Professor Paws — the evidence section

Generated from the app's own concept records. Sources are quoted verbatim.

How we decide what your child sees

Every picture in the app was chosen for a reason we can show you. Here is how one gets chosen, using a question your child will meet: which is bigger, a half or a third?

1. We start with the idea, not the worksheet

Before anything is built we write down what the child is meant to end up understanding, in a sentence. For this one: a fraction is one amount, so two fractions can be put in order the way two amounts can. If we cannot say it in a sentence, we do not build it.

2. We look up how children actually get it wrong

Not guesses — the specific wrong answers researchers have recorded. Plenty of children decide a third is bigger because three is bigger than two. Knowing that changes what we ask: a question a confused child would also get right tells us nothing, so we do not use it.

3. The picture comes from research, not taste

Your child gets **Two bars of the same length**, one cut into halves and one into thirds. They can see which shaded part is longer. That choice is not our preference; it is what the published guidance describes, and the quote is on the next page.

4. We write down what we will not use, too

Pie charts are the obvious thing to reach for, and we rejected them. Unequal-looking sectors are hard to compare by eye, which turns a comparison of amounts into a perceptual guess. Two slices cannot be laid alongside each other, so the child ends up with an impression instead of a comparison. The source we took that from is quoted in full on the evidence page.

5. The child moves it — the screen does not do the thinking

The bars are something to act on, not a display of the answer with steps attached. If a picture shows what it is meant to teach, it fails this test and does not ship.

And we write down what we cannot say

This is a method, not a result. We can show you the reasoning behind every choice; we cannot tell you what it will do for your child, and we do not pretend otherwise. That is set out on what we don't claim.

The evidence behind each concept

20 concepts. For each: what it means, what the child works with, and the sources that named that representation — quoted exactly, with links.

Only sources we have checked ourselves appear here: each one needs a link and the quoted words, or it does not get published. 67 such quotations across the 20 concepts.

Download all three pages as a PDF — generated from the same records, so it says exactly what this page says.

Maths

Multiplying by ten Proportional length scaling

Multiplying by ten makes every quantity ten times bigger. Because our numbers are written in places, and each place is worth ten of the place to its right, a quantity that becomes ten times bigger moves up one place: ones become tens, tens become hundreds. Nothing is added. The zero that appears in the ones column is there because nothing is left in the ones column — it holds the place. It is a consequence of the move, never the move itself.

7 sources for this choice:

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3, printed p. 23. printed p. 23 (PDF page 30 of 165)

  “When appropriate, use representations that are proportional. For example, when teaching place value, the representation for ones should be one-tenth the size of the representation for tens, and the tens should be one-tenth the size of the representation for hundreds. … If the representations were not proportional, the concept of place value would be harder for students to grasp.”

- What Works Clearinghouse / IES. WWC 2021006 (March 2021), Table 3.1, printed p. 23. Table 3.1, the row spanning Counting/skip counting, Addition, Subtraction, Multiplication, Division, Equality

  “Counting/skip counting Addition Subtraction Multiplication Division Equality — Concrete: base 10 blocks, connecting cubes, Cuisenaire rods®, beads, two-colored counters, beans and cup, 1-inch tiles, balances. Semi-concrete: hundreds chart, 5 frames, 10 frames, double 10 frames, strip diagrams, arrays.”

- Uttal, Scudder & DeLoache (1997), as above — on why a STRUCTURED manipulative is the right kind.

  “manipulative systems, such as Dienes Blocks, that have an internal structure that is systematically related to the concepts they represent may help children to focus on the relation between the manipulative and its referent.”

- Uttal, D. H., Scudder, K. V., & DeLoache, J. S. (1997). "Manipulatives as symbols: A new perspective on the use of concrete objects to teach mathematics." Journal of Applied Developmental Psychology, 18(1), 37–54.

  “children's success with the manipulatives did not convey an advantage when they were asked to interpret written expressions of problems that were conceptually similar to the block problems.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Gersten, R., Beckmann, S., Clarke, B., Foegen, A., Marsh, L., Star, J. R., & Witzel, B. (2009). "Assisting Students Struggling with Mathematics: RtI for Elementary and Middle Schools." NCEE 2009-4060.

  “This model of instruction, with its underpinning in Bruner's (1966) work, is referred to as a concrete to representation to abstract (CRA) method of instruction.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Key stage 1, Year 2 programme of study — Number and place value, notes and guidance

  “This should involve working with numerals, words and the 4 operations, including with practical resources [for example, concrete objects and measuring tools].”

Reading and setting a clock Analogue clock face

A clock face shows two different quantities with two hands on the same twelve marks. The same mark means a different thing depending on which hand points at it: the short hand near 3 means the hour is 3; the long hand at 3 means fifteen minutes, not three. The short hand moves continuously and spends almost the whole hour BETWEEN two numbers — where it sits tells you how far through the hour you are, which is why it is not yet the next hour just because it is close to it.

5 sources for this choice:

- NRICH (Millennium Mathematics Project, University of Cambridge). Teachers' Resources for 'Two Clocks'.

  “the analogue clock is really two scales superimposed on each other. This is what makes it so difficult for children to read.”

- Earnest, D., Gonzales, A. C., & Plant, A. M. (2018). "Time as a Measure: Elementary Students Positioning the Hands of an Analog Clock." Journal of Numerical Cognition, 4(1), 188–214.

  “the hour hand is significantly more challenging to position accurately than the minute hand … one fourth grade student indicating 2:50 positioned the hour hand (inaccurately) at the 2.”

- van Bommel, J., & Walla, M. (2025), as above — on the size of the field.

  “few articles actually existed.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 2 programme of study — Measurement / Geometry: position and direction, notes and guidance

  “Pupils make whole, half, quarter and three-quarter turns in both directions and connect turning clockwise with movement on a clock face.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 2 programme of study — Number: multiplication and division, notes and guidance

  “They connect the 10 multiplication table to place value, and the 5 multiplication table to the divisions on the clock face.”

What each digit is worth Ten ones fused into one ten, then base ten pieces in named positions

TEN ONES BECOME ONE TEN — one thing you can hold, count and move as a unit. That fusing is not a step on the way to place value, it IS place value: everything else follows from it. Once ten ones are one ten, a written number stops being a row of separate digits. It can be taken apart into parts that add back to the whole — 73 is 70 and 3 — and, separately, the POSITION a digit sits in decides what that digit is worth: the 7 in 73 is not seven, it is seven tens. Those are two different things to hold, and the second is much harder than the first: a child can partition 73 into 70 and 3 and still say the 7 means seven.

4 sources for this choice:

- Ross, S. H. (1989), the positional / base-ten / multiplicative / additive properties of place value — as enumerated and attributed in Thompson, I. (2003), Mathematics Teaching 184, p. 14. SECONDARY ROUTE: quoted from Thompson, not from Ross directly. Thompson p. 14

  “that the quantities represented by the individual digits are determined by their positions in the number; that as the digits are moved to the left their value increases by an appropriate power of ten; that the value of an individual digit is found by multiplying its face value by the value assigned to its position; that the quantity represented by the whole number is the sum of the values of these individual digits. These properties of place value understanding are described by Ross respectively as the positional, base-ten, multiplicative and additive properties of place value.”

- Uttal, Scudder & DeLoache (1997), as above — on why a STRUCTURED manipulative is the right kind.

  “manipulative systems, such as Dienes Blocks, that have an internal structure that is systematically related to the concepts they represent may help children to focus on the relation between the manipulative and its referent.”

- Uttal, D. H., Scudder, K. V., & DeLoache, J. S. (1997). "Manipulatives as symbols: A new perspective on the use of concrete objects to teach mathematics." Journal of Applied Developmental Psychology, 18(1), 37–54.

  “children's success with the manipulatives did not convey an advantage when they were asked to interpret written expressions of problems that were conceptually similar to the block problems.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures ... When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

A fraction as equal parts of one whole One whole partitioned into congruent parts — not built yet

A fraction names a quantity, not a pair of counts. It says: this whole was shared into a number of EQUAL parts, and we are talking about some of them. The bottom number is not a tally of cuts — it is the claim that the sharing was fair, and it is false if the pieces are different sizes. Equal means equal in AMOUNT, which is not the same as looking identical: a square cut corner to corner and a square cut into strips can both show quarters.

4 sources for this choice:

- Siegler, R. et al. (2010). "Developing Effective Fractions Instruction for Kindergarten Through 8th Grade." IES / What Works Clearinghouse, NCEE 2010-4039. Recommendation 1, Roadblock 1.3, p. 18

  “Roadblock 1.3. When creating equal shares, students do not distinguish between the number of things shared and the quantity shared.”

- NCETM, Primary Subject Knowledge Audit (KS1 & KS2 Mathematics) — Fractions, Q2. Crown Copyright 2022.

  “Common errors in this area may include: children thinking that equal means they must look identical … Each part has the same area (1/4 of the whole) and the parts are not congruent (they do not look identical) but they are equal.”

- Uttal, Scudder & DeLoache (1997), as above — on why a STRUCTURED manipulative is the right kind.

  “manipulative systems, such as Dienes Blocks, that have an internal structure that is systematically related to the concepts they represent may help children to focus on the relation between the manipulative and its referent.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

Which fraction is bigger Two bars of the same length

A fraction is one amount, so two fractions can be put in order the way two amounts can. Neither number on its own decides it: cutting a whole into more pieces makes each piece SMALLER, so a bigger bottom number does not mean a bigger amount. And the two fractions have to be parts of the same size whole, or the comparison means nothing.

3 sources for this choice:

- Siegler, R. et al. (2010). "Developing Effective Fractions Instruction for Kindergarten Through 8th Grade." IES / What Works Clearinghouse, NCEE 2010-4039. Recommendation 1, Roadblock 1.3, p. 18

  “Roadblock 1.3. When creating equal shares, students do not distinguish between the number of things shared and the quantity shared.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures ... When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Education Endowment Foundation (2018, updated 2022). Improving Mathematics in Key Stages 2 and 3: Guidance Report. Henderson, Hodgen, Foster & Marks. Recommendation 2, p. 12, Box C: Using a number line

  “Some pupils noticed that 2/10 is less than 1/2. With the teacher’s help, the pupils represented the three fractions using a number line. ... This helped pupils to see that 1/2 is equivalent to 4/8, and then to work out that the answer is 5/8.”

Where a fraction sits on a number line A 0 to 1 line, the whole shown entire

A fraction is a NUMBER, so it has one place on the line — a point, not a piece. Finding it means deciding what one whole is on that line, cutting the space between 0 and 1 into the number of equal parts the bottom asks for, and counting that many along. The line may run to 5, or to 4, or to 1; the fraction does not move when the line changes, because it is a number and the line is only where we drew it.

5 sources for this choice:

- Cauté, M., Potier Watkins, C., He, C., & Dehaene, S. (2026). "Characterizing error types in the comprehension of fractions: The number line test." Journal of Experimental Child Psychology, 263, 106373. Abstract

  “Error rates were high, almost 80% in 6th grade and 45% in 10th grade. Errors could be classified into seven dominant patterns … Younger and lower-performing children mostly confused fractions with decimals. Older and higher-performing children often confused a fraction a/b and its inverse b/a. All grades also confused the roles of the numerator and the denominator.”

- Siegler, R. et al. (2010). "Developing Effective Fractions Instruction for Kindergarten Through 8th Grade." IES / What Works Clearinghouse, NCEE 2010-4039. Recommendation 1, Roadblock 1.3, p. 18

  “Roadblock 1.3. When creating equal shares, students do not distinguish between the number of things shared and the quantity shared.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Education Endowment Foundation (2018, updated 2022). Improving Mathematics in Key Stages 2 and 3: Guidance Report. Henderson, Hodgen, Foster & Marks. Recommendation 2, p. 12, "What about other types of representation?"

  “The evidence indicates that number lines are a particularly effective representation for teaching across both Key Stages 2 and 3, and that there is strong evidence to support the use of diagrams as a problem-solving strategy.”

- Education Endowment Foundation (2018, updated 2022). Improving Mathematics in Key Stages 2 and 3: Guidance Report. Henderson, Hodgen, Foster & Marks. Recommendation 2, p. 12, Box C: Using a number line

  “Some pupils noticed that 2/10 is less than 1/2. With the teacher’s help, the pupils represented the three fractions using a number line. … This helped pupils to see that 1/2 is equivalent to 4/8, and then to work out that the answer is 5/8.”

Adding and taking away fractions with the same bottom number Two bars cut the same way

When two fractions are made of the SAME SIZE piece, adding them is just counting those pieces. Three eighths and two eighths are five eighths for the same reason three apples and two apples are five apples — the piece is the thing being counted, and the bottom number NAMES that piece rather than counting anything. So the bottom does not change: you have not changed what a piece is, only how many you have.

3 sources for this choice:

- Siegler, R. et al. (2010). "Developing Effective Fractions Instruction for Kindergarten Through 8th Grade." IES/WWC NCEE 2010-4039, Recommendation 3, p. 32. Recommendation 3, p. 32

  “A common mistake that students make is to add or subtract the numerators and denominators of two fractions (e.g., 2/4 + 5/4 = 7/8 or 3/5 – 1/2 = 2/3). Students who err in this way are misapplying their knowledge of whole number addition and subtraction to fraction problems and failing to recognize that denominators define the size of the fractional part and that numerators represent the number of this part.”

- Siegler, R. et al. (2010). "Developing Effective Fractions Instruction for Kindergarten Through 8th Grade." IES / What Works Clearinghouse, NCEE 2010-4039. Recommendation 1, Roadblock 1.3, p. 18

  “Roadblock 1.3. When creating equal shares, students do not distinguish between the number of things shared and the quantity shared.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures ... When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

Adding and taking away in columns Dienes pieces on a column workmat, regrouped by the child

Columns work because ten ones ARE one ten — the same fusing that place value is made of, now run in both directions. Adding, you gather ones until you have ten of them and swap them for a single ten, which is what the small carried digit records. Taking away, when there are not enough ones you break a ten back into ten ones and carry on. Nothing is created or destroyed in either move: the amount is identical before and after, only how it is BUNDLED changes. That is why the digits may be rewritten and the number is still the number.

5 sources for this choice:

- Uttal, Scudder & DeLoache (1997), as above — on why a STRUCTURED manipulative is the right kind.

  “manipulative systems, such as Dienes Blocks, that have an internal structure that is systematically related to the concepts they represent may help children to focus on the relation between the manipulative and its referent.”

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3, printed p. 23. printed p. 23 (PDF page 30 of 165)

  “When appropriate, use representations that are proportional. For example, when teaching place value, the representation for ones should be one-tenth the size of the representation for tens, and the tens should be one-tenth the size of the representation for hundreds. ... If the representations were not proportional, the concept of place value would be harder for students to grasp.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures ... When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Thompson, I. (2003). "Putting place value in its place." Mathematics Teaching, 184, pp. 14–15. ATM. p. 15

  “In Thompson's terms they have some appreciation of the 'quantity value' aspect of place value (73 is 70 plus 3), but not the 'column value' aspect (73 is 7 in the tens column and 3 in the units column). Consequently, it would appear to be somewhat over-optimistic to expect young children to understand the concept of 'moving the digits one place to the left'.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 2 programme of study — Number: addition and subtraction, notes and guidance

  “Recording addition and subtraction in columns supports place value and prepares for formal written methods with larger numbers.”

Adding, within twenty Two groups of counters, shown apart, then combined into one

Adding is putting two amounts together to make one amount. Once a child can do that by counting, the work is no longer the answer but the ROUTE to it: 8 + 7 is worth knowing as 8 + 2 + 5, because ten is easy to hold and the pieces either side of it are small. A child who only ever counts every object has the concept and none of the strategy.

2 sources for this choice:

- What Works Clearinghouse / IES. WWC 2021006 (March 2021), Table 3.1, printed p. 23. Table 3.1, the row spanning Counting/skip counting, Addition, Subtraction, Multiplication, Division, Equality

  “Counting/skip counting Addition Subtraction Multiplication Division Equality — Concrete: base 10 blocks, connecting cubes, Cuisenaire rods®, beads, two-colored counters, beans and cup, 1-inch tiles, balances. Semi-concrete: hundreds chart, 5 frames, 10 frames, double 10 frames, strip diagrams, arrays.”

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 4, Example 4.10, printed p. 36. Recommendation 4, Example 4.10, printed p. 36 (PDF page 43 of 165); strong evidence, 14 studies

  “Show early elementary (grades K–2) students how to use number lines to add and subtract whole numbers. … Always connect the equation to the number line when solving calculation problems with students. First, model a problem with the number line and have students write the corresponding equation. Then present an equation for students to model on the number line.”

Taking away, within twenty Jumps back along a 0-to-max number line, the equation always beside it

Subtracting is moving back along the numbers by a known amount and seeing where you land. The landing place IS the answer, so it is found rather than recalled. And the same fact can be asked the other way round — "what do I add to 4 to reach 13" is the same picture walked forwards, which is why a child who only ever counts back does not yet have the whole idea.

2 sources for this choice:

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 4, Example 4.10, printed p. 36. Recommendation 4, Example 4.10, printed p. 36 (PDF page 43 of 165); strong evidence, 14 studies

  “Show early elementary (grades K–2) students how to use number lines to add and subtract whole numbers. … Always connect the equation to the number line when solving calculation problems with students. First, model a problem with the number line and have students write the corresponding equation. Then present an equation for students to model on the number line.”

- What Works Clearinghouse / IES. WWC 2021006 (March 2021), Recommendation 4, printed p. 30. printed p. 30 (PDF page 37 of 165)

  “The distance between the positions of zero and one establishes the length of the unit and is the same distance between all whole numbers.”

What coins are worth Real-denomination coins, acted on directly — never a numeral standing in for a pile

A coin is worth what it SAYS, not what it looks like and not one. This is the first thing a child meets where counting the objects gives the wrong answer: five pennies and one ten are six coins and fifteen, and the pile with more things in it can be worth less. So the question "how many?" has to be replaced by "how much?", and the amount has to be built by adding what each coin is worth rather than by counting how many there are. Different piles can be worth exactly the same, which only makes sense once value has come loose from appearance.

5 sources for this choice:

- Tracy, D. M. (1998). "Learning about Money" — citing Bradford (1980), Garland (1990) and Stevenson (1990). Difficulties section

  “young children are often confused by the U.S. monetary system, because relative coin sizes do not correlate with relative values.”

- NRICH, "Money Problems?" — the skills section.

  “We have to understand that objects can have a value, which is irrespective of their colour, shape, size, mass, etc.”

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006, Recommendation 3, action step 2. Recommendation 3, printed p. 24

  “When teaching concepts and procedures, connect concrete and semi-concrete representations to abstract representations.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 2 programme of study — Measurement, notes and guidance

  “They become fluent in counting and recognising coins.”

Sharing out and making groups Objects moved into containers, with whatever is left over still on the table

Division answers two different questions with the same calculation. "Share 12 between 3" asks what lands in each of three places — the answer is a SIZE. "How many 3s in 12?" asks how many places you can fill — the answer is a COUNT. Both are 12 ÷ 3, and a child fluent in one can be stuck on the other. And the calculation is not the answer. What division hands back is a quotient and sometimes something left over, and what the question wanted has to be read off that — sometimes the quotient, sometimes the next whole number up, sometimes the remainder itself. Twelve soldiers left over still need a bus.

5 sources for this choice:

- Carpenter, Lindquist, Matthews & Silver (1983), Results of the Third NAEP Mathematics Assessment — as cited in Verschaffel et al. (2009), quoted in Mathematics Teaching Research Journal 15(2), Spring 2023, p. 120. Introduction

  “An army bus holds 36 soldiers. If 1128 soldiers are being transported by bus to their training site. How many buses are needed?”

- NRICH (University of Cambridge, Millennium Mathematics Project), "Difficulties With Division".

  “Division is often introduced as "sharing" and this is certainly one of the simplest approaches. ... A second conception of division is that of grouping and this links to ideas about successive subtraction.”

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006, Recommendation 3, action step 2. Recommendation 3, printed p. 24

  “When teaching concepts and procedures, connect concrete and semi-concrete representations to abstract representations.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures ... When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 2 programme of study — Number: multiplication and division, notes and guidance

  “Pupils work with a range of materials and contexts in which multiplication and division relate to grouping and sharing discrete and continuous quantities, to arrays and to repeated addition.”

Multiplying A filled rectangle — rows and columns the child builds, not counts

A product is not a longer sum. 6 × 9 can be COUNTED as six nines added up, and for whole numbers that works — but what it MEANS is a rectangle six along and nine down, or six groups each the same size. Holding it as a rectangle buys two things adding does not: turning it ninety degrees shows without argument that 6 × 9 and 9 × 6 are the same amount, and it keeps working when the multiplier stops being a whole number, where "add it up that many times" has nothing to say. Multiplying by a half is still a rectangle; it is not still a sum.

6 sources for this choice:

- Chin, K. E. (2019), EURASIA Journal 15(12), em1779 — Conclusion. Conclusion

  “repeated addition may be considered as a supportive conception for the first two items … Then it gradually became a problematic conception.”

- Chin, K. E. (2019), EURASIA Journal of Mathematics, Science and Technology Education 15(12), em1779 (open access, CC BY) — reporting Larsson, Pettersson & Andrews (2017). Literature review

  “Larsson, Pettersson and Andrews (2017) stated that multiplication which is introduced exclusively as repeated addition or equal groups is a problematic instruction … the way teachers taught multiplication as repeated addition was problematic, especially encountered with multiplication of multi-digits and decimals.”

- What Works Clearinghouse / IES. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006, Recommendation 3, action step 2. Recommendation 3, printed p. 24

  “When teaching concepts and procedures, connect concrete and semi-concrete representations to abstract representations.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 2 programme of study — Number: multiplication and division, notes and guidance

  “Pupils work with a range of materials and contexts in which multiplication and division relate to grouping and sharing discrete and continuous quantities, to arrays and to repeated addition.”

- Department for Education (2013, updated 2021). National curriculum in England: mathematics programmes of study. Statutory guidance. Year 4 programme of study — Measurement, notes and guidance

  “They relate area to arrays and multiplication.”

Making an equal fraction by doing the same thing to both numbers The equation with both denominators shown

If you cut every piece of a whole into the same number of smaller pieces, you have more pieces and each is smaller — and the amount you are holding has not changed. That is why doing the SAME operation to the top and the bottom leaves the fraction equal: the bottom says how the whole was cut and the top says how many you took, so cutting twice as finely and taking twice as many is the same amount described differently. The rule is not a trick about numbers; it is the arithmetic of re-cutting, and it only works because the operation is the same on both.

3 sources for this choice:

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 2. Recommendation 2, PDF p. 29 (Figure 5)

  “Fraction strips also can be used to reinforce the concept of equivalent fractions by allowing students to measure the distance between two points using different-sized fraction strips.”

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 2. Recommendation 2, PDF p. 29

  “Although viewing equivalent fractions as the same point on a number line can be challenging for students, the panel believes that the ability to do so is critical for thorough understanding of fractions.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

Adding fractions when the pieces are different sizes Two bars re-cut to a shared piece

Two fractions can only be counted together when they are made of the SAME size piece. Halves and thirds cannot be added as they stand, not because a rule forbids it but because there is no single piece to count: one half and one third is not two of anything. So the work is not the adding — it is re-cutting both wholes the same way first, which changes how the amounts are NAMED and not what they ARE. Once both are sixths, it is the same counting as before.

4 sources for this choice:

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 2. Recommendation 2, PDF p. 29 (Figure 5)

  “Fraction strips also can be used to reinforce the concept of equivalent fractions by allowing students to measure the distance between two points using different-sized fraction strips.”

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 3. Recommendation 3, PDF p. 34

  “A common mistake students make when faced with fractions that have unlike denominators is to add both numerators and denominators.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Education Endowment Foundation (2018, updated 2022). Improving Mathematics in Key Stages 2 and 3: Guidance Report. Henderson, Hodgen, Foster & Marks. Recommendation 2, p. 12, Box C: Using a number line

  “Some pupils noticed that 2/10 is less than 1/2. With the teacher’s help, the pupils represented the three fractions using a number line. … This helped pupils to see that 1/2 is equivalent to 4/8, and then to work out that the answer is 5/8.”

Two fractions that are the same amount Stacked lengths measured against each other

Two fractions can be written differently and still be the SAME AMOUNT. Cutting a whole into more pieces does not give you more — it gives you more, smaller pieces, and taking proportionally more of them lands you back where you were. So 1/2 and 2/4 are not two amounts that happen to be close: they are one amount with two names, and on a number line they are one POINT. The numbers going up is not the amount going up, which is the whole difficulty.

5 sources for this choice:

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 2. Recommendation 2, PDF p. 29 (Figure 5)

  “Fraction strips also can be used to reinforce the concept of equivalent fractions by allowing students to measure the distance between two points using different-sized fraction strips.”

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 2 (summary statement). Recommendation 2, PDF p. 7

  “Use number lines as a central representational tool in teaching this and other fraction concepts from the early grades onward.”

- Siegler et al. (2010), NCEE 2010-4039, Recommendation 1. Recommendation 1, PDF p. 22

  “Students should understand that although there are different ways to partition the pizza, each partitioning method results in equivalent shares.”

- What Works Clearinghouse / IES, U.S. Dept of Education. "Assisting Students Struggling with Mathematics: Intervention in the Elementary Grades." WWC 2021006 (March 2021), Recommendation 3.

  “Use a well-chosen set of concrete and semi-concrete representations to support students' learning of mathematical concepts and procedures … When demonstrating concepts and procedures with concrete and semi-concrete representations, present the mathematical notation simultaneously.”

- Education Endowment Foundation (2018, updated 2022). Improving Mathematics in Key Stages 2 and 3: Guidance Report. Henderson, Hodgen, Foster & Marks. Recommendation 2, p. 12, Box C: Using a number line

  “Some pupils noticed that 2/10 is less than 1/2. With the teacher’s help, the pupils represented the three fractions using a number line. … This helped pupils to see that 1/2 is equivalent to 4/8, and then to work out that the answer is 5/8.”

Reading, spelling and handwriting

Sounds and the letters that spell them One tile per grapheme — the letters that spell one sound move as a single piece, and say that sound when tapped

A written word is a record of the SOUNDS in a spoken word, and the piece that spells one sound is not always one letter. "sh" is a single sound written with two letters; "tch" is a single sound written with three; the two p's in "unhappy" are one sound. So counting the letters does not count the sounds — "thing" is five letters and three sounds. Knowing which letters spell which sound is what turns a word never seen before into a word that can be said, and a word that can be said into letters that can be written. A letter's NAME is a partial and unreliable route to this: most consonant names do contain their sound, and the letters where that breaks — c in cat, g in gate — are exactly the letters that spell more than one sound.

7 sources for this choice:

- Ehri, L. C. (2003). "Systematic Phonics Instruction: Findings of the National Reading Panel." Graduate Center of the City University of New York. Summarising Ehri, Nunes, Stahl & Willows (2001), Review of Educational Research 71, 393–447 (66 comparisons, 38 experiments). Section "How Alphabetic Knowledge Contributes"; overall mean effect size +0.41

  “Systematic phonics instruction teaches beginners the major grapheme-phoneme correspondences and how to use these to decode and spell words.”

- Ehri, L. C. (2022). "What Teachers Need to Know and Do to Teach Letter–Sounds, Phonemic Awareness, Word Reading, and Phonics." The Reading Teacher, 76(1), 53–61. DOI 10.1002/trtr.2095. Verified against the publicly hosted copy linked here. Section clarifying terms

  “Graphemes are one or more letters that symbolize single phonemes, for example, B says /b/, CH says /č/.”

- Ehri, L. C. (2022). "What Teachers Need to Know and Do to Teach Letter–Sounds, Phonemic Awareness, Word Reading, and Phonics." The Reading Teacher, 76(1), 53–61. DOI 10.1002/trtr.2095. Verified against the publicly hosted copy linked here. Section defining phonics, decoding and spelling

  “Decoding involves transforming graphemes into phonemes and blending them to form pronunciations of words. Spelling involves distinguishing and remembering phoneme–grapheme relations specified in written words.”

- Foorman, B., Beyler, N., Borradaile, K., Coyne, M., Denton, C. A., Dimino, J., … Wissel, S. (2016). Foundational skills to support reading for understanding in kindergarten through 3rd grade (NCEE 2016-4008). Washington, DC: U.S. Department of Education, Institute of Education Sciences, NCEE / What Works Clearinghouse. Recommendation 3, How to carry out the recommendation, point 1

  “Teach students to blend letter sounds and sound-spelling patterns from left to right within a word to produce a recognizable pronunciation. … Students read from left to right, successively adding more letters to produce the sound of the word.”

- Ehri, L. C. (2014). "Orthographic Mapping in the Acquisition of Sight Word Reading, Spelling Memory, and Vocabulary Learning." Scientific Studies of Reading, 18(1), 5–21. DOI 10.1080/10888438.2013.819356. Abstract

  “Orthographic mapping (OM) involves the formation of letter-sound connections to bond the spellings, pronunciations, and meanings of specific words in memory. … OM is enabled by phonemic awareness and grapheme-phoneme knowledge.”

- Ehri, L. C. (2003). "Systematic Phonics Instruction: Findings of the National Reading Panel." Graduate Center of the City University of New York — results reported separately for younger and older students. Section reporting Table 2, literacy outcomes by age

  “Among older readers, a different picture emerged. Effects on decoding were moderate, and effects on reading miscellaneous words were small to moderate. However, effects on spelling and reading comprehension were not statistically greater than zero.”

- Department for Education (2023, July). The reading framework: teaching the foundations of literacy. p. 54

  “Letter cards, friezes and posters showing GPCs should match the phonics programme the school has chosen.”

Forming letters and writing a word A stroke-ordered letter guide the child writes over — a start dot where the pencil goes, and guide dots running in the taught direction

A letter is a MOVEMENT, not a picture. "b" is a line pulled down from the top and then a bowl pushed round from the middle; a "b" that ends up looking right but was assembled as a circle with a stick beside it was drawn rather than written. The movement is what becomes automatic, and automatic is the whole point: while forming the letters still takes attention, that attention is not available for the word being spelt or the sentence being written. So writing a word by hand is two jobs at once — knowing which letters, and making them — and being fluent at the second is what lets a child spend everything they have on the first.

8 sources for this choice:

- Santangelo, T., & Graham, S. (2016). "A Comprehensive Meta-analysis of Handwriting Instruction." Educational Psychology Review, 28(2), 225–265. DOI 10.1007/s10648-015-9335-1. True- and quasi-experimental intervention studies with K–12 students. Abstract

  "teaching handwriting resulted in statistically greater legibility (ES = 0.59) and fluency (ES = 0.63) … handwriting instruction produced statistically significant gains in the quality (ES = 0.84), length (ES = 1.33), and fluency of students' writing (ES = 0.48)"

- Caravolas, M., Downing, C., Hadden, C. L., & Wynne, C. (2020). "Handwriting Legibility and Its Relationship to Spelling Ability and Age." Frontiers in Psychology, 11:1097. N = 381. Results — components of legibility across all three groups

  "letter formation had the most consistent relationships with literacy measures in all three groups"

- Puranik, C. S., & AlOtaiba, S. (2012). "Examining the contribution of handwriting and spelling to written expression in kindergarten children." Reading and Writing, 25(7), 1523–1546. DOI 10.1007/s11145-011-9331-x. KINDERGARTEN sample — the mechanism, not our age band. Discussion

  "When children lack adequate transcription skills, they consciously devote their attention to forming letters and spelling words, taking away considerable attentional and cognitive resources from composing text."

- Atkinson, R. K., Renkl, A., & Merrill, M. M. (2003). "Transitioning From Studying Examples to Solving Problems: Effects of Self-Explanation Prompts and Fading Worked-Out Steps." Journal of Educational Psychology, 95(4), 774–783.

  "successively fading … worked-out solution steps as learners transition from relying on examples to independent problem solving reliably fosters performance … [reporting Renkl et al. 2002:] their fading procedure produced reliable effects on near-transfer items but not on far-transfer items."

- Santangelo, T., & Graham, S. (2016). "A Comprehensive Meta-analysis of Handwriting Instruction." Educational Psychology Review, 28(2), 225–265. DOI 10.1007/s10648-015-9335-1. Abstract — moderator analysis by instructional type

  "Motor instruction did not produce better handwriting skills (ES = 0.10 for legibility and -0.07 for fluency)"

- Caravolas, M., Downing, C., Hadden, C. L., & Wynne, C. (2020). "Handwriting Legibility and Its Relationship to Spelling Ability and Age: Evidence From Monolingual and Bilingual Children." Frontiers in Psychology, 11:1097. DOI 10.3389/fpsyg.2020.01097. N = 381, ages 6.3–10.8. Discussion

  "spelling ability, more so than variables related to the amount of practice in handwriting, such as age and hence the amount of schooling experience, exerts a relatively strong and stable influence on handwriting skills, including legibility."

- Merritt, E., Swain, S. N., Vinci-Booher, S., & James, K. H. (2020). "Constraining Stroke Order During Manual Symbol Learning Hinders Subsequent Recognition in Children Under 4 1/2 Years." Frontiers in Psychology, 11:500. DOI 10.3389/fpsyg.2020.00500. Abstract and discussion — the effect is bounded at 4.5 years

  “constraining stroke order via instruction during manual novel symbol learning hinders subsequent recognition in young children (<4.5 years) … the strokes that are used to construct a symbol by hand may be highlighting important features or may be a part of the symbol representation itself”

- Department for Education (2023, July). The reading framework: teaching the foundations of literacy. p. 51

  “For writing (spelling and handwriting), children should: practise segmenting spoken words into their individual sounds; choose which letter or letters to represents each sound; practise a correct pencil grip.”

Spelling a word from memory One word, met whole — its meaning in a sentence, then its sounds, its position rule and its parts, then written from memory and returned to on a schedule

A spelling is not a row of letters to be remembered in order. Which letters a word takes is decided by three things at once: the SOUNDS in it, the POSITION those sounds sit in, and the PARTS the word is built from. The /ch/ at the end of catch is written tch because it follows a short vowel — as in match and fetch — while the /ch/ in chip is not; the /j/ at the end of bridge is dge for the same reason. Those are not exceptions to be memorised one by one, they are rules about WHERE. And unhappy is not a string, it is un + happy, which is why it keeps one p and why replay keeps the play you already know. A speller working from sound alone writes cach and brij: every sound correct, and the word still wrong.

11 sources for this choice:

- Graham, S., & Santangelo, T. (2014). "Does spelling instruction make students better spellers, readers, and writers? A meta-analytic review." Reading and Writing, 27(9), 1703–1743. DOI 10.1007/s11145-014-9517-0. 53 studies, 6,037 students K–12, 58 effect sizes. Abstract

  "Results provided strong and consistent support for teaching spelling, as it improved spelling performance when compared to no/unrelated instruction (ES = 0.54) ... Gains in spelling were maintained over time (ES = 0.53) ... The positive outcomes associated with formal spelling instruction were generally consistent, regardless of students' grade level or literacy skills."

- Niolaki, G. Z., Negri, O., Terzopoulos, A. R., Butterfield, S., Wilson, L., Andreou, G., & Masterson, J. (2023). "What spelling errors can tell us about the development of processes involved in children's spelling." Frontiers in Psychology, 14:1178427. DOI 10.3389/fpsyg.2023.1178427. 641 UK primary children (mean ages 6.34, 8.77, 10.78). Discussion

  "Overall, spelling encompasses different tiers of linguistic awareness (phonology, orthography, morphology and semantics), so to establish solid lexical representations, the spellers need to be aware of all these and their interrelationships."

- Foorman, B., Beyler, N., Borradaile, K., Coyne, M., Denton, C. A., Dimino, J., ... Wissel, S. (2016). Foundational skills to support reading for understanding in kindergarten through 3rd grade (NCEE 2016-4008). U.S. Department of Education, IES, NCEE / What Works Clearinghouse.

  Recommendation 3, How to carry out the recommendation, point 3

  "Teach students to recognize common word parts. After students have learned some common spelling patterns, show them how to break words down into smaller, meaningful parts. ... Activities to support students in learning to manipulate word parts would be most helpful in supporting student understanding of spelling."

- Ehri, L. C. (2003). "Systematic Phonics Instruction: Findings of the National Reading Panel." Graduate Center of the City University of New York — the panel's reading of its own null result for older students. Section reporting Table 2, immediately after the older-reader results

  "may result from a greater need in the higher grades for specific instruction targeting comprehension strategies and background knowledge and for spelling instruction focused on learning individual words."

- Niolaki, G. Z., Negri, O., Terzopoulos, A. R., Butterfield, S., Wilson, L., Andreou, G., & Masterson, J. (2023). "What spelling errors can tell us about the development of processes involved in children's spelling." Frontiers in Psychology, 14:1178427. Results and discussion, comparing the younger and older Key Stage 2 groups

  "As spelling skill increased, and the influence of systematic synthetic phonics presumably became less strong, children appeared to become more reliant on lexical processes."

- Ehri, L. C. (2022). "What Teachers Need to Know and Do to Teach Letter–Sounds, Phonemic Awareness, Word Reading, and Phonics." The Reading Teacher, 76(1), 53–61. DOI 10.1002/trtr.2095. Verified against the publicly hosted copy linked here. Section defining phonics, decoding and spelling

  “Decoding involves transforming graphemes into phonemes and blending them to form pronunciations of words. Spelling involves distinguishing and remembering phoneme–grapheme relations specified in written words.”

- Pashler, H. (chair), Bain, P. M., Bottge, B. A., Graesser, A., Koedinger, K., McDaniel, M., & Metcalfe, J. (2007, September). "Organizing Instruction and Study to Improve Student Learning." IES / What Works Clearinghouse practice guide. Recommendation 1 — level of evidence: MODERATE (not strong; recorded as the guide states it)

  “Space learning over time. Arrange to review key elements of course content after a delay of several weeks to several months after initial presentation.”

- Cepeda, N. J., Pashler, H., Vul, E., Wixted, J. T., & Rohrer, D. (2006). "Distributed Practice in Verbal Recall Tasks: A Review and Quantitative Synthesis." Psychological Bulletin, 132(3), 354–380. Abstract; 839 assessments across 317 experiments in 184 articles

  “This review found 839 assessments of distributed practice in 317 experiments located in 184 articles … Analyses suggest that ISI and retention interval operate jointly to affect final-test retention; specifically, the ISI producing maximal retention increased as retention interval increased.”

- Caravolas, M., Downing, C., Hadden, C. L., & Wynne, C. (2020). "Handwriting Legibility and Its Relationship to Spelling Ability and Age: Evidence From Monolingual and Bilingual Children." Frontiers in Psychology, 11:1097. DOI 10.3389/fpsyg.2020.01097. N = 381, ages 6.3–10.8. Discussion

  “spelling ability, more so than variables related to the amount of practice in handwriting, such as age and hence the amount of schooling experience, exerts a relatively strong and stable influence on handwriting skills, including legibility.”

- Department for Education (2013, updated 2021). National curriculum in England: english programmes of study. Statutory guidance. Year 2 programme of study — Writing: transcription, notes and guidance

  “The process of spelling should be emphasised: that is, that spelling involves segmenting spoken words into phonemes and then representing all the phonemes by graphemes in the right order.”

- Department for Education (2023, July). The reading framework: teaching the foundations of literacy. p. 51

  “For writing (spelling and handwriting), children should: practise segmenting spoken words into their individual sounds; choose which letter or letters to represents each sound; practise a correct pencil grip.”

Making sense of a passage The passage stays on the page — every question is answered with the text in reach, and the help ladder points back into it rather than around it

Understanding a story is not remembering it. It is building a picture of what happened that holds together — and the text never says everything, so parts of that picture have to be worked out rather than found. "She pulled her coat tighter" is not a sentence about a coat; it tells you it was cold, and nothing in the passage says so. That is why the text stays on the page: the answer to a question you cannot answer is to go BACK, find the line that bears on it, and put it beside what you already knew. A reader who never goes back is not reading carefully from memory — they have no way of noticing that their picture stopped making sense.

7 sources for this choice:

- Vaughn, S., Boardman, A., Cirino, P., Coyne, M., Denton, C., Elleman, A., … Wexler, J. (2022). Providing Reading Interventions for Students in Grades 4–9. Educator's Practice Guide, WWC 2022007. U.S. Department of Education, IES, NCEE / What Works Clearinghouse. Recommendation 3, Table 3.1 "Parts of Recommendation 3"

  “Routinely use a set of comprehension-building practices to help students make sense of the text. Part A: Build students' world and word knowledge so they can make sense of the text. Part B: Consistently provide students with opportunities to ask and answer questions to better understand the text they read. Part C: Teach students a routine for determining the gist of a short section of text. Part D: Teach students to monitor their comprehension as they read.”

- Oakhill, J., & Cain, K. (2016). "Supporting Reading Comprehension Development: From Research to Practice." Perspectives on Language and Literacy, Spring 2016, pp. 32–39. International Dyslexia Association. Section "Comprehension monitoring"

  “Good readers evaluate their understanding of text both during and after reading. In doing so, they can identify when a failure to understand has occurred, and if they have the strategic knowledge they can engage in fix-up processes to repair comprehension failures. There are no studies to our knowledge that have targeted comprehension monitoring in isolation.”

- Oakhill, J., & Cain, K. (2016). "Supporting Reading Comprehension Development: From Research to Practice." Perspectives on Language and Literacy, Spring 2016, pp. 32–39. Citing Muter et al. (2004), Oakhill & Cain (2012) and Silva & Cain (2015). Opening section

  “Vocabulary, grammar, and integrative and inference skills explain unique variance in the longitudinal prediction of reading comprehension in the beginning stages of reading development”

- Oakhill, J., & Cain, K. (2016). "Supporting Reading Comprehension Development: From Research to Practice." Perspectives on Language and Literacy, Spring 2016, pp. 32–39. International Dyslexia Association. Section "Remediation and Prevention"

  “Word-reading skills are essential to enable reading comprehension to develop, but we have seen from the work on poor comprehenders that successful comprehension does not develop automatically once word reading is in place.”

- Oakhill, J., & Cain, K. (2016). "Supporting Reading Comprehension Development: From Research to Practice." Perspectives on Language and Literacy, Spring 2016, pp. 32–39. International Dyslexia Association. Reviewing McGee & Johnson (2003) and Yuill & Oakhill (1988b). Section on inference-making interventions

  “have resulted in significantly greater improvements, not only in inference making but also on standardized reading comprehension tests for the inference-trained children compared to control groups. The control groups undertook typical comprehension exercises (reading texts and answering questions about the text)”

- Ehri, L. C. (2003). "Systematic Phonics Instruction: Findings of the National Reading Panel." Graduate Center of the City University of New York — results reported separately for younger and older students. Section reporting Table 2, literacy outcomes by age

  “Among older readers, a different picture emerged. Effects on decoding were moderate, and effects on reading miscellaneous words were small to moderate. However, effects on spelling and reading comprehension were not statistically greater than zero.”

- Department for Education (2013, updated 2021). National curriculum in England: english programmes of study. Statutory guidance. Year 1 programme of study — Reading: comprehension, notes and guidance

  “Comprehension skills develop through pupils’ experience of high-quality discussion with the teacher, as well as from reading and discussing a range of stories, poems and non-fiction.”

What we don't claim

Most products this shape do not publish a page like this. Here is what Professor Paws does not do, and why.

> **We have not run efficacy studies.**
> Nobody has measured whether children who use Professor Paws learn more than children who do not — not us, not anyone. Everything on these pages is about method, and a citation for a method is not evidence that our version of it works.

> **Reading comprehension has no manipulative.**
> The evidence says the teaching is talk and stories, so the passage simply stays on the page and every question is answered with the text in reach.

> **Times tables are typed drills.**
> That part of the app is about quick recall of facts already taught with a picture elsewhere. Putting a manipulative on a speed drill would work against the point of it.

> **One rejection we currently earn.**
> Our own record for Adding, within twenty says a teaching surface should not do this: “counting every counter from one as the taught method, with no route to a derived fact” — and ours currently does. It is here because the record says it, and a record that only described what we had already built would not be worth publishing.

> **Written but not built.**
> A fraction as equal parts of one whole — the representation is chosen and the surface is not in the app yet.

> **A citation is not an endorsement.**
> A quoted source means that is where the representation came from. It does not mean the researchers studied our app or predict anything about your child.

> **We never compare your child to a year group.**
> Curriculum codes are recorded for accuracy about a standard's wording. The app cannot compute a comparison against a grade, and it is built not to.