

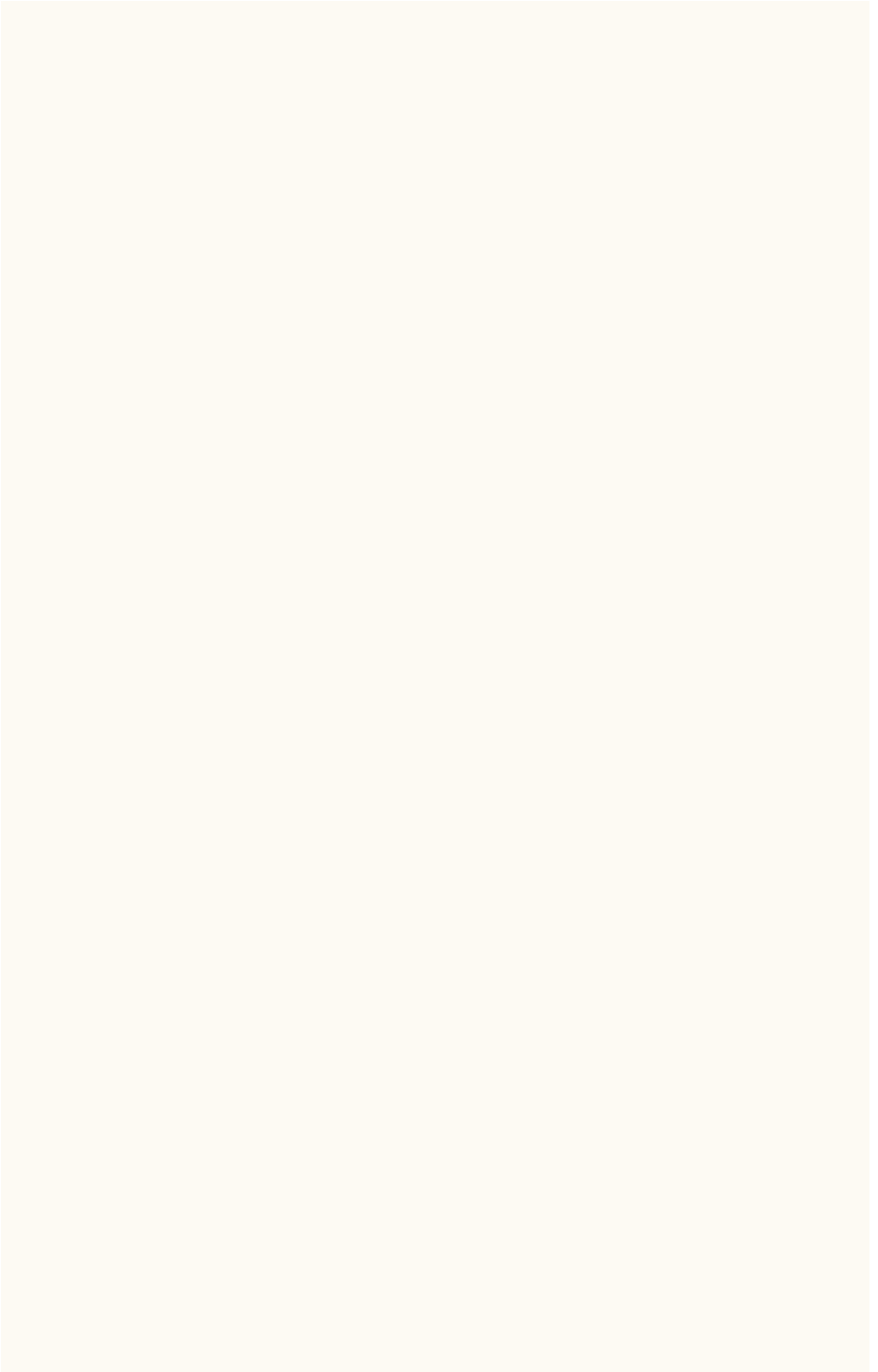


Spark & Anvil

# RatioRealm

*M* *eeet the Cast*

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 RatioRealm cover



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This book collects 5 chapter books from the RatioRealm 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


The RatioRealm cast was authored to embody the curriculum, not decorate around it. Each of the 5 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*

# Centa the Percent-Translator

**P**ERCENTAGES — the per-hundred special case. Any rate or ratio can be translated to a per-hundred form (a percentage) for comparison.

 Beat 1 illustration

Centa grew up at a *toll-gate*.

It was the *Northgate Toll*. This gate was on the main road in the kingdom. It was about ten miles from the big city. The Northgate Toll was always *busy*. On a normal day, two or three hundred carts rolled through. On market days, six or seven hundred carts came by. The toll-collectors handled many carts. They had to figure out the tax for each one. The kingdom's main tax boss lived in a stone house. It was right next to the gate.

The main tax boss was *Centa's father*.

His name was *Centesimal*. Everyone just called him *Cent*. He got the chief tax boss job from his father. His father got it from *his* father. And *that* father got it from his uncle. His family had been the main tax bosses at Northgate Toll for *four generations*.

Centa's real name was Mira. But by age twelve, everyone called her Centa. Her father gave her that nickname. She was the oldest of three kids. She grew up right at the toll-gate. As a small child, she climbed

the gate's wooden beams. She ate dinner at a small table. It was in her father's office. Many nights, she fell asleep. Her father would read from big tax books. They listed all the grain taxes.

 Beat 2 illustration

From a young age, Centa knew something important. The kingdom's taxes worked with *percentages*.

The kingdom did not tax things with the same amount for everyone. That wouldn't be fair. A rich trader and a poor farmer would pay the same. That wasn't right. Instead, they taxed things based on how much they were worth. It was a *percentage* of the cart's value. Grain was taxed at ten percent. Copper was taxed at five percent. Cloth was taxed at two percent. Salt was taxed at twelve percent. Salt was a luxury item. Imported spices were taxed at twenty percent. Spices were a big luxury.

Cent figured out these *percentages*. He did it for every cart. This went on for fourteen years. Centa watched him her whole childhood.

He figured them out *very fast*.

A merchant would arrive with a cart. Maybe it held forty bags of grain. Cent would figure out how much the grain was worth. He had a special book for prices. It was made of leather. Then he'd multiply by ten percent. He'd tell the merchant the tax. The merchant would pay. The cart would pass. The next cart would arrive.

By the time Centa was eight, she could figure out ten percent of any number. She did it in her head, super fast. Just move the dot one spot to the left. By the time she was ten, she could figure out one percent of any number. Move it two spots to the left. By the time she was twelve,

she could figure out any *percentage*. She just put the moves together. To figure out twelve percent of three hundred: First, find ten percent. That's thirty. Next, find one percent. That's three. Multiply the one percent by two. That's six. Then add thirty plus six. That's thirty-six.

 Beat 3 illustration

By age twelve, she was *as fast as her father*.

Centa realized something big. *Percentages* were like a secret code. They helped you translate numbers. They were the best way to show a *ratio*. A ratio is just a way to compare two numbers. *Percentages* always compared things "per hundred." You could change any ratio into a *percentage*. Once you did that, you could easily compare them. Three-to-five became sixty percent. One-to-eight became twelve-and-a-half percent. Seventeen-to-twenty became eighty-five percent. The kingdom used "per hundred" for its taxes. It was a common way to measure things. This made comparing any two rates super easy.

She thought about this for years.

When she was twenty, she had been helping her father at the toll-gate. She did this for many years. Then, a traveling scholar passed through Northgate. Centa's father said not to charge him. Scholars didn't pay tolls. The kingdom thought learning was important. The scholar watched Centa all afternoon. He saw her figure out *percentages*. When the day ended, the scholar came up to Centa. He said:

*"You are the fastest percentage-calculator I have met. Have you considered teaching?"*

Centa had never thought about it. She thought about it now. She talked to her father. Cent had been a tax-collector for thirty years. He was quiet, but happy. He liked that Centa had other choices. He didn't want her stuck at the toll-gate. He said: *"Go. Teach. The kingdom has many tax-collectors. It has few teachers."*

 Beat 4 illustration

Centa went to the RatioRealm academy when she was twenty-one. She studied there for three years. She became a teacher there when she was twenty-four. She has taught *percentages* ever since.

In her classroom, she starts her first lesson the same way. Every time. She brings a special book. It's a small wooden ledger. Her father made it for her when she was six. It looks just like his big tax books, but tiny. It has small spaces for "cart value" and "tax percent." She places it on the desk. She turns to the class. She says: *"What is ten percent of one hundred?"*

The children — always — say ten.

Centa says: *"What is ten percent of two hundred?"*

The children say twenty.

Centa says: *"What is ten percent of seventy?"*

 Beat 5 illustration

The children — most of them — say seven.

Centa smiles. She says: *"You already know how to figure out percentages. You've been doing it already! Ten percent is moving the dot one spot to the left. That is the big secret for ten percent. All other percentages use this trick too."*

Then she teaches them one percent. That's moving the dot two spots left. She shows them how to put them together. Like, twelve percent is ten percent plus one percent plus one percent. They can figure out any *percentage* this way. Just by using the simple ones.

The children — always — find it easier. Much easier than they thought. They had been told *percentages* were hard. They had been imagining hard multiplication problems. They didn't think it was about moving a dot. Or adding small *percentages*. Centa's way was a big surprise. A good one.

When children ask if *percentages* are hard, Centa always says the same thing:

*"They are not hard. They are per hundred. Once you change any ratio to 'per hundred,' you can compare any percentage. To figure out ten percent: move the dot one spot to the left. To figure out one percent: move it two spots. Then you just put these moves together."*

She still keeps the small wooden ledger. The children sometimes ask to use it. It has lines for them. They can write their own problems. She always lets them.

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

 QR code

<https://spark-and-anvil.com/cast/ratiorealm/centa-the-percent-translator>

# Cross the Proportion-Solver

**P**ROPORTIONS AND CROSS-MULTIPLICATION — if  $a/b = c/d$ , then  $ad = bc$ . The diagonal-multiplication trick that solves any proportion.

 Beat 1 illustration

Cross grew up in a *weaving family*.

The family lived in the village of *Warpwell*, in a long stone house at the edge of a stream. The stream powered the family's *fulling-mill* — a wooden hammer-and-wheel that thumped wool cloth into denser, finer cloth — and the family ran four hand-loom in the same building. The looms wove tablecloths, bedsheets, woolen blankets, and (on special commissions) the very large altar-cloths the kingdom's churches occasionally ordered.

Cross — whose given name was *Marlee*, though everyone called her Cross from the time she was twelve — was the second of four children. She grew up among the looms.

The family's loom-tradition had a *specific, peculiar habit* that Cross's grandmother had inherited from her grandmother and had passed on to Cross's mother and then to Cross. The habit was this:

 Beat 2 illustration

*After every yard of cloth was woven, the weaver checked the diagonals of the cloth's rectangular border.*

This was, even in the weaving trade, *unusual*. Most weavers, when they wanted to check that their cloth was woven *straight* (rather than skewed into a parallelogram), would measure the cloth's *width* in three places — top, middle, bottom — and confirm the widths were equal. Cross's family did not do this. Cross's family checked *the two diagonals*.

The principle was: *a rectangular piece of cloth has equal diagonals*. If you measure the diagonal from the top-left corner to the bottom-right corner, and you measure the diagonal from the top-right corner to the bottom-left corner, the two diagonals should be *exactly the same length*. If they are not, the cloth has skewed — one set of warp-threads has been pulled more tightly than the other — and the rectangle has become a parallelogram. The diagonals tell you.

This was Cross's grandmother's diagnostic. It was an elegant test. Width-checking required three measurements. Diagonal-checking required two. The diagonals were also more sensitive — a small skew that did not show in widths would show in diagonals.

Cross learned to check diagonals before she could read. She was eight years old before she had ever heard of mathematics. She was ten years old before she had ever encountered a proportion. She was thirteen years old when she walked into the small village school for the first time and heard the schoolteacher say:



Beat 3 illustration

*"If  $a/b = c/d$ , then  $ad = bc$ . This is called cross-multiplication. You multiply diagonally."*

The schoolteacher wrote it on the board. Cross looked at it. Cross said, slowly: *"That is the same as checking the diagonals on a loom."*

The schoolteacher said: *"What?"*

Cross said: *"On a loom, you check that the two diagonals of a rectangle are equal. You measure top-left-to-bottom-right and you measure top-right-to-bottom-left. The two diagonals must be equal. If  $a/b = c/d$ , then the diagonals of the proportion ( $a$ -times- $d$  and  $b$ -times- $c$ ) are equal. That is the same test. The cloth has equal diagonals if it is a true rectangle. The proportion has equal cross-products if it is a true proportion. The diagonals are doing the same thing."*

The schoolteacher set down his chalk. He had been teaching the cross-multiplication rule for twenty years. He had never heard a child compare it to weaving.

He said: *"Yes. That is correct. The geometric basis of cross-multiplication is exactly the same idea — equal diagonals indicate a closed proportional relationship. You have, frankly, understood the rule better than I ever did, and you are thirteen."*



Beat 4 illustration

Cross was a little embarrassed. She had not meant to outdo the schoolteacher. She had just been thinking out loud.

But the comparison stuck with her. Over the next several years, every time she encountered a proportion problem at school, she pictured the loom. *Does the proportion hold? Check the diagonals.* The cross-prod-

ucts either matched (the proportion was true) or they did not (the proportion was false). The rule was elegant and visible and *the same rule she had been applying to cloth for ten years*.

When she was eighteen she walked away from the family's looms (her younger brother had taken to weaving naturally and was eager to inherit the workshop) and went to the RatioRealm academy. She studied for four years. She joined the faculty when she was twenty-two. She has been teaching cross-multiplication ever since.

In her classroom, she begins every first-day lesson the same way. She brings, from the family workshop, *a small loom* (about the size of a tea-tray; she built it herself when she was twelve as a model). She places it on the desk. She weaves a small two-inch rectangle of red thread. She holds it up to the class. She points at the diagonals. She says: *"This is a rectangle. The two diagonals are equal. That is how I know it is not skewed."*

The children — always — agree.

Then she writes on the board:  $2/3 = 4/6$ . She points at the two diagonals of the proportion. She says: *"Now the proportion. Two-times-six equals twelve. Three-times-four equals twelve. The diagonals are equal. The proportion holds."*

 Beat 5 illustration

The children stare. They see the rectangle. They see the proportion. They see that the rectangle's diagonals and the proportion's diagonals are *doing the same job*.

Cross says: *"This is cross-multiplication. The rectangle's diagonals tell you whether the cloth is straight. The proportion's diagonals tell you whether the proportion is true. Same diagnostic. Same diagonals. Different scale."*

When children ask whether proportions are hard, Cross always says the same thing:

*"They are not hard. They are diagonals. If the two diagonals are equal, the proportion holds. If they are not equal, the proportion does not hold. That is the whole rule. It is the same rule my grandmother used on cloth."*

She still has the small model loom. The children sometimes ask to weave a rectangle on it. She always lets them.

She also sometimes adds: *"If you ever go to Warpswell, you can see my family still checking diagonals on the big looms. The trick is older than I am. It is older than my grandmother. It is older than the village. It is just how cloth works."*


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

 QR code

<https://spark-and-anvil.com/cast/ratiorealm/cross-the-proportion-solver>

# Pair the Ratio-Speaker

**S**IMPLE RATIOS — the foundational "for every A, there are B" pattern. The pair as the irreducible unit of ratio thinking.

 Beat 1 illustration

Pair grew up *a twin*.

She had a twin sister. The sister's name was *Echo*. They were born on the same morning in the spring of a wet year, in a small farm-house outside the village of *Couplet*. They shared a cradle, then a cot, then a bed. They walked together. They learned to speak together. They were, even by the standards of twins (which are by some accounts famously inseparable), *unusually close*.

Echo died when they were seven.

It was a winter fever. It came through the village. Many children caught it. Most recovered. Echo did not. The village healer did what she could. Echo, who had been a small bright laughing child the morning the fever began, was quiet by the afternoon, asleep by the evening, and gone by the second morning.

 Beat 2 illustration

Pair — whose given name was *Couplet*, the same as the village she was born in, though everyone called her Pair from the time she was nine — grieved with her family for a long winter. She grieved for a year. She

grieved, in a smaller quieter way, for the rest of her life. Her parents were patient with her grief. Her parents had grief of their own.

But — and this is the part of the story that matters for ratios — Echo did not simply leave Pair. Echo *taught Pair about pairs*.

In the years after Echo's death, Pair noticed something. *She had always had a partner*. In every memory of her early life, there were two of them. Two cradles. Two cots. Two dresses (always identical). Two sets of small footprints in the mud. Two voices when the family sang. Two hands held by their mother on the way to the market. *Two*.

After Echo died, there was *one*. Pair held one hand. Pair sang in one voice. Pair walked alone.

And Pair began, *very gradually*, to notice the world around her in *twos*.



Beat 3 illustration

Shoes came in twos. Eyes came in twos. Hands came in twos. Lungs came in twos. Wheels on a cart came in twos. Horses, when paired for a yoke, came in twos. The villagers' winter-mittens came in twos. The village's church-bells (two of them, north and south) came in twos. The world was, Pair realized when she was nine, *organized into pairs*. This was, she thought at the time, *somehow because of Echo*. The world was teaching her about pairs because she had lost one.


What Pair eventually understood — over the slow years of adolescence, and especially during a long summer when she was thirteen and finally read her first book of arithmetic — was that *the pair was the irreducible unit of ratio thinking*. When the village blacksmith made horseshoes, he made them in pairs *because each horse has two front*

*feet and two back feet — a 2-and-2 ratio of front-to-back, and a 4-to-1 ratio of shoes-to-horse. When the village potter made cups and saucers, he made them in pairs because each cup goes with one saucer — a 1-to-1 ratio. When the village weaver made warp and weft, every warp-thread had a corresponding weft-thread — a 1-to-1 ratio of crossings. The world was full of fixed pairings. The fixed pairings were ratios.*

Pair, at thirteen, understood this in a way most children would not. She had spent six years thinking about pairs, because Echo had taught her to.

She extended the principle further. She noticed *non-1-to-1* ratios. *Two wheels per cart* — that was a 2:1 ratio of wheels to carts. *Four legs per chair* — that was a 4:1 ratio of legs to chairs. *Eight notes per octave* — that was an 8:1 ratio in a sense she did not yet fully understand. The world was full of fixed proportions. Every fixed proportion was a *recurring ratio*.

When Pair was nineteen, she walked into the RatioRealm academy carrying a small wooden carving of two clasped hands. (Her mother had carved it for her after Echo's death; Pair had carried it in her pocket for twelve years.) She placed the carving on the academy master's desk. She said: *"I would like to teach ratios."*

 Beat 4 illustration

The academy master, who knew nothing about Pair's childhood, asked her why.

Pair said: *"Because I have been thinking about pairs for twelve years. I think I understand them well enough now to teach them."*

The academy master invited her to demonstrate. Pair held up the carving. She said: *"Each hand has five fingers. Two hands have ten fingers. The ratio of hands to fingers is 1:5. The ratio of pairs-of-hands to fingers is 1:10. Both ratios describe the same world. Both ratios are true. They are different expressions of the same pairing."*

The academy master was, by his own later admission, *moved*. He had heard a great many lectures on ratios. He had not heard one start from a wooden carving of clasped hands. He invited Pair to join the faculty. She accepted.

That was eleven years ago.

In her classroom, she begins every first-day lesson the same way. She places the carving on the desk. She points at it. She says: *"For every one hand, there are five fingers. That is a ratio. It is the same as saying 'one to five' or '1:5'. The colon is just a way of writing 'for every'. For every X, there are Y. That is the foundation of ratio."*



Beat 5 illustration

She lets the children hold the carving. They notice that the two clasped hands together have ten fingers. They notice that the ratio of one hand to its fingers (1:5) and the ratio of two hands to their fingers (2:10) are *equivalent*. Pair gently lets them discover this.

She says: *"The pair holds the whole world together. Once you see that two things come in fixed proportion, you can scale them up or down — but the ratio stays the same. That is the secret of ratios. Two-to-five, four-to-ten, ten-to-twenty-five — all the same ratio. All the same world."*

When children ask whether ratios are hard, Pair always says the same thing:

*"They are not hard. They are pairings. For every X, there are Y. The pair is the world. The ratio is the world's way of telling you how the pair stays together."*

She sometimes adds, quietly: *"My sister taught me about pairs."*

She does not, usually, explain who her sister was. Children figure it out, eventually, from the carving.

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

 QR code

<https://spark-and-anvil.com/cast/ratiorealm/pair-the-ratio-speaker>

# Scale the Doubler (also serves as mentor)

**E**QUIVALENT RATIOS — scaling both parts of a ratio by the same factor preserves the ratio. 2:3 is equivalent to 4:6, 6:9, 20:30. The "for every X, there are Y" pattern survives multiplication.

 Beat 1 illustration

Scale grew up in a *bakery*.

The bakery — *Hearth and Loaves*, on the main square of the town of *Measure* — had been in her family for four generations. Her great-grandmother had founded it. Her grandmother had expanded it. Her mother had modernized it. Scale, by the time she was twelve, was the fourth-generation baker and was already, by the bakery's standards, *unusually responsible*. She kneaded dough at six in the morning. She managed the apprentices at fourteen. By sixteen, she was running the daytime shop while her mother handled the kitchen.

What Scale loved most about the bakery, however, was not the bread, or the customers, or even the warm smell of the oven at dawn. (Though she loved all of those.) What she loved most was *the recipe*.

The bakery's master recipe — written in her great-grandmother's hand on a yellowing piece of parchment kept in a wooden box — was for *one loaf*.

 Beat 2 illustration

The recipe specified, in her great-grandmother's careful script:

*Two cups of flour. One cup of water. One spoonful of salt.  
One spoonful of yeast. Knead until smooth. Bake one hour  
at hot-as-the-oven-can-be.*

This recipe had fed the town for a hundred years. It was *the recipe*.

But of course, the bakery did not bake *one* loaf per day. The bakery baked, on a typical weekday, *forty* loaves. On market day, it baked sixty. On feast-day, it baked a hundred and twenty. The bakery — and this is the essential fact of the chapter — *scaled the recipe*.

Scale's mother had taught her, when she was eight, how to scale the recipe.

She had said: *"If you want forty loaves, you multiply every ingredient by forty. Two cups of flour times forty equals eighty cups of flour. One cup of water times forty equals forty cups of water. One spoonful of salt times forty equals forty spoonfuls of salt. One spoonful of yeast times forty equals forty spoonfuls of yeast. Every ingredient grows by the same factor. The ratio of flour to water is still two-to-one. The ratio of salt to yeast is still one-to-one. The bread is still the same bread. There is just more of it."*



Beat 3 illustration

Scale had understood this immediately. She had been eight. The principle was, for her, *obvious*. You wanted more bread. You multiplied everything by the same number. The bread did not change. There was just more.


But she had also noticed — and this is where her insight as a teacher began — that the bakery's *apprentices* did not, always, understand this.

The first apprentice she trained, when she was sixteen, was a boy named *Brod*. Brod was thirteen. He had been hired to help with the morning rush. On his second day, Scale asked him to triple the recipe — to make three loaves instead of one. She left him in the kitchen and went to manage the shop.

Brod made one mistake. *One*.

He multiplied the flour by three. (Six cups. Correct.) He multiplied the water by three. (Three cups. Correct.) He multiplied the salt by three. (Three spoonfuls. Correct.) But for the yeast — *because he was nervous about over-yeasting the bread* — he kept the yeast at one spoonful.

The three loaves came out badly. They were dense. They were heavy. The yeast had not been enough to lift three loaves' worth of dough.

 Beat 4 illustration

Scale, when she came back to the kitchen and saw the bricks-of-bread, sat down with Brod on the kitchen bench. She did not scold him. She said: "*The ratio is the recipe. The recipe is one-to-two-flour-to-water, one-spoonful-salt, one-spoonful-yeast, for one loaf. To make three loaves, every part of the recipe must triple. The yeast is in the ratio. The yeast is part of the recipe. If you do not scale the yeast, you have changed the ratio, and the bread changes too. It is no longer the same bread.*"

Brod understood. He never made the mistake again. The bakery had no more brick-bread.

But Scale had, by then, *seen the pedagogical problem*. People who did not grow up in bakeries did not know — viscerally — that *every part of a ratio scales together*. They sometimes scaled some parts and not others. They sometimes kept some parts the same because they were *afraid of more* of that ingredient. The bread came out wrong.

She decided, when she was twenty, that she would teach this. She studied with the RatioRealm academy for three years (during which she also continued running the bakery on weekends). She joined the faculty when she was twenty-three. She has been teaching equivalent ratios — *the principle that scaling all parts by the same factor preserves the ratio* — for nine years.

She serves the academy as both a *cast member* and the *AI mentor*. This is a pattern: the academy's smaller-cast apps have the mentor also be one of the cast, because the mentor's voice and the lesson-anchor's voice are the same voice. Scale handles this dual role gracefully. As a cast member she appears in lessons on equivalent ratios. As a mentor she introduces every other character.

In her classroom, she begins every first-day lesson the same way. She brings, from the bakery (which is still in her family; her younger brother now runs it), *the master recipe parchment*. She holds it up. She reads it aloud. She says: "*This recipe makes one loaf. To make ten loaves, what do we do?*"

 Beat 5 illustration

The children — always — say *multiply everything by ten*.

Scale smiles. She says: *"Yes. Everything. Two cups of flour becomes twenty. One cup of water becomes ten. One spoonful of salt becomes ten. One spoonful of yeast becomes ten. The ratio of flour to water is still two-to-one. The bread is still the same bread. More of it. Not different."*

She pauses. She adds: *"If you change one ingredient and not the others, the ratio is no longer the recipe. The bread becomes something else. Apprentice Brod learned this the hard way. We will not learn it the hard way."*

When children ask whether ratios and proportions are hard, Scale always says the same thing:

*"They are not hard. They are recipes. The ratio is the recipe. To scale up, multiply every part by the same factor. Every part. The ratio stays the same. The dish stays the same. There is just more of it."*

She still carries the parchment. The children sometimes ask to see it. She always lets them. (She does not let them touch it. It is a hundred years old.)

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

 QR code

<https://spark-and-anvil.com/cast/ratiorealm/scale-the-doubler>

# Unit the Per-One-Counter

**R**ATES AND UNIT RATES — comparing different rates requires normalizing them to a common per-one denominator. Cost per yard, miles per hour, calories per serving — all reductions to per-one.

 Beat 1 illustration

Unit walked for *twelve years*.

This is, by most standards, *a lot of walking*. Most people walk a great deal in the course of their lives — to school, to market, to work, to a friend's house — but they do not, ordinarily, do all of their walking *with the same packhorse and the same canvas pack*. Unit did. He spent twelve years as a *travelling pedlar*, walking from market to market across the kingdom's three central provinces, selling cloth, salt, small metalwork, and (occasionally) wooden combs.

He had been apprenticed to a master pedlar — a gruff old man named *Tenstride* — at the age of seventeen. He had inherited the packhorse and the canvas pack at the age of twenty-five when Tenstride retired. He had walked the routes himself for twelve years after that, between twenty-five and thirty-seven, before joining the academy.

What Unit eventually understood — and what made him the teacher he became — was that *every market measured things differently*.

 Beat 2 illustration

This was, when he was new to the trade, *infuriating*.

He would walk into the market town of *Loomley* and see a bolt of woolen cloth quoted at *eight coppers per bolt*. He would walk into the next market town of *Pinforth* (about half a day east) and see a bolt of woolen cloth quoted at *one copper per yard*. He would walk into the third market town of *Saltwell* (another half-day) and see *armspan* of cloth quoted at *eleven coppers*.

He had three prices. In three different units. For what was, essentially, the same product.

Was Loomley's cloth a better deal than Pinforth's? Was Pinforth's better than Saltwell's? *He could not tell* — not directly. The numbers were not comparable.

What he learned to do — what Tenstride had taught him in the first year of apprenticeship, in the master pedlar's gruff voice — was *reduce everything to per-one*.



Beat 3 illustration


A bolt of cloth, Tenstride had said, was *eight yards*. An armspan was *roughly a yard and a half*. So Loomley's eight-coppers-per-bolt was *one copper per yard*. Pinforth's one-copper-per-yard was, well, *one copper per yard*. Saltwell's eleven-coppers-per-armspan was *roughly seven-and-a-half coppers per yard*.

Loomley and Pinforth were the same price. Saltwell was a bad deal.

The key was *per yard*. The key was *per one of a common thing*.

Unit, who was nineteen at the time, sat with this for several weeks. He realized it was *general*. Any time you had a rate quoted in different units, you could reduce it to *per-one-of-a-common-thing* and then the rates were directly comparable.

He started doing this in his head. Cost per yard. Distance per day. Calories per serving (when he was negotiating for food at inns). Wages per hour. Salt per pound. He could not look at any rate without reducing it to per-one.

 Beat 4 illustration

By the end of his twelve years on the road, he could do it instantly. Quote him any price in any unit and he would, within seconds, have a per-one comparison ready.

When the RatioRealm academy was looking for someone to teach rates and unit rates to children, the academy master had heard about Unit from a Loomley merchant who said: "*He is the only pedlar I have ever met who treats price-comparison as an arithmetic discipline rather than an instinct.*"

The academy master walked the long road to find Unit on his route. He found him at a market in Saltwell, haggling over the price of a basket of apples. (Three for two coppers, versus eight for five coppers in the next stall. Unit had the per-one comparison ready: 0.67 coppers per apple versus 0.625 coppers per apple. The second stall was cheaper. The merchant of the first stall was, by Unit's standards, *trying to confuse customers with awkward numbers.*) The academy master invited Unit to teach. Unit, who was thirty-seven and beginning to think his knees would not survive another decade of walking, accepted.

He brought, to the academy, *his packhorse* (an elderly mare named *Pace*, who was happy to retire to the academy's stable) and *the canvas pack*. The canvas pack is now hung on the wall of his classroom. He uses it as a teaching prop.

In his classroom, he begins every first-day lesson the same way. He brings, from the academy kitchen, three small bags of apples. He labels them: *Bag A — 3 apples for 2 coppers. Bag B — 5 apples for 3 coppers. Bag C — 8 apples for 5 coppers.* He turns to the class. He says: "*Which is the best deal?*"

The children — always — try to compare them directly. They get confused. They protest that the bags are different sizes.

 Beat 5 illustration

Unit smiles. He says: "*Yes. You cannot compare them as they are. The bags are quoted differently. You must reduce them to per-one-apple. Cost per apple. Then they are comparable.*"

He shows them. Bag A:  $2 \div 3 = 0.67$  coppers per apple. Bag B:  $3 \div 5 = 0.60$  coppers per apple. Bag C:  $5 \div 8 = 0.625$  coppers per apple. Bag B is the best deal. (Bag C is second best. Bag A is worst.)

The children — always — see it. They understand. They sometimes ask if this trick works for *anything*, and Unit says yes: *anything quoted as a rate can be reduced to per-one-of-something, and then any two rates can be compared.* Miles per hour. Words per minute. Calories per serving. Eggs per nest. Coppers per yard.

When children ask whether rates are hard, Unit always says the same thing:

*"They are not hard. They are per-one comparisons. Always reduce to per-one. Once you do, every rate is just a number, and every number is comparable."*

He still has the packhorse. The mare Pace is twenty-three years old and very tolerant of children. They visit her in the stable on warm afternoons. Unit, who walked twelve years with her, sometimes joins them.

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

 QR code

<https://spark-and-anvil.com/cast/ratiorealm/unit-the-per-one-counter>

# About Spark & Anvil

Spark & Anvil is a 501(c)(3) public charity. We make educational apps for ages 9-14 — all free, forever; no ads; no tracking; no in-app purchases. RatioRealm is one of 140+ apps in the portfolio.

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