostly military until after hurricane Katrina the use of UAVs were allowed in civilian airspace for search and rescue in 2006. Then in the 2010's researchers created UAVs that could be controlled by smartphones which led us to where we are today. (Information summarized after reading Consortiq. (n.d.). Short History of Unmanned Aerial Vehicles (UAVs). Consortiq. https://consortiq.com/uas-resources/short-history-unmanned-aerial-vehicles-uavs)

There are a few different types of drones. Fixed wing which is like a traditional airplane, helicopter (single rotor), multi rotor, which most drones on the market seem to go towards the quadcopter design with four rotors, and a hybrid of the fixed wing and rotors.

Picture from: https://encyclopedia.pub/entry/43656

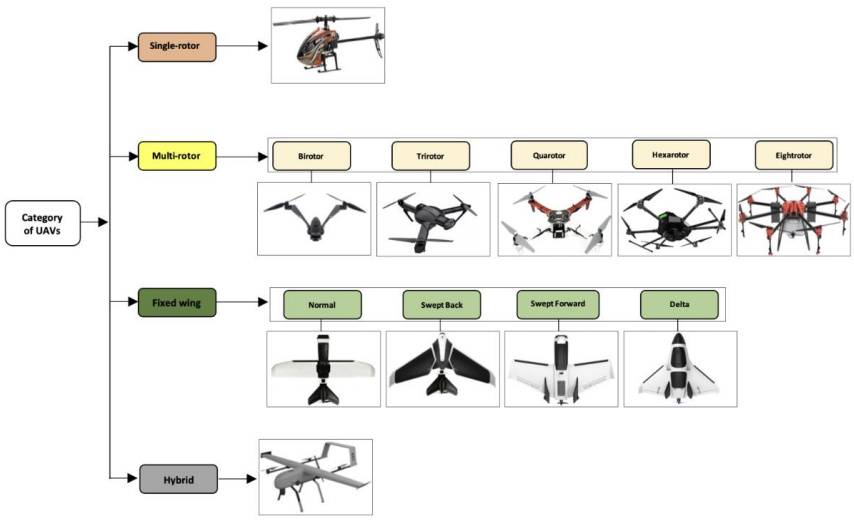
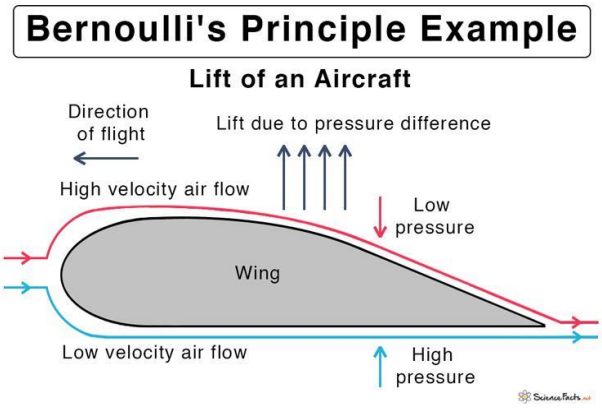


Figure 2. Different categories of UAVs.

The drones operate with the blades or wings being made up of an airfoil which creates lift. Bernoulli's principle of high and low pressure helps us to understand this phenomenon. In order to move a quadcopter the rotors actually slow down in order for the drone to thrust upward and downard, pitch forward or backward, roll left and right and yaw left or right (turn). In this curriculum you will have students learn how to fly via remote control first to garner buy-in, then they will start to code the drones.

High pressure over the top of the surface compared to lower pressure on the bottom surface provides lift. You can Cut a 3-4" strip of paper and blow over the top to observe this phenomenon.



Science Facts. (n.d.). Bernoulli's Principle and Equation. https://www.sciencefacts.net/bernoullis-principle-and-equation.html

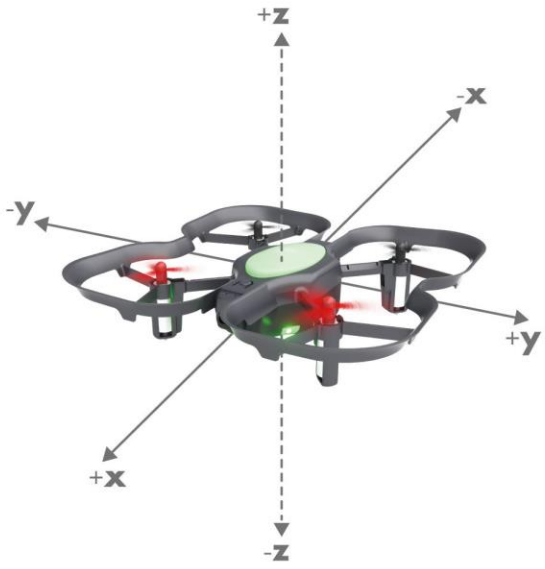
Basic Flight Terms:

Roll- moving left or right on the y axis

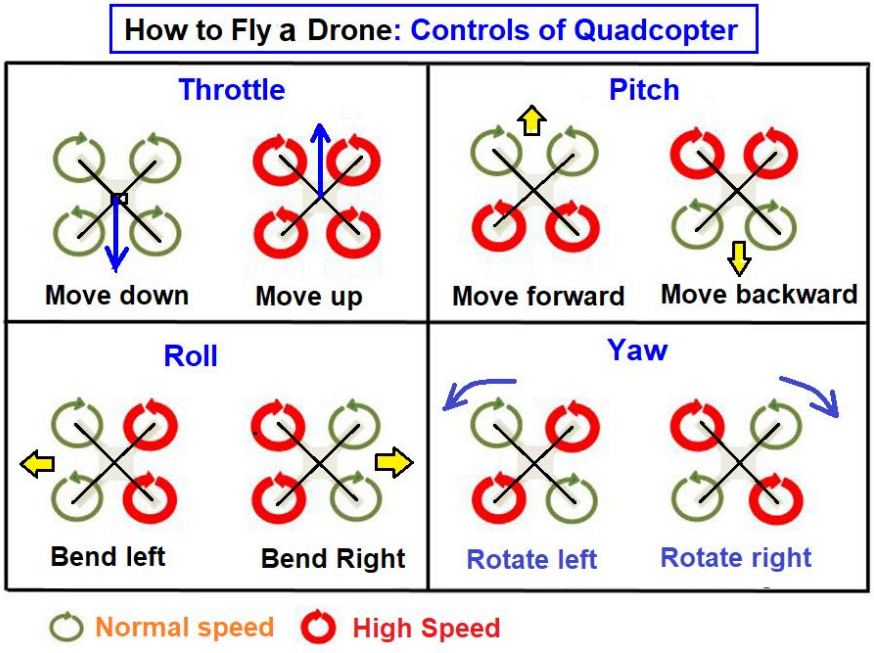
Pitch- moving forward or backward on the x axis

Yaw- when the drone turns right or left on its axis (in place)

Thrust- Propulsive force which leads to a change in the height of the drone on the vertical axis (up or down) on the z axis.



Above Picture from: docs.robolink.com



Controls of Quadcopter Picture from: https://cfdflowengineering.com/working-principle-and-components-of-drone/

Coding

In this TIP seminar we learned the basics of Block coding. This basic coding structure helps anyone who is new to coding as it shows blocks of code in a graphical representation that is puzzle-like in nature. Fitting the code together is like building with legos. It is simple enough to get one to understand coding concepts and to even get some not so basic understandings like loops and variables in such a way that is easy to experiment with and learn with trial and error. The other form of coding we learned was the coding language of python. This coding is more involved and for people who have a basic understanding already. It is syntax dependent so a lot of the trial and error is with typing in the correct commands and actions. Whereas with block coding the trial and error is more putting the pieces together in different ways. Either way the resources to help with coding and drones can be located in the reference section but are named here as: DroneBlocks, Blockly, Scratch and Python. These coding tools will help you and your students program the drones. Additionally, the co drones have a bunch of free resources that will teach you coding and controlling of the drones. See the included references for even more lessons, and to familiarize yourself with the coding editors of your choice. I highly recommend blockly as a both a novice and someone who primarily teaches novices and elementary and middle school aged students. This whole curriculum could be just on coding. In this curriculum, using only the basics of block coding, students can achieve great success. Youtube videos and google are your friends but there are many resources to help you as the teacher get some basic understanding and practice on your part will make you feel more comfortable. One night practicing at home with blockly open and your drone batteries fully charged and you will get the hang of it. After that your students may well teach you as they may have greater understanding. The point is you can start not knowing anything and still get these lessons to the students. If you already understand and have practice with coding, using drones is so much more impactful for your students than just using online coding tools like scratch or other robots if you are in a maker space or computer science type of class.

Real World Applications

During a few classes we met professionals that have careers utilizing and creating drones along with writing complex algorithms. Two of these presentations involved using drones and algorithms for mapping purposes. “Unmanned aerial vehicles (UAVs) are becoming an important tool for surveyors, engineers, and scientists as the number of available cost-effective and easy-to-use systems is rapidly increasing. These platforms offer an attractive alternative to mapping small areas with centimeter-level accuracy. Numerous successful applications have been reported: repetitive surveys of buildings, civil engineering structures or construction sites, as well as land monitoring and precision farming Colomina and Molina (2014).” Cledat, E., Jospin, L. V., Cucci, D. A., & Skaloud, J. (2020). This insight into how professionals got into working with drones, what they studied during their time in school, how they receive funds, along with

observing some of the work behind the scenes of their product were inspirational. Finding information in articles or even youtube for students to see how drones are being applied, and how their coding skills can translate into things beyond education is so important. This translates directly into the curriculum as students will research careers in STEM that involve drone piloting as a project in phase one of this curriculum. The outcome has students create a poster and present on the career in front of the class.

More information on why students should use drones and learn about the careers associated with them can be found within this quote: "Why a Career as a Drone Pilot? There is a growing demand for certified drone pilots. One projection states the need to fill 100,000 positions by 2025. Salaries are competitive ranging from $35,000 to $160,000, depending on skill-level, experience, and geographic location. Pilots can work for an organization or be self-employed. Drone pilots must enjoy working with technology, working outdoors and with members of a team. Some positions provide opportunities for travel. To become a commercial drone pilot, the individual must be at least 16 years of age, be able to read, speak, write, and understand English. The applicant will be in a mental and physical condition to safely operate a drone and must pass the initial Part 107 aeronautical exam. A student should have strong communication skills, robust problem-solving abilities, excellent electronic and mechanical skills, expertise in multitasking, and keen attention to detail" (McPherson & Franklin, 2022, p. 41).

Additionally, in the seminar we watched one team of engineers map out the campus we were located at in real time. This could be a great idea for students to practice even without drones. Aerial photographs from google maps of your school or neighborhood can be used. This type of lesson can also add an art element to using drones. There is a resource from shemaps.com listed in this paper under “websites” with some lessons to help if you elect to go this path. In my personal opinion geography skills are something else that American education typically lacks in compared to international counterparts, so this is another great way to incorporate drones or thinking like a drone pilot in the classroom while touching on skills a teacher may not otherwise be able to touch upon.

Sensors

Drones and other robots use many sensors to be able to navigate the world as a living thing would. Each drone has various sensors that help the drone to function properly and interact with its environment. In this unit sensors are used when learning how to code the drones as distances and colors are some of the easier sensors to have students code in relation to. You can code a drone so that if it gets a certain distance from an object when running its path it will move in another direction or land before crashing. With the Codrone EDU we practiced in class, but with the free blockly lessons, website in the reference section, students can learn how to code their drones to respond to specific colors. Included with the Codrone are various colored landing pads. This can help simulate agricultural uses for drones as recognizing lush green color versus yellow or red

colors of plants that are not thriving can demonstrate healthy and unhealthy crop growth. Sensors also let the drones understand if they can fly. If it is too dark in your classroom, or surfaces are too reflective that the drones are hovering over , the drones may become disoriented and not fly in typical ways while students are using them. These are some tips as sometimes machines do not do exactly what we thought they should be doing and typically, this was due to a sensor issue.

Ethics

"From the start of the military implementing these "flying robots", to affordable drones being available to the everyday person, the use of these unmanned aircrafts are increasing dramatically. However, is it ethical to kill people, to spy on people, or to take away jobs from people?" Hopkins, A. (2017). It is so important to get your students to discuss and question the ethics of emerging technology. As educators it was great to be led in a discussion on this matter and be able to share what we know with each other. One of the highlights of the few weeks in this seminar was being able to discuss the ethics of using drones. Being presented with near future scenarios where drones could be taken over by people who wish to do others harm and how that would affect civilians lives was very interesting. In the unit outlined below there is a day where ethical considerations are discussed as a class. Of course we could spend a whole quarter just on discussions with researching and debating. Such topics as privacy issues, warfare concerns, and personal freedoms as the laws are constantly changing with drone flight regulations are some options that will most likely come up organically. This would be great for an ELA class or in science class to go over scientific debate and the processes. One great resource was quoted in the beginning of this section and is in the works cited subheading. Teachers feel free to read the article to craft questions for your students to debate.

Funding

I believe that hands-on coding and experience working with technology such as drones is paramount for a student's success. Real experiences may awaken something in our students, or give them a base knowledge that can allow them to feel more at ease and capable later in life. There are many grants for STEM out there that are available for all educators, but there are even more that focus on bringing those students who are traditionally and historically left behind to get the resources they need to be successful. Alternatively, you could see if you could fundraise for materials needed with concessions, raffles, or dress down days etc. You could create a donors choose campaign, see if your principal has some funds in their budget, look for industry partners to assist, or see if local universities will partner with you.

The first hurdle in incorporating this curriculum is getting the materials. I want to address this to all those who use, or wish to use, this curriculum. There are ways to get the materials to start. I will explain a few ways in which I found success in an urban district

with little to no money for these expenses and hope that it can at least provide some ideas and launching points for the acquiring of drones and the various other components needed with them. There are grants through the REC Foundation. They supply the Codrone's. They also have an aerial drone competition and are able to supply grants through that program and they are looking to expand. A lot of these organizations get funding themselves through the department of defense and need to use the funds, all it takes is you applying for them in some cases. They will get you started, and ultimately you will have some drones for your program. (https://roboticseducation.org/grants/). Another way is to propose purchasing a few with your principal or school district. I was able to talk my principal into purchasing a few DJI Tello drones after explaining what I wanted to do with the curriculum for robotics. You never know until you ask. Alternatively, I raised money by selling chances for prizes and snacks, I had a plant sale (Stems for STEM) in which we raised funds for materials and drones. I reached out to families stating what we were raising money for and a parent held a bake sale and raised enough for one drone. I have to remind you I am in a low income, limited resource school and I was able to rally stakeholders to my cause. Lastly, look for opportunities to take classes and earn money and education. I was able to find opportunities through my district about programs helping fund after school opportunities, the program I am writing this unit for was an opportunity I applied for, and they will provide training from experts, a stipend, and a drone that I immediately started using in the classroom. Lastly, donorschoose can be an excellent tool, especially when monies will be matched. I know STEM focused campaigns have matching periods. I know it is just one more thing for an educator to do, but as you are reading this, I assume you are passionate enough about this topic to go after what you need, or glimpsed over this as you are in a situation where you have resources at your disposal. Either way, funding the equipment can be tough and I hope these solutions and ideas can help any educator in obtaining materials for using drones in the classroom.

Engineering Project

We were able to see some workshops in this seminar from the professionals working on drones. Building, programming, and working on sensors and algorithms for drones. It was fascinating to see firsthand. The engineering design process was on full display. From ideas, creations, failures, iterations, and successes it was all there and proudly shown to us. It is important to have students fail and struggle as part of their learning process. It is a fine balance for educators to have students struggle just enough where it is interesting. The final project in the unit will culminate the students' knowledge of flight and coding concepts in order to engineer a pick up and deliver device and to manually fly and code an algorithm to simulate a real world application using said device. Students will be supplied with materials ranging from: magnets, fishing line, string, eye hooks, pipe cleaners, hot glue, masking tape, and tacky glue in order to create a device that can lift a payload (paper folded square) and deliver the item to the specific area in the scenario. One example planned is a scenario where a bag of blood is going to be brought

to a mountain town where there was an emergency need for a transfusion. The students' jobs will be to engineer the device, practice coding the path, iterating designs both for coding and engineering, and then together the class will watch each team perform the task.

Feedback and Grades

In this unit there are a few sources for grading. The flight basics quiz, flight journal review, daily participation, obstacle course traversal, career poster and presentation, coded shape path, coded obstacle course, engineered mechanism and flight, and final google form. Reflection is key for the teacher to know how to improve and to give students voice. You can add or take away whatever items needed as far as grading. I found I have to hold my middle school students accountable, and give various grades to make up for when they are not motivated and do not accomplish the task at hand.

Teaching Strategies

The teaching strategies utilized in this unit vary and can be changed to fit the needs of your classroom and the needs of your students. However, the strategies listed below should work in every type of classroom. These strategies are essential to teaching drones in the classroom as they touch on the 21st century skills our learners need to have experience with to be successful.

Hands-on activities and Gamification of Learning

Controlling a drone is fun, exciting and engaging. Starting off with remote control while students learn the basics of how a drone operates is the best way to get student buy-in. Having the flight test in front of the entire class is a little high stakes, but also a fun group activity where everyone is cheering the others on, and sometimes whispering help in order for a mistake to be corrected. Allowing for this adjustment is key to not turn off students to the experience. Culminating into a successful run through an obstacle course with elements made by the teacher, or students for an extension activity, is a fun way to test the practiced skills. Taking those skills and then applying them to coding the drone through the obstacle course feels more game-like to students even though it is a graded assignment. This gamification of the curriculum is more than just edu-tainment and students are learning through this play. Finally, engineering, testing, and the iterative process helps students to solve a simulated real world problem by modifying their drones.

Use of Technology

Ipads and chromebooks can be used to control and code the drones. In my classroom I am lucky enough to have some older edition ipads so that the drone activity seems wholly separate from the students typical school day. Using another device also furthers their abilities to have access to a variety of technology and interfaces. The ipad is also deemed

by students as fun to use, instead of their larger chromebook counterparts. Using drones and coding also gives access to technology in a different way then students are used to. Typically they are consumers and now they are able to be creators of content.

Guest Speakers and Experts plus career based learning

Invite professionals who work with drones who can give presentations or a workshop. In the teachers institute of Philadelphia class I met a local to South Philadelphia business who design, sell, and operate drones that can map areas. This can provide valuable real-world insights and career guidance for students. Other considerations would be to look for a photographer or videographer. Additionally, a real estate agent may know folks that use drones for picture taking as well. If you look on social media you can find drone groups and can inquire with professionals there who may be willing to come into the classroom too. For Philadelphia I found on facebook: Philadelphia Drone User Group, Eastern PA FPV and Drone Pilots, and Pennsylvania Drone Pilot Group. I have also been lucky enough to connect with various STEM professionals and that pipeline has given me access to have some outside experts come into the classroom to present. Youtube videos are also an easy way to listen to an expert and have students take notice of the world outside the classroom walls.

Project-Based Learning

In this unit students will be tasked to create a device that will allow these light drones to pick up and deliver a payload with a focus on medical supplies. "Unmanned aircraft systems, commonly referred to as drones, are emerging as a possible solution for medical emergencies and health care in remote areas…"Drones are used in health care primarily for search and rescue missions and transport of medical devices, medications, defibrillators, testing supplies, and blood to remote areas" (Frith & Amiri, 2022, p. 203). You could just as easily adapt the project to have students create and navigate as a group an obstacle course. You could make environmental monitoring/photography the project. Whether through your green space in or around your school, or in a more controlled way by printing pictures and creating a scenario so that the sensors or video capabilities could be a facsimile of the real world. Each table or team has different roles that they can trade during or for each class period. Pilot, who controls the drone, Spotter who gives warnings and directions to the pilot, coder who creates the code the drone algorithm will follow, and if a fourth is needed the manager who is responsible for keeping all on task, retrieving and returning the devices, reporting to the teacher for instructions, etc. Students will also have to research and present a drone career as a group with various roles like editor, writer, presenter, researcher, etc. This all allows for team work, fosters communication skills, practice their ability to manage their time, it allows for high levels of collaboration, promotes critical thinking, creativity, media and technology literacy, and the all important social skills. Sometimes the best STEM students are introverts and projects allow for their voice to be heard and for them to participate in a way that seems

most comfortable for them, or that pushes them a bit out of their comfort zone as well. Depends on teacher goals and guidance as the projects progress.

Argumentative Writing: Safety and Ethical Considerations:

There is a part of the career program, a discussion in a lesson, and a part of the final google form that has students think of the responsible and ethical use of drone technology. Inevitably, students discuss using drones to "spy" on their neighbors. We will discuss privacy, regulations, and safety precautions with students to ensure they are responsible digital citizens and using the drones at their disposal in the correct ways. Middle school students are too young to take the FAA 107 test, but elements of the test will be introduced in this course. If so inclined this could become a focal point to your lessons. How to debate and argue your points based on facts is a skill that needs to be practiced and honed.

Classroom Activities

Class lessons are designed to be 45 minutes in length. You can teach this over the course of a semester if you see your class(es) frequently, it could be done over the course of two semesters if seen once a week. Furthermore, you could teach what you want from the unit and add your own flair and and make the unit go even further taking place over the course of an entire school year.

Phase One- Flight Basics and Career Poster

PA STEELS: 3.5.6-8.I
Examine the ways that technology can have both positive and negative effects at the same time.
ISTE: 1.5.d Algorithmic Thinking
Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

1.4.d Open-Ended Problems
Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems

NGSS: MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Lesson 1- Introduction to drones, safety agreements/students contract sign, manual review for drones, getting started video watch party, hands on drones with no battery, basic flight controls and human powered movement, how flight works concepts- video: https://www.youtube.com/watch?v=zKSNudPl9UI, introduce flight journals for student reflections:Flight logbook/reflections.

Lesson 2- First day connecting drones, review safety precautions, give out safety glasses and remind long haired individuals to tuck in hair. Students will take off and land only once they are connected, and all students at tables get a chance. Practice movement two tables at a time [yaw (spin), pitch(forwards and backward), roll(left and right), thrust (height)]. Students return drones and glasses to lockers, plug batteries into the charging port. Ten minutes to write in flight journals.

Lesson 3- Ethical considerations for flying and using drones discussion and writing. Begin class by inquiring about the pros and cons of using drones? What are the good uses, and what are some foreseeable negative uses. Lead class discussion. Post articles on google classroom or give handouts out to groups to develop a positive and negative list to discuss. No flight practice or journal today. Reading selections and google forms for drone usage in real life. See work from scholastic and teachers can create more with other resources.

Lesson 4 - Drone careers project introduction. Student projects will be made in canva. It is a free editing tool that is easy to use and helps create wonderful posters. The google docs or slides can be used for ease or for struggling students. Teacher will share a checklist with students in the google classroom and review expectations as a class: 1. Career as Title, 2. skills needed, 3. schools or programs that offer certifications (3+), 4. starting and average salary, 5. companies that would hire for this career, 6. pictures of the career, 7. why your team chose this career totaling, 8. each person presenting a part of the poster, 9. The poster looks visually pleasing to others. 10. The poster review space completed in the flight journal totaling 10 possible points. Poster Today students will work on choosing a template and researching careers. No flying. Flight practice with teams following yaw,pitch,roll,thrust directions. Each team is given four sets of directions so each participant has a different set. Five minutes for flight journal.

Lesson 5- Flight test today! Each team is given a set of directions verbally from the teacher they have to follow, then the next partner resets. As a teacher you can come up with 4 different paths of instructions (one per each student in a group) or one set for the entire table and change up the instructions for each group. In my class there are eight groups of three to four students. This is done one at a time, technically in front of the whole class. Students can practice without a battery at their table the basics, work and research on their drone career project. Once teams are done with the test they will return all supplies to the locker and charger. Five minutes given at the end of class for the flight journal

Phase Two- Obstacle Course

ISTE: 1.5.a Problem Definitions

Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

1.6.a Choose Platforms or Tools

Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.

MS-PS2-2-Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

3.5.6-8.K

Use devices to control technological systems.

Lesson 6- Introduction to the obstacle course. I use hula hoops, pop up tents, cones with sticks in them all laid out on desks in the middle of the room. A gym or more open indoor space would be great but I have learned not to rely on any outside classroom areas. I have had success with a middle path where teams can practice one at a time only going in one direction to the end of the obstacle course. There are other programs now that you can compete on a national level with. The CoDrones are used in REC (https://roboticseducation.org/aerial-drone-competition/) and have 20 foot by 20 foot areas where drones can fly in any manner of directions while in. I have used a folding clothing drying rack to end on easy, medium or hard mode. Students will practice manual flight controls to traverse the course two teams at the starting position at a time. While other wait students will work on the drone career project poster and presentation. Students will return supplies after their groups practice. We will end the class with five minutes left for students to fill out their flight journal.

Lesson 7- Students will practice the obstacle course as teams- trial blindfolded team members. Continue to research and design their drone career project, practice their presentations. Once each team is done supplies will be returned. Five minutes will be given to students to fill out their flight journal.

Lesson 8- Students will Present their Drone Career Project Posters, Teams will be able to practice the obstacle course.

Lesson 9- Obstacle course team trials. This can be graded as a test, quiz, or participation. Getting through the course up to different areas can be given a score. Teams will return supplies after trial and fill out the flight journal.

Phase Three- Coding Drones

NGSS- MS-PS2-2-Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

ISTE: 1.5.a Problem Definitions

Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

ISTE: 1.5.d Algorithmic Thinking

Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

PA STEELS: 3.5.6-8.G

Analyze how an invention or innovation was influenced by the context and circumstances in which it is developed.

lesson 10- Intro into coding basics- If using a codrone students can follow the lessons on the robolink website and use blockly. For the DJI Tello drones you can use drone blocks. Here you will have to create your own lessons on the basics of coding drones or use the droneblocks curriculum for a fee. I have found success using ipads with the dji drones as that is also the controller. Older kids may be able to use their own phone depending on your school's policies. In our school the students cannot use their phones and I use the ipads as the kids are used to using them for the remote control portion so it is a seamless transition. How to connect: https://www.youtube.com/watch?v=w4mB3irdt7A&t=6s . I had zero experience coding and used various youtube videos to get myself ready and then used those same videos to help in class.
https://www.youtube.com/watch?v=5NGPrMP1r2Y&t=5s coding with drone blocks basics. Students will try to code the drones into a rectangle shape around the middle area of the room. Flight journal is now assigned for hw.

Lesson 11- coding intermediate- This lesson students will continue to code the drones and be introduced to the advanced flight modes like flipping. Flight journal hw

Lesson 12- coding advanced- Students will learn about loops to repeat instructions and code a drone to fly in various shapes. Flight journal hw

Lesson 13- Students will now code through the obstacle they had already remote controlled in the first phase of this course. flight journal hw

Lesson 14- Code through obstacle course practice- Lots of trial and error, measuring, understanding that drones shift while in air and do not stop so much as slide to a stop. One student from each team will represent their team through the obstacle course next week. Followed by their second and third then their fourth time permitting. I want students to all have turns but sometimes grading and testing this can be a chore that takes long. This way the group has to decide who the best and second best is based off of their previous practice rounds and choose accordingly. Flight journal hw

Lesson 15- Code through obstacle course test- Each group will start with their best operator with the spotter following the drone as it progresses and the range safety officer making sure it stays on course and the audience is safe. Flight journal hw.

Phase Four- Engineering Design Process Pick up and Deliver

NGSS: MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

PA STEELS: 3.5.6-8.AA

Adapt and apply an existing product, system, or process to solve a problem in a different setting.

3.5.6-8.JJ
Apply informed problem-solving strategies to the improvement of existing devices or processes or the development of new approaches.

ISTE: 1.3.d Explore Real-World Issues

Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.

1.4.a Design Process
Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

1.4.c Prototypes
Students develop, test and refine prototypes as part of a cyclical design process.

Lesson 16- Review with students that everything they learned will be put to the test with a real life example. Quick video of an example:

https://www.youtube.com/watch?v=fjjbeltn4Fo. Longer video by popular youtuber: https://www.youtube.com/watch?v=DOWDNBu9DkU&t=1138s. You can assign one video to view at home. Introduce the Engineering design process challenge- pick up and deliver medicine to a mountain town simulation. Students will have to create a pick up and deliver system to put on the drone and take to a higher elevation area within the classroom. Students will build a device, test it with a manual flight and code the flight for the final test. Materials that will be given to students, but they bring in anything (that's not sharp) into the class: string, fishing line, cardboard, cardstock, scissors and neodymium magnets. Students will create an object to store the pretend medical supplies and design something that the drone can use to fly to the designated spot in the classroom. A shelf with a landing pad. It's an emergency so they have extremely limited time. Today and the next class. Any time extra they will need to work on in other classes, lunch or at home.

lesson 17- Students will build, test, manual flight and start coding the flight

lesson 18- TEST DESIGN DAY! Will you be able to save the people in need of medical supplies? Rubric: 3- Design worked! 2- Design almost worked. 1-Design failed 3- coding trip was successful 2-Manual flight was successful 1-flight failed 3- worked as a group and iterated the design 2- came up with one design and went for it 1-nothing to show

1- Completed google final review.

Last day with drones. Google form final review (graded) Rubric: https://www.jpl.nasa.gov/edu/pdfs/engineeringdesignrubric.pdf

Resources

Works Read and Cited

1. Bolick, M. M., Mikhailova, E. A., & Post, C. J. (2022). Teaching Innovation in STEM Education Using an Unmanned Aerial Vehicle (UAV). Education Sciences, 12(3), 224-224. doi:10.3390/educsci12030224
2. Schaffhauser, D. (2018). Drones Take Off in Education: The use of this technology captivates students while allowing them to learn abstract concepts in off-the-ground ways. T H E Journal, 45(3), 15-19.
3. Bushweller, K. (2022). How to Make Students Better Problem Solvers: Teach Them to Fly. Education Week, 41(32), 3-6.
4. *McPherson, R., & Franklin, E. (2022). Are Drones in Your Student's Future? Agricultural Education Magazine, 95(3), 41-42.
5. Weitlauf, J., Bartholomew, S. R., & Zhang, L. (2018). Engineering design and coding through quadcopters. Technology & Engineering Teacher, 78(1), 14-21.

6. *Frith, K. H., & Amiri, A. (2022). Drones Could Offer Solutions for Emergency Responses and Health Care in Remote Areas. Nursing Education Perspectives, 43(3), 203-204.
7. Weeks, R. (2015). Is There a Drone in Your District's Future? School Business Affairs, 81(3), 11-14.
8. *Wilson, M. (2018). Drone STEM Curriculum: An Opportunity to Introduce the Next Generation of Flight. Techniques: Connecting Education & Careers, 93(8), 60-61.
9. Balogun, A. O., & Miller, J. (2022). Drone Club: Exploring Engineering and Employability Skills outside the Classroom. TechTrends: Linking Research and Practice to Improve Learning, 66(6), 923-930.
10. Fagan, B. J., & Payne, B. R. (2017). Learning to Program in Python -- By Teaching It! Proceedings of the Interdisciplinary STEM Teaching and Learning Conference, 1, 99-107.
11. Ryu, J., Walters, R., & Ziegler, H. (2021). Interstate Drone League (iDrone National) to Promote Hands-on Remote STEM Learning Using Cloud-Based Virtual Meeting Platforms in the Global Pandemic (COVID-19). Journal of STEM Education: Innovations and Research, 22(4), 65-71.
12. Gillani, B., & Gillani, R. (2015). From Droughts to Drones: An After-School Club Uses Drones to Learn about Environmental Science. Science and Children, 53(2), 50-54.
13. NSTA Reports! (2016). Using Drones to Enhance STEM Learning. NSTA Reports!, 27(8), 8-9.
14. Sapry, H. R. M., Azuwalri, S. N. N. binti, & Ahmad, A. R. (2022). Application Of Delivery Drone Technology as A Delivery Solution in the Urban Areas. *Journal of Positive School Psychology, 6*(3), 319-325.
15. "CAREERS: DRONES." (2022). *Geography Bulletin, 54*(4), 45-48.
16. Cledat, E., Jospin, L. V., Cucci, D. A., & Skaloud, J. (2020). Mapping quality prediction for RTK/PPK-equipped micro-drones operating in complex natural environments. *ISPRS Journal of Photogrammetry and Remote Sensing, 167*, 24-38.
17. Hopkins, A. (2017). The Ethical Debate on Drones. *Ethics Essay Contest.*

Appendix

Academic Standards

International Society for Technology in Education (ISTE)

1.3 Knowledge Constructor - 1.3.d Explore Real-World Issues - Students build knowledge by actively exploring real-world issues and problems, developing ideas and theories, and pursuing answers and solutions.

1.4 Innovative Designer - 1.4.a Design Process

Students know and use a deliberate design process for generating ideas, testing theories, creating innovative artifacts or solving authentic problems.

1.4.b Design Constraints - Students select and use digital tools to plan and manage a design process that considers design constraints and calculated risks.

1.4.c Prototypes- Students develop, test and refine prototypes as part of a cyclical design process.

1.4.d Open-Ended Problems - Students exhibit a tolerance for ambiguity, perseverance and the capacity to work with open-ended problems

1.5 Computational Thinker - 1.5.a Problem Definitions - Students formulate problem definitions suited for technology-assisted methods such as data analysis, abstract models and algorithmic thinking in exploring and finding solutions.

1.5.d Algorithmic Thinking- Students understand how automation works and use algorithmic thinking to develop a sequence of steps to create and test automated solutions.

1.6 Creative Communicator - 1.6.a Choose Platforms or Tools- Students choose the appropriate platforms and tools for meeting the desired objectives of their creation or communication.

1.6.b Original and Remixed Works - Students create original works or responsibly repurpose or remix digital resources into new creations.

1.6.d Customize the Message- Students publish or present content that customizes the message and medium for their intended audiences.

1.7 Global Collaborator - 1.7.c Project Teams - Students contribute constructively to project teams, assuming various roles and responsibilities to work effectively toward a common goal.

NGSS

MS-ETS1-1. Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

MS-PS2-2-Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

MS-PS-3-Ask questions about data to determine the factors that affect the strength of electric and magnetic forces.

PA STEELS

Technology and Engineering

3.5.6-8.F Analyze examples of technologies that have changed the way people think, interact, live, and communicate.

3.5.6-8.G Analyze how an invention or innovation was influenced by the context and circumstances in which it is developed.

3.5.6-8.H Evaluate trade-offs based on various perspectives as part of a decision process that recognizes the need for careful compromises among competing factors.

3.5.6-8.I Examine the ways that technology can have both positive and negative effects at the same time.

3.5.6-8.J Use tools, materials, and machines to safely diagnose, adjust, and repair systems.

3.5.6-8.K Use devices to control technological systems.

3.5.6-8.M (ETS) Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

3.5.6-8.P (ETS) Evaluate competing design solutions using a systematic process to determine how well
they meet the criteria and constraints of the problem.

3.5.6-8.Q Apply a technology and engineering design thinking process.

3.5.6-8.R Develop innovative products and systems that solve problems and extend capabilities based on individual or collective needs and wants.

3.5.6-8.T Create solutions to problems by identifying and applying human factors in design.

3.5.6-8.U Evaluate and assess the strengths and weaknesses of various design solutions given established principles and elements of design.

3.5.6-8.V Refine design solutions to address criteria and constraints.

3.5.6-8.W (ETS) Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

3.5.6-8.X Defend decisions related to a design problem.

3.5.6-8.Y Compare, contrast, and identify overlap between the contributions of science, technology, engineering, and mathematics in the development of technological systems.

3.5.6-8.Z Analyze how different technological systems often interact with economic, environmental, and social systems.

3.5.6-8.AA Adapt and apply an existing product, system, or process to solve a problem in a different setting.

3.5.6-8.BB Demonstrate how knowledge gained from other content areas affects the development of technological products and systems.

3.5.6-8.FF Demonstrate how systems thinking involves considering relationships between every part, as well as how the systems interact with the environment in which it is used.

3.5.6-8.JJ Apply informed problem-solving strategies to the improvement of existing devices or processes or the development of new approaches.

3.5.6-8.KK Explain how technology and engineering are closely linked to creativity, which can result in both intended and unintended innovations.

Websites

https://www.robolink.com/products/codrone-edu-set-of-10-kits - Codrone image and website to purchase a classroom set

https://www.ryzerobotics.com/tello-edu- all about the DJI Tello drone

https://scied.ucar.edu/teaching-box/drones/uav-flight-school#:~:text=Explain%20that%20there%20are%20three,propellers%20after%20the%20UAV%20lands- More flight basics

https://shemaps.com/mapping-competition-teacher-resources/- mapping your school lesson

https://www.jpl.nasa.gov/edu/pdfs/engineeringdesignrubric.pdf- rubric for engineering final project

https://www.youtube.com/watch?v=3b9xCC_vaZQ bernoulli's principle video Smithsonian Air and Space

https://www.youtube.com/watch?v=zKSNudPl9UI Smithsonian Four Forces of Flight

https://www.youtube.com/watch?v=pn84aprnqkA DJI Tello basics

https://www.youtube.com/watch?v=uNYxEhRNY-g Co drone overview and teaching ideas for all subjects

https://www.youtube.com/watch?v=5NGPrMP1r2Y&t=5s - coding with drone blocks

https://www.youtube.com/watch?v=fjjbeltn4Fo. - zipline drones for EDP project https://www.youtube.com/watch?v=DOWDNBu9DkU&t=1138s. longer zipline video by popular youtuber

https://consortiq.com/uas-resources/short-history-unmanned-aerial-vehicles-uavs history of drones

https://encyclopedia.pub/entry/43656 types of drones

https://slideplayer.com/slide/14328065/ airfoil example

https://cfdflowengineering.com/working-principle-and-components-of-drone/ Drone information and diagrams of drone flight

https://www.youtube.com/watch?v=N7ZmPYaXoic- What is coding?

Teacher Made Resources

Student Contract: https://docs.google.com/document/d/1sQ4S5ZiJRz3D-ABhbVsp0CrbcsUM5EGJDJSN9YXr3S0/edit?usp=sharing

Flight Journal/Logbook-
https://docs.google.com/spreadsheets/d/1lYAZVt9yvEAGOcxrh6-vY11YrtoAfJmfj8rj2c--czg/edit?usp=sharing

Google form reflection at the end of the lesson:
https://forms.gle/4S6xWoCGsZXW7nV76

Career Poster Checklist as a Poster:
https://www.canva.com/design/DAF2xrOUc3M/FYVdbVp7ECDdAn3kX4rVJw/view?utm_content=DAF2xrOUc3M&utm_campaign=designshare&utm_medium=link&utm_source=editor

List of Materials

Dji Tello drones, ipads for controlling and coding. You can get dji controllers separately and students can use their chromebooks to code and you do not have to worry about remote controlling. I would argue the students would have more buy in though

Co-drones- come with a controller, but you will need students to have a device to code them. Chromebooks seem to work best here.

Obstacle Course Materials:

Hula hoops

Hula hoop foam blocks

Pvc pipe and connectors

Dog training course materials

Cones (stick pvc into the holes)

Pop up play tunnel

Dollar store plastic baskets to flip over and act as landing zones

Engineering Project Material Ideas:

Fishing line

String

Neodymium magnets

Paper cups, cardstock, cardboard

Laptops or ipads (or both)