CROWDS: FIRST LESSON (link to lesson)

Standards alignment:
Common Core: 7.SP.C.8.B

Summary/Overview:
Discover how combinations were used to design crowds of robots in "WALL-E." This lesson introduces the counting principle using tree diagrams.

Lesson Structure: This lesson contains 7 videos and 4 practice exercises which alternate back and forth. One way to run this is to watch and discuss all videos as a group (using a screen at the front of the room) while letting students return to their computers to do the exercises when required.

Total Time Recommended:
Approximately 60 minutes to complete the videos and exercises.

Age: Grade 4 - infinity and beyond!

Objectives:
In this lesson, students will:

- Explore how swarms of robots were created for WALL-E using combinatorics.
- Use combinations to create your own cast of robots of a given size

Materials Needed:

- Indoor classroom, lab, or open space with seating and access to the Internet. Space should have enough seating, ideally facing a teacher/facilitator's projection screen.
- Teacher/facilitator should have a computer connected to a large monitor or projector and speakers.
- This lesson assumes that each student or pair of students will require a device to access the lessons online.

VIDEO 0: Introduction to Combinatorics (length: 2 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Introduction to Combinatorics.” When the video ends, start a discussion with your group using questions below.

Discussion questions (3-5 mins):

- **Q:** Can you think of any tasks at home that you’d like to have a robot do for you?
- **Q:** What are some things that robots *can’t* do (yet)?
- **Q:** How do you think Legos inspired Angus’ approach the process of making robots?
- **A:** Legos are modular and a few pieces can be added and subtracted in many different combinations.

VIDEO 1: Counting with tables (length: 2 mins)

Instructions: How do we keep track of how many robots we've made? Have everyone sit where they can see the screen. From the lesson page, play the video “Counting with tables.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (3-4 minutes):

- **Q:** What is the advantage of using tables to keep track of robot parts?
- **A:** It’s easy to see combinations that have already been used. It also helps you to know how many possible combinations there are.
- **Q:** Could you use this process for combining anything else? A sandwich? An outfit?
- **Q:** How does finding a “good way” to think about a problem make it easier to solve?
- **A:** It can help you to define the problem more clearly

PRACTICE: Table of combinations (5-10 mins)

Drag the robot parts onto the screen to make all combinations of heads and bodies

Instructions: After students are nearly finished, check for understanding before moving on to the next video.

Exercise Questions:

- **Q:** What did you learn about combining heads and bodies in this exercise?
- **Q:** If you added two heads to a robot, did it check of in the table?
- **A:** No, you only see a check if you make one of the six possible combinations of heads and bodies. You would be asked to remove one of the heads at the end.

VIDEO 2: Robot combinations (length: 1 min)

Instructions: Let's review the multiplication principle which allows us to quickly count the number of possible robots. Have everyone sit where they can see the screen. From the lesson page, play the video “Translation Deformers.” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Combination -** when different parts or qualities are joined together.
- **Table -** Made up of cells where rows (horizontal) and columns (vertical) intersect

Discussion Questions (3-4 mins):

- **Q:** How can you quickly count the number of combinations in a table?
- **A:** Multiply the number of rows by the number of columns

PRACTICE: Robot combinations (length: 10 mins)

7 problems covering basic concepts

Instructions: Follow the prompts for each each question. Use hints if you need a little help. The basic thing to remember is that you're multiplying the number of heads by the number of bodies to get the total number of robot combinations.

Exercise Questions:

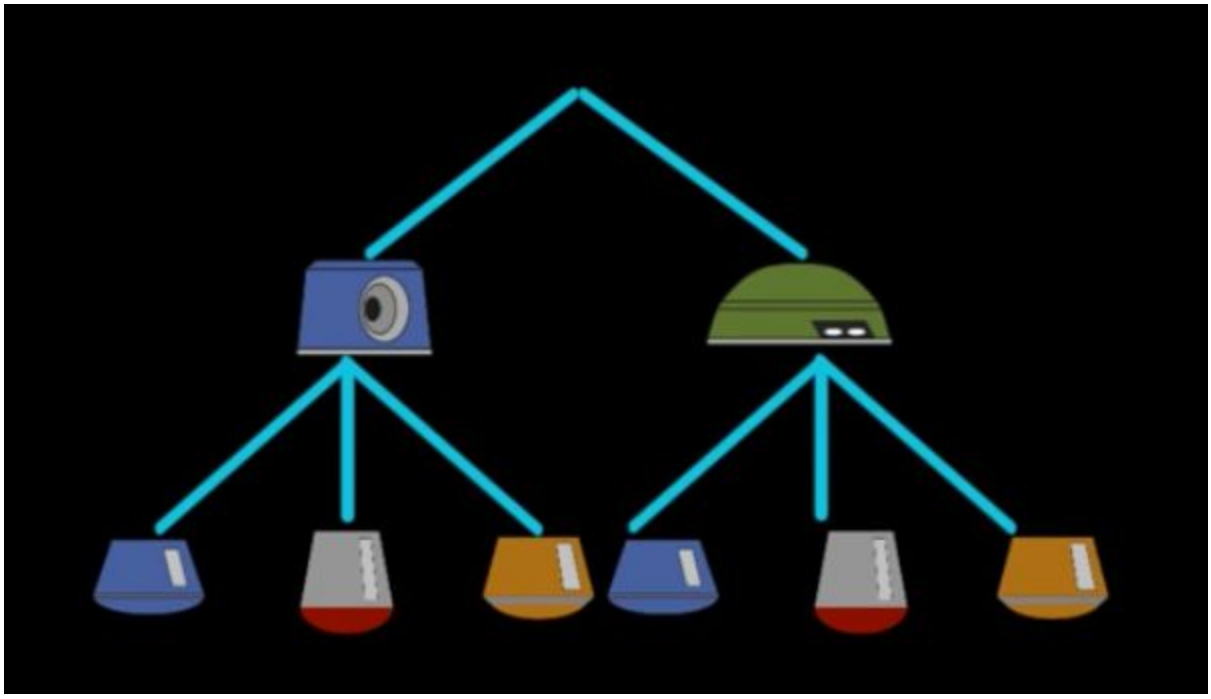
- **Q:** What did you learn about robot combinations in this exercise?

VIDEO 3: Tree challenge (length: 2 min)

Instructions: How can trees be combined to count robots with many parts? Have everyone sit where they can see the screen. From the lesson page, play the video “Tree Challenge.” When the video ends, check for clarifying questions before proceeding to the next exercise.

Discussion Questions (3-4 mins):

- **Q:** What is Frans’ approach to solving new problems?
- **A:** She likes to break that problem down into a bunch of smaller parts that are easier to solve
- **Q:** How do you think we can combine the two diagrams to show that there are SIX combinations of robots?
- **A:** Instead of using tables, we can use tree diagrams like the one shown here:



VIDEO 4: Counting with trees (length: 1 min)

Instructions: Tree diagrams allow us to visualize these counting problems using any number of parts. Have everyone sit where they can see the screen. From the lesson page, play the video “Counting with trees.” When the video ends, start a discussion with your group using questions below.

Key terms / Vocabulary:

- **Combination -** when different parts or qualities are joined together.

Discussion Questions (3-5 mins):

- **Q:** Can the 2D table model work when combining three types of robot body parts?
- **A:** No, It only works for two types of body parts
- **Q:** Are you ready to try combining more body parts?
- **A:** Yes! Let’s go!

PRACTICE: Tree of combinations (length 5 mins)

Instructions: Drag the robot parts onto the screen to make all combinations of heads and bodies.

Exercise Questions:

- **Q:** How did you approach combining your robot parts in this exercise?

VIDEO 5: Casting challenge (length: 10 mins)

Instructions: Now it's your turn to drive. In this video we'll present you with a casting challenge to complete using everything we've learned so far. Have everyone sit where they can see the screen. From the lesson page, play the video “Make a Face.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (4-5 mins):

- **Q:** Do you need the tree diagram to actually figure out how many combinations are possible?
- **A:** Not really. You can simply multiply the numbers for each type of part together to get the total number of combinations
- **Q:** Will you get the number of possible combinations by simply adding all of the numbers of parts together?
- **A:** No, you’ll get the total number of parts available to combine in different ways

PRACTICE: Casting Challenge (length: 5-10 mins)

Instructions: Pick a selection of robot heads, arms, and bodies so that when they are combined in all possible ways, you get a crowd of exactly 12 robots. You have a budget of $300. After students are nearly finished, check for understanding before moving on to the next video. Ask if any students would like to share their combinations.

Exercise Prompts (2-3 mins):

- **Q:** What combinations can stay within the budget?
- **Q:** What's the least amount of money you can spend and still generate 12 robots?
- **Q:** What combinations are extremely expensive and go over budget?

VIDEO 6: Getting to Know Fran Kalal (length: 5 mins)

Instructions: Have everyone sit where they can see the screen. From the lesson page, play the video “Getting to Know Fran Kalal.” When the video ends, start a discussion with your group using questions below.

Discussion Questions (5-10 mins):

- **Q:** What inspired you about Fran’s experience?
- **Q:** Can you think of someone in your life who is like a mentor to you?
- **Q:** Is there a career for you in the future that doesn’t exist yet?

If you’d like to explore this further, we have an hour long hands-on activity that extends this lesson here:

Hands-on activity: Dinosaur Combinatorics (60 mins)