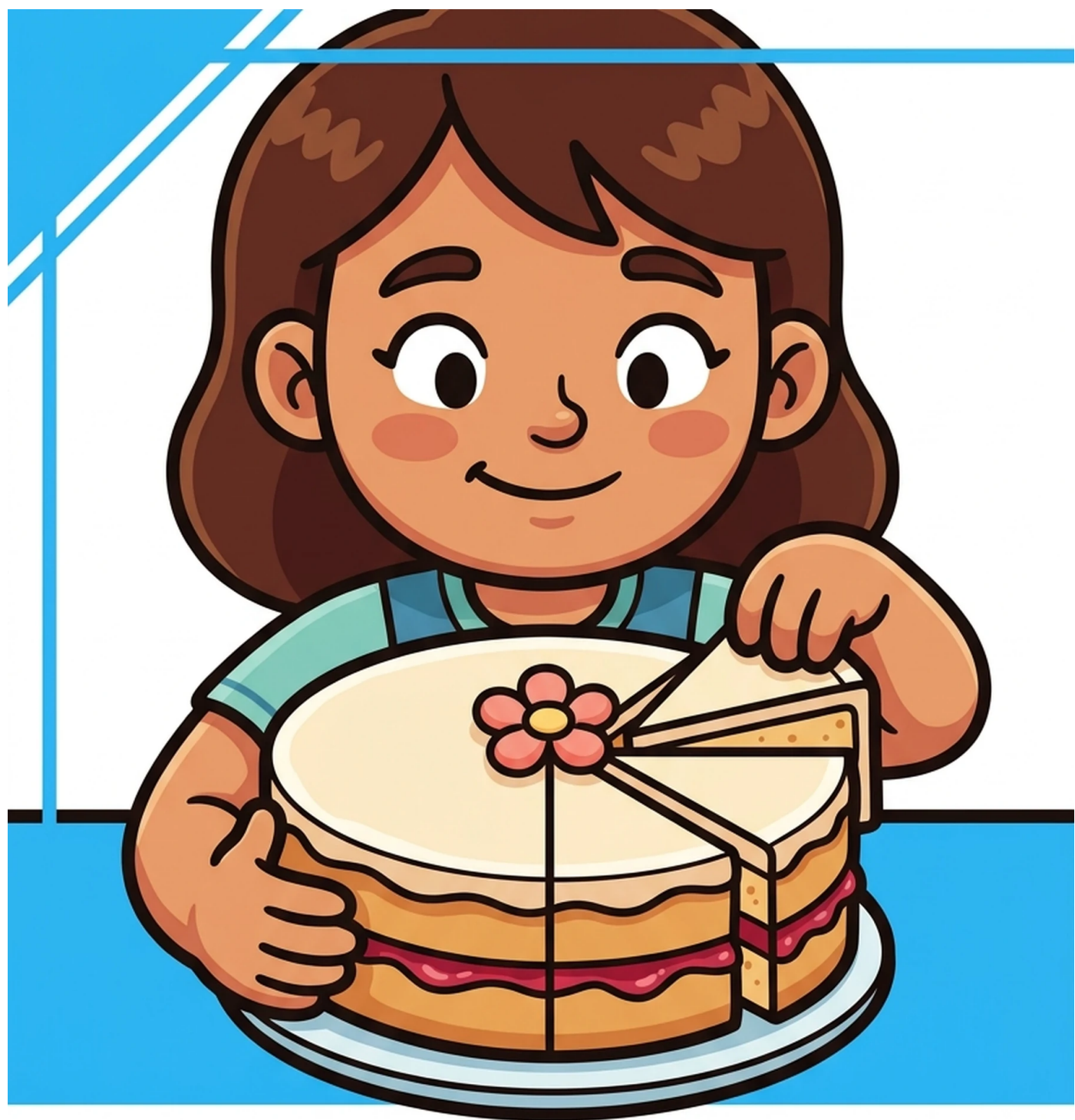




FractionForge

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: story-based learning, where the characters embody the ideas being taught, with a trauma-informed, emotionally-safe approach.

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This is Volume 1 of 2 of the *FractionForge* — *Meet the Cast* series; each volume is a complete standalone book you can read on its own.

For everyone who learns by hearing a story first.

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Introduction

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*

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. $\frac{1}{4}$ means "one of four equal parts."



Halver the teacher was famous for being fair. But when she was a kid, she was famous for something else. She was *terrible* at sharing. Absolutely awful.

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*.

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. Perfectly round. A secret layer of raspberry jam inside. A single sugar flower 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*.

Six hungry kids. One cake.

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. Two halves. Then, in each half, two more lines. Suddenly, six perfect wedges appeared — like a star drawn inside a circle.

Her mom carefully cut along the lines. Six identical pieces of cake sat on the platter. Every single piece was the exact same size. Each wedge was one-sixth of the whole.

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. 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. The other kids were already running outside to play. Nobody was arguing. Nobody was sad. The cake was gone, and somehow — somehow — everybody had ended up with the same thing.

Posy sat at the table for an extra minute, just thinking. She didn't have a word for what she was feeling yet. But it was warm, and it was quiet, and it was something like *settled*.

The idea of those six equal slices stuck in her head for 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 — a fancy word for cutting it into equal parts. The number of parts gave each piece its name. Cut something in two parts? *Halves*. Three parts? *Thirds*. Six parts? *Sixths*.

This was the big secret of fractions. **The denominator — the bottom number — 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 had left his slate on the table, and on it was written: $\frac{1}{4}$. Underneath, scribbled: "*one-quarter — one of four equal parts.*"

Posy stared at the chalk marks. She thought of her brother's birthday cake. Six pieces. Each kid got one-sixth. *One of six equal parts*. The fraction $\frac{1}{6}$ wasn't some scary math code. It was just the name for a slice of cake.

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.



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. She cuts the cake into twenty tiny, perfect wedges. Each student gets one. Each of them has eaten *one-twentieth* of the cake.

"This is partitioning," Halver tells them as they eat. "The whole cake was cut into twenty equal parts. So each piece is called one-twentieth. The 20 on the bottom just tells us how many pieces we made. The 1 on top tells us you each got one. Fractions are just the language of sharing."

Whenever a student asks if fractions are hard, Halver gives the same answer.

"They aren't hard. They're just fair. Cut something into equal parts. Count how many parts. That number is the denominator. That's the whole secret."



She still brings that cake every year. The children always eat it all. Halver never takes a piece. She just watches them.

And every year, when the last fork is set down and the room gets quiet for a second, she feels it again — that warm, settled feeling she felt at seven years old, sitting at the table after her brother's party. The feeling that said *something just got handled the right way*.

She thinks she finally has a word for it now. *Fairness*.

Not the kind of fairness you draw on a chalkboard. Not $1 \text{ over } 20$. The kind you can feel in your chest, when you look around and see that everyone got an equal slice and nobody had to fight for it.

That's the real secret she keeps coming back for. The denominator is a count. But fairness — fairness is something you *feel*.

That's what the math is really for.

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

Pie

WHOLES 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.



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 had added the slice-by-slice retail counter so customers could buy single slices without ordering whole pies.

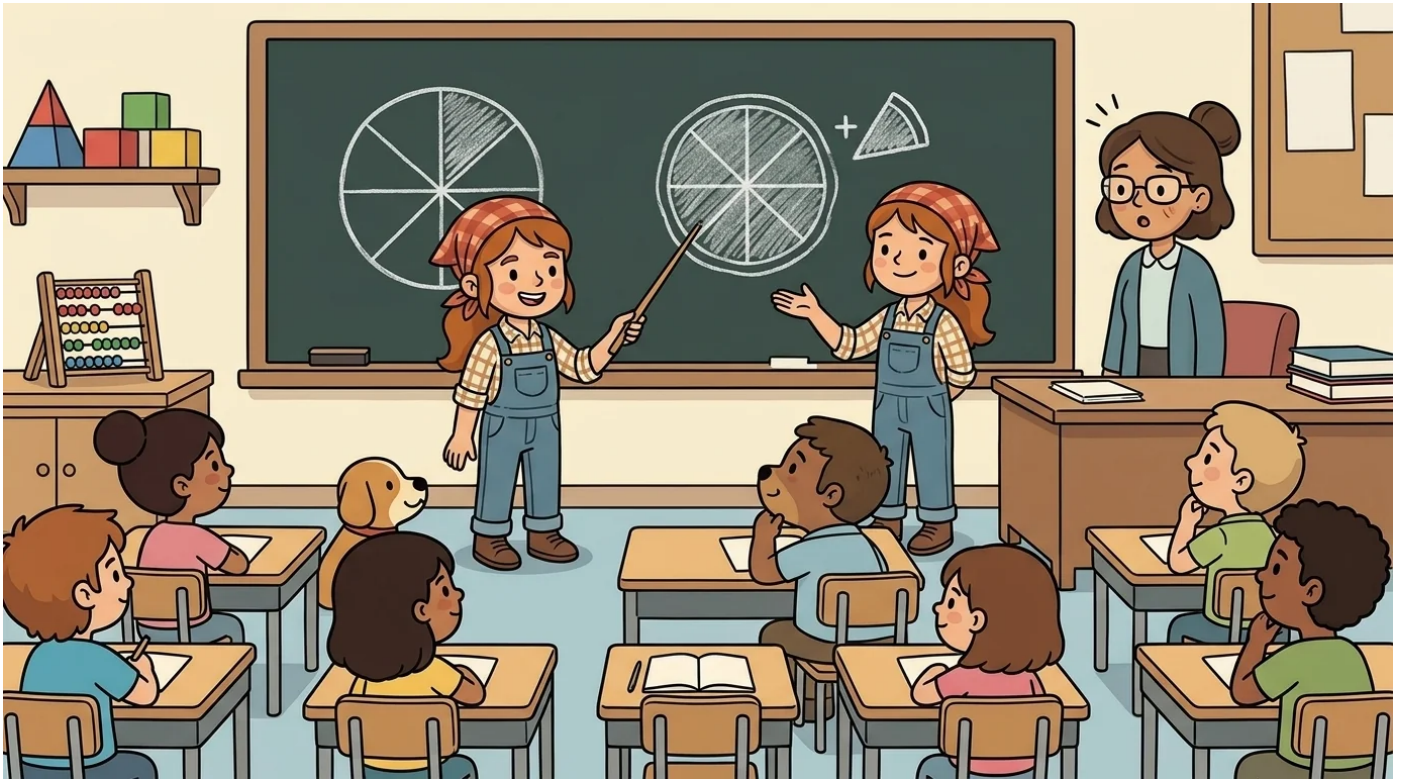
The shop was, by Crustford's standards, *famous*. Travellers came from three towns over to buy its pies. The slogan, painted in large gold letters above the front window, was:

"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 day. *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 cut whatever sizes the customer wanted — 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 — 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 blinked. "That is correct. We call that a *mixed number*."

Pie said: "You can also write it as *nine-eighths*. The 9 is the total slices. The 8 is the slices-per-pie. $9/8$ is the same as 1 and $1/8$. 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?"*

Pie's mother said: *"No. We just sell pies."*

The schoolteacher said: *"Your daughter is a natural teacher of fractions. The slice-and-pie ratio in this shop has done her education."*

Pie's mother said, after thinking: *"She does spend a lot of time computing slice-counts."*

The schoolteacher said: *"If she ever wants to teach formally, she has a place at the FractionForge academy. Tell her."*

Pie's mother told her that evening. Pie thought about it for two years. She loved the pie-shop. She did not, at the time, want to leave. But by the time she was fourteen, she had begun to feel that *the slice-and-pie ratio belonged to more than just the shop*. It was, in a small way, a *piece of mathematics that her family had been quietly preserving*. It deserved a wider audience.

She joined the academy when she was fifteen. Her younger sister inherited her position behind the slice-counter. Pie studied for three years. She joined the faculty when she was eighteen. She has been teaching wholes-and-parts ever since.



In her classroom, she begins every first-day lesson the same way. She brings, from the shop (now run by her cousin), *one whole twelve-inch savory pie*. (A new one every year. The cousin sends them gladly. The cousin says the academy children appreciate the slices more than the regular customers do.) She places the pie on her desk. She turns to the class. She says: "*This is one pie. It has eight slices. Each slice is one-eighth of the whole pie.*"

The children — always — agree.

Then she says: *"If I give you one slice, you have one-eighth. If I give you three slices, you have three-eighths. If I give you eight slices, you have a whole pie. If I give you nine slices, you have one whole pie plus one extra slice. That is a mixed number: 1 and 1/8. It is also an improper fraction: 9/8. Same nine slices. Different name."*

She cuts the pie. The children eat the slices. The children understand mixed numbers and improper fractions before they have finished chewing.

When a child asks whether mixed numbers are hard, Pie always says the same thing:

"They are not hard. They are just more than a whole. When the numerator gets bigger than the denominator, you can count how many wholes you have plus how many extra slices. Same quantity. Different way of writing it."

She still has the slogan painted above her classroom door. *"THE SLICE IS THE UNIT. THE PIE IS THE WHOLE."* She points at it whenever a child looks confused.



After the last class of the day, when the slices are eaten and the children have gone home, Pie always stays behind for a few minutes. She washes the pie tin. She wipes the desk. She folds the box the cousin's pie came in.

The box has the same gold lettering as the shop window. *Crustford and Co.* Same slogan. Same slice ratio her great-great-grandfather decided on six generations ago. Pie looks at the empty tin and thinks, sometimes, about her four-year-old self counting slices on the shop counter while her mother served customers. That child did not know she was learning mathematics. She thought she was learning *how the family did business*. It turned out to be the same thing.

That is the part Pie wants her students to feel, more than anything she puts on the board. *Math is not a separate thing*. It is built into the way ordinary people, in ordinary towns, have always counted what they had. A pie is a whole. A slice is a part. Five generations of pie-makers can pass that down quietly, until somebody notices, and gives it a name, and writes it in books.

The naming is nice. The naming gives the kids vocabulary. But the *feeling* — that warm, ordinary recognition that *I have always known this; I just didn't know that anyone else had a word for it* — that is the lesson Pie hopes they carry. It feels, in her chest, like the moment of stepping off the boat after a long crossing and realizing the new shore is familiar. *Oh*, the feeling says. *I have lived this. It is mine.*

She turns off the lamp. She walks home. The shop, six streets away, is still open. The cousin will be there until eight. There will be one slice left, by then, set aside for Pie's dinner. There always is.

Read it? Now hear Pie's audio drama + go play — scan or visit:



<https://spark-and-anvil.org/cast/fractionforge/pie>

Equi

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



Growing up, my house was a 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 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 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 naming system. She wanted each pair to sound like a team. The names had to be similar, but not the same.

First came Forta and Forga, the oldest. They were eight years ahead of me. Then came Vena and Verra, who were six years older and always whispering secrets. After them, 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.

My twin, Equa, was my living, breathing mirror. We had the same messy brown hair that refused to lie flat. Same crooked smile, especially when we were about to cause trouble. We practiced signing our names until they looked identical. But we weren't exactly the same person.

If you put a plate of fruit between us, she'd snatch the apple. I'd always go for the pear.

We were one pair of twins. But we were two different people. *Same value. Different names.*

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



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

$$\frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{4}{8}$$

"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 puppies. My friend Leo was counting on his fingers. It didn't make any sense. How could $\frac{1}{2}$ be the same thing as $\frac{4}{8}$? 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.

Suddenly, it clicked. My hand shot into the air.

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 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.

"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 $1/2$."

"We're $2/4$!" shouted Vena, who was fifteen.

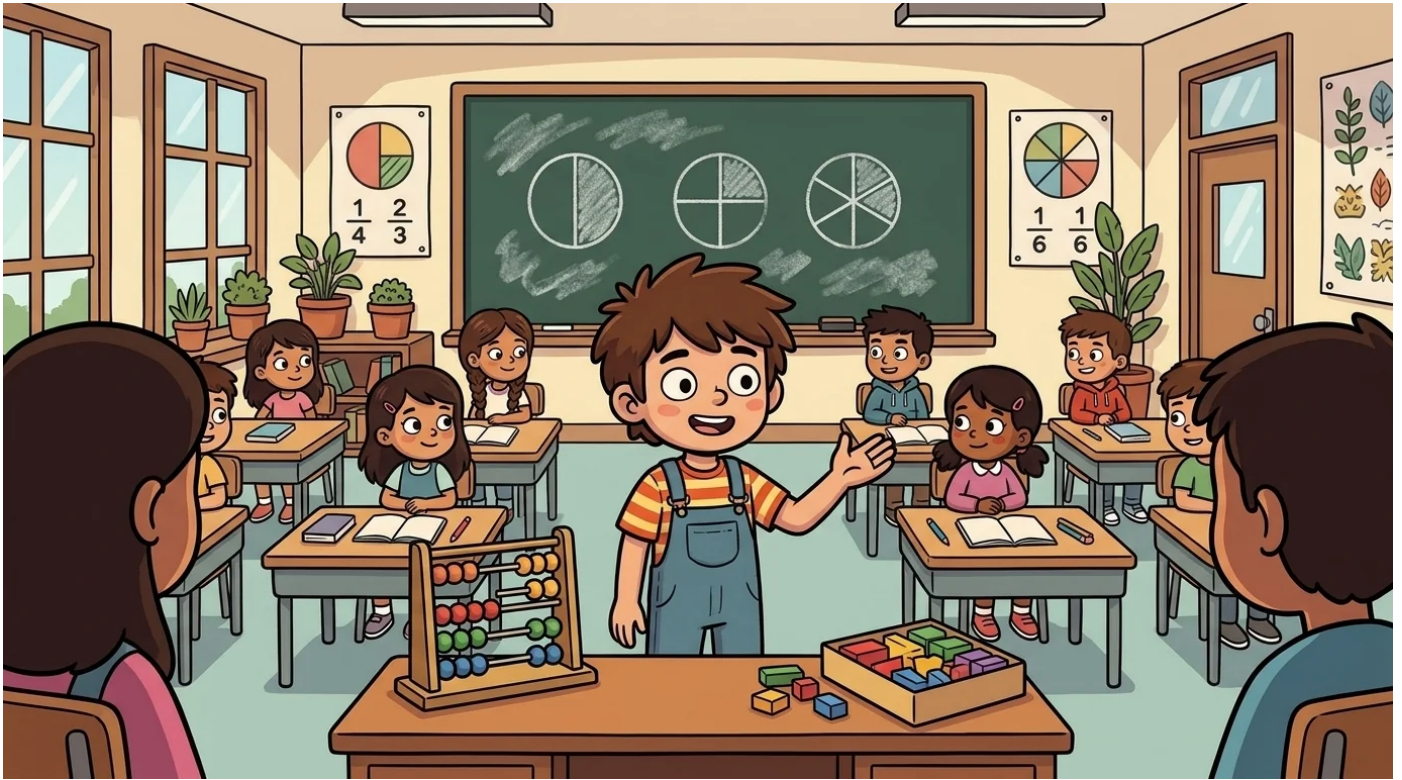
"And we're $3/6$!" yelled Posi, who was thirteen.

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. She'd practice her violin late into the night. I'd be at my desk drawing pie-slice diagrams. The fractions were different now. The amount underneath was still the same.



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.

$$\frac{1}{2} = \frac{2}{4} = \frac{3}{6} = \frac{4}{8} = \frac{5}{10}$$

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

I see them squinting, just like my class did. Then I tell them about my family. I tell them about the house with four sets of twins.

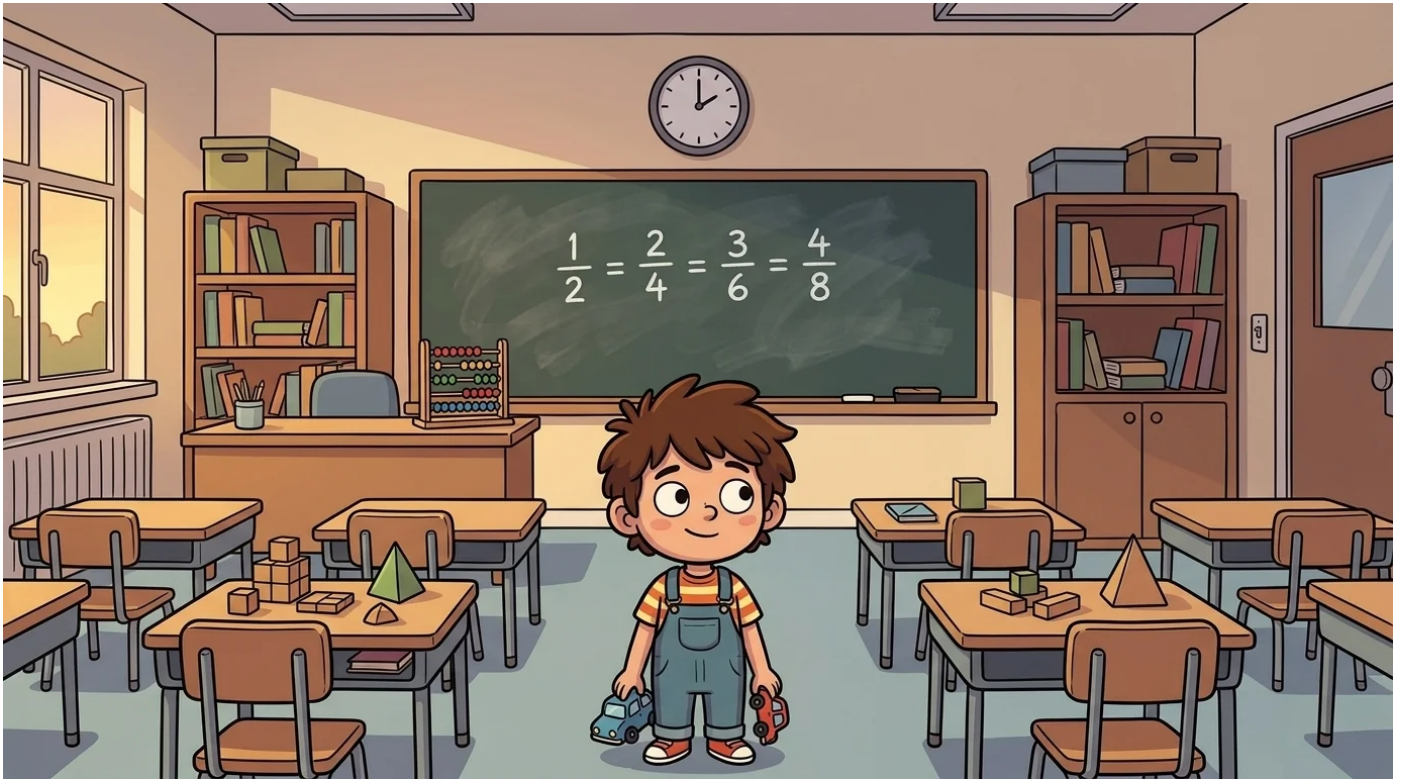
"Fractions can be like that," I say. "They can have different names, like $\frac{2}{4}$ or $\frac{4}{8}$. But underneath, they are really the same amount. They are **equivalent**."

Sooner or later, a hand goes up. "So how do you make one?" a student will ask.

"Easy," I say. "You give it a new name. Pick a number. Any number except zero. Now multiply the top *and* the bottom of your fraction by that same number. Your fraction looks different. But it's still the same amount underneath. It's **equivalent**."

I see them scribbling. They multiply $\frac{2}{3}$ by $\frac{2}{2}$ and get $\frac{4}{6}$. Then they reach for their calculators to check. A little gasp goes through the room. The decimals are exactly the same. It really works.

The gasp is my favourite part. It's the same sound I made, at nine years old, sitting in Mrs. Gable's classroom while I thought about my sisters.



The best day of the year is when my sisters visit my class. All seven of them troop into the room. The kids' jaws practically hit their desks. They see Forta and Forga, who look like grown-up versions of each other. They see Vena and Verra, who still finish each other's sentences. They see Posi and Poso, who immediately start a thumb war in the back. And they see Equa, standing right beside me, with her crooked smile that's just like mine.

That's when they really get it. Not the definition — the *feeling*. The recognition. They look at the four pairs in front of them and something settles in their faces. Two different names. Same person inside. Two different fractions. Same amount underneath.

I love that look. It's the look I felt on my own face when I was nine.

After the lesson, when my sisters have left and the kids have gone home, I stay behind for a minute. I look at the four-pair line still on the board. $1/2 = 2/4 = 3/6 = 4/8$. Equa's already texting me from the train — *did they like us? did you cry? — you cry every year, you know*.

I read her message and smile.

Equivalence, I think, is not really about numbers. It's about that warm, quiet feeling you get when something looks completely different on the outside and *yet you know, with your whole self, that it is the same thing underneath*. You can teach the rule. You can show the math. But the rule lands when the *recognition* lands — when a kid looks at two different-looking things and finally feels, in the soft place behind the ribs, *those are the same*.

That feeling is the lesson. The numbers are just how I learned to point at it.

I close my notebook. I turn off the lights. And I head home to text my twin back.

Read it? Now hear Equi's audio drama + go play — scan or visit:



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

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



- prompt: "Have you ever felt sure you were done with a problem, only to notice there was more to it? What did that feeling turn into once a friend worked it through with you?"

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?"



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 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."



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.



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.

Read it? Now hear Equi and Stretch's audio drama + go play — scan or visit:



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

Stretch

COMMON DENOMINATORS — scaling fractions to a common base for comparison and addition. To add $\frac{1}{3} + \frac{1}{4}$, scale both to $\frac{1}{12}$. 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.



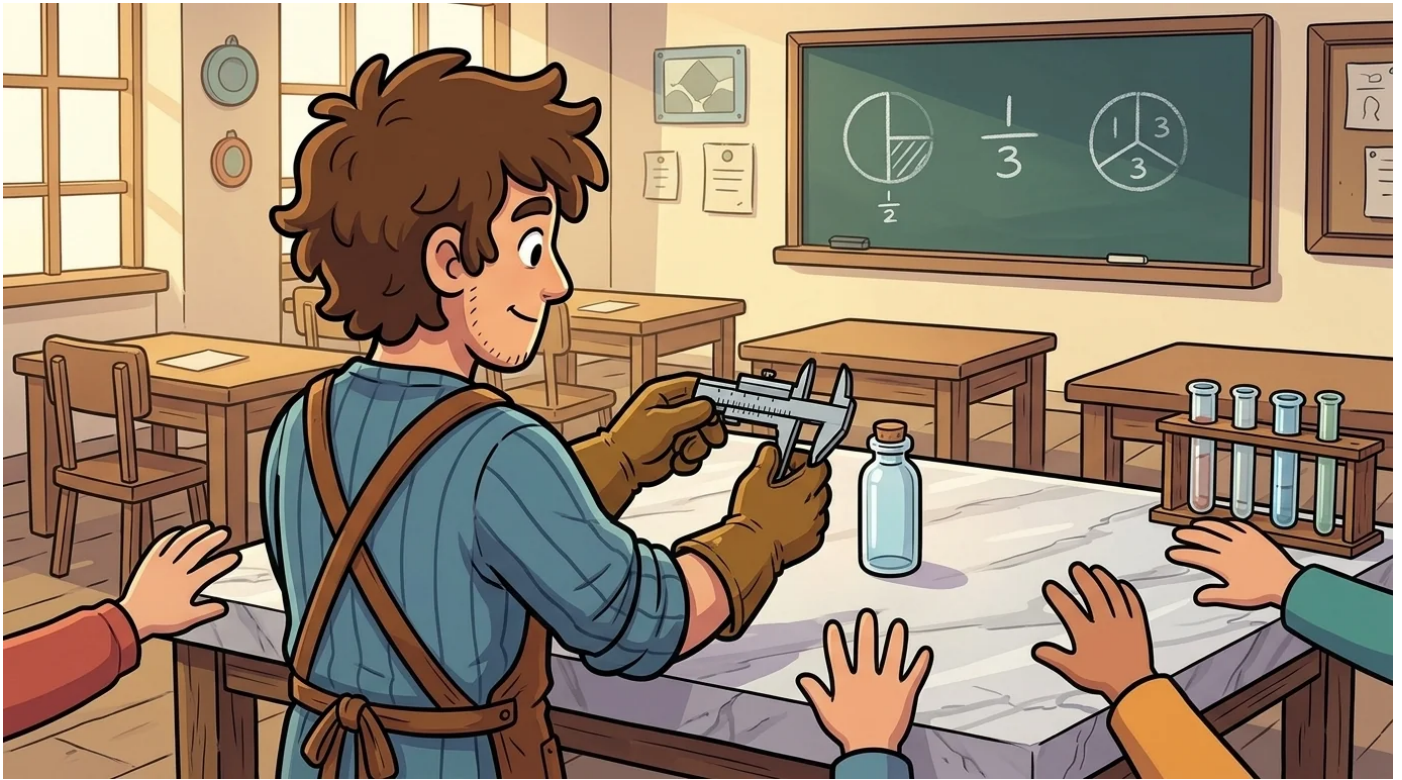
Stretch learned this, slowly, over years. By age eighteen, he was a master. He could roll a six-foot tube. It would be one thumb wide. And perfect everywhere. Not even a hair's difference. He was, by workshop standards, *very good*.

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: $\frac{1}{3} + \frac{1}{4}$. 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: $\frac{4}{12} + \frac{3}{12} = \frac{7}{12}$." "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!"

And when he says it, his voice goes soft and glad, the way a person's does when they finally feel they belong somewhere. For a long time he wasn't sure what he was for. Now he knows — and it feels less like a job and more like coming home. He hands the caliper to a child, watches them measure, and feels quietly, warmly certain that he is exactly where he is meant to be.

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Gather and Stretch

COMBINING UNLIKE FRACTIONS — you can only add or subtract pieces that are the same size. When they aren't, you first scale them to a common size (Stretch's common denominator), and only then can you gather them into one total (Gather's sum).



Gather could add almost anything in his basket. Almost.

He was a round, busy badger, and at the FairShare Village academy he spent his days dropping fraction pieces into the big woven basket on his back, giving it a shake, and announcing the total. Two-fifths of a ribbon and one-fifth of a ribbon? In they went. "Three-fifths," he'd say. Easy.

But this morning a young mouse named Pip brought him a different sort of problem.

"I have one-third of a blue ribbon," Pip said, "and one-fourth of a red ribbon. How much ribbon is that altogether?"

Gather reached for his basket, cheerful as ever. He dropped in the third. He dropped in the fourth. He gave the basket a shake.

And then he stopped, his cheer fading. He peered inside. He shook again, harder. He frowned.

"It won't tally," he admitted. "A third and a fourth. They're... different sizes. My basket only knows how to count pieces that match. These two don't match, so I can't count them up. For the first time in ages, Pip, I'm stuck."



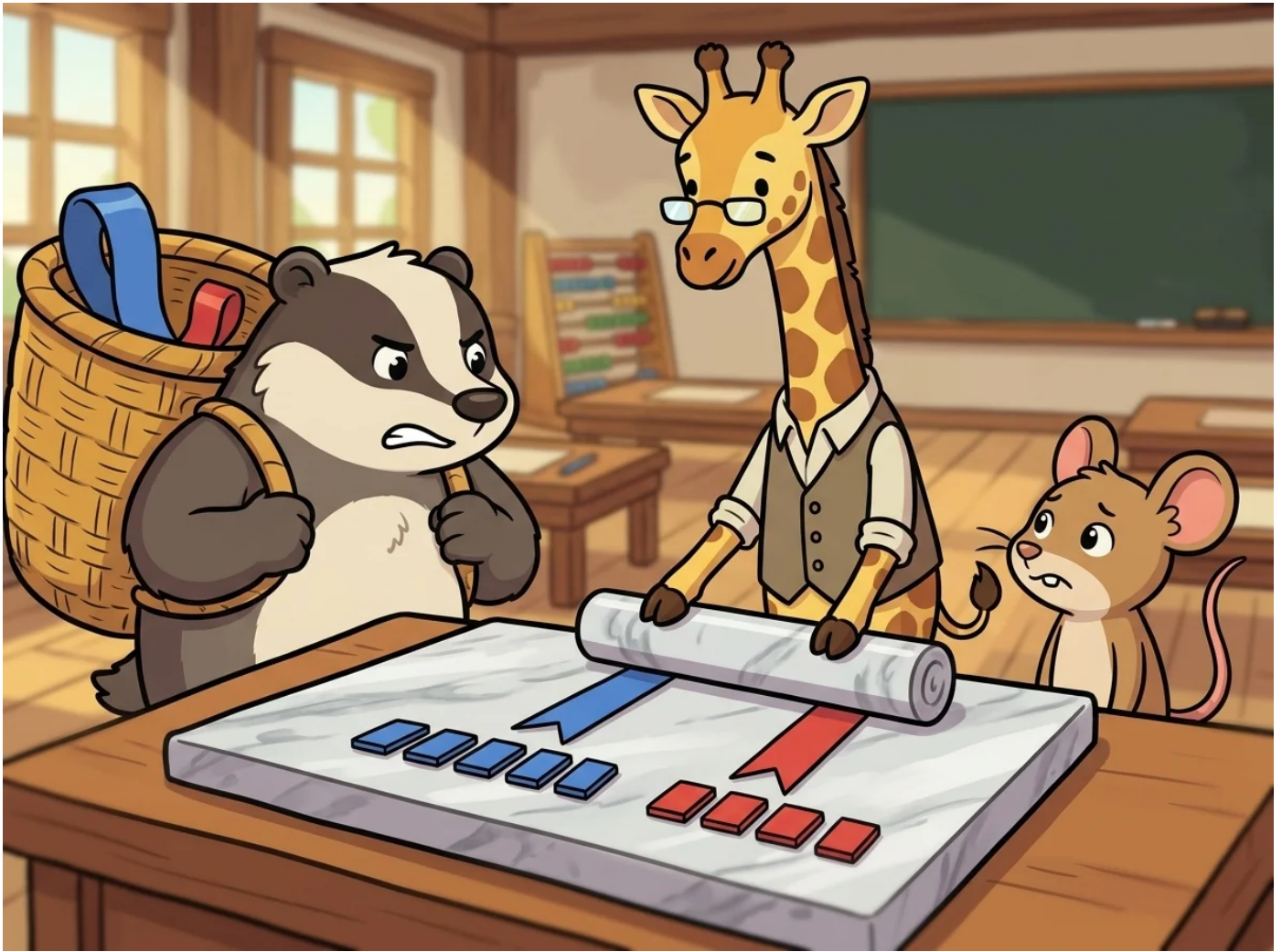
Gather sat down with a heavy *flump* and explained, because he believed in being honest with a kid.

"Here's my whole secret," he said. "Adding fractions is just counting — *when the pieces are the same size*. Two fifths plus one fifth is three fifths, because every piece is a fifth. I just count them. One, two, three. Done." He tipped his basket so Pip could see the matching pieces from an earlier problem, all the same neat size.

"But a third is a big piece, and a fourth is a smaller piece," he went on, holding one of each. "If I count 'one piece, two pieces,' I'm lying, because the pieces aren't equal. Two *different* sizes don't make 'two' of anything. It's like saying one apple plus one grape is two apples. It just isn't true."

Pip looked at the mismatched ribbons. "So you can never add a third and a fourth?"

"I can't," Gather said. "Not the way they are. Somebody has to make these pieces the same size *first*. And making things the same size, Pip" — he brightened, and turned toward the door — "well, that's not my craft. But I know exactly whose it is. STRETCH!"



Stretch arrived carrying a long, smooth marble slab under one arm, the way he always did.

Before he was a teacher, Stretch had been a glass-blower's apprentice, and his whole craft had been making things a perfect, even size — rolling hot glass along the marble slab until it was exactly the same width from end to end. Now he did the same thing with fractions.

"Mismatched pieces," he said, eyeing the third and the fourth. "My favorite. Watch." He laid both ribbons on his slab. "I can't change how *much* ribbon there is — that would be cheating. But I *can* cut each one into more, smaller, equal pieces, so they finally match each other."

He rolled the slab. "A third — if I slice it into four equal slivers each, it becomes four-twelfths. Same amount of ribbon, just shown in smaller pieces." He rolled again. "And the fourth — if I slice it into three equal slivers each, it becomes three-twelfths. Again, same amount, smaller pieces." He sat back, pleased. "Now look. Four-twelfths and three-twelfths. Both measured in *twelfths*. The pieces finally match. I haven't added a thing — I've just made them speak the same size."

Pip stared. "They're the same kind of piece now."

"Twelfths, both of them," said Stretch. "That's all a common size is. A size both fractions can agree to be."



Gather peered over Stretch's shoulder and his whole face lit up.

"Oh, *now* I can work," he said. He scooped up the four-twelfths and the three-twelfths — all the same size now, every sliver a twelfth — and dropped them into his basket. He gave it his familiar little shake.

"Four pieces, then three more pieces. All twelfths. All matching." He held up the combined ribbon, beaming. "Seven-twelfths. One-third plus one-fourth is seven-twelfths."

Pip's mouth fell open. "You needed each other," she said slowly. "Stretch couldn't add them up — that's your job. But you couldn't add them at all until Stretch made them match. Neither of you could do it alone."

"Never could," said Gather happily. "I bring things together. But I can only ever bring together things that are the same. Stretch makes them the same. He stretches; I gather. That's the whole dance." Stretch gave a small, proud nod from behind his slab. "Half the answer is making the pieces match," Gather said, "and half is bringing them in. We each only ever do one half."



Later, when the academy had gone quiet, Gather sat with his empty basket and Stretch leaned his marble slab against the wall, and the two old friends watched the last light fade over FairShare Village.

Pip lingered in the doorway. "I used to think adding fractions was one thing," she said. "But it's really two. Make them match. Then bring them together."

"Two things," Stretch agreed gently. "Done by two friends."

Gather nudged the slab with a paw. "I'd be stuck forever on every mismatched problem in the world without this fellow and his slab," he said. "And he'd have a workshop full of beautiful matching pieces and no one to gather them up." He gave a contented sigh. "Funny, isn't it. The thing I'm worst at is the exact thing he's best at. So we're never stuck — not as long as we're stuck *together*."

And as Pip walked home through the village, two ribbons' worth of math finally settled in her head, she found she wasn't thinking about twelfths at all. She was thinking how good it felt — that quiet, leaning-on-each-other kind of good — to know that the thing you can't do alone is so often just the thing a friend was made for.

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- **QuillSpell** — spelling craft through the Word Wizard cast
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Methodology

This book uses story-based learning — the characters embody the ideas being taught — grounded in the work of Jerome Bruner (on narrative and cognition) and Sebastian Habgood (on weaving learning into the play itself), with a trauma-informed, emotionally-safe approach drawn from SAMHSA's trauma-informed care framework.

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

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