



GeometryForge

Meet the Cast

STANDARD EDITION

Spark & Anvil

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This book collects 7 chapter books from the GeometryForge 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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This is Volume 1 of 2 of the *GeometryForge — 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 GeometryForge cast was authored to embody the curriculum, not decorate around it. Each of the 7 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*

Master Hypotenuse

RIGHT-TRIANGLE RELATIONS — $a^2 + b^2 = c^2$. The square on the longest side equals the sum of the squares on the other two.



- prompt: "He kept his grandfather's rope for forty years. What is something you hold onto because of the person or feeling attached to it, more than what it's for?"
 - prompt: "He built bridges 'with even more pleasure than before' once he saw the bigger pattern. When has understanding *why* something works made you enjoy doing it more?"

Master Hypotenuse was, before he was a teacher, *a builder of small bridges*.



This is not a metaphor. He built actual bridges — wooden footbridges across small streams in his home valley of Crossing, which is a valley that has more small streams than it has roads. The valley needed bridges. Master Hypotenuse, for sixteen years between the age of seventeen and the age of thirty-three, built them.

His method of building bridges was — even by the standards of the valley, where everyone had opinions about bridges — *unusually careful*.

He always carried, on a leather thong over his shoulder, *a knotted rope*. It was a particular rope. It had been his grandfather's. It was about thirty feet long. It had twelve knots in it, evenly spaced, so that the spaces between the knots were equal. His grandfather had told him: "*This rope is for getting things right. Use it for everything that matters.*"

What Master Hypotenuse used it for, mostly, was *making right angles*.

To build a footbridge, you needed two abutments — one on each side of the stream — and they had to be square to the stream. Square. Right-angled. Not approximately, not roughly, not by-eye. *Square*. If your abutment was off by even a few degrees, your bridge planks did not sit flat. Water collected. Wood rotted. The bridge, two winters later, sagged.



Master Hypotenuse's trick with the rope was old. It was older than him. It was older than his grandfather. It went like this:

You laid the rope out in a triangle. You used three of the segments for one side — three knot-lengths. You used four segments for another side. You used five segments for the third side. You closed the triangle. *The angle between the side of three and the side of four was always, exactly, ninety degrees.* Every time. Without measuring with anything else. Without any instrument. Just the rope.

This trick — Master Hypotenuse, in his twenties, would explain to anyone who asked — was because *three squared plus four squared equals five squared*. $9 + 16 = 25$. The numbers fit. The triangle had to be right-angled.

He spent his bridge-building years quietly turning this fact over in his head.

What he eventually understood — and it took him most of those sixteen years, because he was not a quick man, only a patient one — was that the rope-trick was a single instance of *a much larger pattern*. The same was true for 5-12-13. The same was true for 8-15-17. The same was true for *any* three numbers a , b , c where $a^2 + b^2 = c^2$. You laid out a triangle with those side-lengths and the angle opposite c was, *exactly*, a right angle.



And — and this was the part that made him sit down on the bank of a stream one summer evening and stay there until dark — the reverse was also true. *Any right triangle, no matter what shape, had this property: the square on the longest side equals the sum of the squares on the other two.* The rope was just one example. The principle was universal.

Master Hypotenuse, on that evening, did not name what he had understood. He did not call it the Pythagorean theorem (which was the name a different tradition, in a different valley, had given it many centuries before). He simply sat by the stream and thought: *the right angle is hiding in the square. The square is hiding in the right angle. Every right triangle is the same right triangle, just stretched.*

He went back to building bridges. But he built them, after that summer, with even more pleasure than before. Every bridge was a small instance of a universal pattern. Every right-angled abutment was a tiny demonstration.

When the EquationQuest academy (which has a sister school for geometry, called the GeometryForge academy, in a nearby valley) was looking for someone to teach right-triangle relations to children, the valley's bridge-builders' guild sent Master Hypotenuse's name. He had, by then, been building bridges for sixteen years and had become slightly famous in the region for the fact that none of his bridges had ever sagged. The academy master wrote him a letter. Master Hypotenuse, who was thirty-three and beginning to think his back needed a less wet line of work, accepted.

He arrived at the academy carrying the knotted rope.



He still carries it. It is the first thing he shows children in their first lesson on the Pythagorean theorem. He lays it out on the classroom floor. He counts off three knots, then four, then five. He pulls the rope taut into a triangle. He says: *"Look at the angle between the three-side and the four-side. That is a right angle. The rope made it for me."*

Children stare. Children try it themselves. Children get it.

He adds, gently: *"Three squared plus four squared equals five squared. That is why. The numbers know what they are doing. The rope is just helping them show it."*

When children ask him whether the Pythagorean theorem is hard, Master Hypotenuse always says the same thing:

"It is not hard. It is only patient. You square the two short sides. You add them. The answer is the square of the long side. Every right triangle agrees."

Lady Inscribed-Angle

CIRCLE THEOREMS — inscribed-angle is half the central-angle subtending the same arc. The angle at the rim, half of the arc you see across.



Lady Inscribed-Angle grew up on the shore of *Lake Drumhead*.

This was, even by the standards of the kingdom — which has a great many small lakes — *an unusual lake*. It was, as far as anyone could measure, *perfectly circular*. Not approximately. Not roughly. *Perfectly*. The villagers of the surrounding village (which was also called Drumhead, because the village had been there longer than the kingdom had a habit of giving things distinct names) had measured the lake every generation for three hundred years. Every measurement agreed: a perfect circle, about half a mile across.

Lady Inscribed-Angle — whose given name, before the academy, was *Pell* — was born and raised on the rim of this lake.

The children of Drumhead had a game. It was old. Older than anyone could remember. It was called *the chord-walk*.



The game went like this: a child stood at a chosen point on the rim of the lake. The child picked two *other* points on the rim, anywhere they liked, and walked the arc from one to the other. While they walked, they kept their head turned so they were always looking at the chord — the straight line between the two endpoints they had picked. When they had walked the arc, they came back to the chosen starting point and the older children, who had been watching, would measure two things: the angle at which the starting child had been standing (between the two picked points), and the length of the arc the child had walked.

Then the older children would announce a number. Always the same kind of number. *Half*.

The arc walked was always *twice* the angle at the starting child's position. *Always*.

This was the game. It was not explained. It was a thing the children of Drumhead grew up with. It was, the villagers said, *what the lake taught*.

Pell was eleven when she started thinking about this seriously.



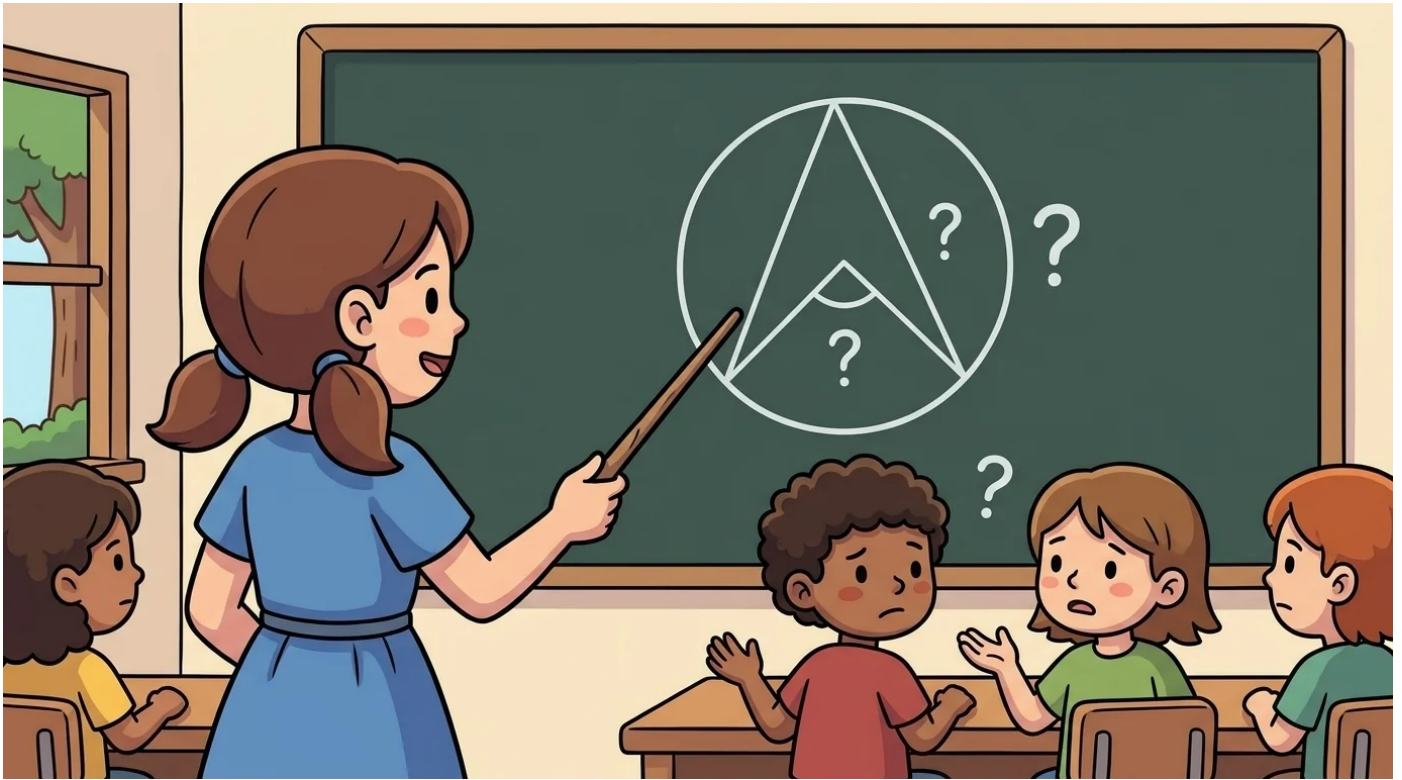
She walked the chord, by her own count, *three hundred and seventeen times* over the course of one summer. She tried it from every starting point on the rim. She tried it with chords short enough that the arc was just a tiny sliver, and chords long enough that the arc went more than halfway around the lake. She tried it standing on a rock, on a tree-stump, on her cousin's shoulders. The rule held. *The angle at the rim was always half the arc.*

She did not, at eleven, know why. She knew only *that*.

When she was sixteen, a travelling tutor came through Drumhead — a quiet woman named Mira who taught geometry to children in villages along the coast — and Pell asked her the question. Mira sat down on the rim of the lake. She drew three pictures in the wet sand. She said:

"The angle you stand at is called an inscribed angle. The angle a person standing at the center of the lake would measure to the same two points is called the central angle. The central angle is the same as the arc, just expressed as a number of degrees instead of a length. And the inscribed angle is always — exactly, every time, for any circle — half of the central angle."

Mira drew it. Pell watched. Pell understood.



She said: *"The lake has been teaching this to children for three hundred years. Nobody told us what it was called."*

Mira smiled. She said: *"The lake teaches very well. The names are just for the children who do not have a lake."*

Pell, who was sixteen, decided in that moment that she wanted to be the person who taught children-without-lakes what the lake had taught her. She studied with Mira for two years, then with the academy of GeometryForge for three more, then took the name *Lady Inscribed-Angle* (which, in the academy's tradition, is what you do when your character has fully embodied a single geometric primitive). She has been teaching ever since.

She still goes home to Drumhead twice a year. She still walks the chord. She still gets the same result.

When children arrive in her classroom for the first time, she always begins the same way. She draws a circle on the board. She draws a chord. She marks a point on the rim. She marks the center. She says: *"This is the inscribed angle. This is the central angle. Which is bigger?"*

The children — always — guess wrong the first time. They say the inscribed angle is bigger, because it looks closer to them.



Lady Inscribed-Angle smiles. She says: *"It looks bigger. It is half. The central angle is twice."*

Then she lets them measure it. Then she lets them try it from a different point on the rim. Then she lets them try it from a different chord. They always get the same answer.

She tells them, gently: *"This is a thing about circles. It is true for every circle. You do not need a lake to test it — but you do need a circle, and you need patience, and you need to walk the chord."*

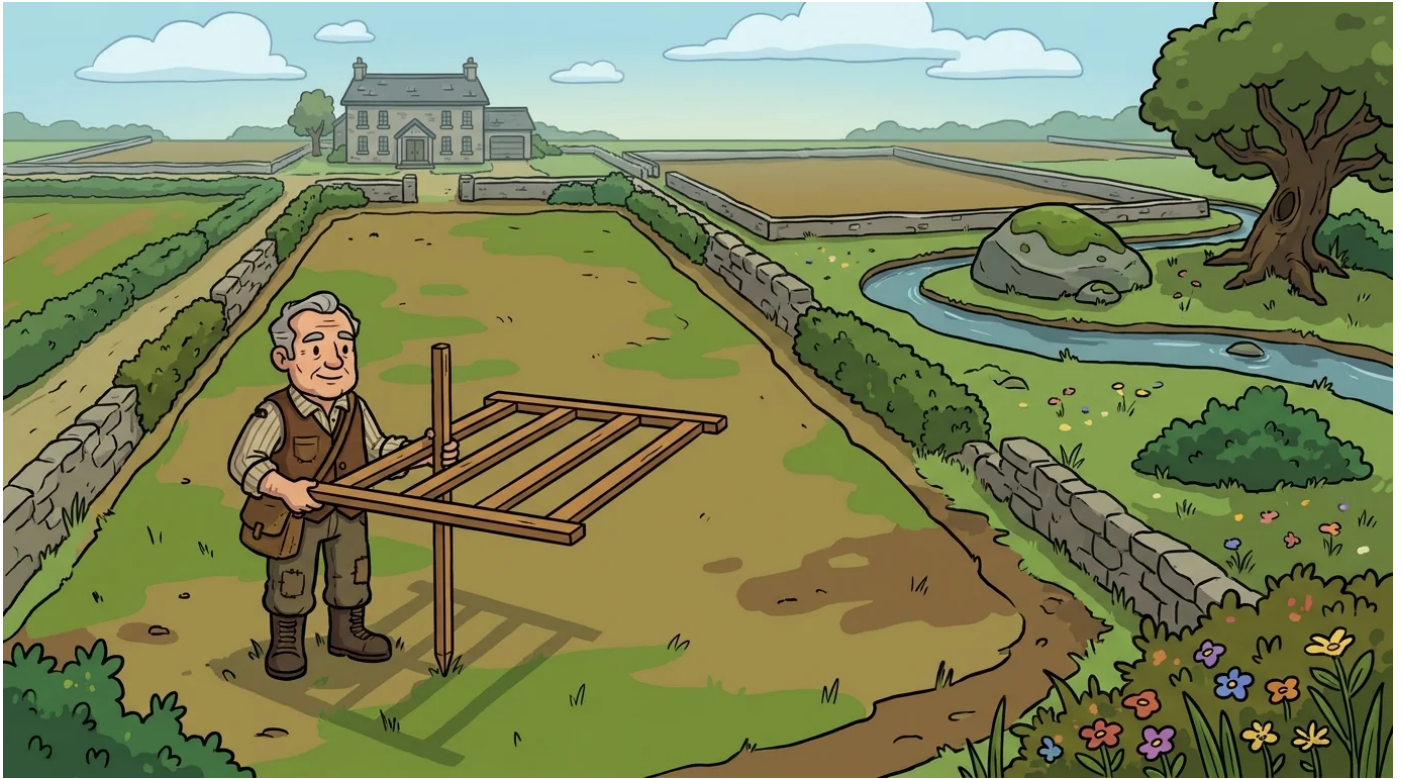
When children ask whether the inscribed-angle theorem is hard, Lady Inscribed-Angle always says:

"It is not hard. It is only half. The angle at the rim is half the arc you see. Every time. Every circle."

She tilts her head, slightly, when she says it. She has, the academy children have noticed, *fox ears*, and the ears prick forward whenever a circle appears in a problem. She does not seem to do this on purpose. The circles, she says, simply *call to her*. And when a child finally feels the theorem click — when their whole face goes soft and surprised, the way hers did on the rim of the lake — those fox ears prick all the way forward, because that warm, glad little jump in her chest is the thing she came so far from Drumhead to feel again.

Sir Transverse

PARALLEL-LINE TRANSVERSALS — when a transversal cuts two parallel lines, corresponding angles are equal; alternate interior angles are equal; the intercept theorem holds (proportional segments).

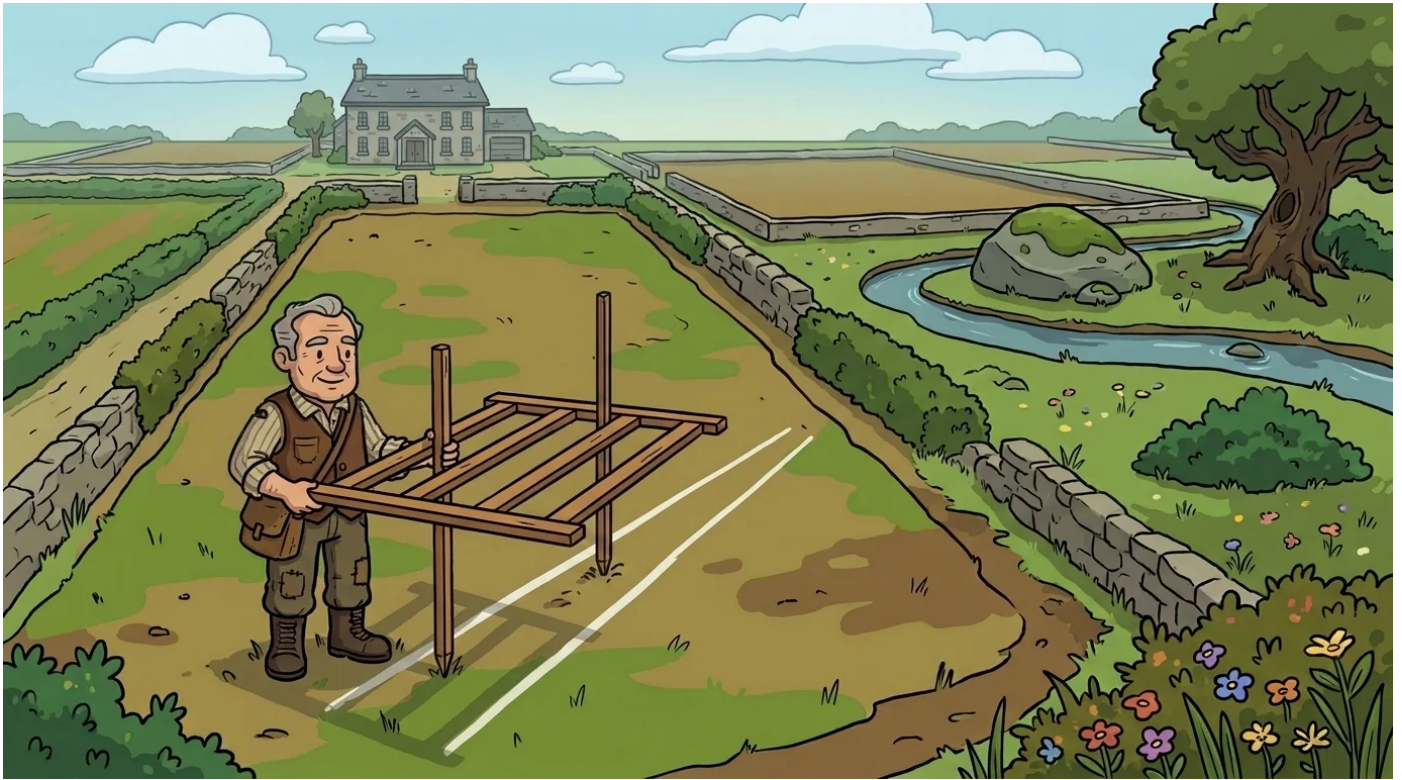


- prompt: "Sir Transverse cared most that every family's share of the field was *fair*. Have you ever felt strongly that something needed to be fair — and how did it feel when it finally was?"
 - prompt: "The children gasped when they saw the ratio hold like magic, and Sir Transverse remembered feeling exactly that way at nineteen. When have you felt a jolt of wonder at something working out perfectly?"
 - prompt: "People walked away from his fields happy instead of arguing. How does it feel when a fight gets settled calmly and everyone leaves at peace?"

Sir Transverse measured fields. He did this for thirty years.

He worked for the kingdom's land office. It was a quiet government place. The office sat in a sleepy stone building. His job was to divide fields. He had to make sure they were *fair*.

This was not as simple as it sounds.



The fields of the kingdom were, mostly, rectangles. Some were longer than they were wide. Some were squarer. Some fields had funny corners. A stream might cut them off. Or a big rock. Maybe an old tree stood there. It was there before the field. But most fields had four sides. They had two long sides and two short sides.

The trouble was that *the long sides were parallel*.

Families often needed to divide fields. Maybe parents had died. Then brothers and sisters shared. Neighbors might argue over a line. Sometimes friends owned land together. They always wanted a *fair* share.

Fairness in fields meant one thing. It meant: each owner got a strip. The strips had to be the same *proportional* width. This was measured along the parallel sides.

If a field was 300 paces long, and three kids shared it, they wanted three strips. Each strip was 100 paces wide. If a field was 240 paces long, and four kids shared it, they wanted four strips. Each strip was 60 paces wide. Simple.

But fields are not always nicely lined up north-to-south. Sometimes the parallel sides are not even *the longest* sides. Sometimes they cut diagonal strips. Maybe a strip needed to touch the road. Or reach the stream. Each sibling wanted a piece like that. And then *the math becomes interesting*.



Sir Transverse was thin. He had long, stork-like legs. Everyone called him *Sir*. He had been *Sir* since he was six. It was a family nickname. No one knew why.

When he was nineteen, he found something out. It was his second year as a surveyor. He saw that if you cut a field with a diagonal line. He called this a *transversal*. It went across two parallel boundary lines. Then he cut another diagonal line. This second line was parallel to the first. The strip between these two diagonals always had a special width. This width was *proportional* to how far the strip was from the main parallel lines.

This was the *intercept theorem*. It's a very old math rule. Sir Transverse, of course, did not know it had a name. He simply observed it. He measured it on every field he surveyed for the next four years. It held. Every time.

By age twenty-three, he was a master. He walked into any field. He saw the people arguing. He asked one question: "*How do you want the strips to touch the road?*" In ten minutes, he laid out fair strips. He used only his measuring-staff. And a knotted cord.

He never measured the whole field. He never figured out its total area. He didn't need to. He just cut parallel lines. He used parallel *transversals*. The proportions worked themselves out.

The people arguing always left happy. This made Sir Transverse, by age thirty, famous. Everyone wanted him. He was the busiest surveyor in three provinces.

He spent thirty years doing this work. He divided many fields. He counted them carefully. One thousand, four hundred, sixty-two fields. He never had a complaint. He never had a re-survey. He never, even once, made a strip a half-pace too wide or too narrow.



His friends at the land office had a saying about him. They joked that he had *the soul of a ratio*. It was a funny thing to say, but they meant it.

The GeometryForge academy needed a teacher. They wanted someone to teach *proportional reasoning*. This meant the *intercept theorem*. And how *transversals* cut parallel lines. The academy master heard about Sir Transverse. His nephew told him. The nephew had been in a tough family field fight. Sir Transverse had solved it.

The nephew said, "He is amazing!" He added, "He makes fair division a math rule. Not just an argument."

The academy master wrote Sir Transverse a letter. Sir Transverse was forty-nine. His knees were getting old. He worried about walking in the rain. He accepted the job.

He brought his measuring-staff and a coil of knotted cord. He still has both. He keeps them in the corner of his classroom.

He teaches the *intercept theorem* his own way. He teaches it by walking. He lays a long cloth strip on the floor. It has two parallel lines marked with chalk. He picks two students. He gives them each a length of red string.

He says, "You are a *transversal*." He tells them, "Walk across the cloth. Hold your string tight. Choose any angle, but stay straight."



The students walk. The red strings cross the parallel lines at angles. Sir Transverse watches.

Then he asks them to walk a *second* transversal. This one must be parallel to the first. The class measures the strip between them. The strip is always *proportional*. Always.

No matter the angle, the *ratio* always holds. The strip's width compared to its distance from the parallel lines stays the same.

The children gasped. Their eyes went wide. They had never seen math work like magic before. Sir Transverse just smiled. He had felt the same way at nineteen. He was patient with their wonder.

He says gently, "The *transversals* were straight. The boundaries are parallel. The proportions just work. You didn't even have to do math."

He adds, "*Geometry, when the lines agree, is fair.*"

Kids ask if the *intercept theorem* is hard. Sir Transverse always says the same thing:

Apprentice Sides

AREA FROM SIDES — the area of a triangle can be computed from its three side-lengths alone (Heron's formula: $s = (a+b+c)/2$, area = $\sqrt{s(s-a)(s-b)(s-c)}$). The principle: you do not need the height.



Apprentice Sides was apprenticed at age twelve.

This was, in the kingdom, the usual age. Children of twelve were considered old enough to follow a craftsperson around, carry their tools, observe their work, and gradually pick up the trade by what was called *long imitation*. Apprenticeships lasted seven years. By nineteen, you were a journeyman. By twenty-five, if you were good, you were a master in your own right.

Apprentice Sides — whose given name was *Bryn*, though almost nobody remembers this, including Bryn herself most days — was apprenticed to a surveyor named *Old Hardridge*.

Old Hardridge was, by all accounts, *a strange surveyor*. He worked alone. He took apprentices reluctantly. He measured fields the way other surveyors did, but he refused — *adamantly* refused — to measure one thing.



Heights.

This had a specific meaning in the surveying trade. A field, when you measure it, has a length and a width along its boundaries (these are *sides*) and, if the field is a triangle, the area is usually computed by *taking one side as the base and dropping a perpendicular from the opposite vertex to find the height*. You then multiply: $\text{base} \times \text{height} \div 2$. This is the standard method. Every surveyor learns it.

Old Hardridge refused.

"Heights are a lie," he used to tell Bryn, in his gravelly voice, the first hundred times she asked him why. *"The sides are what you can stand on. The sides are what you can walk along. The sides are real. The height is what you have to calculate by dropping an imaginary line through the air. The air does not hold a measurement. The sides do."*

Bryn was twelve. She did not, at first, understand. She thought Old Hardridge was being grumpy. (He was being grumpy. But that was not the only thing he was being.)

What she eventually understood — over the course of the apprenticeship, and especially during the third year, when Old Hardridge let her start measuring small triangular gardens herself — was that *Old Hardridge had a method*. A method most surveyors had forgotten. A method that worked from *the three side-lengths alone* and gave the area of the triangle without needing the height.



Old Hardridge called the method *the three-sides trick*. He taught it to Bryn the way he taught everything — slowly, repeatedly, in his gravelly voice, with a chalk slate and a small clay model of a triangle. The trick went:

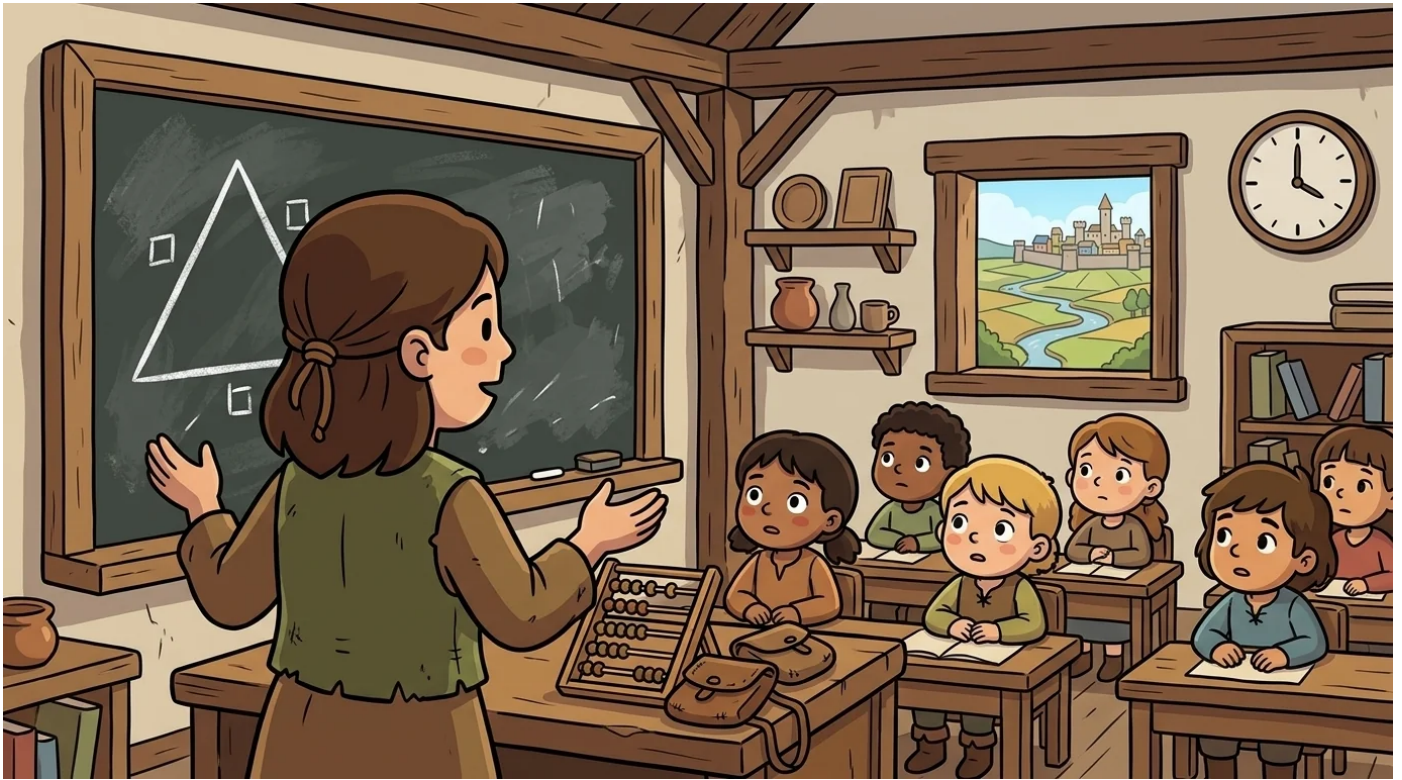
Take the three sides. Call them a , b , c . Add them together and divide by two — that is s , the half-perimeter. Then the area is the square root of s times $(s - a)$ times $(s - b)$ times $(s - c)$. Always. Every triangle. No height needed.

Bryn was fifteen when she finally believed him. She measured a triangular field she could see was about thirty paces on the longest side, used the trick, got an area. Then — out of stubbornness — she measured the same field the standard way, dropping a perpendicular, finding a height of about twelve paces, multiplying $\text{base} \times \text{height} \div 2$. The two answers agreed. *Exactly.*

She did it again. Different field. Different shape. The two methods agreed.

She did it a third time. And a fourth. And a fifth.

The two methods *always* agreed.



When she was sixteen, she asked Old Hardridge how the trick could possibly work. How could just-the-sides give you the area, without ever needing to know the height?

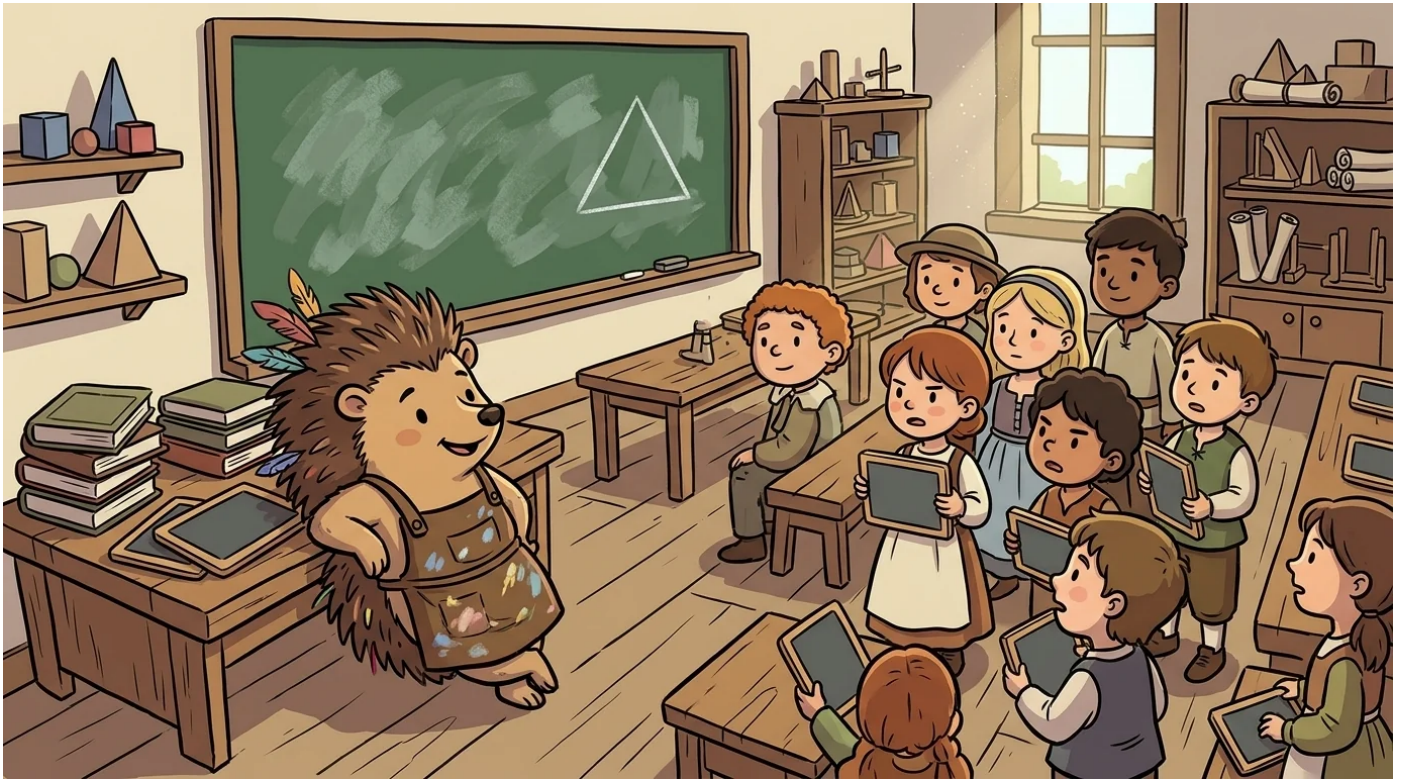
Old Hardridge said: *"The sides know where the height is. The sides hold the height. You only think you need to drop the line. The sides are already telling you."*

Bryn did not understand him at the time. She understood him much later, when she had been a journeyman for several years and had derived the formula for herself algebraically (it turns out that the half-perimeter formula and the standard formula are the same formula, written differently — the half-perimeter version just hides the height inside the algebra). But by then Old Hardridge had retired and was sitting on his porch in the village, and when Bryn went to visit him and told him she had finally understood, he just nodded and said: *"I told you."*

She kept his slate. It is the same slate she uses today, in her classroom, when she teaches children the three-sides trick. It is scratched and chipped and stained with chalk. It is the slate she learned on.

Bryn is now thirty-one. She has been teaching for six years. She is still called *Apprentice* — even by the academy master, even by her students. This is because, she says, *she is still learning*. Old Hardridge taught her one trick. She has spent ten years finding more triangles to use it on. There are, she says, more triangles than she will ever measure.

When children arrive in her classroom for the first time, she hands them a small slate and a piece of chalk. She draws a triangle on the board. She labels the three sides: a , b , c . She says: *"Compute s . Then take the square root of s times $(s - a)$ times $(s - b)$ times $(s - c)$. That is the area. Try it. I will not tell you the height. You do not need it."*



The children — always — protest. They say they need the height. They have been taught they need the height.

Apprentice Sides smiles. She says: *"Old Hardridge taught me the same protest. I made it for three years. Then I tried the trick. The trick was right. The protest was wrong."*

The children try the trick. They check their answer against the textbook formula. The two agree.

Apprentice Sides — who has chalk-stains on her apron and quill-feathers behind her spine-tufts (she is a hedgehog-child; the spine-tufts are charming) — leans back against her desk. She says: *"The sides know where the height is. The sides hold the height. You do not need to drop the line. The sides are already telling you."*

She adds, after a moment: *"Old Hardridge would be very pleased that you tried it."*

And the children — who came in sure they needed the height, and found out they did not — sit a little taller. There is a warm, surprised feeling in the room, the kind you get when something you were afraid of turns out to be simpler than you thought. Apprentice Sides knows that feeling well. It is the one she has been chasing since she was fifteen.

Captain Construction

COMPASS-AND-STRAIGHTEDGE CONSTRUCTIONS — bisector, perpendicular, equilateral triangle, regular hexagon, circle-given-three-points. Geometry built with only two tools, never measuring with a ruler.



Captain Construction was, for twenty-two years, *a shipwright*.

He built small wooden boats in the coastal town of *Hull Bay*. The boats were, mostly, fishing boats — single-mast, single-sail, single-hull, suitable for two or three fishermen and a morning's catch. He built them in a long wooden shed at the head of the bay. The shed smelled of pine resin and rope-oil. The floor was always sawdust. The walls were always damp.

Captain Construction — whose given name was *Bram*, though everyone called him Captain since he was nineteen, even though he had never captained a boat in his life (the title was a workshop nickname that stuck) — was a bear-headed shipwright with thick brown fur on his arms and a leather toolbelt that was, even by shipwright standards, *full of more tools than it strictly needed*.

But Bram only ever *used* two of those tools when he was laying out the curves of a hull.

A compass.



And a straightedge.

This was, to other shipwrights in Hull Bay, *absurd*.

Other shipwrights used rulers. They used measuring-sticks marked in thumbs and palms and forearm-lengths. They used templates copied from their fathers' templates. They penciled distances on the wood, measured them, marked them, sawed them.

Bram refused.

"A ruler is a lie waiting to happen," he used to growl, in his bear-rumbly voice, to anyone who asked him why. *"The marks on a ruler wear off. The wood swells. The marks shift. A measurement made with a ruler can be off by half a thumb and you do not know it. A construction made with compass-and-straightedge is the same construction every time. The compass arc does not care if the wood has swelled. The straightedge does not care if the chalk has worn. The construction is the geometry. The geometry is the boat."*

This was, to Bram, an article of faith.



He had learned it from his father, who had learned it from his grandfather, who had learned it (the family said) from a shipwright in the next valley over who had been famous for never losing a boat to a structural fault. The compass-and-straightedge tradition was, in Bram's family, *three generations old*.

He spent twenty-two years building boats this way. He laid every curve as a compass-arc. He found every right angle by constructing a perpendicular from a chosen point to a line — never by measuring with a square. He divided every spar into halves and thirds by constructing bisectors and trisectors — never by counting thumb-widths. The work was slower. The work was more careful. The work was *correct*.

In twenty-two years, he built one hundred and forty-six boats.

In twenty-two years, *not one of his boats sank*.

This was — and it remains — *unusual*. The going rate for fishing boats in Hull Bay was that about one in every twenty would suffer some structural failure within five years. Bram's boats did not. The reason, the harbour-master eventually decided after thirty years of watching Bram work, was that *the geometry was right*. Other shipwrights built boats that worked. Bram built boats that *had to work* — because every curve had been derived from a single principle, every angle had been constructed, every dimension had been the logical consequence of every other dimension. The boat was not assembled from parts. The boat was *constructed* from a small number of axioms.

When the GeometryForge academy was looking for someone to teach compass-and-straightedge constructions to children, the academy master had heard about Bram from a sea captain who had bought one of his boats. The sea captain said: "*He does not build boats. He builds proofs that happen to float.*"



The academy master wrote Bram a letter. Bram, who was forty-one and beginning to think his bear-shoulders would not survive another decade of bending over a hull, accepted.

He brought his compass and his straightedge. He still has both. He calls the compass *the swing-arm*, because, he says, it swings around its center the way a gate swings around its hinge.

In his classroom, the first lesson is always the same. He sets out, on every child's desk, a compass and a straightedge. He says: *"Today we are not going to measure anything. We are going to **construct** everything. The compass first. The straightedge second. No measuring. That's the deal."*

The children — always — protest. They ask how they can possibly draw anything accurate without measuring.

Captain Construction smiles. (Bear-headed smiles are slow and gradual but they are warm.) He says: *"You will see. The geometry will tell you what to do. The compass will tell you how far. The straightedge will tell you which way."*

He then shows them the first construction. Bisecting an angle. The method is older than the kingdom. The method is older than Bram's grandfather. The method does not require a ruler. The method does not require measurement. The method gives an angle bisector that is, *exactly*, a bisector.



The children try it. The bisector works. They check it with a protractor (the academy keeps protractors for verification; Bram tolerates them grudgingly). The bisector is exactly half of the original angle. Every time.

Captain Construction nods. He says: *"This is geometry. The compass and the straightedge are the only tools you need. Everything else follows."*

He adds, in his bear-rumble: **"Also: my boats did not sink. The geometry, in case you are wondering, was *exactly* the same as this. Just bigger."**

When children ask whether compass-and-straightedge construction is hard, Captain Construction always says the same thing:

"It is not hard. It is only patient. Compass first. Straightedge second. No measuring. The geometry tells you what to do. Trust the geometry."

He still keeps the compass on his belt. The children sometimes ask to hold it. He always lets them — and he watches their faces, the careful, delighted way they turn it, and it makes his old bear-heart glad. That quiet pride, he says, is the whole reason he came ashore to teach: not to be right, but to hand the calm, sure feeling of *this will hold* to someone new.

Compass Wraith

LOCUS — the set of all points satisfying a given condition. Special case: the circle as the locus of points equidistant from a center.



- "E"
 - "S"
 - "W"
 - reflection-prompts:
 - prompt: "The Compass Wraith shows all the places a point could be, not just one answer. When have you felt the wonder of realizing there were more possibilities than you first thought?"
 - prompt: "The children find her thrilling but not scary. Have you ever felt that excited, tingly kind of curious about something a little mysterious?"
 - prompt: "Her silver arc fades within a minute, but the children remember it for far longer. What is a quiet moment you've felt stay with you long after it ended?"



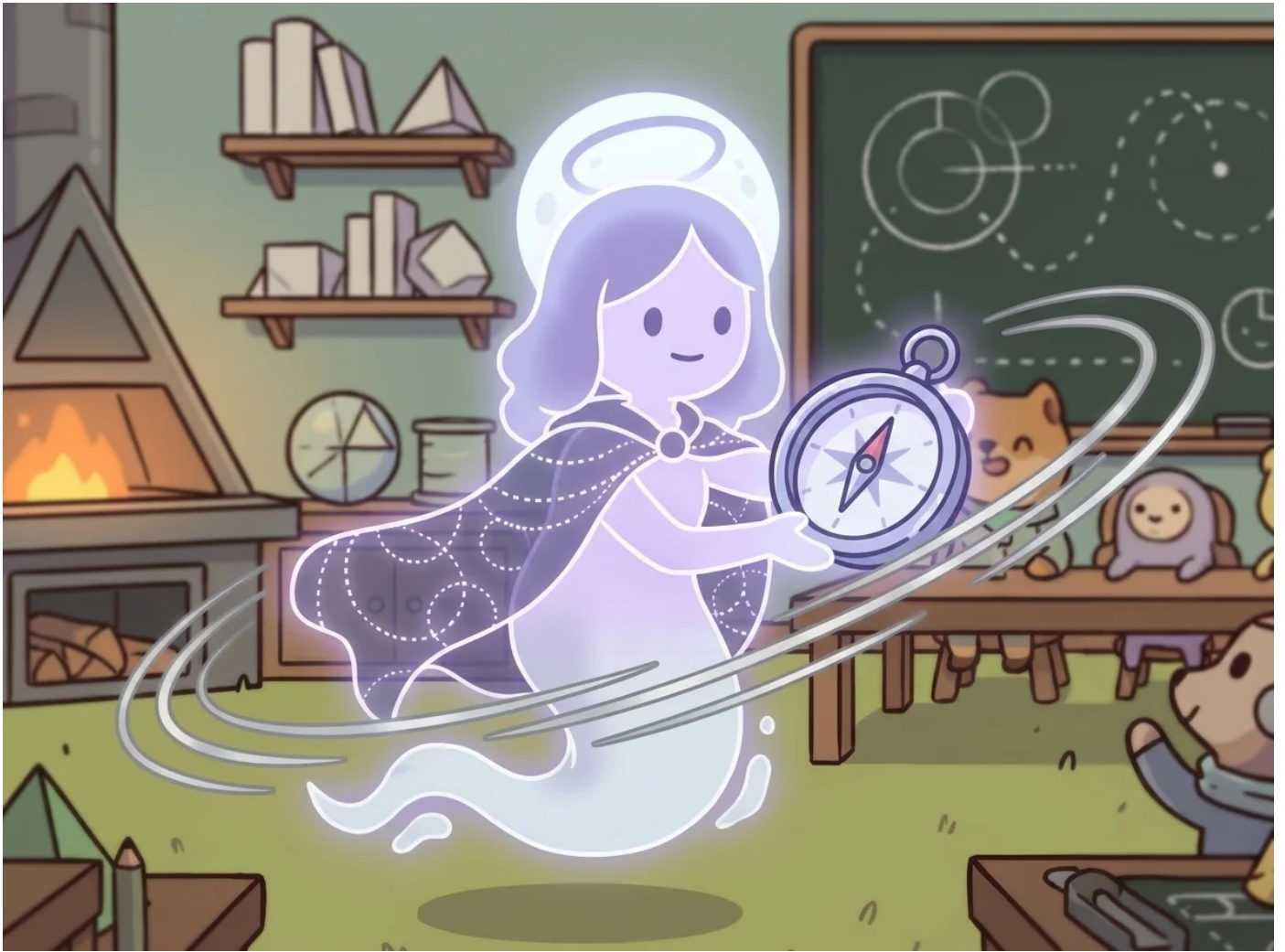
This is a thing that needs to be said at the start, because the other GeometryForge cast members are all — Master Hypotenuse, Sir Transverse, Apprentice Sides, Axia, Theora, Captain Construction, Lady Inscribed-Angle, Madame Polygon, Master Tangent — *alive*. They eat, they sleep, they go home for holidays, they have favourite teas. The Compass Wraith does not eat. The Compass Wraith does not sleep. The Compass Wraith does not have a favourite tea.

The Compass Wraith is a spirit.

She is translucent — pale violet, with a moonlight halo. Her lower body fades into mist. She wears a cape woven from dotted lines, like the tracing-paths a compass leaves. She holds a glowing compass that traces silver arcs through the air. She moves without footsteps.

The other cast members accept this cheerfully.

Children find her, on the first day they meet her, *slightly thrilling*. They are not afraid of her. (She is, despite being a spirit, *kind*.) But they are aware that she is unusual. They watch her closely. They ask the other cast members about her. The other cast members shrug and say: "*She has always been here. The academy is older than any of us. The Compass Wraith was here before the academy was here.*"



The Compass Wraith — whose name, the academy master has been told, is *Lune* (though she has never confirmed this) — appears in the geometry curriculum whenever a problem asks the question:

"Where could the point be?"

Not — and this is important — *"where is the point?"* The point's location is, in those problems, *not yet known*. The problem gives a condition. The condition is something like: *"a point five paces from this rock"* or *"a point that is equidistant from these two trees"* or *"a point that is closer to the river than to the road."* The problem then asks the student to draw, on a map or a diagram, *all the places the point could possibly be*.

The set of all such places is called *the locus*.

Most loci are circles, lines, or arcs of circles. (The locus of points five paces from a rock is a circle of radius five centered on the rock. The locus of points equidistant from two trees is a perpendicular line bisecting the line between the two trees. The locus of points closer to a river than to a road is a region — bounded by a parabola, but children do not need to know that yet.)

Working out a locus is not easy for children. It requires *thinking about all the possibilities at once* — which is a habit of mind children do not naturally have. They want to find *the* answer. They do not want to find *all possible* answers.



When a locus problem appears in a kit, the Compass Wraith *materializes*. She does this without warning. The classroom is in the middle of a discussion about some other topic. Suddenly the air shimmers, slightly. A pale violet figure appears at the front of the room. Her glowing compass is in her hand. She raises it. She turns slowly. The compass traces a silver arc through the air.

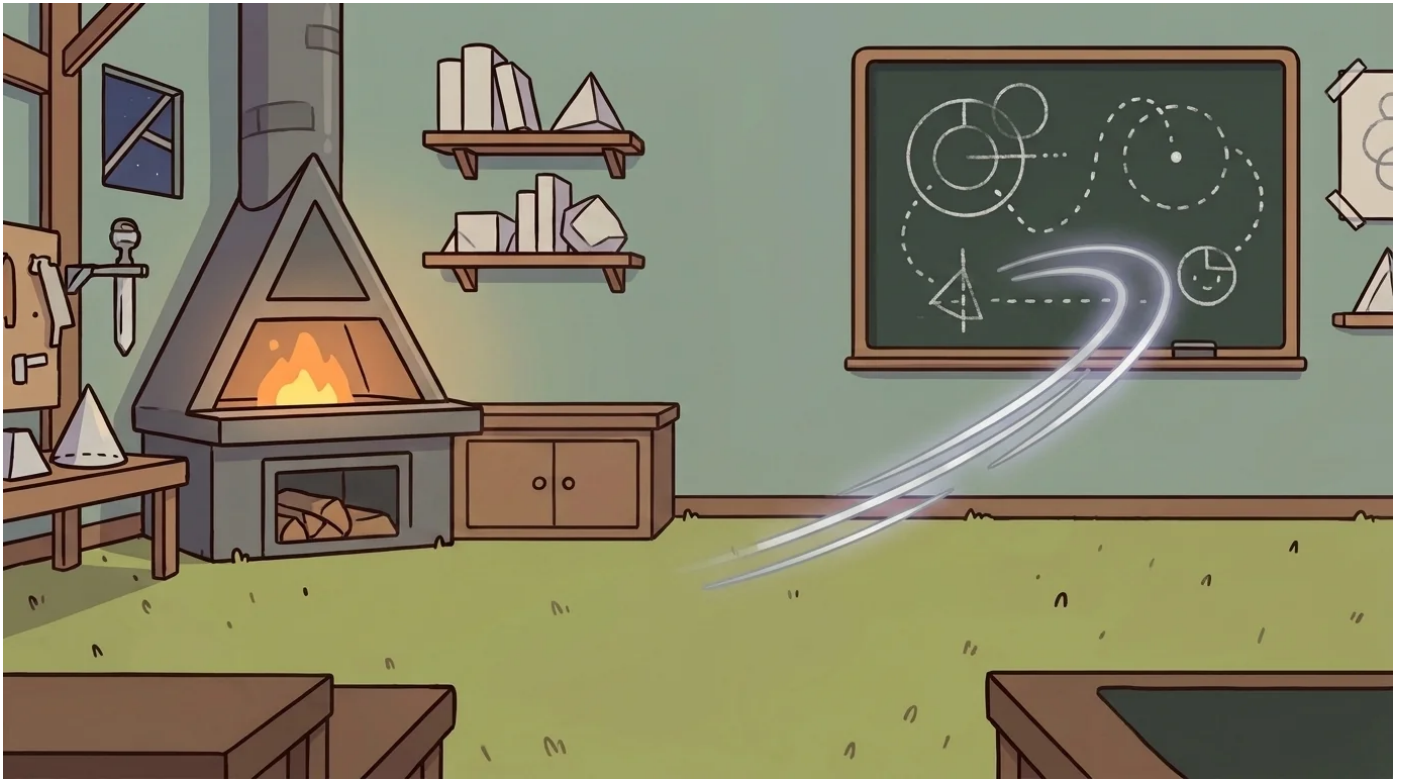
The arc is the locus.

The Compass Wraith does not, usually, speak. She simply *shows*. The children watch the silver arc unfold. They see the set of all possible points. They understand, viscerally, what *locus* means.

Sometimes she does speak. When she does, her voice is airy and slightly distant, but warm. She says things like:

"Every point that is equally far from here. I show you all of them at once."

Or:



And then the silver arc traces the answer.

When the locus is a circle, she draws a perfect circle. When the locus is a line, she walks a perfectly straight path. When the locus is more complex — an arc, a pair of lines, a region — she shows it in soft silver outlines that hang in the air for a few seconds before fading.

Then she vanishes.

The other cast members are used to this. The other cast members will be in the middle of a sentence and the Compass Wraith will appear, do her work, and disappear, and the cast member will simply continue the sentence. (Sir Transverse, who is the most matter-of-fact of the cast, has been known to say *"Thank you, Lune"* without breaking his stride. The Compass Wraith, even mid-vanish, nods at him.)

Children eventually come to look forward to her arrivals. They ask: *"Will the Compass Wraith come today?"* And Lady Inscribed-Angle, who knows the curriculum's locus-problems by heart, will say: *"Yes. Around the middle of the lesson. She always comes when there is a circle to draw."*

The Compass Wraith does not, as far as anyone can tell, age. She has been doing this work — whatever exactly this work is, in whatever realm she inhabits when she is not appearing in classrooms — for as long as anyone at the academy can remember. She is the academy's quietest faculty member and also, the academy master sometimes thinks, *the most reliable*.

Madame Polygon

REGULAR POLYGONS — interior-angle sum is $(n-2) \cdot 180^\circ$. Exterior-angle sum is always 360° . Regular n -gons have n -fold rotational symmetry. Some regular polygons tile the plane; some do not.



- "60"
- "120"
- "x"
- "y"
- "z"
- "60°"
- "120°"
- "30°"
- "90°"



reflection-prompts:

- prompt: "Madame Polygon still loves the children's gasp when her fan opens, even after fourteen years. What is something small that still makes you feel a spark of delight, no matter how many times you see it?"
- prompt: "As a girl, Polly noticed that pentagons just wouldn't fit together without gaps. Have you ever felt bothered, in a good curious way, by something that almost fit but didn't quite?"
- prompt: "She says polygons are not abstract — each one has its place, like a citizen. Have you ever felt more at ease once you understood where something (or someone) belonged?"

Madame Polygon is *the spokesperson of the Polygon Council*.



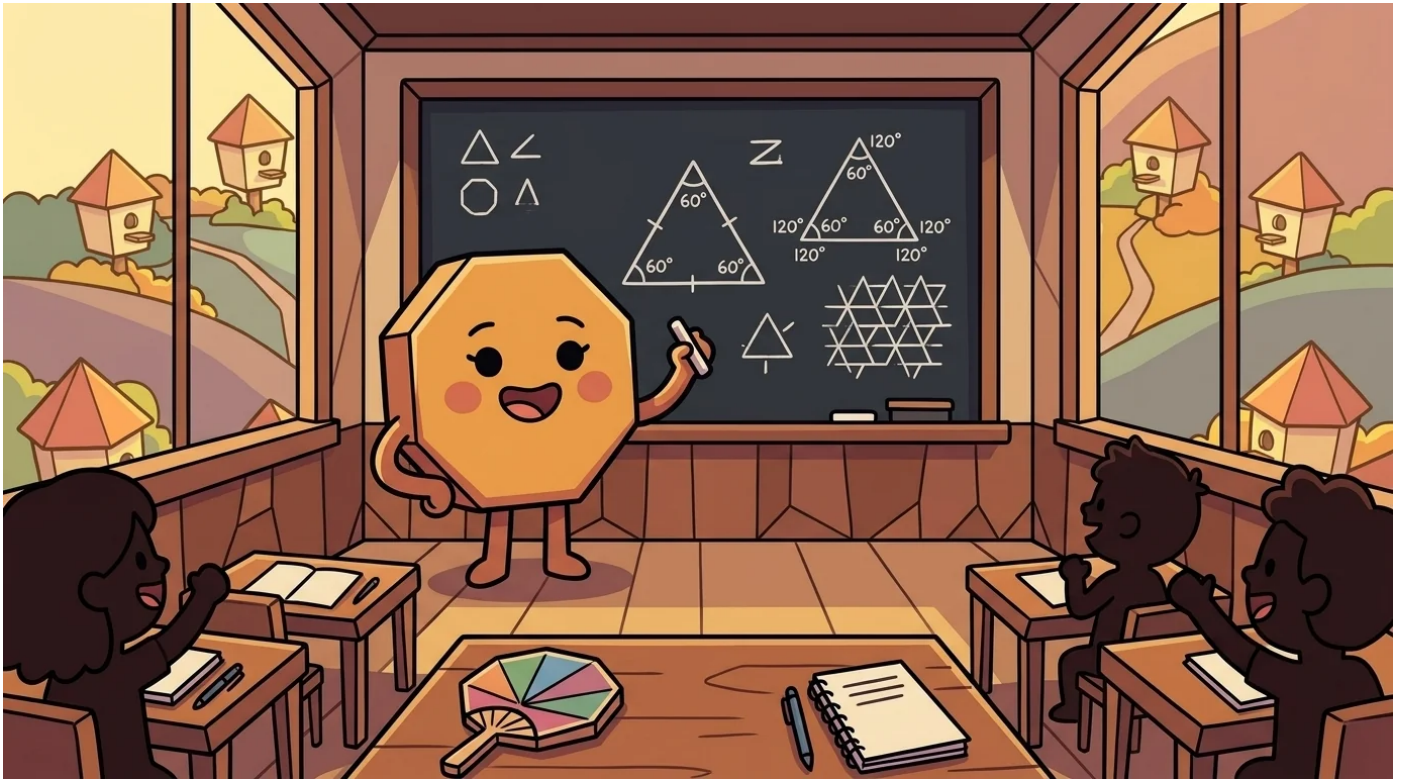
But the Polygon Council *does* meet. They meet in the kingdom's eastern hills. They have met there forever. The Council gathers in the town hall. It's in the village of *Tessellation*. Locals say polygons built this village. Not people.

Every street in Tessellation is a polygon side. Every building is sided by a regular polygon. The market square is a hexagon. The town hall is a dodecagon. Even the dovescotes are pentagons. There are six of them! The whole village fits like a puzzle. Kids in Tessellation know their shapes. They can spot a twenty-sided polygon. Even from far away. Even in the dark.

Madame Polygon grew up in Tessellation.

She was the oldest of three sisters. Her family name was Polygon. Her younger sister was Hexa. Hexa was very good with hexagons. Her youngest sister was Octavia. Octavia lived in the dodecagon town hall. She ran the regional tile shop. You won't meet Hexa or Octavia today. They pop up later in Kit 13.

Madame Polygon's real name is *Polly*. The academy kids find this out later. They always love it. Polly joined the Polygon Council at twenty-six. The Council needed a spokesperson. For years, they had none. The old one was a heptagon. A very proper seven-sided shape. He just wanted to relax. He liked his seven-sided life. He would not come back.



Polly was the perfect choice. She had spoken for polygons since she was seven.

This was normal in Tessellation. Kids there played with polygons. But Polly was extra good. Even for Tessellation. At seven, she taught her cousins. They were only four. She showed them pentagons and hexagons. They just wouldn't fit together. Not without gaps. The angles didn't make a full circle. Not where they touched.

At twelve, she could do math on a slate. She found the *inside angle* for any shape. It was a special formula: *interior angle equals $(n-2) \cdot 180^\circ$ divided by n* . She showed her younger cousins how it worked. You cut the shape into triangles. Just draw lines from one corner. It always made $(n-2)$ triangles.

At sixteen, she knew even more. Only three shapes fit perfectly together. Triangles, squares, and hexagons. No gaps at all. Their angles fit exactly into a circle. She could draw all three tilings on a slate. Her chalk never left the slate.

The GeometryForge academy needed a teacher. Someone to teach shapes to kids. The Polygon Council picked Polly. Everyone agreed. Polly was twenty-seven. She had been spokesperson for one year. She said yes. She has taught there for fourteen years now.



Her dress has many shapes. Different ones. She carries a fan. It folds up small. With one flick, it opens wide. It becomes a perfect dodecagon. Twelve sides. She picked twelve sides on purpose. She says dodecagons are *underrated*.

The children love her. They draw her in their notebooks. They even try to make their own shape-fans.

In her classroom, she starts every first-day lesson the same way. She walks in. She puts her dodecagon-fan on the desk. She turns to face them. Her voice is big and dramatic. Like a Council meeting.

"The Council convenes. Each polygon has its angles, its symmetry, its place. Today we begin with the regular triangle. We will work our way up."

Then she teaches about the regular triangle. It has three sides. Inside angles are 60 degrees. Outside angles are 120 degrees. It can spin three ways. It fits together with other triangles. She teaches it slowly. Very grand. The children are confused at first. But they start to like it. By the end, they know many shapes. Triangle, square, pentagon, and hexagon. They can even say the interior-angle sum formula.

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. GeometryForge 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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