

# **FractionForge**

## ***Meet the Cast***

**STANDARD EDITION**

# Spark & Anvil

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This book collects 6 chapter books from the FractionForge cast — each character embodies a different curricular primitive; together they teach the full subject.

Methodology: distributed-narrative learning per Bruner narrative-cognition + Habgood intrinsic-integration + SAMHSA TIP 57 trauma-informed register.

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*For everyone who learns by hearing a story first.*

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# Introduction

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The FractionForge cast was authored to embody the curriculum, not decorate around it. Each of the 6 characters you'll meet in this book teaches a specific primitive — a particular tactic, a particular technique, a particular way of seeing. Together they form an ensemble: the cast IS the curriculum.

Read in any order. Each chapter stands alone.

Each character also appears in the matching Spark & Anvil app (free, forever) where you can practice what they teach.

— *The editors at Spark & Anvil*

# Dot

*DECIMAL POINT* — a special-case fraction notation where the denominator is always a power of 10.  $0.3 = 3/10$ .  $0.07 = 7/100$ . The decimal point's position determines the denominator.



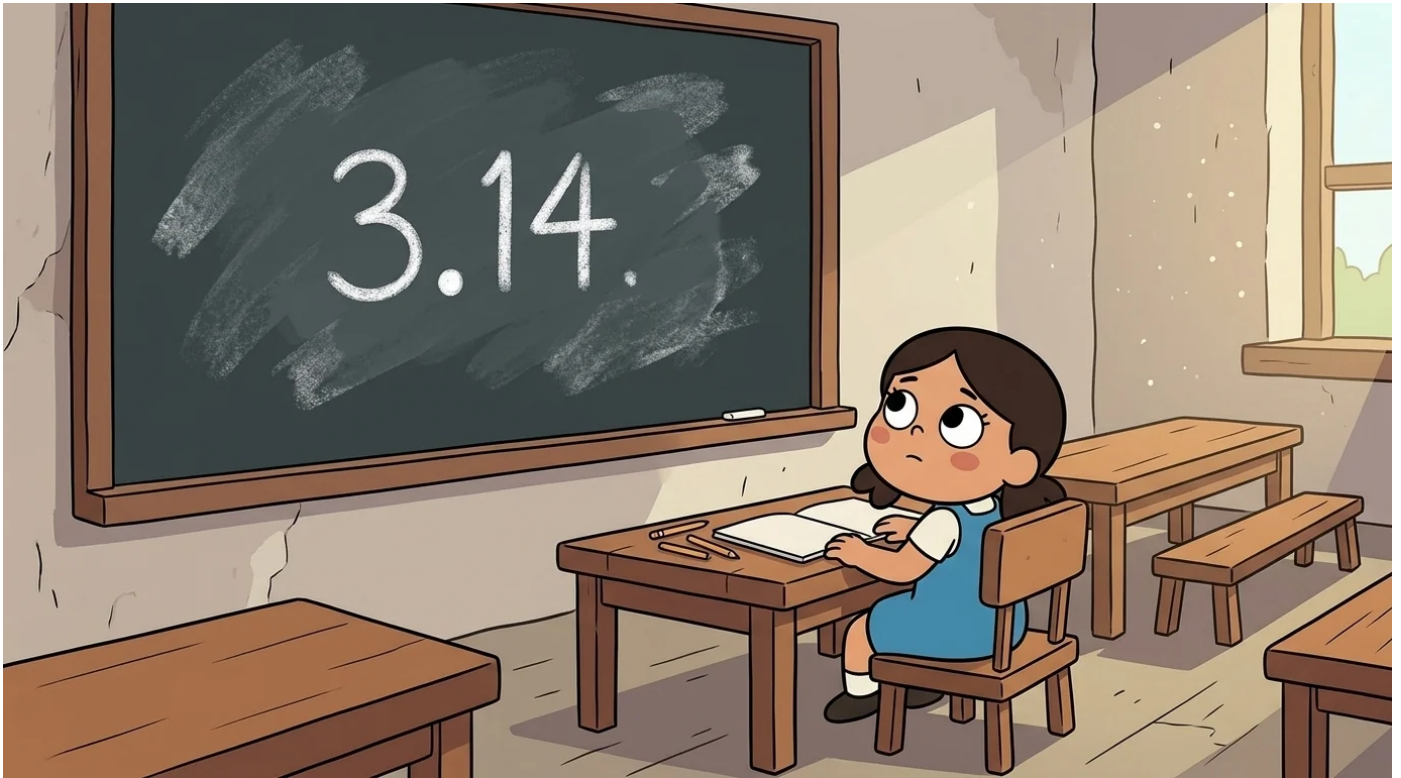
Dot was, for most of her childhood, *the smallest person in every room*.

This is, when you are a child, a *strange feeling*. Adults always see you. Adults often address you as if you were younger than you are. Adults sometimes step around you because they did not notice you were there, and then they apologize, and then they ask if you are all right, and then they pat you on the head, which is not necessarily what a small person wants. The world, when you are small, is *full of large things politely trying not to bump into you*.

Dot — whose given name was *Mila*, though she has gone by Dot since her older brothers nicknamed her at age four — grew up in a household of *tall, loud, fast-moving siblings*. She had four older brothers. They were all, even by adult standards, large. By the time her oldest brother was seventeen and Mila was four, he could pick her up under one arm and carry her up the cottage's stairs without breaking stride. (He did this often. He thought it was funny. Mila thought it was *deeply unfair* and would have *much preferred to walk up the stairs herself*, but she did not yet have the words to object.)

Her brothers called her Dot because she was *a small dot in the family painting*. She did not mind the name. She liked it, actually. *Dot* felt accurate. She was a dot.

But — and this is the chapter's essential fact — *Dot understood, very early, that her smallness did not mean she was unimportant*. She understood that *small things, placed correctly, could mean a great deal*.



This was a thing she learned from her grandmother.

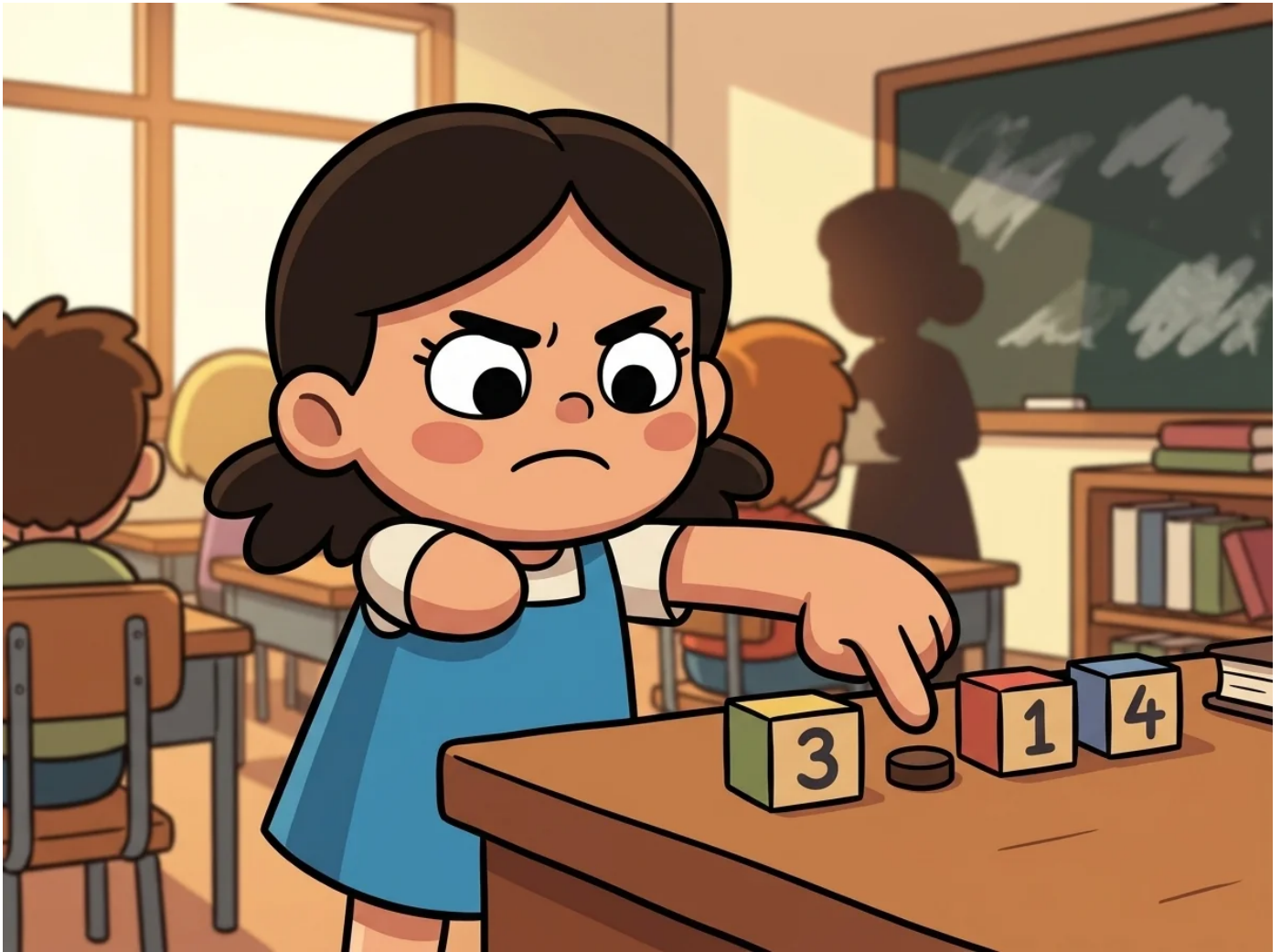
Her grandmother — *Vade*, who had been a calligrapher in her younger years and who still maintained the family's library of carefully-lettered books — had taught Dot to read by *pointing at each letter with a fingertip*. The fingertip touched the letter for a heartbeat. The fingertip moved to the next letter. *Vade* said, very slowly: \*"Each letter is small. Each letter only has meaning *in its place*. If you move the letter, the word changes. If you remove the letter, the word breaks. Small things matter when their *place* matters."\*

Dot understood this immediately. She had been four. She had learned to read in three months.

Over the next several years, Dot internalized the principle. *Small things, placed correctly, were not unimportant. They were the placement itself*. A comma in the wrong place changed a sentence. A grain of sand in a clock's gears stopped the clock. A small candle in a dark room *was* the light.

When Dot was nine, she encountered decimals at the village school. The schoolteacher wrote on the board:

3.14.



The schoolteacher said: \**"This is a decimal number. The dot between the 3 and the 14 is called the *decimal point*. It separates the whole part from the fractional part. The 3 is three whole units. The 1 is one-tenth. The 4 is four-hundredths."*\*

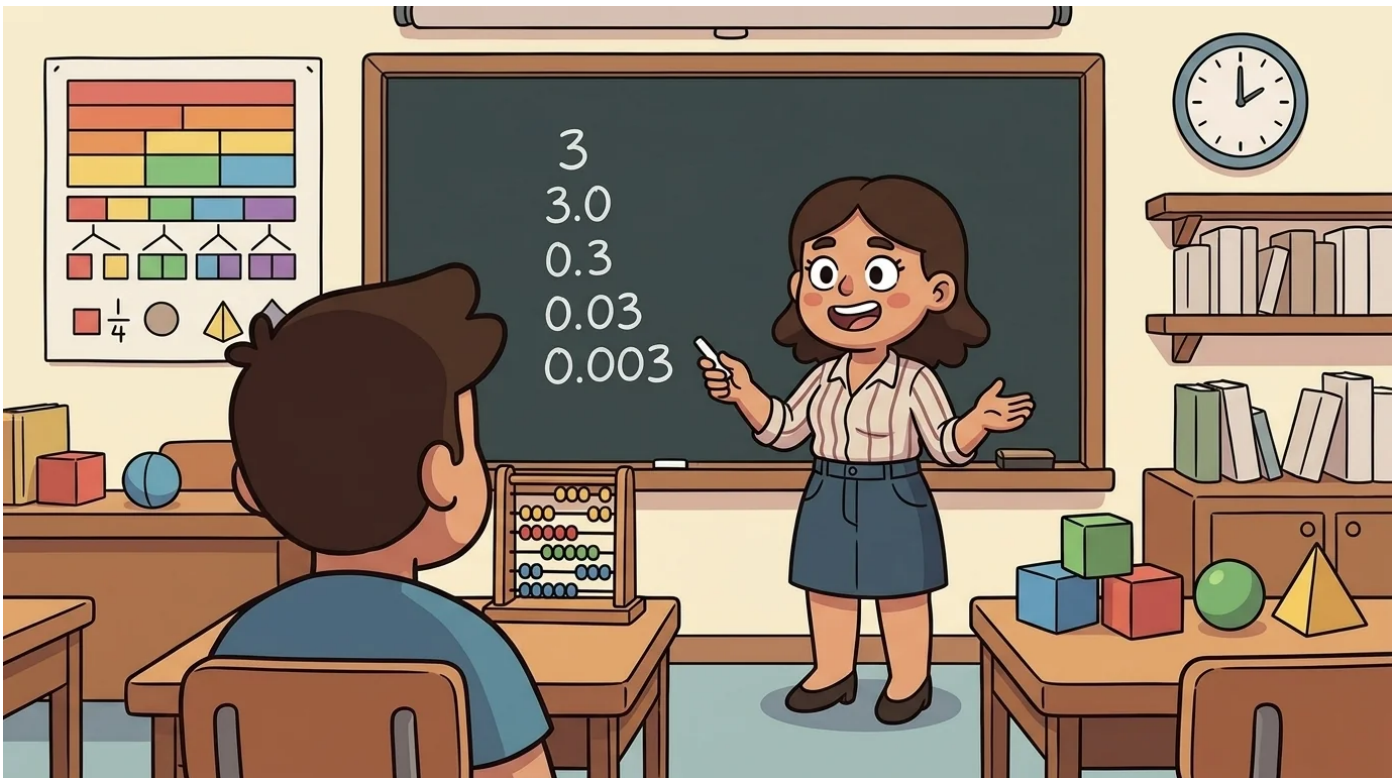
Dot stared.

She said: *"The dot is the most important part of the number."*

The schoolteacher said: *"Why?"*

Dot said: \**"It tells you which digit means what. Without the dot, you would have the number 314, which is three hundred fourteen. With the dot, you have 3.14, which is three-and-some-fraction. The dot decides whether the 3 is *three units* or *three hundred units*. The dot is small. The dot decides everything."*\*

The schoolteacher was, by his own later admission, *struck*. He had been teaching decimals for fifteen years. He had not heard anyone state the case for the decimal-point's importance quite that directly.



He said: "Yes. That is exactly right. The decimal point is small but it is *essential*. Its position determines what every digit means. Move the decimal point one place to the right, and every digit moves one place to the *left* in value — every digit becomes ten times bigger. Move the decimal point one place to the left, and every digit becomes ten times smaller."\*

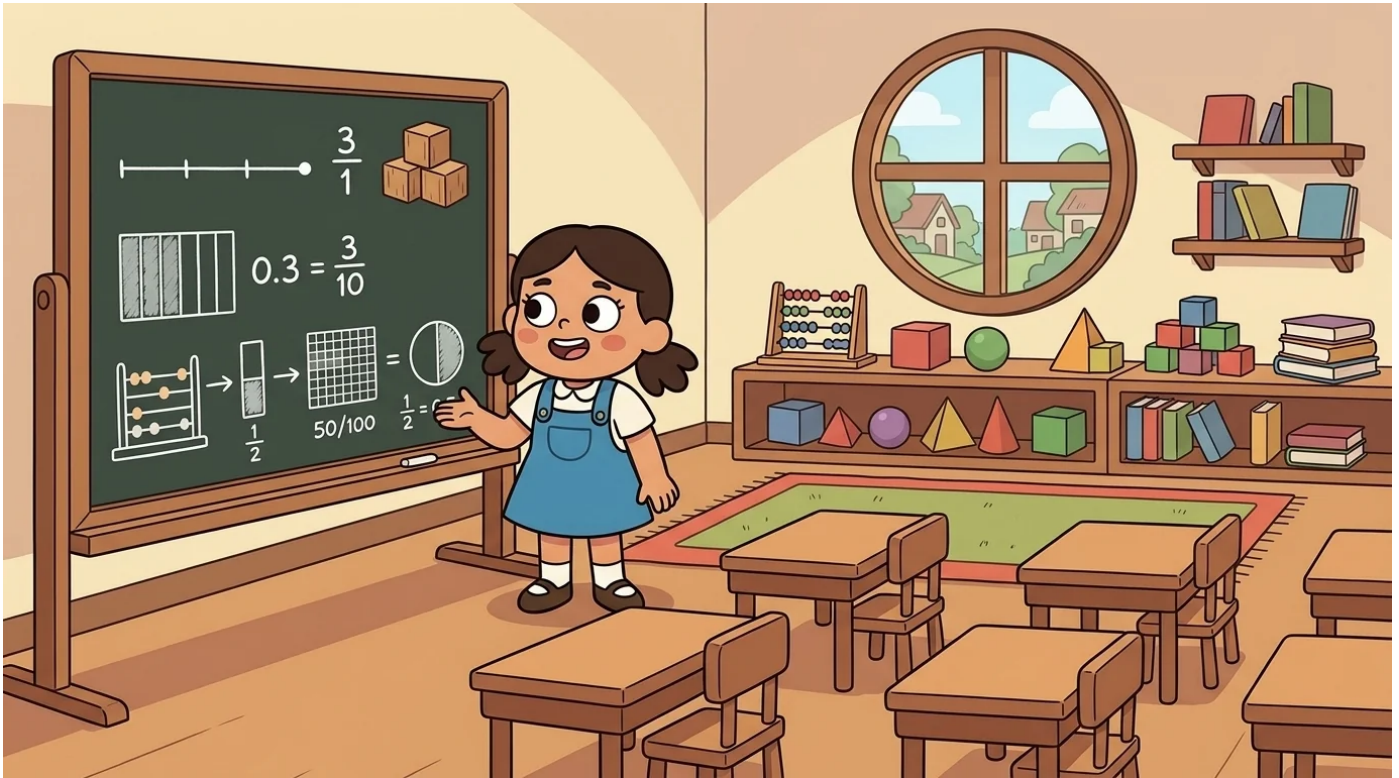
Dot nodded. She thought of her grandmother. *Small things, placed correctly, were the placement itself.* The decimal point was such a small thing. The decimal point *was* the placement.

She has been teaching the decimal point ever since. She studied at the FractionForge academy from sixteen to nineteen. She joined the faculty at twenty. She is now thirty-one. She is no longer the smallest person in every room (she had a late growth spurt and is now of slightly-above-average height) but she is *still called Dot* and she does not mind.

In her classroom, she begins every first-day lesson the same way. She writes on the board:

3 3.0 0.3 0.03 0.003.

She turns to the class. She says: "*These all contain the digit 3. They are not the same number. What makes them different?*"



The children — always — say *the dot*. (Sometimes they say *the decimal point*, but most of them call it the dot.)

Dot smiles. She says: \*"The dot is small. The dot decides everything. 3 is three whole units. 3.0 is also three whole units (the zero is just confirming there is nothing in the tenths position). 0.3 is three tenths. 0.03 is three hundredths. 0.003 is three thousandths. The digit 3 is the same. The *place* changes. The *value* changes by a factor of ten with every step."\*

She then writes:  $1/2 = 0.5 = 50\%$ . She says: \*"Decimals are fractions. 0.5 means 5/10, which equals 1/2. Percentages are fractions with denominator one hundred. 50% means 50/100, which equals 1/2. These three are the *same value* in three different writing systems. The fraction, the decimal, the percent. All three are equivalent."\*

The children — always — see it. Once Dot has made the connection between fractions and decimals, the rest of the curriculum opens up.

When children ask whether decimals are hard, Dot always says the same thing:

\*"They are not hard. They are *fractions with denominator a power of ten*. The decimal point's *place* tells you which power of ten the denominator is. Tenths after the dot is *over ten*. Hundredths is *over one hundred*. Thousandths is *over one thousand*. Decimals are just a different way to write the same fractions you already know."\*

She still has her grandmother's calligraphy slate. She brings it to class sometimes. She points at letters. She says: "*My grandmother taught me about placement before I knew there was such a thing as a decimal point. The same idea. Different letters.*"

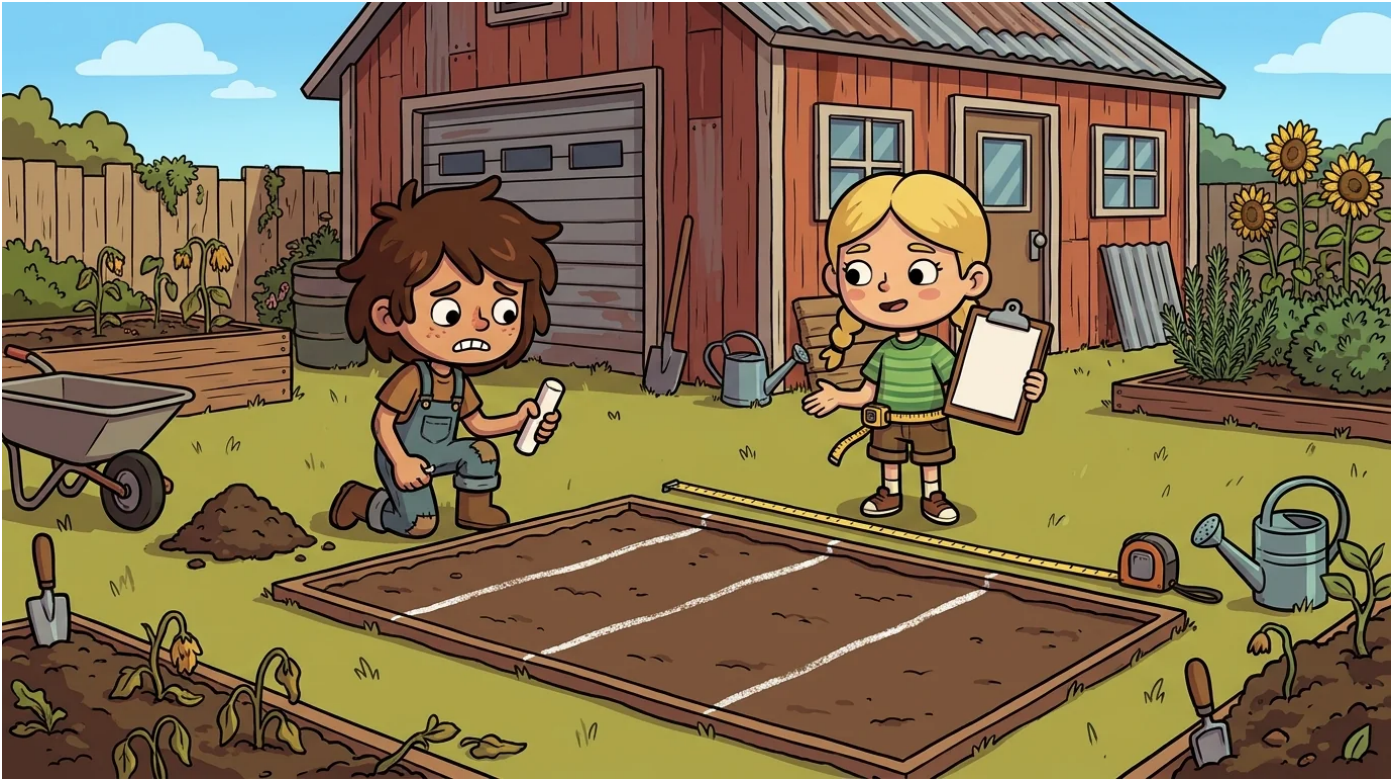
**Listen along + meet more of the cast at:**



<https://spark-and-anvil.com/cast/fractionforge/dot>

# Equi and Stretch

*EQUIVALENT SCALING — Equi (different forms, same value) + Stretch (scaling fractions to a common base) — together, the rule and the application of the same idea*



The school's garden plot was a long rectangle behind the workshop. It had been there for as long as anyone could remember. Most years, the kids just planted whatever they wanted in whatever spot, and most years, the carrots ended up in the rosemary patch and the rosemary ended up shaded out by the sunflowers. This year was different. This year, the gardening club had FOUR groups, and each group wanted EQUAL SPACE.

Equi had a stick of chalk and a worried look. Stretch had a tape measure and a calmer one.

"Four groups," Equi said. "One long rectangle. So we split it into four equal strips. Easy."

She drew four chalk lines across the dirt, dividing the plot into four equal vertical strips. Each group would get one strip. Strip A for the herbs group. Strip B for the salad-greens group. Strip C for the root-vegetables group. Strip D for the sunflowers group.

"Done," Equi said.

"Almost done," Stretch said.

Equi looked at her. "Did I miss something?"

"Look at the herbs group's list," Stretch said. She held up a clipboard. "They have THREE separate herb plots — basil, parsley, and mint. They can't share one strip; basil and mint hate each other. So they need THREE separate sub-strips inside their one strip."

Equi looked at the clipboard. "Oh."

"And the salad-greens group has SIX kinds of lettuce. Each kind needs its own row."

"Oh."

"And the root-vegetables group has TWO sub-plots — one for carrots, one for radishes."

"And the sunflowers?"

"One sub-plot. Just sunflowers."

Equi stared at the chalk lines. The herbs group needed thirds within their strip. The salad-greens group needed sixths within theirs. The root-vegetables group needed halves. The sunflowers group needed the whole strip. Four strips, four different ways of slicing. She had a feeling that this was going to require thinking.



Stretch crouched down by the chalk lines. "Here's what I'd start with," she said. "Each group has the same outside boundary. One-quarter of the whole plot, right? Their strip. So when we look INSIDE each strip, every group is slicing their own quarter into sub-portions."

"Right."

"Herbs group's strip is one-quarter of the plot. They need to slice their quarter into three equal sub-portions. Each sub-portion is one-third of their quarter. Which means each sub-portion is one-twelfth of the whole plot, because thirds-of-quarters is twelfths."

Equi blinked. "Did you just multiply?"

"I just multiplied. One-third times one-quarter equals one-twelfth. Same idea as your equivalence rule, but applied to a slicing problem."

"That's not multiplication, that's *scaling*. You took the herbs group's quarter and you stretched it down into a finer scale. The quarter became three twelfths."

"Yes," Stretch said. "That's what I do. I stretch fractions to a common scale so we can compare them across groups."

Equi thought about this. "So if I want to know how much space basil gets relative to one whole row of lettuce..."

"You stretch them both to the same scale. The basil takes one-twelfth of the plot. One row of lettuce takes one-sixth of the salad-greens strip, which is one-twenty-fourth of the whole plot. So basil and one row of lettuce, both on the same scale: one-twelfth versus one-twenty-fourth."

"Which means basil is twice as big as one row of lettuce."

"Right."

Equi was quiet for a long second. Then she said: "I have been teaching kids that  $\frac{2}{3}$  equals  $\frac{4}{6}$  for two years and I have never thought about it as *stretching* before. I have always thought about it as *naming the same number differently*. Like a kid having a nickname."

"Both are right," Stretch said. "Same idea seen from two angles. You see the equivalence. I see the scaling. Together we get the answer."



Equi picked up a fresh piece of chalk. "Okay," she said. "Let me try restating what you're saying so I'm sure I have it. We can't just give each group their strip and call it a day, because each group will slice their strip differently. So we need to scale every group's sub-portions to a COMMON scale, so we can see who has more space and who has less and whether everything still adds up."

"Right."

"And the common scale is — what? Twelfths? Twenty-fourths?"

Stretch took the chalk from Equi and drew a small grid in the dirt. "We need a common denominator. Something all four groups' sub-portions can be expressed in. Herbs needs thirds-of-the-strip. Salad-greens needs sixths-of-the-strip. Root-vegetables needs halves-of-the-strip. Sunflowers needs the whole strip — which is just one."

"Three, six, two, one," Equi said.

"What's the smallest number that all four of those divide into evenly?"

"Six."

"So if we slice each strip into sixths, then:"

She drew on the dirt:

- Herbs group's three sub-portions take up TWO sixths each.
- Salad-greens group's six sub-portions take up ONE sixth each.
- Root-vegetables group's two sub-portions take up THREE sixths each.
- Sunflowers group's one sub-portion takes up SIX sixths (the whole strip).

"Now everyone is on the same scale," Stretch said. "Sixths-of-a-strip."

Equi looked at the diagram in the dirt. "And this is what you mean by common denominator."

"Yes."

"And this is also what I mean by equivalent fractions. Every group's portion has been renamed in sixths."

"Yes."

"They are the same idea."

"They are the same idea."



Equi stood up and brushed the dirt off her knees. "All right," she said. "Let me also restate one more thing, because I want to be sure. The thing we just did is: we took four groups with four different ways of slicing, and we scaled them ALL to a common base — sixths — so we could plan the whole garden as one shared scale. Each group still slices their own strip however they like. But on PAPER, on this diagram, everything is in sixths."

"Right."

"So when the herbs group says 'basil gets one of our three sub-portions,' we can translate that to 'basil gets TWO sixths of the herbs strip.' And when the salad-greens group says 'arugula gets one of our six sub-portions,' we translate that to 'arugula gets ONE sixth of the salad-greens strip.' And both of those measures are now comparable, even though basil and arugula are in different strips."

"You just defined the whole point of common denominators in one sentence," Stretch said.

"I just *restated* the whole point of common denominators," Equi said. "And the only reason I could restate it is because you showed me what scaling looks like in dirt."

She smiled.

"My equivalence rule and your scaling rule are the same trick, told two different ways."

"And applied to garden plots, they let us share space fairly."



The garden club kids came out from the workshop and gathered around. Equi handed out copies of the diagram. Each group's strip was visible. Inside each strip, the sub-portions were drawn at the common scale. The herbs group could see their basil, parsley, and mint sub-portions. The salad-greens group could see their six lettuce rows. The root-vegetables group could see carrots and radishes. The sunflowers group could see the whole strip was theirs.

"How do we know it's fair?" one of the kids asked.

Equi pointed at the diagram. "Each group's outside boundary is exactly one-quarter of the plot. Same. And inside their strip, they get to slice however they need. We translated each group's slicing into the same scale — sixths-of-a-strip — so we could see them side by side."

Stretch nodded. "Which means when you're standing in the herbs strip and you see basil get two sixths of the strip, you know — without asking anyone — that two sixths of a quarter is exactly two-twenty-fourths of the whole garden. And that's a real, measurable, fair share."

The kid thought about this. "So even if basil and arugula are in different strips, I could tell you exactly how much bigger basil's plot is than arugula's plot."

"You could."

"Basil is twice as big."

"Right."

Equi smiled. Stretch smiled. The four chalk lines stretched across the dirt, holding a whole garden's worth of work.

"Equivalent forms," Equi said.

"Common scales," Stretch replied.

"The same trick."

"Told twice."

Listen along + meet more of the cast at:



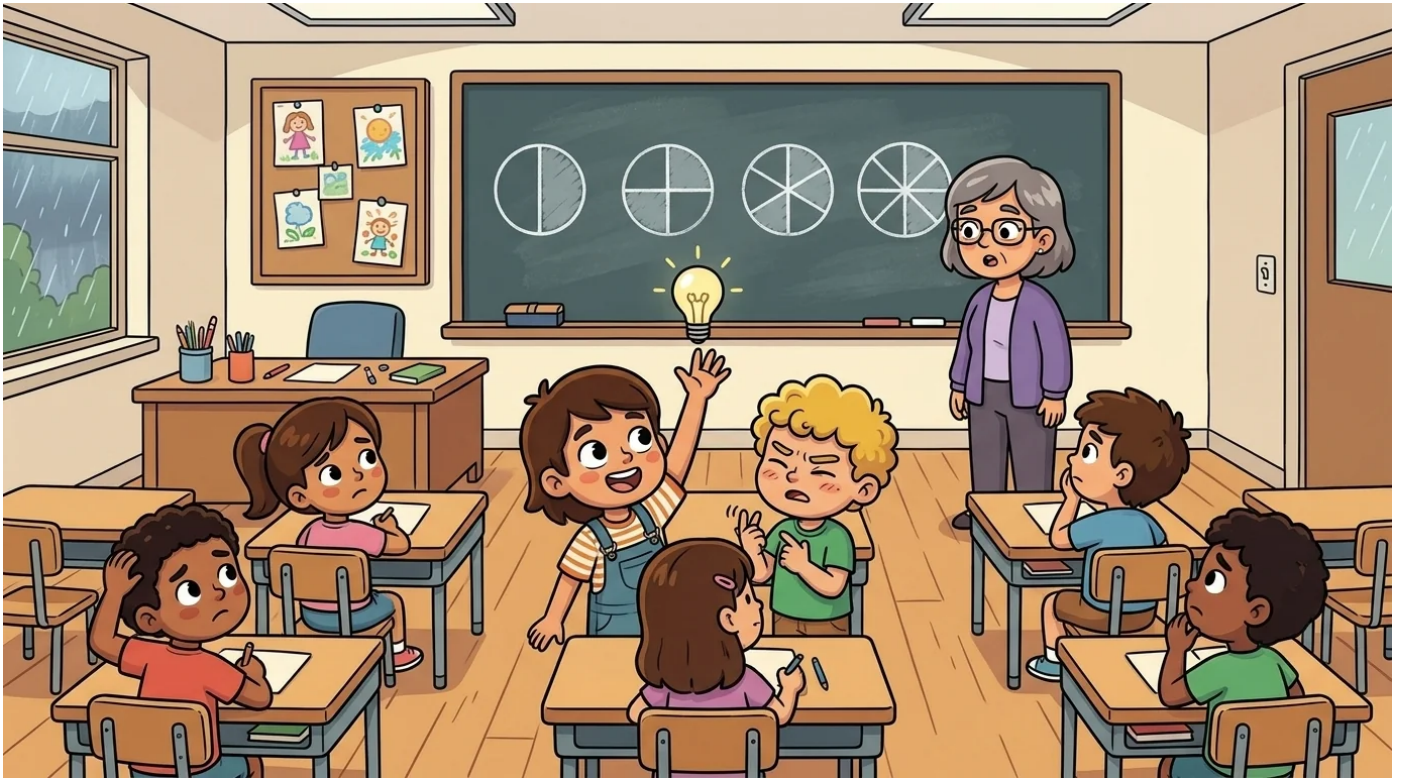
<https://spark-and-anvil.com/cast/fractionforge/equi-stretch>

# Equi

*EQUIVALENT FRACTIONS — different forms, same value. Multiply (or divide) numerator and denominator by the same number; the fraction is equivalent.  $\frac{2}{3} = \frac{4}{6} = \frac{6}{9} = \frac{8}{12}$ .*



- "1"
- "2"
- "3"
- "4"
- "5"
- "6"
- "8"
- "9"
- "10"
- "12"
- "1/2"
- "2/4"
- "3/6"
- "4/8"
- "5/10"
- "Lessons"
- "Student"



- "lessons"  
gate-allow-text-pattern: '^ [0-9]{1,2}\$ | ^ [0-9]+ / [0-9]+ \$'

## Chapter 3 — Equi and the Four Pairs of Twins

Growing up, my house was a total mirror maze. But the mirrors weren't made of glass. They were made of people. Everywhere I looked, I saw a copy of someone else. That's because I lived with three sets of identical twin sisters. And I was a twin, too. That made four pairs of us, all under one roof.

My parents definitely didn't plan it. It just... happened. Then it happened again. And again. Our family doctor would just shrug and grin. He called us "a statistical anomaly we will simply enjoy." My dad had a different name for it. He called us his "buy-one-get-one-free deal, times four."

Life at home was a beautiful, chaotic mess. It was loud and unbelievably crowded. Getting a turn in the bathroom was like winning the lottery. But the weirdest part was that everyone always had a partner.

Mom had a system for naming us. She wanted each pair of twins to sound like a team. The names had to be similar, but not exactly the same.

First came Forta and Forga, the oldest. They were eight years ahead of me and basically ran the house. Then came Vena and Verra, who were six years older and always whispering secrets. After them were Posi and Poso, four years older and masters of pranks.

Finally, there was us. Equa and me, Equi. I was born ninety seconds after her, which she never let me forget. We were the youngest. The fourth and final set of twins.



If you put a plate of fruit between us, she'd snatch the apple. I would always go for the pear. We were one pair of twins. But we were two different people. Same value, just with different names.

I didn't know that idea had a name. Not until I was nine years old.

One rainy Tuesday, my teacher, Mrs. Gable, turned to the chalkboard. She had a piece of chalk that screeched with every number. She wrote a long line that made my brain hurt.

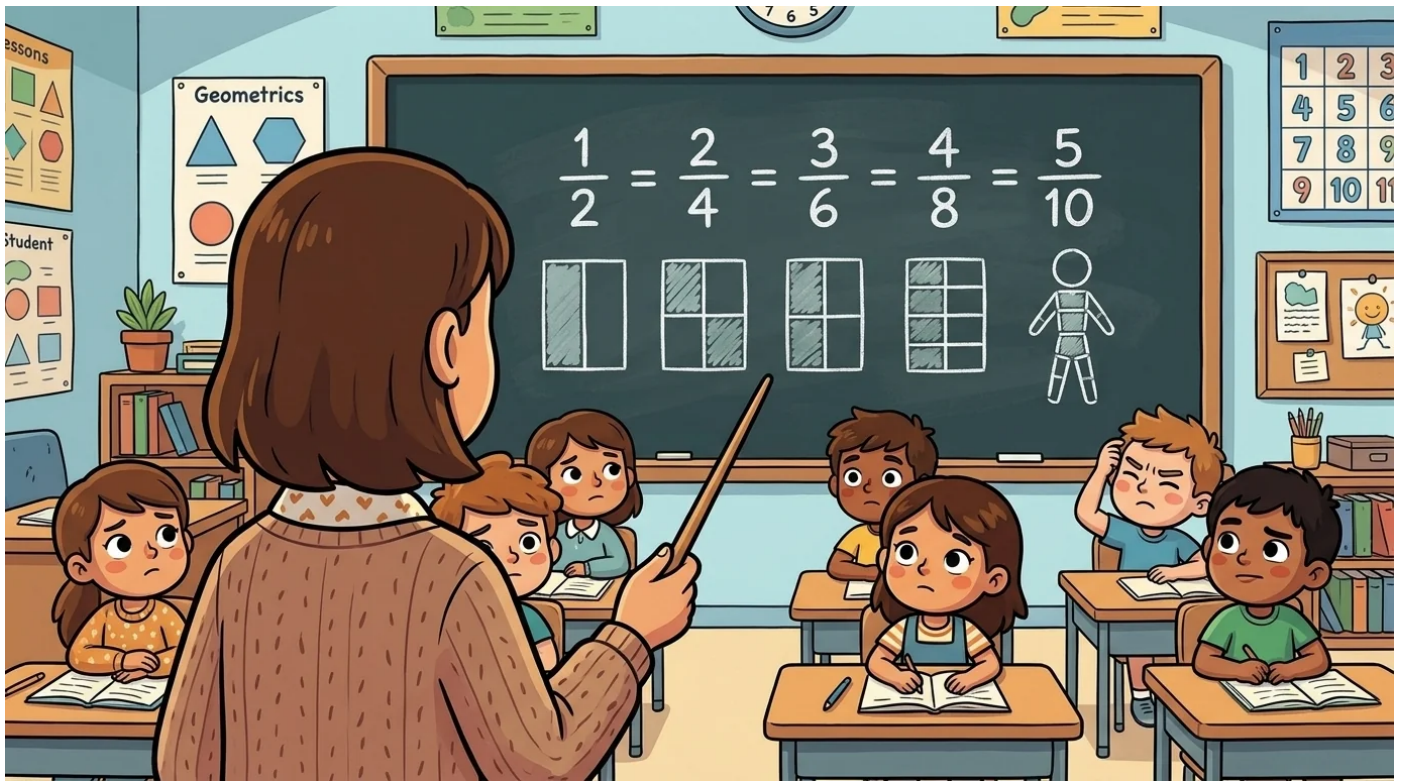
$$1/2 = 2/4 = 3/6 = 4/8$$

"These four fractions look different," she said, tapping the board. "But they are all the *same value*. They are **equivalent**."

A confused silence fell over the room. I could see kids squinting and tilting their heads like confused puppies. My friend Leo was counting on his fingers. It didn't make any sense. How could  $1/2$  be the same thing as  $4/8$ ? They were built from totally different numbers.

But I wasn't looking at the numbers on the board. I was picturing my sisters.

Forta and Forga. Vena and Verra. Posi and Poso. Equa and me.



Mrs. Gable looked surprised. My hand didn't usually shoot up during math. "Yes, Equi?"

"They're like my sisters," I blurted out.

She blinked. "Like your sisters?"

The whole class swiveled around to stare at me. I took a deep breath. "I have four sets of twins in my family," I explained. "Each pair has two different names, right? But the twin-pair itself is the same. They're... **equivalent**." I pointed at the board. "Fractions are just like that. The numbers on the top and bottom change, like the names change. But the *real amount* you have is still the same."

Mrs. Gable stared at me for a long moment. She had taught math for fifteen years. She had never heard anyone explain it that way before.

Then she nodded slowly. A huge smile spread across her face. "That is exactly right," she said. "**Equivalent fractions** are the same value. They just have different names. Just like your twins."

That night at dinner, I told everyone what happened. The table exploded with noise.

"So we're a math problem now?" Forta asked. She was seventeen and way too cool for everything. She nudged her twin, Forga. "I guess that makes us 1/2."



"And we're 3/6!" yelled Posi, who was thirteen.

Equa and I looked at each other and grinned. "We're 4/8!" we shouted together.

Mom turned from the stove, holding a wooden spoon. "You are *children*," she said, pointing the spoon at the eight of us. "You are not fractions. Now please set the table."

But the joke stuck. From that day on, we were the Fraction Family.

Years later, I went to the FractionForge academy to become a teacher. My sister Equa went to a different school to study music. We were still a matched pair. Still **equivalent**, but following our own paths.

Now, I'm the teacher. I stand at the front of the room. I write the same thing on the board that Mrs. Gable did.

$$1/2 = 2/4 = 3/6 = 4/8 = 5/10$$

"These all look different," I tell my class. "But they're all the same amount. How can that be?"

**Listen along + meet more of the cast at:**



<https://spark-and-anvil.com/cast/fractionforge/equi>

# Halver

*PARTITIONING* — splitting a whole into equal parts. Each part is named by how many such parts make up the whole; that count is the denominator.  $1/4$  means "one of four equal parts."



- "FAIRSHARE VILLAGE SCHOOL"
    - "SHAPES"
    - "1"
    - "2"
    - "3"
    - "4"
    - "5"
- gate-allow-text-pattern: '^[0-9]+/[0-9]+\$'

## Chapter 1 — Halver and the Pie at the Birthday Party



She tells her students this story on the first day of school. "My secret power," she says with a wink, "is that I used to be really greedy." The kids always giggle. But Halver is serious. "You have to understand a problem from the inside to really solve it."

Her real name was Posy, back then. The trouble started at her little brother's fourth birthday party. He was turning four. There were six kids crammed into their tiny cottage. Her brother, three of his loud friends, Posy, and her know-it-all older cousin.

And in the center of the table sat *one perfect cake*.

Her mother had baked it that morning. The whole cottage smelled like sugar and warm jam. Their village was called Fairshare, a place famous for two things. Amazing bakers and people who were good at solving arguments. The villagers said the two were connected. Posy's mom's cake was proof. It was perfectly round, with a secret layer of raspberry jam inside. A single sugar flower sat right on top. It wasn't just nice. It was a masterpiece.

Posy stared at the masterpiece. She saw a huge problem. That perfect cake had to be cut up. It had to be *divided*.



A fair piece was not what Posy wanted. Not at all. She wanted a *giant* piece. The biggest piece. She had been dreaming of this cake for two weeks. Of course, she didn't say this. She was seven, not a monster. You couldn't *say* you wanted the biggest slice at your own brother's party. But she thought it so loudly she was surprised the windows didn't rattle.

Her mother picked up the long cake knife. "Alright," she said, looking at the kids. "Six children. One cake. How should we cut it?"

Posy's cousin, who was eleven and knew everything, puffed out his chest. "Easy," he announced. "Cut it in half. Then cut each half into three smaller pieces. That makes six equal slices."

Her mother smiled. "Exactly right. Each piece will be one-sixth of the whole cake."

She traced a line down the middle with the back of the knife. The cake was now in two halves. Then, in each half, she drew two more lines. Suddenly, six perfect wedges appeared. The lines looked like a star drawn inside a circle.



Posy got her slice. She examined it from all angles. It was, she had to admit, totally fair. Every other kid had a slice that looked just like hers. No one could complain. No one got cheated. It was annoyingly perfect.

She ate her piece. It was delicious. The jam was sweet and tangy. It was, she calculated, exactly one-sixth as good as eating the entire cake herself. But it was still pretty good. She licked her fork clean and watched the empty plate go back to the kitchen.

But the idea of those six equal slices stuck in her head.

Over the next few years, the memory of that cake kept popping up. She started to realize something. Fairness was a kind of math. To share something fairly, you had to *partition* it. That was a fancy word for cutting it into equal parts. The number of parts gave each piece its name. Cut something in two parts? They were called *halves*. Three parts? *Thirds*. Six parts? *Sixths*.

This was the big secret of fractions. **The denominator — that's the bottom number in a fraction — is just a count of how many equal pieces you cut the whole thing into.**

The idea finally clicked into place when she was twelve. Her cousin was home from school and left his slate on the table. On it was written:  $1/4$ . Underneath, he'd scribbled: "*one-quarter — one of four equal parts.*"



It was an amazing discovery. Fractions were just the language of sharing. The bottom number counts the total slices. The top number counts how many slices you have. Simple.

Right then, she decided what she wanted to do. She was going to teach this to everyone.

Her cousin had started calling her "Halver" as a joke. The name stuck. She liked it better than Posy anyway. She studied fractions at a special academy. When she finished, they asked her to stay and teach. She's been teaching kids about partitioning ever since.

Now, every year on the first day of school, she does the same thing. She brings in a small, plain cake from the village bakery. Her little brother runs it now. She places the cake on her desk. "Alright," she says to her new students. "There are twenty of you. How do we share this one cake fairly?"

And every year, the kids shout the same answer. "Cut it into twenty pieces!"

Halver nods and smiles. She carefully cuts the cake into twenty tiny, perfect wedges. Each student gets one piece. Each of them has eaten *one-twentieth* of the cake.

**Listen along + meet more of the cast at:**



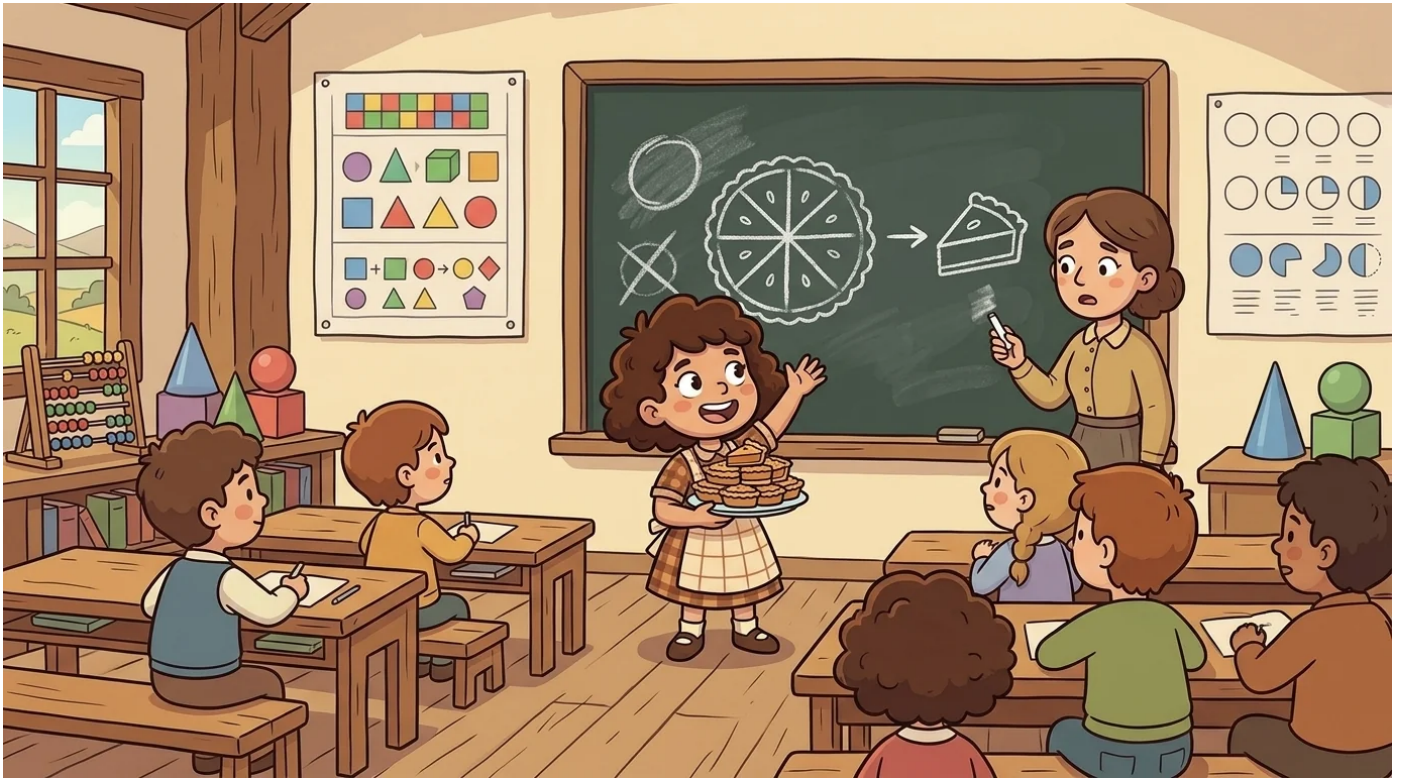
<https://spark-and-anvil.com/cast/fractionforge/halver>

# Pie

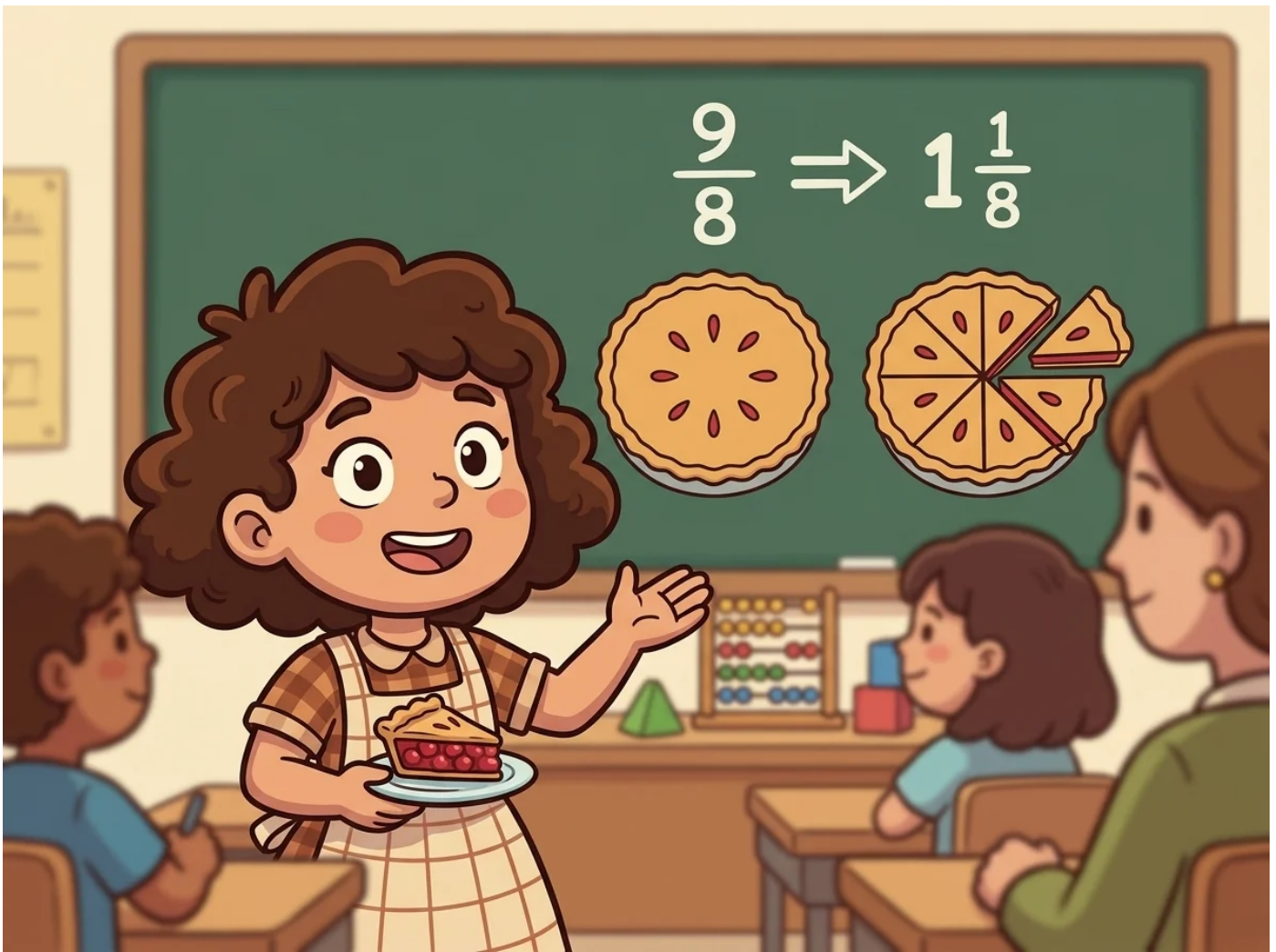
WHOLE AND PARTS — mixed numbers, improper fractions, the whole-as-pie anchor.  $9/8$  is one whole pie plus one extra slice;  $1$  and  $1/8$  is the same quantity expressed differently.



- "CRUSTFORD"
  - "CRUSTFOOD"
  - "Co."
  - "THE SLICE IS THE UNIT."
  - "THE PIE IS THE WHOLE."
  - " $1/8$ "
  - " $9/8$ "
  - "1"
  - "a"
  - "CRUSTFOO"
  - "CRUSTFORDS"
  - "Crustford"
  - "Crustford and Co."



- "and"
    - "THE"
    - "SLICE"
    - "IS"
    - "UNIT."
    - "UNIT"
    - "PIE"
    - "Pie"
    - "Slice"
    - "Unit"
    - "The"
- gate-allow-text-pattern: "[A-Za-z0-9/./]+"



Pie grew up in a *pie-shop*.

The pie-shop — *Crustford and Co.*, on the main street of the town of *Crustford* — had been in her family for *five generations*. Her great-great-grandfather had founded it. Her great-grandfather had standardized the pie-sizes. Her grandfather had added the savory line. Her grandmother had added the breakfast pies. Her parents — who still ran the shop when Pie left for the academy — had added the slice-by-slice retail counter so customers could buy individual slices without having to order whole pies.

The shop was, by Crustford's standards, *famous*. Travellers came from three towns over to buy its pies. The shop's slogan, painted in large gold letters above the front window, was:

*"THE SLICE IS THE UNIT. THE PIE IS THE WHOLE."*

This slogan was, Pie eventually realized, *the foundation of her future career*.

Crustford pies had been standardized since her great-grandfather's generation. *Every Crustford pie was twelve inches across*. Every Crustford pie was *cut into eight slices*. Every slice was *exactly the same size*. This had been an aggressive standardization in its time — most village pie-makers had cut their pies in whatever sizes the customer wanted, with no fixed ratio — but Crustford's great-grandfather had decided that *consistency was good for the customer*. The customer always knew what a Crustford slice was. The customer could always compare prices. The customer could always know, *exactly*, how much pie they had paid for.



Pie — whose given name was *Tess*, though everyone called her Pie from the time she was two and a half — grew up with the slice-and-pie ratio as a *foundational fact of her life*.

By the time she was four, she could answer questions like: "If you have three slices and your brother has four slices, how many slices total?" (Seven.) "How much of a whole pie is that?" (Seven-eighths.) "And if your sister brings two more slices to the table?" (That makes nine slices, which is *one whole pie plus one extra slice — one and one-eighth pies*.)

She did this in her head, all day, every day, throughout her childhood. It was not, to her, *arithmetic*. It was *just how pies worked*.

When she was eleven, she walked into the village school for the first time. (Her parents had homeschooled her until then; she had been working in the shop.) The schoolteacher introduced *fractions* to the class. She drew a pie on the board. She said: "A pie cut into eight pieces. Each piece is one-eighth. If you eat three pieces, you have eaten three-eighths."

Pie raised her hand. She said: "What if you eat nine pieces?"

The schoolteacher said: "You would have eaten more than the whole pie."

Pie said: \*"Yes. You would have eaten *one and one-eighth* pies. The first eight pieces are a whole pie. The ninth piece is one-eighth of another pie."\*



The schoolteacher said: "That is correct. We call that a *mixed number*. The 1 is the whole-pies-count. The  $\frac{1}{8}$  is the extra-slice-fraction."

Pie said: "You can also write it as *nine-eighths*. The 9 is the total slices. The 8 is the slices-per-pie.  $\frac{9}{8}$  is the same as *1 and  $\frac{1}{8}$* . They are the same quantity. Just written differently."

The schoolteacher stared at her.

The schoolteacher said: "How do you know that?"

Pie said: "We sell pies."

The schoolteacher, after a long pause, said: "That is called an *improper fraction*. The numerator is larger than the denominator. It can always be converted to a mixed number. And the mixed number can always be converted back. They are equivalent."

Pie nodded. She had not known the names. She had been doing the operation, in her head, since she was four.

That afternoon, the schoolteacher walked to Crustford and Co. and bought a single slice. She asked Pie's mother: "Has anyone in your family ever taught fractions formally?"

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# Stretch

*COMMON DENOMINATORS — scaling fractions to a common base for comparison and addition. To add  $1/3 + 1/4$ , scale both to  $1/12$ . The common denominator makes the fractions directly addable.*



Stretch was, before he was a teacher, *a glass-blower's apprentice.*

Stretch learned his craft in a workshop. It was in Anneal, a town by the sea. Anneal was on the kingdom's southern coast. An old master named Forge ran the shop. Forge was a perfect name for him. He worked with fire and metal. The other workers always joked about it. Forge had heard the joke for forty years. He stopped laughing after three years. But he let them keep joking. The workshop made glass tubes. They made tubes for labs. They made tubes for magic-makers. They made pretty glass decorations. But their best work was medicine vials. These vials had to be perfect. They needed the exact same width all over.

The medicine-vial work was the workshop's bread and butter.

Healers needed special glass vials. They came in exact sizes. Like half a thumb wide. Or one thumb wide. Or even two thumbs wide. Each vial had to be exactly the same size. A vial with a wobbly width was no good. You couldn't measure the medicine right. The cork wouldn't fit tight. The stuff inside would get all mixed up. Healers paid top money for perfect vials. They had to be the same width. Everywhere, down to a tiny hair.



Forge's workshop made the best vials in three provinces. The secret was *the stretching*.

Stretch's real name was Hadrian. But everyone called him Stretch. They started calling him that when he was sixteen. He began working for Forge at age twelve. His first year was spent sweeping the workshop. His second year was spent feeding the furnace. His third year, finally, was spent at the *marble slab*.

The marble slab was the centerpiece of the workshop. It was a long, flat piece of marble. It was shiny and smooth. About six feet long. And two feet wide. It sat on a strong iron stand. The slab was used for *stretching molten glass*. A worker grabbed hot, gooey glass. It came right from the furnace. They put it on a long metal stick. Then they rolled it. Back and forth on the marble slab. They rolled it slowly. They rolled it very carefully. They kept rolling until all the glass was the same width.

This was the operation Stretch eventually understood as *finding a common denominator*.

The hot glass, when it left the furnace, was *not uniform*. It was *thick in some places and thin in others*. Think of it like fractions. Fractions with different bottom numbers. You can't really compare them yet. Not until they are on the same scale. To make the glass into a usable tube, you had to *roll it*. The rolling forced *every part of the glass to the same diameter*. Once every part was the same diameter, the tube was *uniform*. You could cut it into vials. Each vial was the same width as every other.



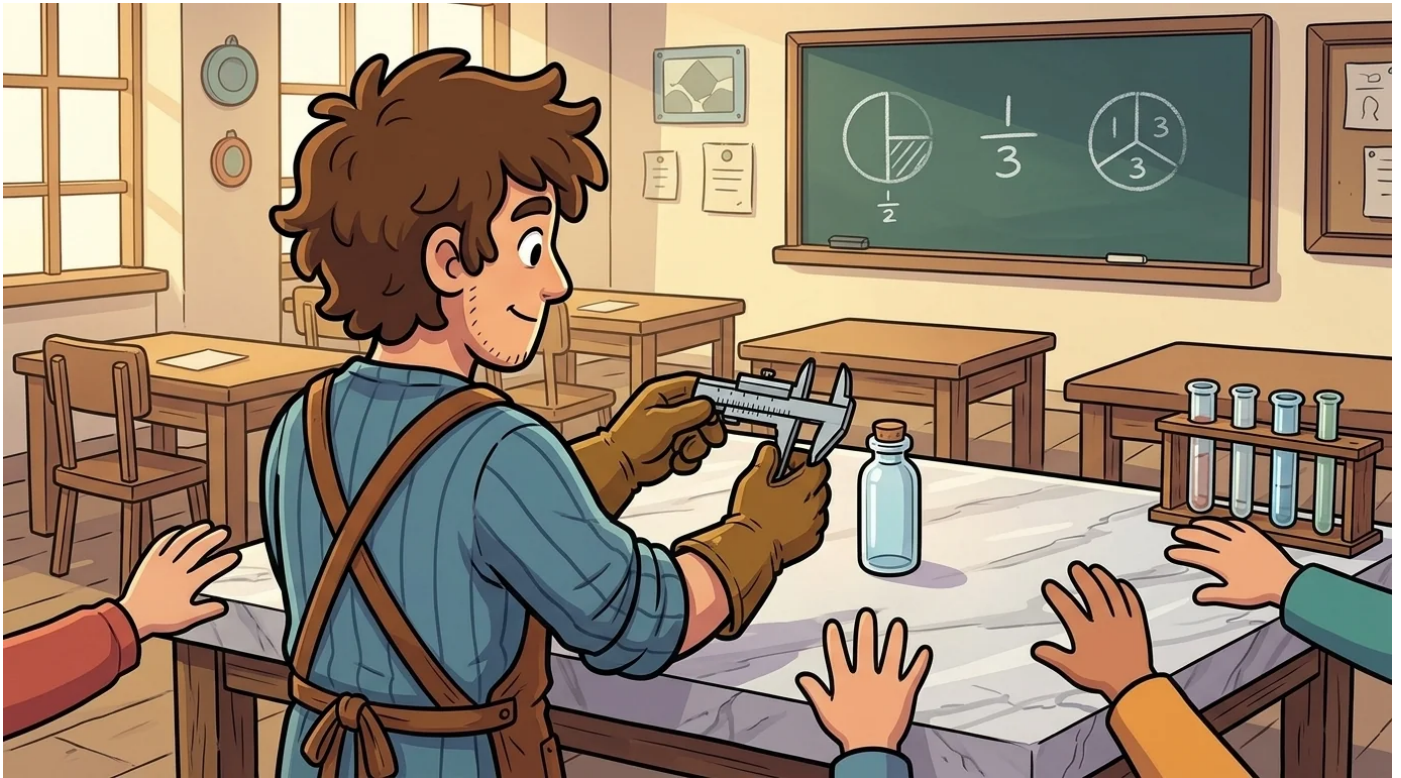
Stretch learned this, slowly, over years. By age eighteen, he was a master. He could roll a six-foot tube. It would be one thumb wide. And perfect everywhere. Not even a hair's difference. He was, by workshop standards, *very good*.

He stayed at the workshop until he was twenty-six. His father died when Stretch was twenty-six. Stretch got his father's small farm. He left the workshop to run it. He stayed on the farm for two years. He hated it. He was not good with sheep. And it was a sheep farm. He sold the farm. He returned to Anneal.

But Forge had retired. The workshop had a new master. That master did not need an old apprentice. Stretch was twenty-eight now. He didn't know what to do next. He sat on the harbor wall. He just thought and thought.

What he thought, eventually, was that *the rolling-the-glass-to-uniform-diameter operation was an arithmetic operation*. He had spent his apprenticeship doing it physically. But this was the same idea. Bring all the parts to a common scale. That's what you do with fractions. When they have different bottom numbers. You need to make them the same. Then you can add or compare them.

The connection was clear, once he saw it.



He went to the FractionForge academy. He told the academy master what he had been thinking. The master listened carefully. Then he said, "You are right!" "Making fractions have the same bottom number..." "...is just like making glass the same width." "We need teachers who can show this." "Will you teach for us?"

Stretch said yes.

That was twelve years ago. He has been teaching **common denominators** ever since.

In his classroom, he begins every first-day lesson the same way. He brings something from Anneal. He visits there twice a year. The new workshop owner helps him. He gives Stretch a special glass tube. It's a small piece of stretched glass. He places it on the desk. He holds up a small caliper. He measures the tube at one end, in the middle, and at the other end. He says, "This tube is one thumb wide." "It's the same width everywhere." "A glass-blower rolled the hot glass." "They used a marble slab." "The rolling made every part the same width." The rolling brought every part to a **common diameter**.

The children — always — examine the tube.



Then he writes on the board:  $1/3 + 1/4$ . He says, "These fractions have different bottom numbers." "Three and four." "We can't add them like this." "We need a **common denominator**." "The smallest one is twelve." "One-third becomes four-twelfths." "One-fourth becomes three-twelfths." "Now we can add them:  $4/12 + 3/12 = 7/12$ ." "They have been **stretched to a common scale**."

The children — always — see it. The connection between the glass-tube and the fraction-arithmetic clicks.

When children ask whether common denominators are hard, Stretch always says the same thing:

"They are not hard. They are *stretching*. You roll the fractions out to a common base. Once they share a base, you can add them, subtract them, compare them. It is the same operation as rolling glass on a marble slab. Bring everything to a uniform scale."

He still has the small caliper. The children sometimes ask to measure the tube. He always lets them.

He sometimes adds, "If you visit Anneal..." "...the workshop still rolls glass there." "It's on a marble slab." "That idea is older than me!"

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# About Spark & Anvil

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- **SynaForge** — sensory-affirming creative tools through Lull, Soften, and the Quiet that is Also Creating

## Methodology

Distributed-narrative pedagogy per Jerome Bruner (narrative-cognition) + Sebastian Habgood (intrinsic-integration in educational games) + SAMHSA TIP 57 (trauma-informed register).

Trauma-informed-design framework per Eggleston et al. (2025) and Stoltenburg et al. (2024).

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