Development of a 4th-8th Grade Curriculum for Flying and Programming Mini Drones

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DEVELOPMENT OF A 4TH-8TH GRADE CURRICULUM FOR
FLYING AND PROGRAMMING MINI DRONES

by

Jordan L. Bartholomew
and Russell S. Mayo

A Plan B submitted in partial fulfillment
of the requirements for the degree

of

MASTER OF SCIENCE

in

Technology and Engineering Education

Approved:

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Gary Stewardson, Ph.D.          Wade Goodridge, Ph.D.
Major Professor                 Committee Member

______________________________
Edward Reeve, Ph.D.
Committee Member

UTAH STATE UNIVERSITY
Logan, Utah

2018
ABSTRACT

Development of a 4th-8th Grade Curriculum for Flying and Programming Mini Drones

by

Jordan Lynn Bartholomew
Russell Scott Mayo
Utah State University, 2017

Major Professor: Dr. Gary Stewardson
Department: Technology and Engineering Education

This project was a joint effort by Jordan Bartholomew and Russell Mayo. The project consisted of three parts. Part one was the development of the lesson content led by Jordan Bartholomew. Part two was the production of a multimedia package that included lesson videos, animations and logos for the ROAV copter mini curriculum, led by Russell Mayo. Part three included a journal article to introduce the curriculum co-written by both Jordan and Russ. The curriculum was developed for hands-on experiential learning and includes a computational thinking component. The lesson videos were intended for self-instruction or in a classroom setting. The curriculum was piloted with elementary and middle school students. This project documents the curriculum and journal article. This project will be submitted individually by each author for their master’s plan-B project.
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>ABSTRACT</td>
<td>iii</td>
</tr>
<tr>
<td>TABLE OF CONTENTS</td>
<td>iv</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
<td>v</td>
</tr>
<tr>
<td>SECTION I: Proposal</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Purpose</td>
<td>2</td>
</tr>
<tr>
<td>Need</td>
<td>2</td>
</tr>
<tr>
<td>SECTION II: Article to Be Published</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>4</td>
</tr>
<tr>
<td>ROAV copter challenge</td>
<td>5</td>
</tr>
<tr>
<td>Conclusion</td>
<td>8</td>
</tr>
<tr>
<td>SECTION III: Reflections</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>13</td>
</tr>
<tr>
<td>Recommendations</td>
<td>13</td>
</tr>
<tr>
<td>REFERENCES</td>
<td>14</td>
</tr>
<tr>
<td>APPENDIX A</td>
<td></td>
</tr>
<tr>
<td>CODING WITH PARROT MINI DRONES CURRICULUM</td>
<td>15</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Scope and sequence of coding with Parrot drones curriculum</td>
<td>7</td>
</tr>
<tr>
<td>2.</td>
<td>Student learning the safe handling of mini drone</td>
<td>8</td>
</tr>
<tr>
<td>3.</td>
<td>Students remotely operating mini drone during curriculum pilot</td>
<td>8</td>
</tr>
</tbody>
</table>
SECTION I

Introduction to Coding With Drones

In the field of Technology and Engineering Education (TEE), the rate at which new content is presented is rapidly increasing. When new technologies emerge often times they are so impactful on the world in which we live that the demand for education on such technologies is vital. When drones first emerged, they were used almost primarily by the military. When they became accessible to industries and even consumers, their potential uses multiplied with the increasing availability. Many industries today are pushing for the widespread education and use of drones. In fact, the agriculture industry in particular is one of the driving forces that is pushing for the use of drones and less stringent Federal Aviation Administration (FAA) regulations. Tasks that would take farmers days can now be done in minutes using a drone equipped with the right data collecting technology. This could include surveying wet and dry areas of a field or flying over to check crop harvest readiness.

Many Technology and Engineering education programs are driven by the demands from industry. In recent years, the demand for skilled drone pilots has dramatically increased, and the need for skilled technicians and programmers has as well. The Association for Unmanned Vehicle Systems International (AUVSI, 2013) estimated over 100,000 new jobs to be created in unmanned aerial vehicles by 2025 (p. 3). With this demand from industry, technology programs need to step up the preparation of students for these opportunities. Not only do students need to learn the skills of flying, they also need to master the skills of programming and computational thinking to solve complex problems.

Within the last few years the term coding has flooded school curriculum. Even to the
levels of middle and elementary school. There are many programs that are teaching students to make apps, games and web pages, but there are few that are teaching students to program drones.

**Purpose**

The purpose of this project was to develop a comprehensive piloting, coding, and data collecting curriculum for the upper elementary and middle school aged students. This curriculum offers both hands on experiences and teaches problem solving skills. The curriculum is designed to take a student with little or no prior experience and guide them to be able to pilot, then eventually program a Mini drone to perform a task. The tutorial style videos will guide students and teachers through the steps with clarity and ease. The videos were designed to make it easy for students to pause, or back up to further grasp key concepts.

This curriculum will be distributed through the [http://roavcopters.usu.edu/curriculum](http://roavcopters.usu.edu/curriculum) web page and an article will be submitted for publication in the *Technology and Engineering Teacher*. This article will not only introduce the curriculum but include details of a student skill based competition that the curriculum prepares students to compete in. This curriculum and competition will challenge students in problem solving, coding and computational thinking. The curriculum found in appendix A, includes the scope and sequence, lesson outlines, activities and assessments.

**Need**

Just like many of the robotic competitions that are prevalent in technology education programs now, this curriculum encompasses true STEM education. It will also aid the development of drone programs in the future. There are many programs that offer robotics, automation and programing, but there are no current programs or curriculum sets that offer drone piloting, coding, problem solving, and computational thinking at the 4th-8th grade level. This
curriculum and its complementing videos will bring with it a new excitement to the classroom and allow students to explore a new emerging pathway focused on drone technology. The curriculum is divided into 4 units of instruction that follow a scope and sequence. Each lesson contains activities and assessments. This curriculum can be implemented in its entirety in 2-3 weeks but can be adapted into longer lessons depending on the age group and skill level.
SECTION II

Article

Introduction

Revolving like clockwork, it can be seen that a new and exciting technology comes around and makes an influential impact on the world as we know it. For example the Computer Numerical Control (CNC) machines in manufacturing, the 3D printer for prototyping, and the laser engraver/cutter for making models.

From parks to fields, drones or multi-rotor copters are becoming more popular as a hobby as well as a tool in industry. This is largely in part due to the advancing technology of the onboard control systems that are being integrated into these unmanned aerial vehicles (UAVs). Even the inexpensive models found at department stores will include a basic set of sensing technologies such as an onboard flight controller containing a gyrometer that measures rotational movement and an accelerometer that measures acceleration. These allow the pilot to control the copter with ease. While the pilot controls direction and speed, the flight controller controls balance and stabilization making it easy to fly. With the addition of global positioning system (GPS) modules, these UAVs or drones can be programmed to fly in a specific path or hold to a specific spot and hover. Even some of the most basic copters have built in fail safes for landing autonomously. Most people who pick up a controller for the first time are surprised at how easy they are to operate. Because they are so easy to fly, hobbyists and professionals are flocking to this growing technology.

More than just flying for hobby or sport, drones are becoming a powerful tool. By adding a camera and other sensing technologies, drones become an invaluable asset to many industries. Some of them include news agencies, photography, movies, surveillance, transport,
search and rescue, and agriculture. Where expensive helicopters were required before, these relatively inexpensive multi-rotor copters can execute the most basic to more complex tasks. A properly equipped quadcopter can fly over a natural gas pipeline and detect leaks. Another could quickly take flight with infrared cameras to locate a lost hiker. The possibilities are truly endless and the jobs that will be created seem to be as well. It is projected that by 2025, over 103,776 jobs will be created related to UAVs with a projected economic impact of $3.5 billion each year over the next ten year (AUVSI, 2017).

Drone pilots are already in demand and the need for skilled technicians to build, program, and repair drones, is growing just as fast. In order to keep up with these demands, there needs to be training programs for both technicians and pilots and what better way to promote and recruit than in a high school setting. For years, technology education students have participated in robotic competitions of many varieties. These educational competitions not only provide students with fun opportunities, but students are also learning engineering and physics principles through hands on interaction with building robots. This same type of program can be applied to quadcopters. Dr. Gary Stewardson, associate professor of technology and engineering education at Utah State University (USU), agrees that quadcopters are the next logical step to staying current with industry demands (G. Stewardson, 2016). Stewardson has developed a challenge based approach to educating students in this new exciting technology.

ROAV copter challenge

ROAV (remotely operated aerial vehicles) copter challenge is a tournament style competition where students demonstrate various skills (see http://roavcopters.usu.edu/). Although the challenge is in its early stages, it has already gained interest from teachers, students and industry. In its first year (2016-2017) Stewardson and his colleagues trained over
20 teams and ran two competitions. Currently, the competition consists of a variety of skill based challenges, depending on the quadcopter platform used in each age specific division. There are three divisions, elementary, middle, and high school. The platform for the elementary and middle school is the "Parrot Mambo" minidrone. High school students will utilize the "Parrot Bebop 2" drone. Students compete in five different skill challenges consisting of manual flight, autonomous flight, computational thinking, relay race, and data acquisition.

The manual flight consists of different obstacles that the pilot must navigate through, over, under, and around in the field. At the elementary level this is done with plain sight where the middle and high school levels require first person view (FPV) headsets. Autonomous flight is where the drone is programmed to fly a particular path through the course using software. Currently the Mambo is using a drag and drop programming language called Tynker. The computational thinking component includes a number of missions that students will have to complete in the shortest amount of time. Students will be allowed to complete multiple missions in one trip or multiple single mission trips. The relay portion of the challenge utilizes a pyramid shaped baton that is carried by the drone around the course. The last component, data acquisition consists of teams developing ways to accurately collect data. With the use of a pair of small arduino programmable boards called "moteinos" equipped with long range (LoRa) radio transceivers and sensors, teams will have to retrieve information from elements in the field. An example of this would be to determine the color (red, green or blue) emitted from LEDs mounted out of site in a bucket. Like most robotic competitions, there are many variations that can be changed each year to maintain a high level of challenge for the teams. These challenges will be designed to reflect real world applications of UAVs in industry.
With the growing demand of programming and coding in K-12 classrooms from the next generation science standards (NGSS) and the standards for technological literacy (ITEA, 2007), graduate students at USU, Russ Mayo and Jordan Bartholomew, have taken ROAV a step further by developing curriculum bringing the quadcopters to the 4th through 8th grade level. One of the major difficulties for the ROAV copter challenge was the ability to train teachers and students in order to compete in the competition. Clinics were becoming difficult to organize due to geographical concerns of accessibility. ROAV mini is a curriculum set designed to introduce students to the new technology of drones as well as teach logic, programming and computational thinking with the aid of tutorial style videos.

During the creation of this curriculum, there were a few decisions that needed to be made. The first decision was which drones should be used. The Parrot Mambo was selected due to its’ ease of programming with the Tynker app. It also has a small light frame that doubles as a prop guard. The frame includes connecting points on the bottom and top of the frame to easily attach blocks or even 3D printed brackets which is useful for students to design and produce their own unique mounting system for the sensor board. The Mambo also has some nice built in safety features and comes at a price point that makes it a logical choice for classroom curriculum.

Sensing technology to collect data was another primary concern. Because Learning, a Utah based technology company caught our eye (see https://www.becauselearning.com) their product to collect data. Because Learning produces a product called the ROAV copter sensor kit which contains a product called the space board (see https://store.ardusat.com/products/rova-copter-sensor-kit). The space board contains nine different sensors. This board has been used for a variety of educational endeavors including, weather balloons, satellites, and even measuring
acceleration of CO2 cars. The combination of the Parrot Mambo and the Because Learning space board creates an exciting vehicle for an engaging curriculum. ROAV mini brings with it a variety of fun lessons to the instruct and challenge students.

The Curriculum

Lessons include short videos full of engaging content from vocabulary and terms to 3D animations and illustrations. Figure 1 shows the scope and sequence of the curriculum.

Coding with Drones: Scope and Sequence

Unit 1: Following safety procedures
1.1 Follow mini drone safety practices
1.2 Sync control device to specific minidrone
1.2a Documentation for renaming drones

Unit 2: Flying the Parrot mini drone remotely
2.1 Hover the minidrone at specified altitudes
2.2 Fly the minidrone in a square pattern without using pitch and roll controls
2.3 Fly the minidrone in a square pattern using yaw controls
2.4 Fly the minidrone through an obstacle course
2.5* Design an obstacle course and fly through it remotely

Unit 3: Flying the Parrot mini drone autonomously using Tynker
3.1 Program the minidrone to fly a simple pattern
3.2 Program the minidrone to fly through an obstacle course
3.3* Design an obstacle course and fly through it autonomously

Unit 4: Collecting data autonomously
4.1 Collect data using Ardusat space board
4.2 Design problem (making a mount for the space board)
4.3 Retrieve data remotely using minidrone and space board
4.4* Retrieve data autonomously using minidrone and space board

* Optional, for faster learners or for an extra challenge

Figure 1. Scope and sequence of the curriculum
The lessons start with unit one focusing on safety procedures. Technological literacy implies a student should be able to assess and use the technology in a safe manner. Students learn basic safety practices like never touch the drone while the props are spinning and allowing only one operator at a time to handle the remote and the drone. A quiz is used to assess safety knowledge levels before moving on to future lessons. Figure 2 shows an instructor demonstrating to a student the proper handling of the drone.

![Figure 2. Student observes the proper handling of the drone.](image)

Once the students have taken a safety quiz, they then move on to the second unit focusing on the manual flight of the drone. These lessons teach students the basic controls of the drone. Students learn proper aviation terms including yaw, pitch, and roll. Students will manually fly the drone through a series of obstacles. Figure 3 shows students navigating obstacles during a curriculum pilot.
Unit three takes the student through the basics of programming using the Tynker app. This app connects the drone to a graphical programming language where the students can drag elements together to create a program. Unit four includes lessons that provide students with real world applications of using drone technology. Students will learn about sensing technology through the use of the ArduSat space board (https://store.ardusat.com/products/ardusat-space-board). Students will then design and fabricate a mounting bracket to attach the board to the mini drone in order to retrieve data. This will ultimately prepare students with the physical infrastructure, to compete in a remote sensing skill challenge.

The ROAV mini competition has many components. The first component is a precision flight challenge where students will remotely fly the drone through a series of obstacles. The second component is a remote sensing challenge where students will have a number of missions to complete. Some examples of tasks included in these missions are reading the temperature of an aluminum plate, and determining color of light being emitted by LEDs, in a five gallon
bucket. The competition will continue to evolve and implement new missions. Students will decide how and what missions to complete to receive points in a given time. This is where students will learn and apply computational thinking. "Computational thinking is the thought processes involved in formulating a problem and expressing its solution(s) in such a way that a computer—human or machine—can effectively carry out" (Wing, 2014, ¶ 5). In essence, it is the ability to break down a complex problem into smaller tasks. This type of thinking is linked to computer code. Each line of code is a part of an algorithm. A program may be made up of many algorithms. Students will demonstrate how to effectively solve a problem in the competition in order to complete various missions.

Conclusion

Like many new technologies implemented into classroom curriculum, drones are another engaging method of integrating STEM education. Technology teachers are always looking for ways to engage students and provide meaningful lessons that will impact their students lives. This ROAV mini curriculum shows significant promise through its exciting and dynamic approach to teach programming and technology. It should prove exceptionally motivating to students and teachers. The curriculum is easy to implement and the competitions take the students to a new level of active learning. This will be a new and exciting part of technology and engineering education for years to come.
REFERENCES


SECTION III

Reflections

Conclusion

This curriculum was developed as a way to engage students in coding and remote sensing. Additionally, it focuses on computational thinking, which is an important skill of future 21st century professionals. Through hands on activities and real world scenarios, students can see connections between the lessons and practical applications. When piloted, students were excited and their level of confidence increased as they gained the skills necessary to complete the tasks. In many situations, there were several people passing by that would stop and watch as the students navigated the drone through and around the obstacles. Although no formal studies of this curriculum have been implemented, the excitement and engagement it provided created evidence that there is room for a curriculum such as this.

Recommendations

This curriculum has incorporated lessons that are challenging to many students. Although there are lesson outlines provided, there are many ways that the lessons could be extended to more depth. Additional lessons on topics of flight, drone design and even automation systems could enhance the curriculum for older age groups. This curriculum was intended to introduce and captivate younger students and encourage students to solve problems through computational thinking. One question that could be asked is, how effective is this curriculum at teaching what it is suppose to teach? This will hopefully be answered with further studies and projects.
REFERENCES


Coding with Drones: Scope and Sequence

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Coding with Parrot Mini Drones

Unit 1: Following safety procedures

Terminal Objective 1.1: Follow mini drone safety practices

Performance Objective 1.1: While observing and operating mini drones, follow safety practices at all times.

Enabling Objectives:

1. Identify Hazards
2. Demonstrate understanding of safety practices for operators and spectators

Materials and Supplies:

- Parrot mini drone: Cargo or Mambo
- Quiz 1.1: *Mini Drone Safety Practices*

Learning Activities:

1. Video ROAV mini 1.1 v1
2. Discussion of possible risks

Summative Assessment:

1. Quiz 1.1: *Mini Drone Safety Practices* with answer key

Supplemental teacher resources:

- Know before you fly (FAA rules for drones)
  http://knowbeforeyoufly.org/
Quiz 1.1: Mini Drone Safety Practices

Name: ____________________________ Date: __________________

Indicate whether the statement is true or false by wiring T for true or F for false next to the statement.

1. _____ It is OK to fly a drone over people?
2. _____ The fly zone is safe to stand in while drone is flying.
3. _____ A drone must be flown at least 10 ft. away from people.
4. _____ It’s not safe to pick up the drone when props are spinning.
5. _____ It’s OK to look away from the drone for just a second.
6. _____ Safety glasses must be worn when drone is in operation.
7. _____ Safety netting is required while flying more than one drone in an area.

List two possible risks while operating the mini drone.

8. ____________
9. ____________

Read the following statement:

I understand and will follow the practices outlined in this lesson while participating in this activity.

Signature: ____________________________ Date: __________________
Quiz 1.1: Mini Drone Safety Practices
Answer Key

Name: _______________________________ Date: ________________

Indicate whether the statement is true or false by wiring T for true or F for false next to the statement.

1. __F__ It is OK to fly a drone over people
2. __F__ The fly zone is safe to stand in while drone is flying
3. __T__ A drone must be flown at least 10 ft. away from people
4. __T__ It’s not safe to pick up the drone when props are spinning
5. __F__ It’s OK to look away from the drone for just a second
6. __T__ Safety glasses must be worn when drone is in operation
7. __T__ Safety netting is required while flying more than one drone in an area

8-9 List two possible risks while operating the mini drone.

Answers can come from discussion

- Could connect to wrong drone
- Props could break on impact
- Drone could fail and fall out of sky
- Props can cause harm to hands or skin
- Drone can lose connection and fly toward spectators
Coding with Parrot Mini Drones

Unit 1: Following safety procedures

Terminal Objective 1.2: Sync control device to a specific minidrone

Performance Objective 1.2: Follow procedures for syncing control device to specific mini drone

Enabling Objectives:
1. Locate settings within app for Classroom mode
2. Safely demonstrate connecting to correct minidrone

Materials and Supplies:
- Parrot mini drone: Cargo or Mambo
- Free flight 3 app installed on a Bluetooth enabled device

Learning Activities:
1. Video: Parrot Minidrones - MAMBO - Tutorial #1: Setup
   https://www.youtube.com/watch?v=dXt88r4r2uI
2. Demonstration
   Students will identify where in the Free Flight 3 app to locate which drone they are connecting to.

Summative Assessment:
1. Performance Assessment 1.1: Connecting to minidrone

Supplemental teacher resources:
1. Operation of Mambo minidrone
2. 1.2a: Documentation for renaming the mini drone

Performance Assessment 1.2:
Connecting to minidrone

Name: ___________________________ Date ___________________________

Terminal Objective 1.2: Sync control device to a specific minidrone

Performance Objective 1.2: Follow procedures for syncing control device to specific minidrone

Assessment

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<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safe practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Demonstrated proper power up and power down procedures</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Correctly identified assigned drone</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Connected successfully to minidrone</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: ___________________________ Date: ___________________________

Coding with Parrot Mini Drones
Unit 1: Following safety procedures

1.2a: Documentation for renaming the mini drone

When working in a classroom setting with multiple drones, the possibility of connecting to the incorrect drone is likely. To mitigate this problem, it is recommended to rename the drones to a unique and easily recognized name. The default name for the Parrot Mambo is "Mambo_xxxxxxx". Examples of unique naming sequences would be Mambo_1, Mambo_2 and so on. Other examples could include colors such as Red, Blue, or Green. School names and team IDs could be used to eliminate confusion at competitions. It is good practice to have the names of the drones identified on the drone for easy reference. Using a label maker, permanent marker, colored tape or even spray paint are good ways of identifying the drones quickly.

Steps for renaming mini drone

1. Connect drone to freeflight mini app
2. Long press on SSID name of connected device. Default is Mambo_xxxxxxx
3. Rename device. You may have to restart mini drone and reconnect smart device.

Coding with Parrot Mini Drones
Unit 2: Flying the Parrot mini drone remotely

Terminal Objective 2.1: Hover the Parrot mini drone

Performance Objective 2.1: Using an iPad or Android tablet, hover the Parrot mini drone at two specified heights ± 1 foot.

Enabling Objectives:
1. Identify parts of the mini drone
2. Charge mini drone batteries
3. Connect mini drone to remote control (tablet)
4. Demonstrate the use of controls for throttle
5. Practice hovering the mini drone in safe manner

Materials and Supplies:
- iPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install Free flight mini app on tablet (found in app store)
- Safety glasses for all participants
- Parrot mini drone: Cargo or Mamba
- USB charging device
- Activity Sheet 2.1: Parts of the mini drone (for each student) and answer key
- Hover challenge 2.1 (for reference) and Performance Assessment 2.1: Hover challenge
- Construction style tape measure with lock

Learning Activities:
1. Video ROAV mini 2.1 v1
2. Practice charging battery (if needed), connecting devices, and hovering the mini drone.
3. Complete Activity Sheet 2.1: Parts of the mini drone

Formative Assessment:
1. Practice charging battery (if needed), connecting devices, and hovering the mini drone.
2. Complete Activity Sheet 2.1: Parts of the mini drone

Summative Assessment:
1. Safely perform hovering maneuver at two specified heights. Evaluate students using Performance Assessment 2.1: Hover Challenge
Supplemental teacher resources:

- How do quadcopters and multicopters fly? Video
  [https://www.youtube.com/watch?v=Z_T6LBwuBK](https://www.youtube.com/watch?v=Z_T6LBwuBK)

- Setting up mini drone from Parrot

- Getting started Parrot Mambo

- Updating firmware on mini drone
Activity Sheet 2.1: Parts of the mini drone

Match the parts with the correct name by writing the letter in the space provided.

1. ___ Prop Guard  3. ___ Prop  5. ___ Body
2. ___ USB cable  4. ___ Battery  6. ___ Frame

Answer the following questions regarding charging.

7). List the steps for charging the mini drone
   a)
   b)

8). What indicates that the battery is fully charged?
Activity Sheet 2.1: Parts of the mini drone

Answer key

Match the parts with the correct name by writing the letter in the space provided.

1. _F__Prop Guard  3. _B__Prop  5. _D__Body
2. _E__USB cable  4. _A__Battery  6. _C__Frame

Answer the following questions regarding charging.

7). List the steps for charging the mini drone
   a. Insert battery into mini drone
   b. Connect USB to charger or computer

8). What indicates that the battery is fully charged?
   The red charging light will change to green.
Hover Challenge 2.1

To set up this challenge you will need a tape measure or some way to determine a specified height. For this example, we will use a common construction tape measure with a working lock.

Steps:
1. Establish designated fly and safe zones in an open area
2. In the fly zone, extend tape measure to 7 feet and lock
3. Place tape measure with the end on the ground so tape is extended into the air. (see figure 1.1)
4. Have student operating the minidrone, place drone in the fly zone
5. Move to the safe zone
6. Have student practice the task of hovering at 3 feet and 7 feet heights
7. Evaluate student’s performance using Performance Assessment 2.1: Hover

Figure 1.1
Performance Assessment 2.1:
Hover Challenge

Name:______________________________________ Date______________________

Terminal Objective 2.1: Hover the Parrot mini drone

Performance Objective 2.1: Using an iPad or Android tablet, hover the Parrot mini drone at two specified heights.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safe practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Demonstrated proper power up and power down procedures</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Hovered at 3 feet ± 1ft.</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Hovered at 7 feet ± 1ft.</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by:______________________________________ Date:______________________
Coding with Parrot Mini Drones

Unit 2: Flying the Parrot mini drone remotely

Terminal Objective 2.2: Fly the mini drone in a square pattern using pitch and roll controls.

Performance Objective 2.2: Using an iPad or Android tablet with the free flight mini app, fly the mini drone safely in a square pattern using pitch and roll controls in both clockwise (CW) and counterclockwise (CCW) directions.

Enabling Objectives:
1. Identify pitch and roll as it relates to a quadcopter
2. Demonstrate how pitch controls forward and reverse, and roll controls left and right
3. Demonstrate forward, reverse, left, and right movements of the mini drone

Materials and Supplies:
- iPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install free flight mini app on tablet (found in app store)
- Safety glasses for all participants
- Parrot Mini Drone: Cargo or Mamba and USB charging device
- Flight Challenge 2.2 (for reference)
- Rope or other means of creating a square space
- Performance Assessment 2.2: Square Challenge, Pitch and Roll (copy for each student)

Learning Activities:
1. Video: ROAV mini 2.2 v1
2. Practice flying square pattern using pitch and roll controls

Formative Assessment:
1. Practice flying mini drone controlling pitch and roll
2. Safely perform square pattern maneuver in boundaries. (Refer to Square challenge)

Summative Assessment:
1. Evaluate students using Performance Assessment 2.2: Square Challenge, Pitch and Roll

Supplemental teacher resources:
- Flight controls for free flight 3 mini app
- Optional flypad accessory
  https://community.parrot.com/t5/Mambo-Knowledge-Base/Parrot-Flypad/ta-p/145932
Square Challenge 2.2

To set up this challenge you will need rope or some way to establish a square. For this example, we will use rope and barriers to create the square area.

Steps:
1. Establish designated fly and safe zones in an open area
2. Rope off a square area using barrier stands. (figure 1.)
3. Have student operating the minidrone, place drone in the fly zone
4. Move to the safe zone
5. Have students practice flying in a CW & CCW square pattern using pitch and roll controls (figure 2.)
6. Evaluate students using Performance Assessment 2.2: Square Challenge, Pitch and Roll

Figure 1.  
Figure 2.
Performance Assessment 2.2:  
Square Challenge

Name: __________________________ Date ________________________________

Terminal Objective 2.2: Fly the mini drone in a square pattern using pitch and roll controls

Performance Objective 2.2: Using an iPad or Android tablet with the free flight mini app, fly the mini drone safely in a square pattern using pitch and roll controls in both clockwise and counterclockwise directions.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safe practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Demonstrated proper power up and power down procedures</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew the mini drone in a CW square pattern using pitch and roll controls</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew the mini drone in a CCW square pattern using pitch and roll controls</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: ____________________________________________ Date: __________________________
Coding with Parrot Mini Drones

Unit 2: Flying the Parrot mini drone remotely

Terminal Objective 2.3: Fly the mini drone in a square pattern using yaw controls.

Performance Objective 2.3: Using an iPad or Android tablet with the free flight mini app, fly the mini drone safely in a square pattern using yaw controls in both clockwise (CW) and counterclockwise (CCW) directions.

Enabling Objectives:
1. Identify yaw as it relates to the mini drone
2. Demonstrate how yaw controls rotating left and right

Materials and Supplies:
- iPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install free flight mini app on tablet (found in app store)
- Safety glasses for all participants
- Parrot Mini Drone: Cargo or Mamba
- USB charging device
- Flight Challenge 2.3 (for reference)
- Rope or other means of creating a square space
- Performance Assessment 2.3: Square Challenge, Yaw (copy for each student)

Learning Activities:
1. Video: ROAV mini 2.3 v1
2. Practice flying square pattern using pitch and yaw controls

Formative Assessment:
1. Practice flying mini drone controlling yaw
2. Safely perform square pattern maneuver in boundaries. (Refer to Square challenge)

Summative Assessment:
1. Evaluate students using Performance Assessment 2.3: Square Challenge, Yaw

Supplemental teacher resources:
- Flight controls for free flight 3 mini app
- Optional flypad accessory
  https://community.parrot.com/t5/Mambo-Knowledge-Base/Parrot-Flypad/ta-p/145932
Square Challenge 2.3

To set up this challenge you will need rope or some way to establish a square. For this example, we will use rope and barriers to create the square area.

Steps:
1. Establish designated fly and safe zones in an open area
2. Rope off a square area using barrier stands. (figure 1.)
3. Have student operating the minidrone, place drone in the fly zone
4. Move to the safe zone
5. Have student practice flying in a CW & CCW square pattern using yaw controls. (figure 2.)
6. Evaluate students using Performance Assessment 2.3: Square Challenge, Yaw
Performance Assessment 2.3: 
Square Challenge, Yaw

Name: __________________________________________ Date: _______________________

Terminal Objective 2.3: Fly the mini drone in a square pattern using yaw controls

Performance Objective 2.3: Using an iPad or Android tablet with the free flight mini app, fly the mini drone safely in a square pattern using yaw controls in both clockwise (CW) and counterclockwise (CCW) directions.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safe practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Demonstrated proper power up and power down procedures</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew the mini drone in a CW square pattern using yaw controls</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew the mini drone in a CCW square pattern using yaw controls</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: __________________________________________ Date: _______________________


Coding with Parrot Mini Drones

Unit 2: Flying the Parrot mini drone remotely

Terminal Objective 2.4: Fly the mini drone through an obstacle course

Performance Objective 2.4: Using an iPad or Android tablet with the free flight mini app, fly the mini drone safely through an obstacle courses with accuracy.

Enabling Objectives:
1. Demonstrate precision flight of the mini drone using pitch, yaw, and roll

Materials and Supplies:
- iPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install free flight mini app on tablet (found in app store)
- Safety glasses for all participants
- Parrot Mini Drone: Cargo or Mambo with USB charging device
- Flight Challenge 2.4 (for reference)
- 3 hoops and some way to secure
- 2 foam floor tiles, 2 feet x 2 feet
- Performance Assessment 2.4: Remote flight challenge (copy for each student)
- Understanding Check 2.4: Remote flight (copy for each student) and answer key

Learning Activities:
1. Video: ROAV mini 2.4 v1
2. Understanding Check 2.4: Remote flight

Formative Assessment:
1. Practice flying mini drone through obstacle course
2. Understanding Check 2.4: Remote flight use answer key

Summative Assessment:
1. Safely perform obstacle course flight. (Refer to Remote flight challenge)
2. Evaluate students using Performance Assessment 2.4: Remote flight challenge

Supplemental teacher resources:
- Parrot Mambo Racing Club (just for fun)
- https://www.youtube.com/watch?v=CR5lA4AMHIU
- Optional flypad accessory
  https://community.parrot.com/t5/Mambo-Knowledge-Base/Parrot-Flypad/ta-p/145932
Remote flight challenge 2.4

To set up this challenge you will need 3 hoops fixed in an upright position and two foam floor tiles.

Steps:
1. Establish designated fly and safe zones in an open area
2. Set up challenge using hoops and floor tiles. (see figure 1.)
3. Have operating student place mini drone in the fly zone
4. Move to the safe zone
5. Have student practice the task of maneuvering mini drone through the hoops
6. Evaluate students using Performance Assessment 2.4: Remote flight challenge

Figure 1.
Understanding Check 2.4:  
Remote flight

Name: ___________________________ Date: __________________

Fill in the blank with the proper flight control on the image below

<table>
<thead>
<tr>
<th>Word bank</th>
<th>Yaw Left</th>
<th>Yaw Right</th>
<th>Pitch Forward</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitch Backward</td>
<td>Roll Left</td>
<td>Roll Right</td>
<td></td>
</tr>
<tr>
<td>Throttle Up</td>
<td>Throttle Down</td>
<td>Auto Land</td>
<td></td>
</tr>
</tbody>
</table>
Understanding Check 2.4: Remote flight Answer key

- Throttle up
- Pitch Forward
- Yaw Left
- Roll Right
- Yaw Right
- Roll Left
- Throttle down
- Auto Land
- Pitch Backwards
Performance Assessment 2.4: Remote flight challenge

Name: ____________________________ Date ____________________________

Terminal Objective 2:4 Fly the mini drone through an obstacle course

Performance Objective 2.4: Using an iPad or Android tablet with the free flight mini app, fly the mini drone safely through an obstacle courses with accuracy.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safe practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Demonstrated proper power up and power down procedures</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew the mini drone generally following path</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew the mini drone hitting 1 or less obstacles</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Landed mini drone touching pad</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: ____________________________ Date: ____________________________
Coding with Parrot Mini Drones

Unit 2: Flying the Parrot mini drone remotely

Terminal Objective 2.5: Created an obstacle course

Performance Objective 2.5: Using an iPad or Android tablet with the free flight mini app, create an obstacle course to challenge mini drone pilots flying skills.

Enabling Objectives:
1. Brainstorm course ideas

Materials and Supplies:
- iPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install free flight mini app on tablet (found in app store)
- Safety glasses for all participants
- Parrot Mini Drone: Cargo or Mamba
- USB charging device
- Flight Challenge 2.5 (for reference)
- Items for students to use for creating obstacle course
- Performance Assessment 2.5: Remote flight challenge (copy for each student)
- Understanding Check 2.4: Remote flight (copy for each student)

Learning Activities:
1. Obstacle course design and build
2. Practice flying through obstacle course

Formative Assessment:
1. Build and test obstacle course using mini drone

Summative Assessment:
1. Evaluate students using Performance Assessment 2.5: Remote flight challenge(optional)

Supplemental teacher resources:
- Flight controls for free flight 3 mini app
- Optional flypad accessory
  https://community.parrot.com/t5/Mambo-Knowledge-Base/Parrot-Flypad/ta-p/145932
Remote flight challenge 2.5 (optional)

In this challenge, students will design and build their own obstacle course to fly through. The performance rubric for this activity ads the criteria of having three or more elements in the course. To make this more interactive as a class, have students set the criteria for the obstacle course. Encourage students to design course on paper with an explanation of what they are wanting to do before they build. Students will love the flexibility with this challenge and it’s fun to see the creativity of the students.

Steps:
1. Group students (2-3 works well)
2. Let students design obstacle course on paper
3. Establish designated fly and safe zones in an open area
4. Take turns with groups setting up their course
5. Have operating student place mini drone in the fly zone
6. Move to the safe zone
7. Have students practice the task of maneuvering through the course
8. Evaluate students using Performance Assessment 2.5: Remote flight challenge (optional)
Performance Assessment 2.5: 
Remote flight challenge (optional)

Name: ___________________________ Date _________________________

Terminal Objective 2.5: Created an obstacle course

Performance Objective 2.5: Using an iPad or Android tablet with the free flight mini app, create an obstacle course uses creativity to challenge mini drone flight.

Assessment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Much below Expectations 1 Point</th>
<th>Below Expectations 2 points</th>
<th>Meets expectations 3 points</th>
<th>Exceeds Expectations 4 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course elements</td>
<td>1 element</td>
<td>2 elements</td>
<td>3 elements</td>
<td>4+ elements</td>
</tr>
<tr>
<td>Course Difficulty</td>
<td>Requires little skill to fly through e.g. straight lines</td>
<td>Requires left and right turns</td>
<td>Requires left and right turns and different heights</td>
<td>Requires great piloting skills e.g. tight spaces, or quick maneuvers</td>
</tr>
<tr>
<td>Follows flight path</td>
<td>Breaks path</td>
<td>Generally, follows path</td>
<td>Maintains path</td>
<td></td>
</tr>
<tr>
<td>Accurate Landing</td>
<td>Down the street (Misses tile)</td>
<td>In the yard (Touching tile)</td>
<td>On the porch (Middle of tile)</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: To pass this objective, the student must follow safety practices and receive a score of 12 or higher.

Assessed by: ___________________________ Date: _________________________
Coding with Parrot Mini Drones

Unit 3: Flying the Parrot mini drone autonomously using Tynker

Terminal Objective 3.1: Program the mini drone to fly a simple pattern

Performance Objective 3.1: Using Tynker app, program the Parrot mini drone to fly a simple pattern within boundaries.

Enabling Objectives:
1. Define programing
2. Identify programing elements (blocks)
3. Sketch program design (pseudocode)
4. Program flight pattern using Tynker app
5. Test program to perform flight task

Materials and Supplies:
- iPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install Tynker app on tablet (found in app store)
- Safety glasses for all participants
- Parrot mini drone: Cargo or Mambo and USB charging device
- Simple Pattern 3.1 (for reference)
- Performance Assessment 3.1: Simple pattern (one for each student)
- Roll of masking tape and 2 foam 2'x2' floor tiles

Learning Activities:
1. Watch: Video ROAV mini 3.1 v1
2. Create flight plan using pseudocode

Formative Assessment:
1. Practice programing using blocks in Tynker app
2. Safely perform autonomous flight of simple pattern.

Summative Assessment:
1. Evaluate students using Performance Assessment 3.1: Simple Pattern

Supplemental teacher resources:
- Enabling Classroom Mode
- Video: Enabling Classroom Mode for Tynker
Simple Pattern 3.1

To set up this challenge you will need some tape to mark out squares and boundaries. You may want to use a rug and have students fly above for reference. For this example, the pattern is provided but alternative patterns can be used to increase challenge or practice. Students will create a program to fly the pattern within the taped boundaries.

Steps:
1. Establish designated fly and safe zones in an open area
2. In the fly zone, mark out boundaries and starting square (red) on the floor using tape
3. Mark landing square (blue) on the floor (figure 1)
4. Set mini drone on red square
5. Have students create program to follow pattern at initial take off height (3 feet)
6. Have student operating minidrone, place drone in the fly zone
7. Move to the safe zone
8. Have student run program to perform simple pattern
9. Evaluate student’s performance using Performance Assessment 3.1: Simple pattern

Figure 1
Performance Assessment 3.1: Simple Pattern

Name: ___________________________________________ Date _______________________

Terminal Objective 3.1: Program the mini drone to fly a simple pattern

Performance Objective 3.1: Using Tynker app, program the Parrot mini drone to fly a simple pattern within boundaries.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safety practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Demonstrated proper power up and power down procedures</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew mini drone following simple pattern</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Flew mini drone within boundaries</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: ___________________________________________ Date: _______________________

Coding with Parrot Mini Drones

Unit 3: Flying the Parrot mini drone autonomously using *Tynker*

Terminal Objective 3.2: Program the mini drone to fly through an obstacle course

Performance Objective 3.2: Using *Tynker* app, program the mini drone to fly through an obstacle course with precision.

Enabling Objectives:
1. Define the following terms: dead reckoning, open loop, closed loop, feedback
2. Change values on movement blocks
3. Sketch program design (pseudocode)
4. Program flight pattern using *Tynker*
5. Troubleshoot program
6. Execute program to perform flight task

Materials and Supplies:
- IPad with iOS 8.0 or later or Android tablet with 4.0 or later
- Download and install *Tynker* App on tablet (found in app store)
- Safety glasses for all participants
- Parrot Mini Drone: Cargo or Mambo and USB charging device
- *Autonomous Challenge 3.2* (for each student)
- *Performance Assessment 3.2: Operation Delivery* (for each student)
- 3 Hula-hoops, tape, 2 foam 2’x2’ tiles

Learning Activities:
1. Video: ROAV mini 3.2 v1
2. Create flight plan in pseudocode
3. Practice programing using blocks in *Tynker*

Formative Assessment:
1. Safely perform flight with *Autonomous Challenge 3.2* activity

Summative Assessment:
1. Evaluate students using *Performance Assessment 3.2: Operation Delivery*

Supplemental teacher resources:
- Amazon prime air’s first customer delivery
  [https://www.youtube.com/watch?v=vNySOR12Ny8](https://www.youtube.com/watch?v=vNySOR12Ny8)
Autonomous Challenge 3.2: Operation Delivery

Name: ____________________________________________ Date: ______________________

Situation
Amazon and other companies are working toward using drones to deliver orders to their customers. This type of drone system is complex and requires precision and accuracy. Choosing most efficient routes and avoiding obstacles is key for the success of this type of transport. Drone programmer pilots need to be able to program these drones to follow paths in order to deliver packages safely.

Challenge
As a team of independent programmers, you have been asked to test early drone hardware and software to see if this can be achieved. The customer, Amazon is wanting these tests done before acquiring FAA approval. Your challenge is to program the mini drone to go through an obstacle course with precision and efficiency. The course will consist of the following layout set up in the gym. There will be a pad for takeoff and one for landing. The drone must take off and travel through three hula-hoops before landing. The challenge will be to get through the obstacles without crashing in the shortest amount of time.

1) Sketch your program here using pseudocode

```plaintext
START

```
2) **Program using Tynker.** Your program will probably not work the first time. You will need to try out your program and make adjustments to achieve this goal. Make sure you document what changes you made.

Changes to program:

Follow safety practices while completing the following

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Much below Expectations 1 Point</th>
<th>Below Expectations 2 points</th>
<th>Meets expectations 3 points</th>
<th>Exceeds Expectations 4 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoids obstacles</td>
<td>Touched ground during flight</td>
<td>Hits more than one</td>
<td>Hits 1 object</td>
<td>No collisions</td>
</tr>
<tr>
<td>Follows flight path</td>
<td></td>
<td>Breaks path</td>
<td>Generally, follows path</td>
<td>Maintains path</td>
</tr>
<tr>
<td>Accurate Landing</td>
<td></td>
<td>Down the street (Misses tile)</td>
<td>In the yard (Touching tile)</td>
<td>On the porch (Middle of tile)</td>
</tr>
<tr>
<td>Time(standard)</td>
<td>15+ seconds</td>
<td>+10-14 seconds</td>
<td>+6-9 seconds</td>
<td>+1-5 seconds</td>
</tr>
</tbody>
</table>

3) **Reflection** What was the hardest part of this challenge? What would you have done different?
Autonomous Challenge 3.2 (reference)

To set up this challenge you will need 3 hoops fixed in an upright position and two foam floor mats.

Steps:
1. Establish designated fly and safe zones in an open area
2. Set up challenge using hoops and mats. (see fig 1.1)
3. Have operating student place mini drone in the fly zone
4. Move to the safe zone
5. Have student test and troubleshoot code
6. Evaluate student’s performance using Performance Assessment 3.2: Operation Delivery

Figure 1.1
Performance Assessment 3.2: 
Operation delivery

Name: ___________________________ Date _______________________

Terminal Objective 3.2: Program the mini drone to fly through an obstacle course

Performance Objective 3.2: Using Tynker, program the mini drone to fly through an obstacle with precision.

Assessment

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Much below Expectations 1 Point</th>
<th>Below Expectations 2 points</th>
<th>Meets expectations 3 points</th>
<th>Exceeds Expectations 4 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avoids obstacles</td>
<td>Touched ground during flight</td>
<td>Hits more than one</td>
<td>Hits 1 object</td>
<td>No collisions</td>
</tr>
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<td>Generally, follows path</td>
<td>Maintains path</td>
<td></td>
</tr>
<tr>
<td>Accurate Landing</td>
<td>Down the street (Misses pad)</td>
<td>In the yard (Touching pad)</td>
<td>On the porch (Middle of pad)</td>
<td></td>
</tr>
<tr>
<td>Time (standard)</td>
<td>15+ seconds</td>
<td>+10-14 seconds</td>
<td>+6-9 seconds</td>
<td>+1-5 seconds</td>
</tr>
</tbody>
</table>

Note: To pass this objective, the student must follow safety practices and receive a score of 12 or higher.

Assessed by: ___________________________ Date: _______________________

Assessment:
- Follows safety practices: Yes □ No □
- Avoids obstacles: Touched ground during flight □
- Follows flight path: Breaks path □
- Accurate landing: Down the street (Misses pad) □
- Time (standard) set by Teacher: 15+ seconds □

Total: _______________________

Note: To pass this objective, the student must follow safety practices and receive a score of 12 or higher.
Coding with Parrot Mini Drones

Unit 4: Collecting data autonomously

Terminal Objective 4.1: Collect data using ArduSat space board

Performance Objective 4.1: Using a computer, collect data using an ArduSat space board and read sensor values.

Enabling Objectives:
1. Define what sensors do
2. Identify different types of sensors
3. Set up an ArduSat sensor experiment
4. Record sensor data

Materials and Supplies:
- Computer with internet connection using chrome browser (plugin required for arduino)

Learning Activities:
1. Video: ROAV mini 4.1 v1
2. ArduSat Space board Sensors [https://ehub.ardusat.com/experiments/4709](https://ehub.ardusat.com/experiments/4709)

Formative Assessment:
1. Activity sheet 4.1: Sensors

Summative Assessment:
1. Evaluate students using Performance Assessment 4.1: Record Sensor Data

Supplemental teacher resources:
- ROAVcopter sensor-kit [https://www.becauselearning.com/](https://www.becauselearning.com/)
- ArduSat experiment hub [https://ehub.ardusat.com/experiments/overview](https://ehub.ardusat.com/experiments/overview)
- ArduSat Safety video [https://www.youtube.com/watch?v=17iPwzWK440](https://www.youtube.com/watch?v=17iPwzWK440)
Activity Sheet 4.1: Sensors

Name: ___________________________ Date _______________________

Identify different types of sensors

1) What is a sensor and what does it do?

2) What do the following sensors measure?
   a) Luminosity Sensor:

   b) Temperature Sensor:

   c) Accelerometer:

   d) Gyroscope:

   e) Magnetometer:

   f) Ultra Violet Light Sensor:

   g) Infrared Thermopile:

   h) RGB sensor
Performance Assessment 4.1:  
Record Sensor Data

Record Sensor Data

1. Connect the Ardusat space board to the Moteino using the grove connector and wires.
2. Connect the Moteino to the computer using the USB cable.
3. Log into the Ardusat ehub then open the sensor experiment found here:  
4. Find various items to measure using the space board.
5. Fill out the table with the data collected.

**Note:** To pass this objective, 8 out of 10 responses satisfactory.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>What item did you measure?</th>
<th>What was the value?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminosity Sensor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(ambient)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infrared Thermopile</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(directional)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RGB sensor</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

What was the most exciting thing you measured and why?

Where might you see these sensors used?
Coding with Parrot Mini Drones

Unit 4: Collecting data autonomously

Terminal Objective 4.2: Design and produce a working mount for the space board.

Performance Objective 4.2: Using a 3D printer, Legos, or other means, design and produce a working mount for the space board to connect to the Mini Drone.

Enabling Objectives:
1. Utilize the Engineering Design Process
2. Measure components and parts
3. Select a means of producing a mount
4. Produce a functional mount

Materials and Supplies:
- Rulers and other measuring devices such as dial or digital calipers.
- CAD software or pencil and paper for producing working drawings
- 3D printer and required supplies or
- Assortment of building bricks e.g. Legos ©
- Screws or way of fastening Space board to mount

Learning Activities:
1. Video: ROAV mini 4.2 v1
2. Design Challenge worksheet 4.2

Formative Assessment:
1. Activity sheet 4.2: Design Challenge worksheet

Summative Assessment:
1. Producing a working solution Performance Assessment 4.2: Sensor board mount

Supplemental teacher resources:
- Explanation of engineering design process,(good for students) https://www.youtube.com/watch?v=fxJWin195kU&t=52s
- Lego © Brick dimensions https://grabcad.com/tutorials/lego-01-basic-dimensions-bricks-explained
Activity Sheet 4.2: Design Challenge

Name: ___________________________ Date ____________________

Part I: Brainstorm possible solutions

Use the space below to sketch possible designs for the mount.

Part II: Measurements

Use measuring devices to acquire necessary measurements such as overall length, width and height, of parts, and diameter and location of holes and features.

1.
2.
3.
4.
5.
6.
7.
8.
9.
10.
11.
12.
13.
14.
Performance Assessment 4.2:
Sensor Board Mount

Design Solution Rubric

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Much Below Expectations (1 point)</th>
<th>Below Expectations (2 points)</th>
<th>Meets Expectations (3 points)</th>
<th>Exceeds Expectations (4 points)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attachment</td>
<td>Sensor board does not mount properly, and does not attach securely to drone</td>
<td>Sensor board does not mount properly, or does not attach securely to drone</td>
<td>Sensor board attaches soundly and mount attaches firmly to drone</td>
<td>Protects sensor board and stays attached after impacts</td>
</tr>
<tr>
<td>Size/Weight</td>
<td>Much too heavy for drone to lift off</td>
<td>Large in size or weight effects drones ability to lift off</td>
<td>Contains a small footprint and is able function properly with drone flight</td>
<td>Design is well thought out and is balanced with size/weight and strength</td>
</tr>
<tr>
<td>Functionality</td>
<td>Totally covers ultrasonic sensor on drone</td>
<td>Interferes with ultrasonic sensor on drone</td>
<td>Does not obstruct drone sensor or other components</td>
<td>Offers flexibility with other items such as the battery and the LoRa radio</td>
</tr>
</tbody>
</table>

**Note:** To pass this objective, the student must create a mount that receives a score of 9 or higher.

Assessed by: ____________________________ Date: __________________
Coding with Parrot Mini Drones

**Unit 4:** Collecting data autonomously

**Terminal Objective 4.3:** Retrieve data remotely using mini drone and space board

**Performance Objective 4.3:** Safely retrieve data remotely using mini drone and space board to remotely read sensor values.

**Enabling Objectives:**
1. Define what sensors do
2. Identify different types of sensors
3. Set up an Ardusat sensor experiment
4. Record sensor data

**Materials and Supplies:**
- Laptop with internet connection using chrome browser (plugin required for arduino)
- 3D printed mount for space board or building block alternative (from lesson 4.2)
- 8-inch wire tie to secure Moteino
- LED bucket assembly placed on stool (see RGB bucket document)
- Electric hotplate with 12”x 12"x 1/8” aluminum sheet on top

**Learning Activities:**
1. Video: ROAV mini 4.3 v1

**Formative Assessment:**
1. Activity sheet 4.3: *Pilot Data Mission*

**Summative Assessment:**
1. Evaluate students using *Performance Assessment 4.3: Pilot Data Mission*

**Supplemental teacher resources:**
- ROAVcopter sensor-kit [https://www.becauselearning.com/](https://www.becauselearning.com/)
- Ardusat experiment hub [https://ehub.ardusat.com/experiments/overview](https://ehub.ardusat.com/experiments/overview)
Activity Sheet 4.3: Pilot Data Mission

Name: ____________________________ Date: ________________________

Challenge

As a team, you are to attach the space board to the mini drone and pilot the mini drone remotely to collect sensor data. There are two data sets that will need to be retrieved. The first is temperature and the next is a color reading. Your challenge is to navigate obstacles and to collect the data required.

Field set up

Ambient temperature reading: ____________

Data retrieved: Indicate the reading by placing a checkmark in the correct circle.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Room</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Reading</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Color

<table>
<thead>
<tr>
<th></th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Reading</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

3) Reflection: What was the hardest part of this challenge?
Performance Assessment 4.3:
Pilot Data Mission

Name: __________________________ Date: __________________

Terminal Objective 4.3: Retrieve data remotely using mini drone and space board

Performance Objective 4.3: Safely retrieve data remotely using mini drone and space board to remotely read sensor values.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safety practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Piloted the minidrone to retrieve sensor data</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Correctly identified temperature sensor reading</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Correctly identified color sensor reading</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: __________________________ Date: __________________
Coding with Parrot Mini Drones

Unit 4: Collecting data autonomously

Terminal Objective 4.4: Retrieve data autonomously using mini drone and space board

Performance Objective 4.4: Safely retrieve data autonomously using mini drone and space board to remotely read sensor values.

Enabling Objectives:
1. Define what sensors do
2. Identify different types of sensors
3. Set up an Ardusat sensor experiment
4. Record sensor data

Materials and Supplies:
- Laptop with internet connection using chrome browser (plugin required for arduino)
- ROAVcopter sensor-kit https://store.ardusat.com/products/rova-copter-sensor-kit
- 3D printed mount for space board or building block alternative (from lesson 4.2)
- 8-inch wire tie to secure Moteino
- LED bucket assembly placed on stool (see RGB bucket document)
- Electric hotplate with 12” x 12” x 1/8” aluminum sheet on top

Learning Activities:
1. Video: ROAV mini 4.4 v1
2. Data Retrieval Mission Experiment https://ehub.ardusat.com/experiments/4487

Formative Assessment:
1. Activity sheet 4.4: Autonomous Data Mission

Summative Assessment:
1. Evaluate students using Performance Assessment 4.4: Autonomous Data Mission

Supplemental teacher resources:
- ROAVcopter sensor-kit
  https://store.ardusat.com/products/rova-copter-sensor-kit
- https://www.becauselearning.com/
- Ardusat experiment hub
  https://ehub.ardusat.com/experiments/overview
Activity Sheet 4.4: Autonomous Data Mission

Name: _______________________________ Date: ____________________

Situation
You and your team are working with a group of farmers to quickly and accurately gather data from a crop field. This data is critical to the planning and production of the crops. Your team is required to retrieve temperature readings from various places in the field as well as color readings from the plant leaves. This information will be used to assess the health and nutrition levels of the crop. Your team has decided to use a drone for the vehicle because of speed and its ability to be programmed autonomously.

Challenge
Your team's goal is to retrieve the various readings using the Parrot mini drone and Ardusat Space board. Your team will attach the necessary hardware to the mini drone, program the mini drone and collect the data. For this challenge, there will be an electric hot plate representing the crop that you will fly over and determine if the plate is hot or room temperature. There will also be a bucket containing a light source that you will need to determine if the light is red, green or blue. This data will be sent to the laptop wirelessly where it can be viewed by a team member. Your goal is to retrieve the data autonomously as quick as possible. Keep in mind flight time of mini drones will now be reduced due to the extra load.

Field set up

![Diagram of field setup with a takeoff and landing pad, temperature and color indicators, and a 10 feet boundary]
Ambient temperature reading: ______________

**Data retrieved:** Indicate the reading by placing a checkmark in the correct circle.

<table>
<thead>
<tr>
<th>Temperature</th>
<th>Room</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Reading</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Color</th>
<th>Red</th>
<th>Green</th>
<th>Blue</th>
</tr>
</thead>
<tbody>
<tr>
<td>2) Reading</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

3) **Reflection:** What was the hardest part of this challenge? What would you do different?
Performance Assessment 4.4: Autonomous Data Mission

Name: ________________________________  Date ________________________________

Terminal Objective 4.4: Retrieve data autonomously using mini drone and space board

Performance Objective 4.4: Safely retrieve data autonomously using mini drone and space board to remotely read sensor values.

Assessment

<table>
<thead>
<tr>
<th>Skill Check</th>
<th>Pass</th>
<th>Retry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Followed safety practices</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Programmed minidrone to retrieve sensor data autonomously</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Correctly identified temperature sensor reading</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Correctly identified color sensor reading</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: To pass this objective, all skill check items must receive a pass.

Assessed by: ________________________________  Date: ________________________________