Bottle Flipping
Lesson 1: Discover Phase

Australian Curriculum: Mathematics (Year 3)

ACMNA058: Model and represent unit fractions including 1/2, 1/3, 1/4, 1/5 and their multiples to a complete whole.
ACMMG061: Measure, order and compare objects using familiar metric units of length, mass and capacity.

Lesson abstract

Students are introduced to the context and the inquiry question: "What fraction of a bottle needs to be filled with water to be the best for bottle flipping?" They brainstorm what they know about bottle flipping and see it done. The mathematics of fractions is reviewed and students describe the amount of water in the bottles using fractions. Students experiment informally with flipping different bottles and various amounts of water.

Mathematical purpose (for students)

Fractions can describe how much water is in a bottle.

Mathematical purpose (for teachers)

The amount of water in a bottle can be described as a fraction of the capacity of the bottle. The size, shape and amount of water in bottles may affect how successfully they can be flipped. Relevant mathematical terminology related to fractions, bottle shape and size is used in context. Data needs to be collected as evidence to find and then justify the best fraction for bottle flipping. The idea of a fair test is introduced.

Lesson Length 45 minutes

Vocabulary Encountered

- height, base, volume, millilitres
- half, quarter, third, fifth, eighth, tenth
- other fraction names as required
- fair test, data

Lesson Materials

- Plastic drink bottles with a variety of bases, heights and volumes (e.g. soft drink, water). Collect in advance. At least one for each pair; more bottles useful.
- Water, markers, measuring jugs (50 ml to 600 ml)
- Funnels, water colouring (optional)
- Student work books
- Tablet or camera – 1 per group (optional)
- Access to computer display (optional)

Exploring Bottle Flipping

Inquiry Question:
What fraction of a bottle needs to be filled with water to be the best for bottle flipping?

Preparation

Ask students to collect a variety of drink bottles at least two weeks prior to starting this inquiry.

Decide in advance what fractions you will encourage students to test. These lessons are written around testing 6 unit fractions (½, ¼, 1/3, 1/5, 1/8, 1/10). However, you could use other sets of fractions depending on your mathematical goals. For example, some students could test all eighths (1/8, 2/8, 3/8,…). An advantage here is that they could find the right volumes of water to put in the bottles by successively halving the total volume. Some students could try all fifths, showing the value of calculating the required amount and measuring. The answer to the inquiry will generally be a fraction near one third.

Teachers can read about bottle flipping on Wikipedia https://en.wikipedia.org/wiki/Bottle_flipping and there are many online videos available. The first few seconds of the Institute of Physics video www.iop.org/resources/topic/archive/water-bottle-flip/page_68405.html shows the bottle flip very clearly.

Explore the inquiry question

1. To promote enthusiasm and engagement in this inquiry, introduce bottle flipping. *Who has ever heard of bottle flipping? Who has tried it?* Brainstorm what students know about bottle flipping.
2. It is likely some students know how to flip a bottle. Demonstrate yourself or let a student demonstrate, but be careful not to draw attention to how much water is used, at this stage. Then challenge several students to flip an empty bottle. They will discover that it appears impossible to land it upright. Perhaps an empty bottle is too light.
3. Display the inquiry question, *"What fraction of a bottle needs to be filled with water to be the best for bottle flipping?"* Ask students to record the question in their workbook and add the title DISCOVER.
4. Inform them today they will be exploring the mathematics required to answer the question. Brainstorm with students the mathematical opportunities in the inquiry question. *What mathematics do you think we might use to answer this question?* [e.g., fractions, volume of water, data]

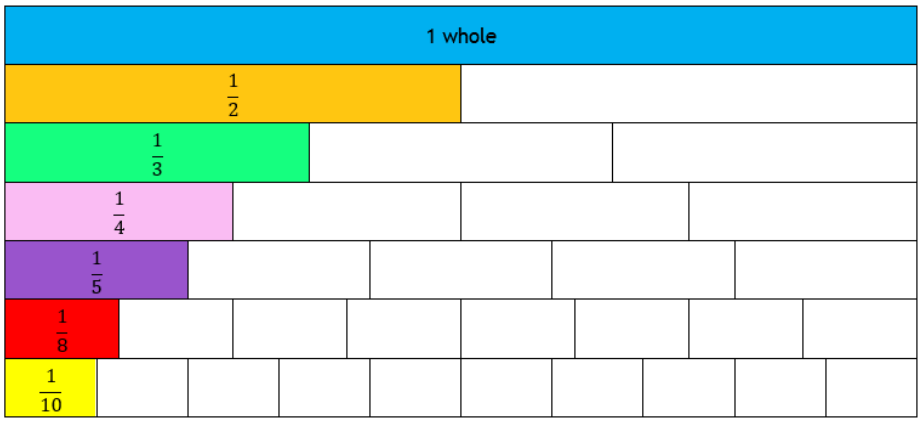
Introduce the mathematics needed

5. Ask students what is meant by a fraction and provide examples. Build on their understanding, focusing on a **fraction** being a way of representing the result of division of a 'whole' into equal 'parts'. Introduce or review fraction notation (e.g. the **numerator** is the number of parts chosen, and the **denominator** is the total number of parts). The numerator and denominator are separated by a horizontal line called a **vinculum.)**

It is important that students have a clear understanding of the fractions that will be involved (in the case used in these lessons, the unit fractions). For example, unit fractions

- are proper fractions whose numerator is one
- can be written symbolically - ½, ¼, 1/3, 1/5, 1/8, 1/10
- can be written as words - half, quarter, third, fifth, eighth, tenth, whole
- are often displayed diagrammatically
- the size of a fraction amount varies according to the size of the whole
- if the whole is the same (as in the Fraction Wall) bigger denominators make smaller fractions.

A Fraction Wall such as the one below can be used to review students' knowledge of fractions.



A fraction wall.

6. Display a variety of plastic bottles. Have students make a quick prediction with a partner what fraction of water is needed to successfully flip the bottle. Share predictions **with the class** to ascertain students' prior knowledge of the terminology of fractions and measurements.
    - Emphasise with students the need to use fraction terminology (e.g. "I think that the bottle should be three quarters full", not just "I think the water level will be about here.")
    - During the class sharing, ensure students have a clear understanding of the following terminology: base, height, half, quarter, third, fifth, eighth, whole, full. Revoice student responses with the mathematical terminology, if needed.

Explore different bottle sizes and fractions

7. Tell students that they will work with a variety of bottles and water levels as they flip bottles to land upright. Distribute the empty bottles and have students put some water into their bottle and estimate what fraction of the bottle is filled. (At this stage it is not necessary to measure exactly. For example: about ¼ is acceptable).
8. Allow students time to bottle flip and develop skills for later. This may be more suitable outdoors. This will help build students' contextual knowledge, which will assist them to determine which fractions to test and which are likely to flip successfully.

Checkpoint

9. Students regroup and share experiences. *What surprised you? Who thinks their bottle flipping was successful? Why were you successful? Did you use a special technique to flip your bottle? Were you standing/sitting/kneeling? Tell me about the size of the bottles?*
10. Draw attention to the difference for tapered bottles between the fraction of the volume and the fraction of the height. This alerts students to the need in the next lesson to measure volume, rather than height of water level for some bottles. To highlight the difference, perhaps ask:
    - *If you drink half of the soft drink from a bottle, will the level of the drink that is left be halfway up the bottle?*

11. Direct attention to the amount of water. For example, you may ask:
    - *Did you notice anything about the amount of water in the bottles?*
    - *Did some amounts seem to work better than others?*

Conclusion

12. Refer back to the inquiry question, "*What fraction of a bottle needs to be filled with water to be the best for bottle flipping?*" Ensure students understand that to gather useful data, all elements of a fair test will need to be considered and agreed upon to answer the question. Have students share with a partner elements of a fair test to consider, before recording their ideas in their journal. E.g., *All bottle flips should be done from a sitting position. All bottles should be the same type. Trial a specific number of flips for a variety of water levels that will be measured as unit fractions.*

Why does it work? (Optional)

13. Now or later, some students maybe interested to know more about the science of bottle flipping. The UK's Institute of Physics website shows how recording the motion and playing it back in slow-motion helps reveal what is going on (see www.iop.org/resources/topic/archive/water-bottle-flip/page_68405.html, but be sure not to give away the solution!. As the bottle moves through the air, the liquid inside starts to rise up the sides. This increases the bottle's *moment of inertia* and so makes it spin more slowly, much like a diver who extends his arms and legs to slow his spin. The amount of water is very important to help the bottle land upright.