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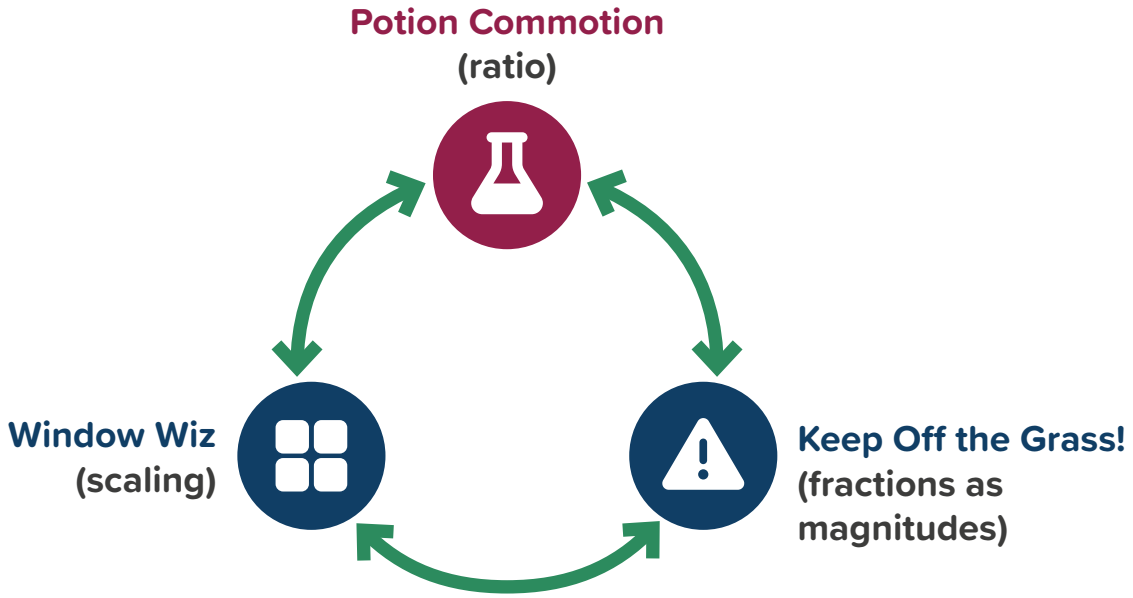
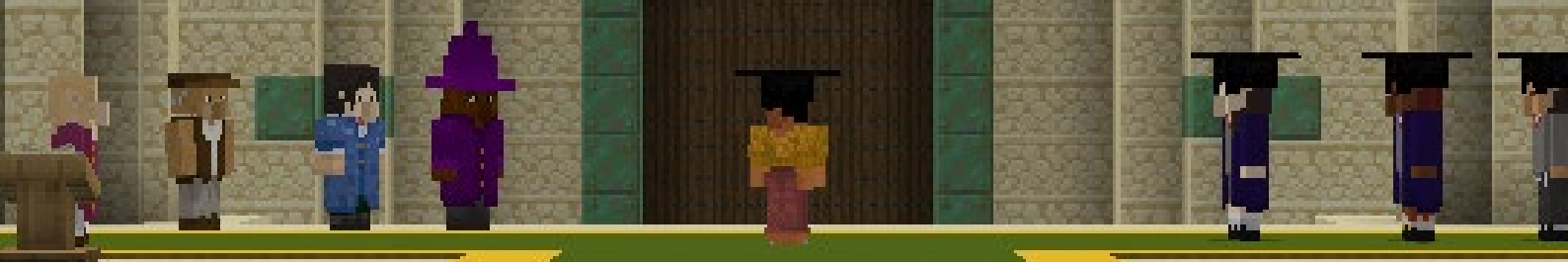
for Potion Commotion

CAMBRIDGE Mathematics

Connections to other Ratio Riddles activities

This is one of three activities in Ratio Riddles. These activities complement one another and provide a useful set of experiences that can help students build strong and flexible foundations in proportional reasoning:





Game activity and learning

Pupils' comprehension of ratio develops from their daily activities of comparing amounts, sharing and measuring. Early on, pupils should be immersed in tasks that involve making comparisons, dividing items into portions and measuring various objects or quantities. As part of these hands-on practical experiences, being encouraged to articulate their thought processes and reasoning can result in a more meaningful understanding of ratio.

Challenge

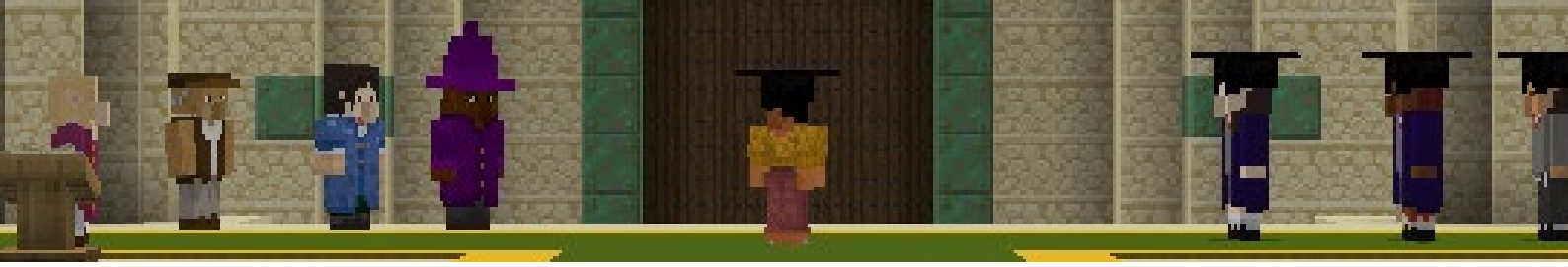
Teaching ratios through a game involving the mixing of magical ingredients presents several challenges. Students may struggle to grasp the concept of ratio as a relationship between two or more quantities, especially when they need to maintain or adjust the ratio in different scenarios. Additionally, accuracy in measuring and mixing ingredients can be difficult to ensure, leading to incorrect results. These challenges are compounded by the need to understand mathematical language and apply ratios in more complex, problem-solving contexts.

Connections

The concept of ratio connects to many other mathematical ideas and real-world applications. Ratios can be an alternative representation of proportions, fractions and percentages, helping students see the broader context of these mathematical relationships. Understanding ratios also lays the groundwork for algebraic reasoning, such as working with rates and scaling in equations, and geometric reasoning, involving scaling and dimension. Additionally, real-world applications, like cooking or combining ingredients, demonstrate the relevance of ratios, helping students to see their practical value beyond the classroom.

Scaffolding

To support students in learning about ratio through gameplay, the experience has been scaffolded into smaller steps. The game incorporates a demonstration which introduces the concept of ratio with simple activities where students mix two ingredients in the ratio 2:1. As they gain experience, the complexity gradually increases, requiring them to adjust the ingredients needed in keeping with a consistent ratio. Encouraging collaboration in pairs will provide an opportunity for students to discuss strategies and troubleshoot together, with the potential for a more engaging and effective learning process. Subsequently incorporating reflective discussions after each challenge may help to reinforce the concept and allow students to ask questions, hear from their peers, and resolve any misconceptions that have arisen.

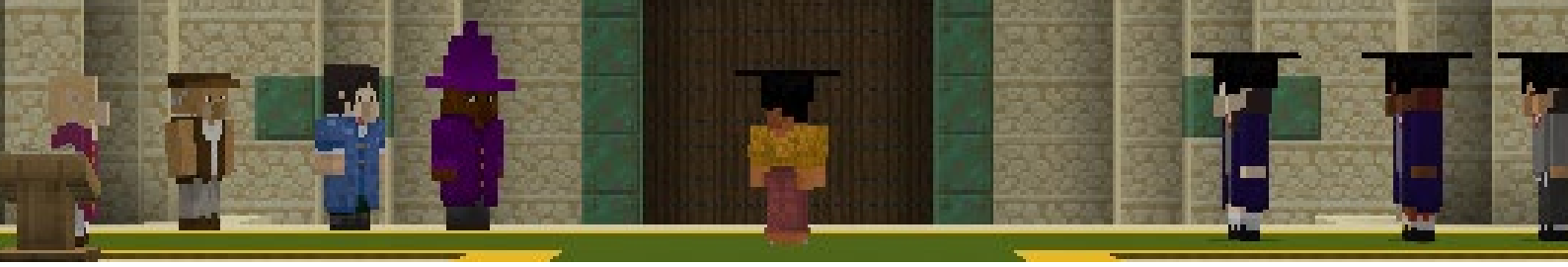


Gameplay guide

In this activity players compete in the “well-diving championship” under the guidance of the Professor of Alchemy. A starting tutorial lets players concoct some “chocolate milk” by combining 2 parts cocoa beans to 1 part milk. This activity serves a dual purpose. First, it introduces players to the core gameplay mechanics, allowing them to become comfortable with the controls and interactions that will be essential in the full game. Second, it reinforces the mathematical concept of ratio, providing an opportunity for students to either encounter or refresh their understanding in a practical and enjoyable context. Having met this basic ratio, players can then build on this understanding to tackle more complex challenges in the subsequent stages of the game, where a deeper understanding of ratio will be critical for success.

If the player experiences difficulties, they can click the “I’m stuck” button, and the Professor of Alchemy will offer advice, walking them through steps they can take to create the potion they want using the correct ratio.

In the main game, students can get all the coins in the well and win the contest by mixing batches of potions in the correct ratio. To succeed, players will need to make a Night Vision potion using a ratio of 3 carrots to 5 portions of glowstone dust, and then a large batch of Breathing potion with a ratio of 3 pieces of kelp to 5 pufferfish to 8 mermaid tears.



Players can throw ingredients into the cauldron individually by choosing the slot number and pressing ‘q’, or they can click on the cauldron to bring up cauldron slots and place items from their inventory into the slots. The wall behind the cauldron will show the current ingredients inside. Note that after a player reaches the bottom of the well, they will need to make and drink more potions if they want to try again

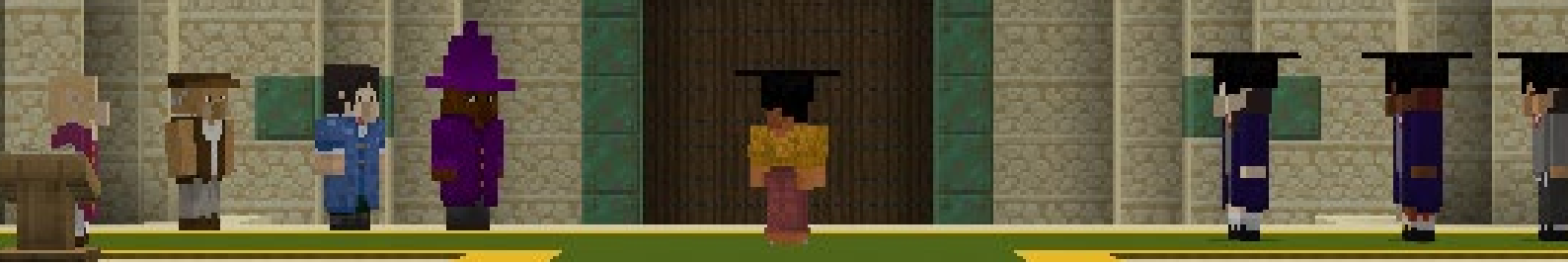
After players have collected three coins, they will have the option to proceed to Junior Graduation or collect more coins. After they have collected all six coins, they can proceed to Senior Graduation. Once they graduate from the activity, the Dean of Students gives them a portfolio and a camera; they can take pictures anywhere in the activity and export their portfolio as a keepsake if they wish.

Concept focus

This learning activity offers two conceptual focus areas of mathematics for exploration: understanding ratio as a relationship between quantities, and scaling ratios proportionally. Examples are provided below of the ideas under each focus area which students may encounter whilst playing the game.

Understanding ratio as a relationship between quantities

- Emphasising that a ratio represents a multiplicative comparison or relationship between two or more quantities, rather than just isolated numbers.
- Unlike whole numbers or fractions, which may be used to represent single quantities or magnitudes, a ratio expresses the relationship between two or more quantities. For example, a ratio of 3:1 could describe the relationship between the number of pieces of flatware to every plate on a table, where there are three pieces of flatware (knife, fork and spoon) to every one plate. This concept is fundamental because it allows students to see ratios as flexible representations that describe how one quantity changes relative to another.
- In the game students mix different ingredients in specific ratios to achieve desired effects, showing how changing one part of the ratio affects the whole mixture, and conversely that scaling up or down each part proportionally maintains the same ratio of ingredients within the mixture, even if the individual amounts change.



Scaling ratios proportionally

Scaling ratios involves multiplying or dividing each part of the ratio by the same factor to maintain the same proportional relationship. For example, if a recipe requires a ratio of carrots to apples of 3:5 this means that for every 3 carrots used, 5 apples are needed. The recipe can be scaled up, to feed more people for example, by using 6 carrots and 10 apples, but the ratio of the quantities remains 3:5. This concept is crucial for understanding how ratios are used in real-life situations. In the game, students are tasked with producing more draughts of a big batch of potion with a fixed ratio, reinforcing their understanding of how to work with ratio in a flexible and practical way.

Observe gameplay and prompt thinking

Students will need to make both potions, including two draughts of the Breathing potion, maintaining the correct ratio, in order to keep them breathing underwater long enough to reach the bottom. If students want to know why they aren't getting to the bottom, you could talk to them about what they've tried so far. If you think they would benefit from thinking more deeply about ratio (partly to be able to succeed in the game) you could ask them to do one of the activities described below.

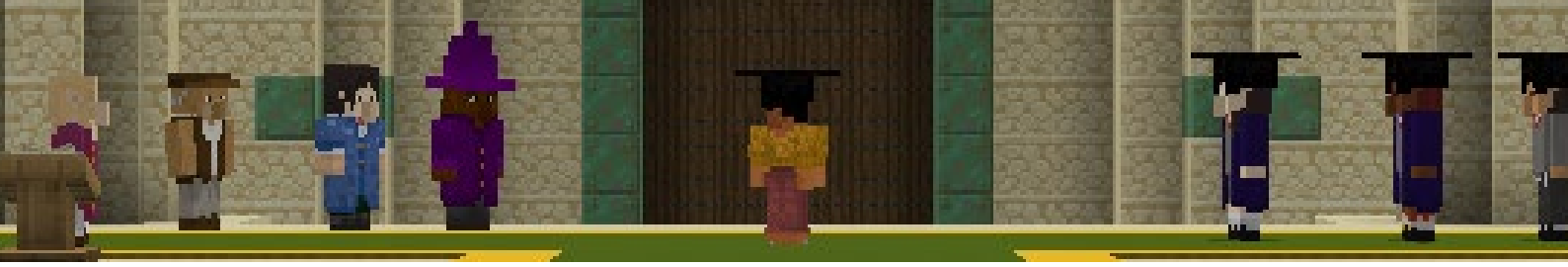
After/before/in between playing, you might like to:

- Try an **Always/sometimes/never** activity
  Share the following statements and ask students to discuss whether the statements are always true, sometimes true, or never true.

  1. Doubling all terms in a ratio does not change the proportional relationship between the quantities involved. [Answer: Always]
  2. The proportional relationship between quantities stays the same if the same number is added to each term of a ratio. [Answer: Sometimes]
  3. A equivalent ratio can be created by dividing both/all terms by the same nonzero number. [Answer: Always]
  4. If the ratio of A to B is 2:7 and B to C is 7:9, then the ratio of A to C is 2:9. [Answer: Always]
  5. If the ratio of students who prefer lemonade to ice cream is 3:5, then the total number of students is 8. [Answer: Sometimes]
  6. To find the total number of parts in a ratio, you multiply together all the numbers. [Answer: Never]

  If available, students could use an AI chatbot to ask for clarification (not to search for an answer directly); for instance, asking questions to test ideas and to explore different interpretations.

  The "never true" and "sometimes true" statements can create disruption, prompting students to question and examine their understanding. This disruption can seed productive confusion, encouraging students to explore what they think and the reasoning that underpins it. They could be challenged to rewrite the "never true" statements to make them true, or invited to create new statements for their peers to evaluate, fostering a collaborative learning environment. Additionally, discussing different scenarios for the "sometimes true" statements allows students to explore specific contexts where the statements are true and understand why they are not true in other contexts, thus further enhancing their critical thinking and metacognitive skills.



- Play a game of **Reasoning with ratios**
  This is a game for a pair of students. They will need two 0–9 dice, a stopwatch or timer device, and paper and a pen/pencil.
  1. Each student rolls a die each and finds the product of the numbers; for example, rolling a 3 and a 5 gives a product of 15.
  2. This product is the number of imaginary counters that they are going to try to share out.
  3. They agree together an amount of time – for example, 1 minute or 2 minutes – and set a timer.
  4. Each student makes their own list of ratios which would allow the number of counters to be shared into whole numbers of counters between as many people as they like. (The meaning of the word 'sharing' here is different to the idea of 'fair sharing' which students might be used to. Here it means each person will have a part of the total number of counters, not that they have the same number each.)
  5. When the time is up, the students compare their lists and score them as follows:
     - **5 points each:** A unique ratio (one that their partner doesn't have and agrees would work).
     - **2 points each:** A duplicate ratio (one that is agreed will work and that their partner also has written down or an equivalent version of it).
     - **1 point total:** Any ratios that the student has written down themselves which would result in a number of players receiving the same number of counters as given by another ratio; for example for a dice product of 12, answers of 1:3, 2:6, 3:9, etc., would only score a **total** of one point, not one point for each case.

Notes
The scoring here deliberately rewards different ways of sharing represented as a ratio and encourages identification of equivalent ratios in order to avoid expending energy on these for no extra points.

It should be expected that questions and discussion might arise from dice rolls that give a product of zero. In making sense of the parts of a ratio and the proportional relationship represented by them, students might also have the misconception that products which are prime numbers will be problematic or limiting, which isn't the case, but discovering this might take some exploration.

A common misconception about ratios is that the individual terms of a ratio have to be factors of the total amount. To show that this isn't true, some examples for a dice product of 12 could be:

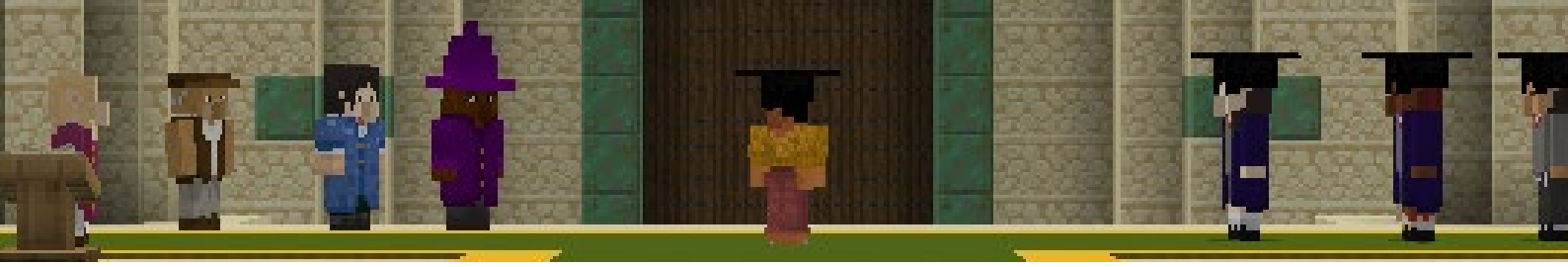
1:5
11:1
7:5

etc.

Encouraging students to be creative and playful with their ratio suggestions will provide an opportunity for students to connect their understanding with other mathematical ideas, e.g., fractions, multiples and factors. For example, answers for a dice product of 12 could include:

3:3
1:2:3
2:2:2:2:2:2

These would all score points for being different from each other. But an answer of 1:1, whilst correct, would result in two people having the same number of counters as when the ratio 3:3 was used, so wouldn't qualify as being unique for 5 points.

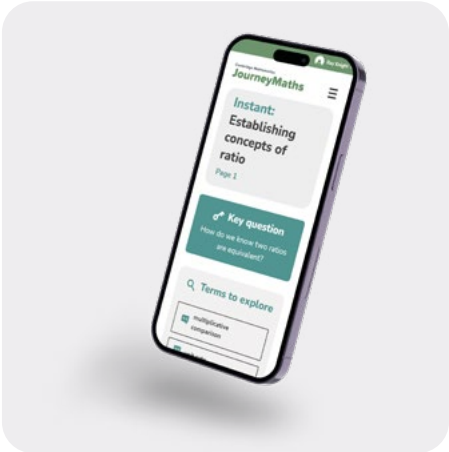


- Connect to NRICH tasks
  - » **Age 5 to 7: Thirsty?** https://nrich.maths.org/problems/thirsty
  - » **Age 7 to 11: Rod ratios** https://nrich.maths.org/problems/rod-ratios
  - » **Age 7 to 11: Orange drink** https://nrich.maths.org/problems/orange-drink
  - » **Age 11 to 14: Mixing paints** https://nrich.maths.org/problems/mixing-paints
  - » **Age 11 to 14: Mixing lemonade** https://nrich.maths.org/problems/mixing-lemonade

Further reading from Cambridge Mathematics

Espresso 36 – What does research suggest about developing concepts of ratio?

Read Espresso 36



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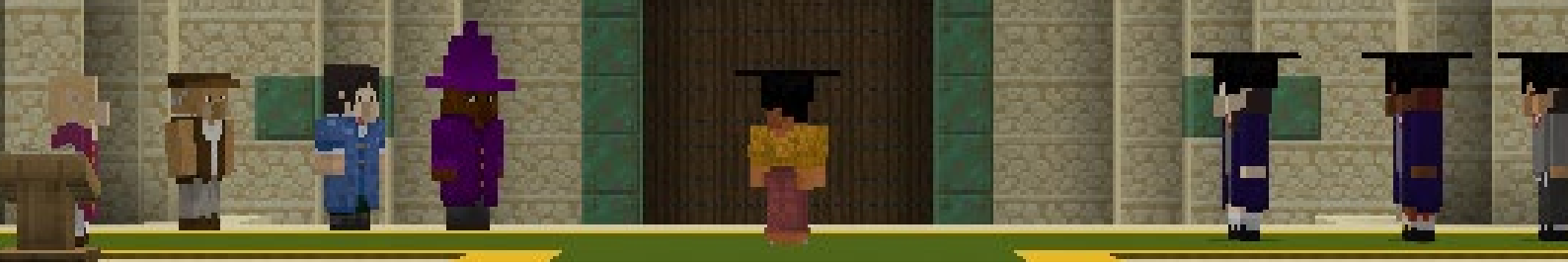


Curriculum connection examples

The following are examples of curriculum standards to which this activity could contribute:

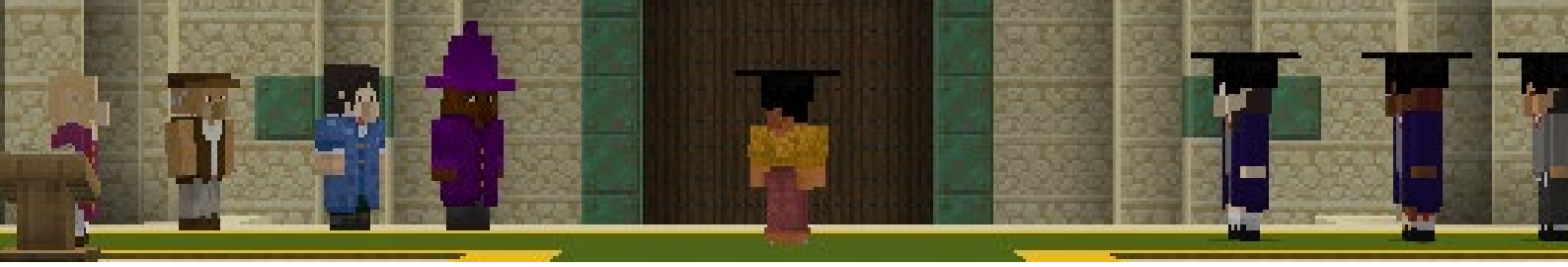
Common Core Mathematics Standards (United States)

- CCSS.Math.Content.6.RP.A.1 “Understand the concept of a ratio and use ratio language to describe a ratio relationship between two quantities. For example, ‘The ratio of wings to beaks in the bird house at the zoo was 2:1, because for every 2 wings there was 1 beak.’ ‘For every vote candidate A received, candidate C received nearly three votes.’”
- CCSS.Math.Content.6.RP.A.2 “Understand the concept of a unit rate a/b associated with a ratio a:b with $b \neq 0$, and use rate language in the context of a ratio relationship. For example, ‘This recipe has a ratio of 3 cups of flour to 4 cups of sugar, so there is ¾ cup of flour for each cup of sugar.’ ‘We paid $75 for 15 hamburgers, which is a rate of $5 per hamburger.’”
- CCSS.Math.Content.6.RP.A.3 “Use ratio and rate reasoning to solve real-world and mathematical problems, e.g., by reasoning about tables of equivalent ratios, tape diagrams, double number line diagrams, or equations.”
- CCSS.Math.Content.7.RP.A.1 “Compute unit rates associated with ratios of fractions, including ratios of lengths, areas and other quantities measured in like or different units. For example, if a person walks ½ mile in each ¼ hour, compute the unit rate as the complex fraction ½/¼ miles per hour, equivalently 2 miles per hour.”
- CCSS.Math.Content.7.RP.A.2 “Recognize and represent proportional relationships between quantities.”
- CCSS.Math.Content.7.RP.A.3 “Use proportional relationships to solve multistep ratio and percent problems. Examples: simple interest, tax, markups and markdowns, gratuities and commissions, fees, percent increase and decrease, percent error.”

National Curriculum in England

“Pupils should be taught to”:

- **Upper Key Stage 2, Year 6 Ratio and proportion –** “solve problems involving the relative sizes of 2 quantities where missing values can be found by using integer multiplication and division facts”
- **Upper Key Stage 2, Year 6 Ratio and proportion –** “solve problems involving the calculation of percentages [for example, of measures and such as 15% of 360] and the use of percentages for comparison”
- **Upper Key Stage 2, Year 6 Ratio and proportion –** “solve problems involving similar shapes where the scale factor is known or can be found”
- **Upper Key Stage 2, Year 6 Ratio and proportion –** “solve problems involving unequal sharing and grouping using knowledge of fractions and multiples”
- **Key Stage 3 Ratio, proportion and rates of change –** “use ratio notation, including reduction to simplest form”
- **Key Stage 3 Ratio, proportion and rates of change –** “divide a given quantity into 2 parts in a given part:part or part:whole ratio”
- **Key Stage 3 Ratio, proportion and rates of change –** “express the division of a quantity into 2 parts as a ratio”
- **Key Stage 3 Ratio, proportion and rates of change –** “understand that a multiplicative relationship between 2 quantities can be expressed as a ratio or a fraction”



- **Key Stage 3 Ratio, proportion and rates of change –** “relate the language of ratios and the associated calculations to the arithmetic of fractions and to linear functions”
- **Key Stage 4 Ratio, proportion and rates of change –** “compare lengths, areas and volumes using ratio notation and/or scale factors; make links to similarity (including trigonometric ratios)”

Acknowledgements

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Credits

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