Why is Maths so hard?

This plural "maths" is fairly new to me. I have to ask – why make plural a word that means a unified logical structure, unless you include astrology, tea leaves and palm reading? Mathematics is not magic, it is logic in rather pure form.

A nurse is to inject a patient with 25 mg of a medication. She has an 80 mL vial containing 1 gram of dissolved medication. "Ah-Ha, ratio-and-proportion" says she, as she pulls 2 mL into her syringe. At one time, the ability to form ratios seemed to be the peak of intelligence. It was/is *Ratio-type* thinking, or "***ratio***nal" thought. (Not *magic-type*, or "***magic***onal".)

Each semester, about half the students entering Intermediate Algebra classes find the following new to them.

- **Add** Take a basket and add 3 puppies (put 3 into it).
  You find 3 puppies in the basket.

Addition

basket holds 0 (nothing)
Add 3 $0 + 3 = what$
Count to get the result

- **Multiply** Take 4 such baskets of 3 puppies each.
  Count 'em … 12 puppies
  Multiply: add 4 copies of 3 things together get 12.

Multiplication

$4 \times 3 = what$

means $3 + 3 + 3 + 3 = 12$

- **Divide** This is the opposite of multiply, can be a lot harder.
  Separate 12 puppies into 4 baskets. How many in each?
  Divide: 4 copies of *what* can be multiplied to make up 12 items?
  To decide that you get 3 puppies in each basket, you had to extend your current understanding of "multiply."

Division

$12 / 4 = what$

Same as

$4 \times what = 12$

means $what = 3$

- **Exponents** This is a kind of multiplication, so start with the Multiply definition:
  In that definition, change word *add* to the word *multiply*.
  Powers: 3^4 means multiply 4 copies of three things together to get 81.
  Success with "powers" requires understanding "multiply"

Exponents

$3^4 = 3 \times 3 \times \mathbf{3 \times 3}$
$= 3 \times \mathbf{3 \times 9}$
$= \mathbf{3 \times 27}$
$= \mathbf{81}$

Our point ➔ Every step you take upwards in math reaches a new level in the logic of how things fit together. Your upwards reach is based on your current level of understanding how things work. Like climbing a ladder, you move to the next step up by standing on the current step.

This sequential learning is the only way to climb up to exponential growth, calculus, differential equations, group theory, topology and onwards. It is never any harder to move up to the next step, but each climb requires a firm, solid footing on the current step. All the parts of mathematics meld into the beautiful ladder or tree of clear thinking.

Many students have never been challenged to understand basic operations like multiplication and its extension, division. They have nowhere to stand to begin the climb. So, yah, math can be "hard."

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