Bottle Flipping
Lesson 2: Devise Phase

Australian Curriculum: Mathematics (Year 3)

ACMNA058: Model and represent unit fractions including 1/2, 1/4, 1/3, 1/5 and their multiples to a complete whole.
ACMMG061: Measure, order and compare objects using familiar metric units of length, mass and capacity.
ACMSP068: Identify questions or issues for categorical variables. Identify data sources and plan methods of data collection and recording.

Lesson abstract

Students begin recording a plan to answer the inquiry question. They determine what "best" means in the inquiry context, acknowledging that a fraction of water in the bottle is a key consideration. Students practice flipping bottles with various amounts of water, and in different size and shape bottles, before seeking feedback on their initial ideas for a fair test and for systematic recording of results.

Mathematical purpose (for students)

The amount of water in the bottle to be flipped can be represented as a fraction.

Mathematical purpose (for teachers)

Students need to find amounts of water that are given fractions of the volume of the whole bottle. Dividing the height into equal parts on a tapered bottle will not produce an accurate fraction of the volume. To fill a given fraction of a bottle, the capacity of the bottle (e.g. 600 ml) needs to be divided into the right number of parts. (For example for one third the volume is to be divided into 3 equal amounts). This can involve students in division (e.g. 600 divided by 3, or trial multiplications to find that 3 x 200 = 600, or physical division of water). Equal parts may not always look alike but they must have the same mass and hence volume.

At the end of the Devise phase, groups will be able to:

- Describe the fractions and the corresponding amounts of water they have initially considered.
- Provide feedback to others: seeking clarification, considering successful and unsuccessful flips and suggesting alternate pathways for challenges presented.

Lesson Length 60 minutes

Vocabulary Encountered

- unit fractions
- millilitres,
- data collection
- rotating

Lesson Materials

- All equipment for bottle flipping from Lesson 1.
- Evidence Triangle poster (optional)

We value your feedback after these lessons via https://www.surveymonkey.com/r/CV2TXTT

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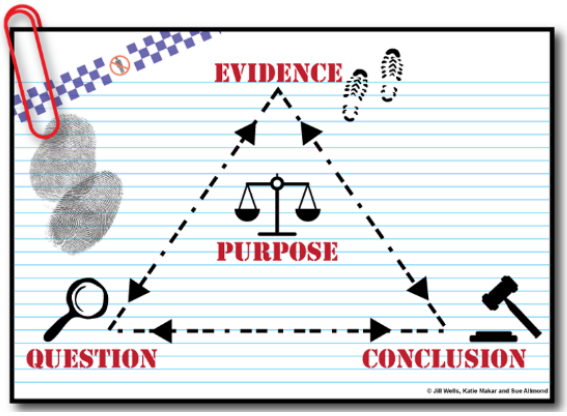
What Do We Mean By "Best"?

1. Have students add the title DEVISE underneath the previous lesson's ideas and representations. Revisit the question, *"What fraction of a bottle needs to be filled with water to be the best for bottle flipping?"*
2. Inform students that in today's lesson they will begin to work towards a solution..
3. Display the Evidence Triangle and introduce the need for mathematical evidence that supports the Inquiry solution. Inform students they will be gathering and recording data that will used as evidence when they share their progress and present their results to their peers.



4. In pairs or groups of three, have students brainstorm what they think the "best unit fraction" means and record suggestions in their workbook. '*Best'* is a relative term used later to justify their final solution.
5. As a class, discuss how to design a fair test. if we want to determine the best fraction to successfully flip a bottle, what needs to be kept the same to ensure the testing is fair and what has to vary? Share and justify suggestions as a class:

    - *The bottles need to be flipped the same way and from the same starting position.*
    - *The same bottle needs to be tested with all the fractions.*
    - *We could use one bottle, and change the fraction after it has been flipped enough, or we might be able to get identical bottles so that we can fill them with different fractions of water.*
    - *Some of the drink bottles were too heavy to keep flipping properly – don't use those.*
    - *Some people would be better at flipping than others.*
    - *It would be good if we had time to see if the same fraction was best for bottles of different shapes and sizes.*

    Construct a class poster or powerpoint slide to record suggestions to refer to throughout the Inquiry.
6. Draw on students' ideas to step through how everyone will need to flip the bottle (possibly with a student demonstrating in slow motion). For example,

    - *Hold the bottle from its neck-and-cap area.* (Pause as this is demonstrated.*)*
    - *Give it a little flick sending the bottom of the bottle out and rotating away from you.* (Pause as this is demonstrated.)
    - *Give it enough arc so that as the rotation is being completed, the water slushes back to the bottom, allowing the bottle to fall straight down.*

7. Once a flipping method has been determined, agree on the approach that all groups will adopt.

Plan the test and record number of bottle flips

8. Group students (2-3 students per group). Have them return to the inquiry question they have recorded in their journal and highlight the key mathematical information in the question.

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

9. Emphasise with groups they need to agree on which fractions of water they will test and also consider all variables to ensure their testing is fair.
10. Ask students how they will measure the amount of water needed in their bottles to get each of the unit fractions. For now, accept their responses. This will provide an opportunity to discuss ways they can accurately measure in the Checkpoint later in the lesson.
11. Have groups decide how many flips they will plan to do for each fraction so they have enough evidence to convince others which of fraction is best. Each group will record their trials of successful and unsuccessful trials in their workbooks. (In Lesson 3, a prepared recording sheet is used – at this stage it is worthwhile having students experiment with what needs to be recorded.)
12. Remind students that group jobs are to be shared and everybody is expected to try to flip the bottles for each of the fractions. Link this latter requirement to the need for a fair test. Each person needs to check that the recording of the data (successful and unsuccessful flips) is accurate.
13. Briefly observe each group as they flip their bottles to ensure they are recording their attempts accurately. Prompt where necessary e.g. *How are you recording that? What else to you need to add to make it clearer?* (Students name, fraction, both success and failure)
14. Allow groups time to begin gathering some data. Rotate between groups taking note of issues students are having, useful approaches that can be adopted by others or practices that could be improved. If groups encounter setbacks rather than offer direct suggestions, use prompting questions. For example:
    - *What are you trying to do?*
    - *What have you tried?*
    - *What else could you try?*
    - *What do you need help with to enable you to move forward?*
15. Pay particular attention to how students are finding the required fractional amount of water. There are several possibilities. Some groups may do this physically: take the total amount of water in a bottle and divide it into equal parts by pouring into other bottles. Other groups will read or measure the total volume (e.g. 600 ml) and divide this by the number of parts required. Others will use trial multiplications until the volume of the required part is found.
16. After all groups have had time to collect some data (10-20 minutes), pause the class and move to the Checkpoint (below).

Coloured water makes it easier to see the water level for each of the fraction measurements. This group also recorded the volume, written in millilitres. They tested 5 unit fractions in one type of bottle.

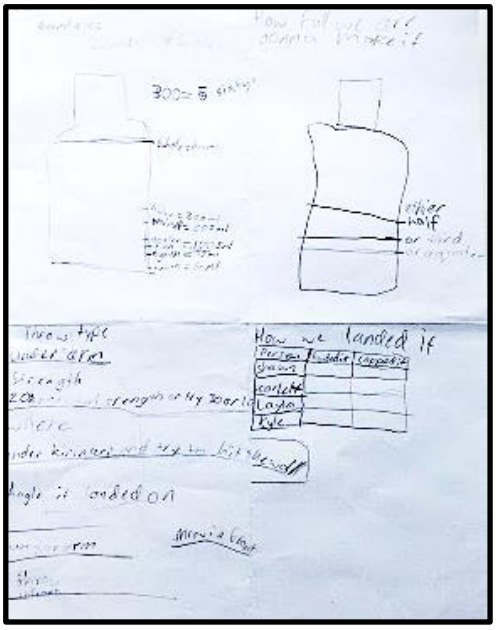
Checkpoint: Sharing Ideas

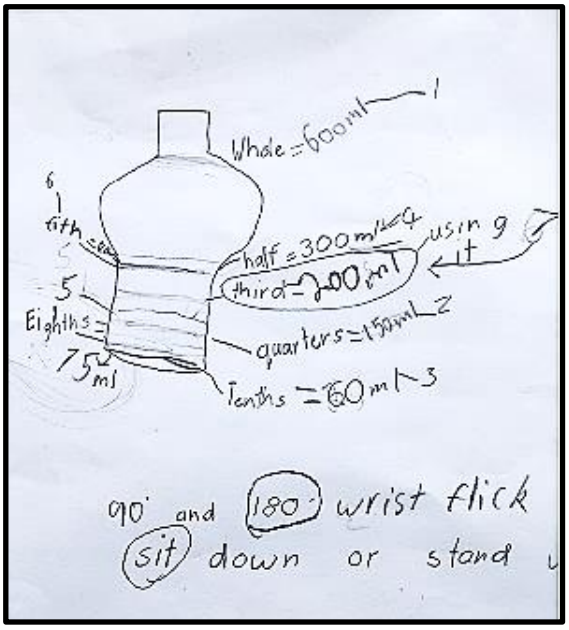
17. The sharing has two foci: the planning of the fair test, and how the fractional amounts of water can be found.
18. Before groups share their initial ideas remind them that they are expected to listen actively to how groups have begun to solve the problem and to seek clarification if they do not understand. Sharing needs to be

done as a whole class activity in the Devise Phase to showcase the ideas of others. Ideas which have the potential to improve the accuracy of the mathematics should be highlighted.

19. As each group shares ideas and experiences, have them:
    - Explain what they have done including why they have chosen those particular fractions
    - Explain how they filled the bottles to the right level
    - Explain why they have chosen their particular method of recording the otucomes
    - Answer any requests for clarification
    - Present any challenges they are facing and require assistance with
    - Describe what they will need to do next to answer the question.

Examples of student work:

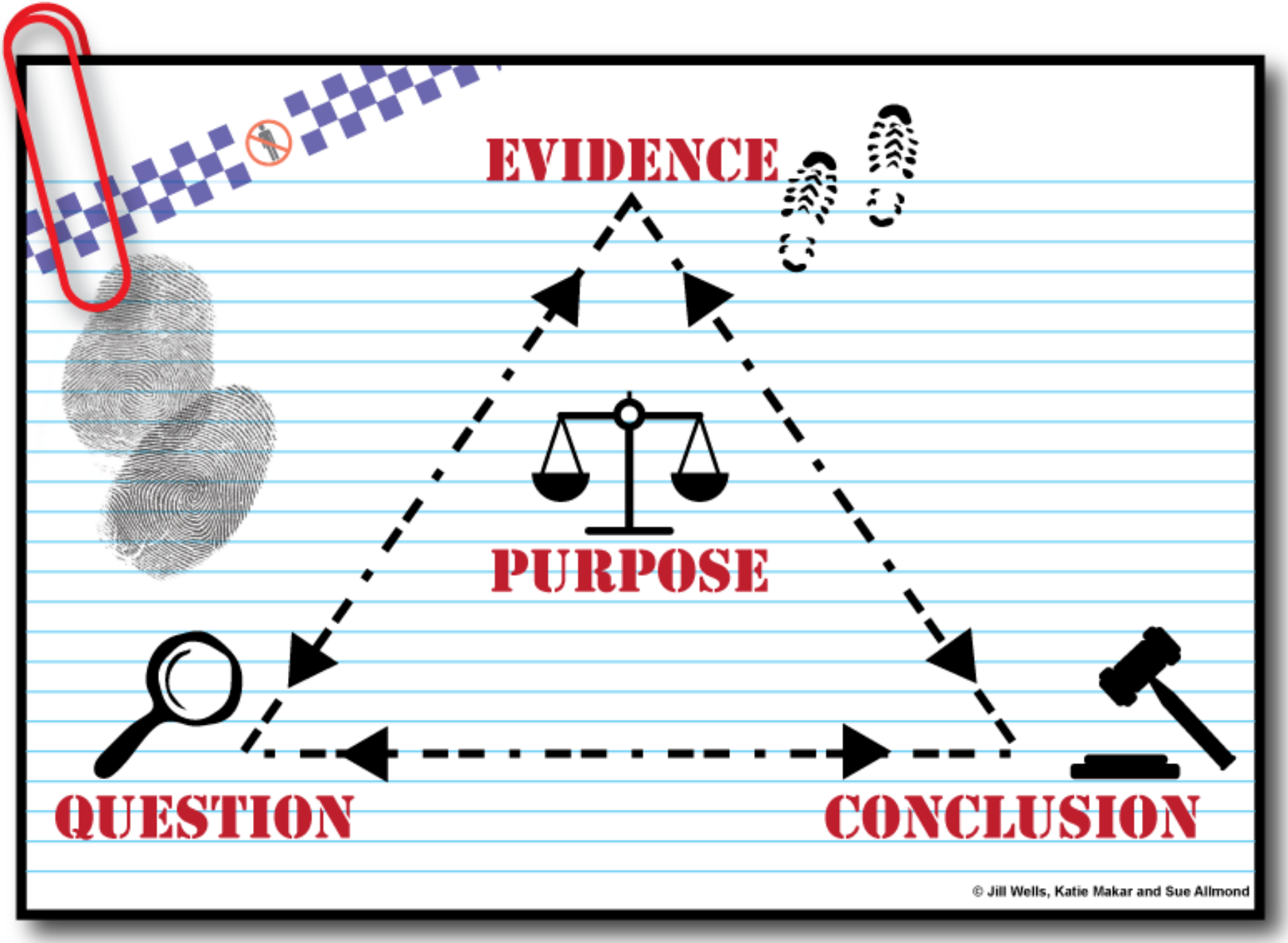




Conclusion

20. From the sharing, allow groups a few minutes to discuss and record ideas that will improve their data collection and recording. For example: *We should keep our results in an organised manner so it is easier to record and share with the class eg tally marks. We should clearly label our water measurement on the bottle.* Encourage groups to also consider what ideas from other people that they could add to their evidence and build on in the Develop Phase. Some examples are shown below:

With a marker, clearly label <u>each</u> of the unit fractions (1/2, 1/3, ¼, 1/5, 1/8, 1/10) and /or water levels (can be millilitres) on the agreed size bottles (600 ml).


EVIDENCE
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CONCLUSION
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