

Part I — Framing

What Is a Diagram For?

Online, with a lab for each exercise: thinking-in-diagrams.aryehnielsen.com

All six diagram types Part I · Framing · Chapter 1 of 12 · the opening chapter

What does a diagram show that a paragraph doesn't? A diagram puts every *cause* of a quantity at that quantity, shows a circle that a paragraph's order hides, and, with dashed lines, shows *which* effects its author judges less supported.

Empty shops on the high street

The spring newsletter of a market town's traders opened with this paragraph:

Since the council raised parking charges, fewer people come into town. The council's own footfall counter shows visitors down by a fifth over two years, and our own figures show takings per shop falling with them, month by month. Seven shops have closed, and every owner gave falling takings as the reason. Every empty shop gives people one less reason to come, so fewer still come. Some blame online shopping, but people shopped online before the charges went up.

What the notation expresses

Variables

A **variable** is a quantity that can rise or fall, named as a noun phrase: *visitors to the high street*, *takings per shop*.

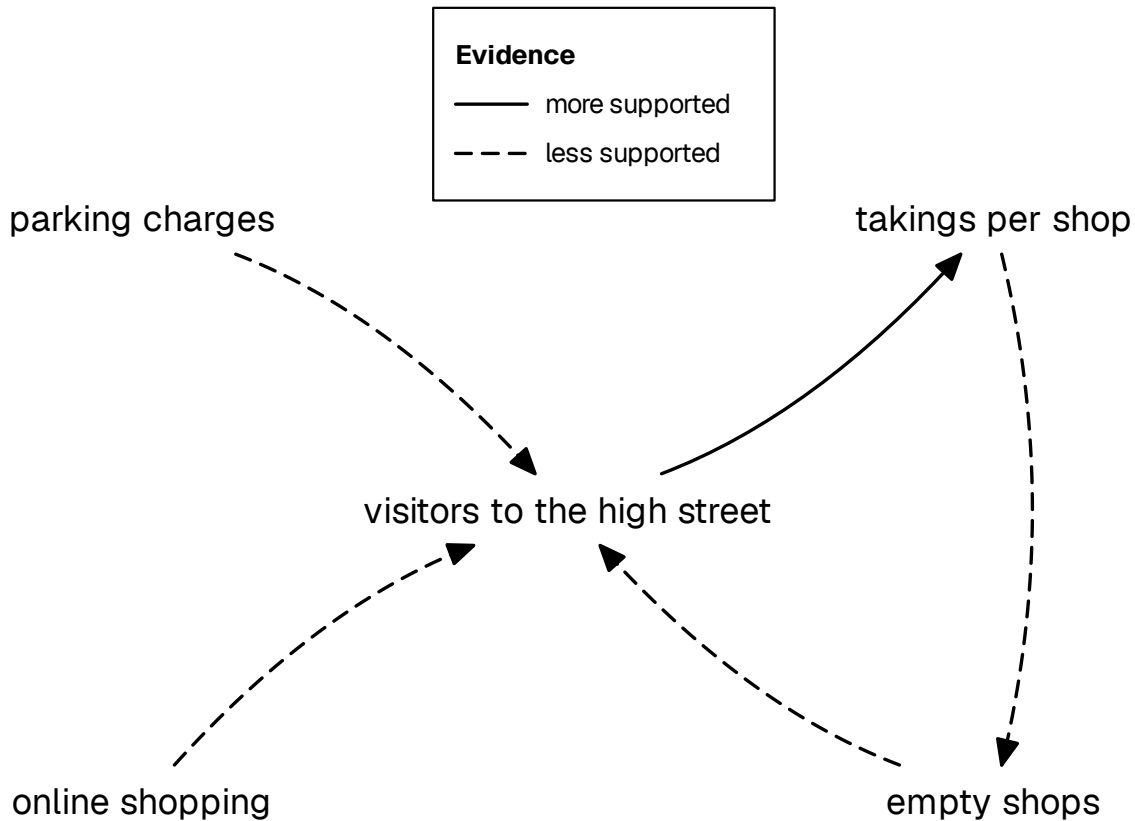
An action is not a variable: *shoppers stay away* names something that happens, and *visitors to the high street* names what rises or falls when it does. The test for a name is in chapter 4

thinking-in-diagrams.aryehnielsen.com/feedback/loops-that-amplify-loops-that-correct/#variables.

Effects

An **effect** is a line with an arrowhead from one variable to another: a change in the first changes the second.

Takings per shop → *empty shops*: as takings fall, shops close.



Every figure in the chapter is the start of a causal loop diagram, whose effects gain a polarity, + or –, for which way the change runs: by the upgrade thinking-in-diagrams.aryehnielsen.com/framing/surfacing-influences/#causal-claims in chapter 3, where a direction has been measured, and on every effect in chapter 4 thinking-in-diagrams.aryehnielsen.com/feedback/loops-that-amplify-loops-that-correct/#polarity.

Evidence coding

Evidence coding shows the author's judgment of how well supported each effect is as a causal mechanism: in a diagram with a dashed effect, a solid effect is one the author judges *more supported*, and a dashed one *less supported*, a hypothesis. A dashed line means nothing else in this book.

Support comes in kinds, some stronger than others: a comparison of places where the first variable changed with places where it didn't; a count of the second changing alongside the first; an explanation of how the first changes the second; testimony; a hunch. Where the line between solid and dashed falls is the author's decision: one author draws solid only what a comparison supports, another anything better than a hunch, and a reader can question either.

The traders draw theirs at a count. They counted takings falling with visitors, month by month, and draw *visitors* → *takings* solid; the owners' reasons for closing are testimony, and *takings* → *empty shops* is dashed, though a trader who took the owners at their word could draw it solid.

A variable counted alone supports no effect. The footfall counter measures *visitors to the high street*, down by a fifth, but nobody counted visitors *alongside* a change in the charges, in online shopping or in empty shops, so the

traders dash those three effects too.

A diagram with no dashed effect carries no coding: its solid effects are its author's claims, their support unrecorded.

CHECK YOUR UNDERSTANDING

A neighbour is sure the new streetlights on her road have cut burglaries there, and draws streetlights on the road → burglaries on the road as a solid effect. Which of these would give her the strongest grounds for drawing it solid?

- a Burglaries on her road counted for a year before the lights went in and a year after
- b The police count showing twelve burglaries on her road this year
- c Her twenty years on the road, and how sure she is

Feedback: Answers, chapter 1

The legend

The **legend** is a box listing the codings a diagram uses; any diagram with a dashed effect must have one. Its evidence entry shows a solid line for *more supported* and a dashed line for *less supported*. It also lists any viewpoint tags thinking-in-diagrams.aryehnielsen.com/feedback/delays-drivers-and-competing-loops/#viewpoint-tags, chapter 5's small boxes naming who stresses an effect.

The drawing and the paragraph

The paragraph runs from the charges to the shops; the drawing shows four things its order hides:

- **A circle.** *Fewer still come* leads back to the first variable: *visitors → takings → empty shops → visitors* is a closed path, in chapter 4 a loop
thinking-in-diagrams.aryehnielsen.com/feedback/loops-that-amplify-loops-that-correct/#loops.
- **Two causes at one variable.** Parking charges and online shopping both end at *visitors to the high street*. The traders blame one and dismiss the other, on the same evidence: none.
- **Causes with nothing into them.** Nothing drawn changes the charges or online shopping.
- **Where the traders draw the line.** Of the circle's three effects, only *visitors → takings* is solid.

In the paragraph, what bears on visitors is spread over three sentences; in the drawing, it is the three lines ending at *visitors*. A diagram puts at one place what is used together, and shows what a paragraph leaves to be worked out (Larkin and Simon, 1987).

Reading someone else's diagram

Of each effect, solid or dashed, ask what changes; whether a change in the first changes the second, or only comes before it; and how anyone knows. Of the coding, ask where the author drew the line between solid and dashed, and whether you would draw it there: a solid effect is its author's judgment, not proof that one change causes the other. Of the whole, ask what is missing: a cause nobody drew, or an effect that would close another circle.

The lab's checks test structure, never whether an effect holds: a check counting dashed effects passes a diagram with the *wrong* ones dashed.

CHECK YOUR UNDERSTANDING

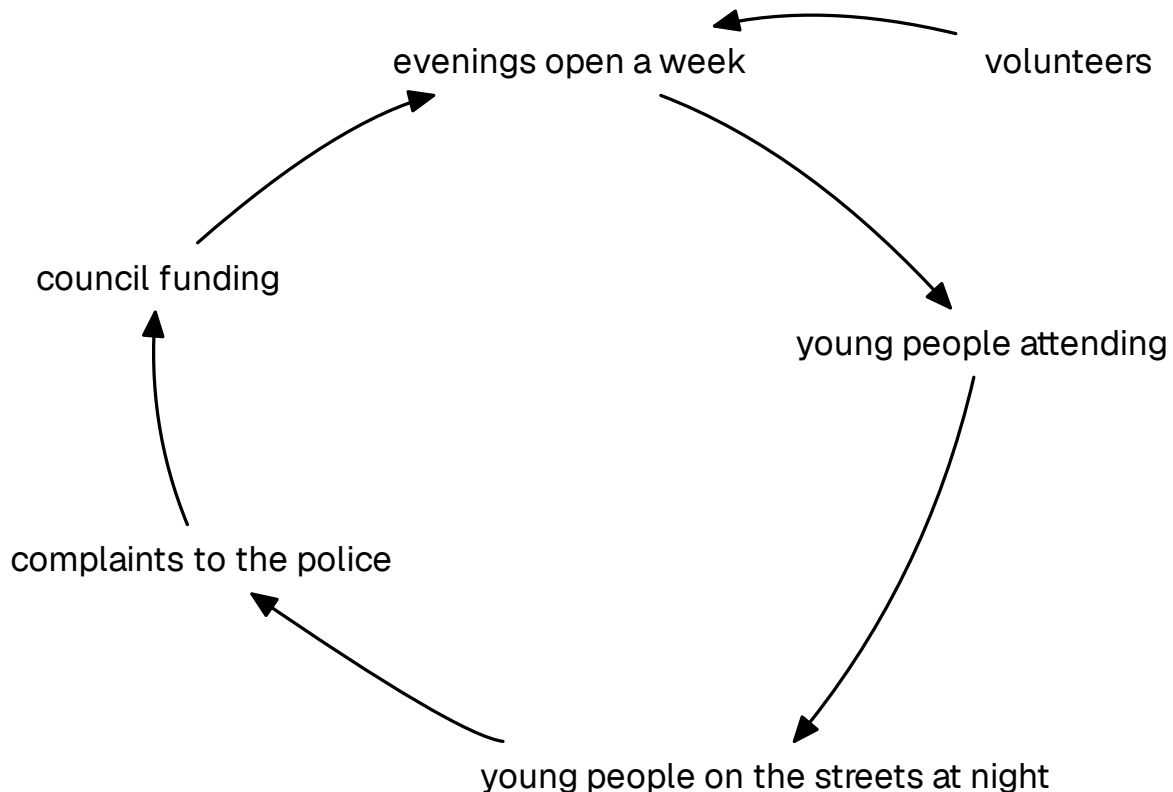
A florist draws roadworks on her street → customers a day as a solid effect: her till shows customers fell by a third the week the roadworks began. Which question about that effect has her till left open?

- a** Whether the roadworks changed her customers, or only came before the fall
- b** What changes
- c** Whether customers fell

Feedback: Answers, chapter 1

The bad diagram

What's wrong with this diagram, from a youth club's bid to the council for another year's funding?



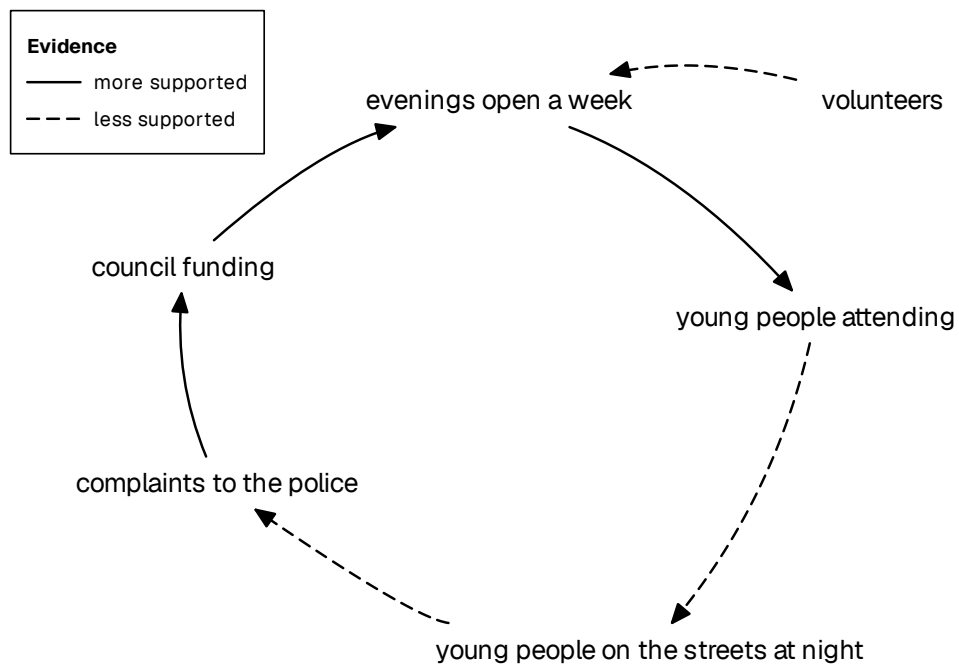
Every effect is solid, and three rest on counts: the club's sign-in sheets count attendance by evening, the council publishes its youth grant each year beside complaints to the police in the club's area, and the club's accounts show how many evenings the grant pays for. That attending keeps young people off the streets at night, that fewer on the streets means fewer complaints, and that more volunteers would open more evenings are the club's beliefs. The club draws no line between counts and beliefs, so a reader can't tell the sign-in sheets from a belief about the streets at night.

The corrected diagram

Bad diagram



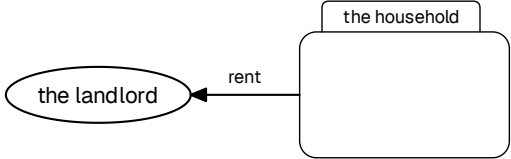
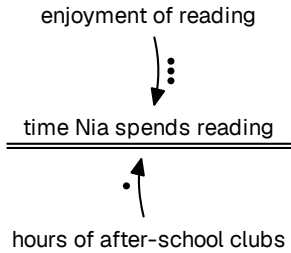
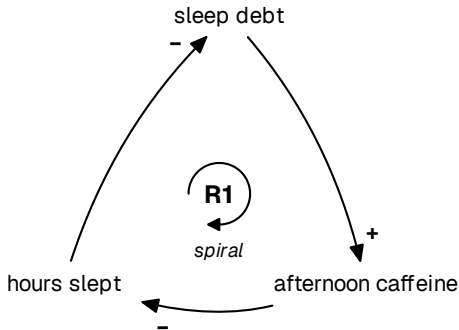
Corrected diagram



Labels unchanged. 3 effects dashed as less supported: young people attending → young people on the streets at night, young people on the streets at night → complaints to the police and volunteers → evenings open a week; legend switched on.

A count of young people on the streets near the club, on nights it opens and nights it doesn't, would give the club grounds to draw *young people attending* → *young people on the streets at night* solid.

The central diagram types

Type	Adds to variables and effects	Chapters
system context map thinking-in- diagrams.aryehnielsen.com/framing/drawing-the-boundary/#what-the-notation-expresses	A named boundary, the parties outside it in ovals, and named exchanges crossing it, in place of variables and effects	2
		
influence map thinking-in- diagrams.aryehnielsen.com/framing/surfacing-influences/#what-the-notation-expresses	Influence claims, effects with no polarity; weight in dots; one central outcome; clusters	3
		
causal loop diagram thinking-in- diagrams.aryehnielsen.com/feedback/loops-that-amplify-loops-that-correct/#what-the-notation-expresses	A polarity on every effect; loops; delays; boundaries and external drivers	4–5
		

Type	Adds to variables and effects	Chapters
stock & flow diagram thinking-in-diagrams.aryehnielsen.com/accumulation/what-accumulates/#what-the-notation-expresses	Stocks, the flows that fill and drain them, clouds, and signals carrying readings to flows and to other variables	6–7
feedback control diagram thinking-in-diagrams.aryehnielsen.com/control/sense-compare-correct/#what-the-notation-expresses	A role written above each variable that plays one, over the causal loop diagram's marks, its effects called signals; where the controlled variable accumulates, a stock and its flows	8–9
system archetype thinking-in-diagrams.aryehnielsen.com/pattern-and-judgment/structures-that-recur/#what-the-notation-expresses	A declared archetype and roles, over the causal loop diagram's marks	10–11
Archetype: fixes that fail 		

Which type to draw for which question is in chapter 12

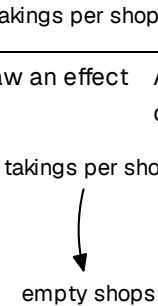
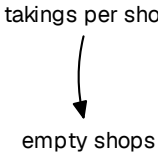
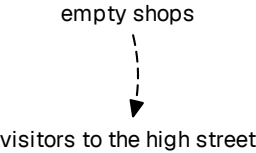
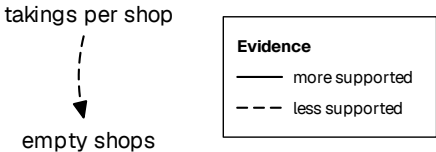
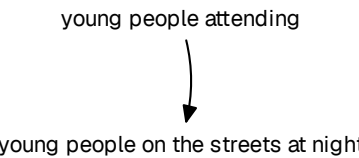
thinking-in-diagrams.aryehnielsen.com/pattern-and-judgment/choosing-the-diagram/#what-each-type-answers. You draw each exercise as one type in the lab, with only the marks you need for it.

What stays informal

One claim, or several that don't meet, go in a sentence: *the charges keep shoppers away*. Causes with no effects between them go in a list. The chapter's figures show no direction, amount or timing; each is drawn from a later chapter on. Each type's case for a sentence instead is in chapter 12

thinking-in-diagrams.aryehnielsen.com/pattern-and-judgment/choosing-the-diagram/#when-not-to-draw.

Notation moves

Notation move	When	What it shows	Example
Name a variable		What rises or falls	<i>takings per shop</i> , not <i>shops lose money</i>
			
Draw an effect	A change in one quantity changes another	What changes what	<i>takings per shop</i> → <i>empty shops</i>
			
Dash a hypothesis	You judge the effect less supported	Where you drew the line between more and less supported	<i>empty shops</i> → <i>visitors to the high street</i>
			
Add a legend	An effect is dashed	The codings in use	<i>Evidence: more supported, less supported</i>
			
Ask how they know	You read someone else's diagram	What supports each effect, and where the author drew the line	<i>young people attending</i> → <i>young people on the streets at night</i>
			

Common misreading

Read one way, a solid effect is proven everywhere. Its support was gathered *somewhere*, under some conditions: induced traffic, solid on chapter 5's road

thinking-in-diagrams.aryehnielsen.com/feedback/delays-drivers-and-competing-loops/#evidence-coding, was found across American cities (Duranton and Turner, 2011), and a town of another shape may differ.

Read the other way, a dashed effect is false, or minor. It is less supported, not less important: the high street's dashed *empty shops* → *visitors* closes the circle.

The strongest objection

Evidence comes in degrees, and the coding has two: an effect counted in one town and one counted in twenty are drawn with the same solid line. The IPCC's authors grade evidence as *limited*, *medium* or *robust*, agreement as *low*, *medium* or *high*, and an outcome's likelihood in seven steps, from *virtually certain* to *exceptionally unlikely* (Mastrandrea and others, 2010).

With the coding, each effect carries one answer, which side of its author's line it falls on, readable at a glance. Where the line falls, and the degrees on either side of it, go in the sources and the prose beside the drawing, where the IPCC's authors put theirs: a *traceable account* of each finding's evidence, in the text.

Check your understanding

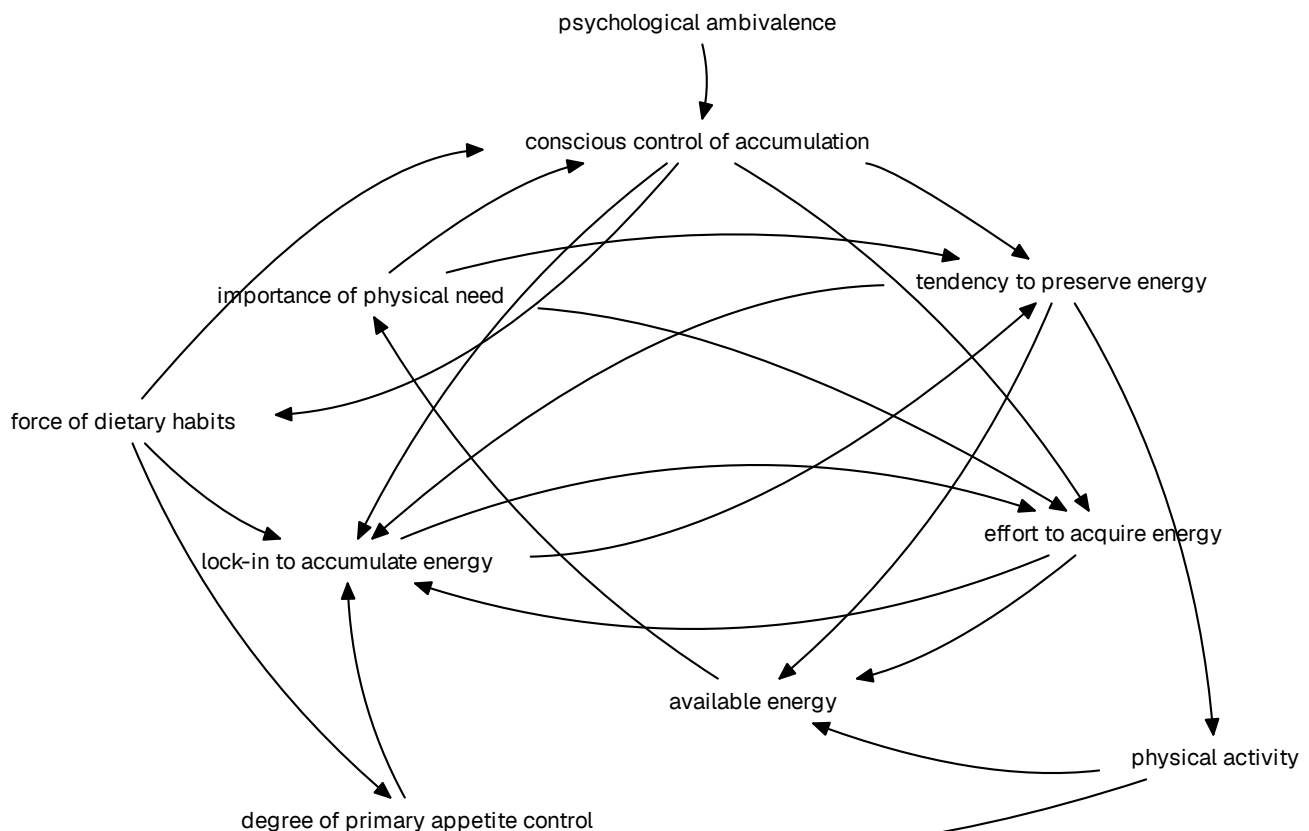
CHECK YOUR UNDERSTANDING

A theatre company's report to its funders has a diagram of nine variables and twelve effects, every effect solid, and no legend. What can a reader tell from it about the evidence for each effect?

- a Every effect is well supported
- b Every effect is a hypothesis
- c Nothing: each effect's evidence has to be asked about

Feedback: Answers, chapter 1

Foresight's obesity system engine, redrawn



Redrawn from Philippe Vandenbroeck, Jo Goossens and Marshall Clemens, Tackling Obesity: Future Choices – Obesity System Atlas (Foresight, Government Office for Science, 2007)

assets.publishing.service.gov.uk/media/5a7b881fed915d4147620fb2/07-1177-obesity-system-atlas.pdf, Map 19, System Engine + 4 Key Variables.

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www.nationalarchives.gov.uk/doc/open-government-licence/version/3/.

Map 19's ten variables, of about 110 in the whole map, and the 22 effects among them; its solid arrows, marking a positive influence, and its dotted lines ending in a square, marking a negative one, all drawn solid with an arrowhead and no polarity; its colors and the thick bands marking the engine left out; its names lowercased, two shortened.

QUESTION 1 OF 3

Which of these effects could a study support by counting the change in the second variable alongside a change in the first?

- a Psychological ambivalence → conscious control of accumulation.
- b Physical activity → available energy.
- c Every effect, since each is drawn with an arrowhead.

QUESTION 2 OF 3

In the source, twelve of these effects are dotted lines ending in a square. What did that line mean there, and why are those effects drawn solid here?

- a That the effect was less supported, as a dash means here.
- b A weaker effect than a solid line.
- c A negative influence, the second variable moving opposite to the first; here a dash means less supported, a hypothesis, so they are drawn solid, with no polarity.

QUESTION 3 OF 3

No effect here is dashed. Which of the solid effects did the atlas's authors judge more supported?

- a Nobody can tell from the lines: a diagram with no dashed effect carries no coding.
- b All of them: a solid effect is more supported.
- c None of them: with no legend, a solid effect is a hypothesis.

Feedback: Answers, chapter 1

Exercises

Passing the checks means meeting the brief, not being right.

DF 01 Greta's morning drawing

A paragraph drawn

Reasoning ●○○○○ 1 of 5 Polish ●○○○○ 1 of 5

Greta draws for twenty minutes before work each morning and keeps a log. After three months she wrote in it: “I time one sketch every morning, and it now takes me five minutes, down from nine. My times fell fastest in the weeks I drew longest, and not at all in the fortnight I was ill and barely drew. Beside each sketch I mark from one to five how much I enjoyed the session, and the mornings I sketched fastest are the ones I marked highest. On those mornings I keep going past twenty minutes, and the log shows it. I started an online course in January, and I think its lessons have made me faster too, but I've kept no count of the lessons beside my times.”

The brief

- ☐ Draw four variables.
- ☐ Draw an effect wherever Greta writes that one quantity changes another.
- ☐ Code the one effect with the weakest support as a hypothesis, so it is drawn dashed.
- ☐ Each name is a quantity that can rise or fall: minutes drawn each morning, not draws every morning.
- ☐ The effects close a circle.

Your palette



Draw here

A large grid of dots for drawing the diagram.

DF 02 Esther's grandchildren's visits

Two readings of one calendar

Reasoning ●●○○○ 2 of 5 Polish ●○○○○ 1 of 5

Esther marks each visit from her grandchildren on her kitchen calendar. “Until my son's family moved two hours' drive away, they came every month. Since the move they've come four times a year, and the calendar shows the drop from the first month after it. Last spring the eldest took a Saturday job at a bakery, and I think that keeps them all away now, though I haven't compared the calendar with her shifts. And I think the less often the children come, the less they want to come, and the less they want to, the less often they come. I haven't asked them.” Her son agrees that the drive cut the visits, and says it alone explains them.

The brief

- ☐ Draw four variables.
- ☐ Draw an effect wherever Esther or her son says one quantity changes another.
- ☐ Code the three effects with the weakest support as hypotheses, so they are drawn dashed.
- ☐ Each name is a quantity that can rise or fall: visits a year, not the grandchildren visit.
- ☐ Esther and her son disagree only about dashed effects.

Your palette



Draw here

A large grid of dots for drawing the diagram.

DF 03 Hedgehogs in Britain's countryside

Sorting a report's evidence

Reasoning ●●○○○ 2 of 5 Polish ●●○○○ 2 of 5

A county wildlife trust's newsletter sums up the report The State of Britain's Hedgehogs 2022 for its members. "Surveys show rural hedgehogs down by between a third and three-quarters in twenty years. Fewer are found dead on roads too, perhaps three-quarters fewer since 1990, though traffic has grown: with fewer hedgehogs about, fewer are killed. Whether road deaths are behind the decline, the report's authors call unclear. Badgers eat hedgehogs and compete with them for earthworms and beetle larvae, and the authors call it likely that badgers reduce hedgehog numbers where there are many of them. Studies show that wide, grassy field margins hold more earthworms and ground beetles; whether hedgehogs are fewer where their prey is scarcer is among the questions the authors list as still being studied. Researchers found that on arable land hedgehogs seek out village gardens to feed and are densest there, and a small hole at the foot of a fence opens one garden to the next."

The brief

- ☐ Draw at least five variables.
- ☐ Draw an effect wherever the report's authors find or suspect that one quantity changes another.
- ☐ Code at least two effects as hypotheses, so they are drawn dashed.
- ☐ Each name is a quantity that can rise or fall: hedgehogs killed on roads each year, not roadkill.
- ☐ An effect is solid where you judge its support strong enough; when the authors call an effect likely, that is testimony, weaker than a count.

Your palette



Draw here

A large grid of dots for drawing a diagram.

A circle closed by a model

Notes from ESA's Space Environment Report 2026 and NASA's Orbital Debris Quarterly News. Launches add satellites to orbit, and 2025 had the most launches yet counted. Satellites leave orbit at the end of their life, brought down or left to fall: 1,200 intact satellites and rocket stages re-entered the atmosphere in 2025. On 10 February 2009 the working satellite Iridium 33 and the disused Cosmos 2251 collided at more than 11 km a second; both broke apart, and by the end of March 823 of their larger fragments had been catalogued. More fragments come from satellites and rocket stages that break apart without a collision, which ESA counts as the largest source of fragments today. Accidental collisions are few: Iridium 33 and Cosmos 2251 was the fourth known, and the first between two intact spacecraft. That more satellites and fragments in orbit bring more collisions, enough to set off a cascade of them over the coming centuries, comes from models: Donald Kessler and Burton Cour-Palais's in 1978, and ESA's now.

- ☐ Draw at least five variables, with satellites in orbit and fragments in orbit apart.
- ☐ Draw an effect wherever one quantity in the notes changes another.
- ☐ Code the two effects that come from models, not counts, as hypotheses, so they are drawn dashed.
- ☐ Each name is a quantity that can rise or fall: collisions each year, not a collision.
- ☐ The two dashed effects, from satellites and fragments in orbit to collisions, come from models, not counts, and close the circles.

The diagram illustrates three types of relationships between variables:

- causal**: A solid arrow points from "price" to "sales". Below "price" is the label "variable", and below "sales" is the label "effect".
- evidential**: A dashed arrow points from "training" to "quality". Below "training" is the label "evidence", and below "quality" is the label "coding".
- variable**: The word "customers" is shown without a connecting arrow.

CS 01 Kelsham Primary School: the head teacher's letter

Counts and beliefs in one letter

Reasoning ●●○○○ 2 of 5 Polish ●●○○○ 2 of 5

In October 2026 Ruth Okafor, head teacher of Kelsham Primary School, wrote to parents. “We have 88 pupils on roll this October, against 126 in October 2020. This September 9 children started with us and 16 left, Year 6 among them. The county council's records show each September's starters falling with the births in our villages four years before. Each October's count sets our funding, £4,800 a pupil: when the roll fell to 108 in 2023, it paid for four teachers, not five, and Years 3 and 4 became one class. With 88 pupils in four classes, our classes are small. Some of you tell us that mixed-age classes are why families have moved to Brayford Primary School, and others that small classes are why you stay. Nobody has counted either.”

The brief

- ☐ Draw at least six variables, with the children starting each September and the pupils leaving each year apart.
- ☐ Draw an effect wherever Ruth Okafor writes that one quantity changes another.
- ☐ Code the two effects with the weakest support, the reasons parents give, as hypotheses, so they are drawn dashed.
- ☐ Each name is a quantity that can rise or fall: pupils leaving each year, not families move.
- ☐ An effect is solid where you judge a count by the school or the county council supports it.

Your palette



Draw here

A large grid of dots for drawing.

Sources

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Answers

Chapter 1 · What Is a Diagram For?

A neighbour is sure the new streetlights on her road have cut burglaries there, and draws streetlights on the road → burglaries on the road as a solid effect. Which of these would give her the strongest grounds for drawing it solid?

- a Burglaries on her road counted for a year before the lights went in and a year after
Yes. That counts the change in burglaries alongside the change in the lights, the strongest support of the three. Whether the lights cut burglaries, or only came before a fall on every road, is still to be asked of it; a count on roads without new lights would answer it.
- b The police count showing twelve burglaries on her road this year
Not quite. That counts a variable, burglaries on her road, once: no change in it is counted alongside the lights going in. A variable counted alone supports no effect.
- c Her twenty years on the road, and how sure she is
Not quite. Knowing the road makes her testimony informed, and testimony is weaker support than a count. She may still draw the effect solid; a reader who knows that is all she has can question where she drew the line.

A florist draws roadworks on her street → customers a day as a solid effect: her till shows customers fell by a third the week the roadworks began. Which question about that effect has her till left open?

- a Whether the roadworks changed her customers, or only came before the fall
Yes. The till counted the fall alongside the roadworks, and on that count she draws the effect solid. The same week might have brought rain, a school holiday or a new florist two streets away, and the count would be the same.
- b What changes
Not quite. Customers a day, the variable the effect ends at, is what changes, and the till counts it.
- c Whether customers fell
Not quite. The till counted the fall, in the week the roadworks began; that count is her grounds for drawing the effect solid.

A theatre company's report to its funders has a diagram of nine variables and twelve effects, every effect solid, and no legend. What can a reader tell from it about the evidence for each effect?

- a Every effect is well supported
Not quite. A diagram with no dashed effect carries no coding, so its solid lines don't show where the company drew a line between more and less supported, or whether it drew one. All twelve effects may rest on counts, or none.
- b Every effect is a hypothesis
Not quite. A hypothesis is drawn dashed, and nothing here is. With no coding, an effect resting on a count and one resting on a belief are drawn alike.
- c Nothing: each effect's evidence has to be asked about
Yes. With no dashed effect there is no coding and no evidence entry in a legend. Each line is the company's claim, and how anyone knows is a question for each of the twelve.

QUESTION 1 OF 3

Which of these effects could a study support by counting the change in the second variable alongside a change in the first?

- a Psychological ambivalence → conscious control of accumulation.
Not quite. Neither quantity has an agreed count, so nobody can count a change in one alongside a change in the other without first defining both.
- b Physical activity → available energy.
Yes. Both can be counted: minutes of activity, and energy used against energy eaten. A study counting one alongside the other would support this effect.
- c Every effect, since each is drawn with an arrowhead.
Not quite. An arrowhead shows which way an effect runs, not whether anyone could count it. Lock-in to accumulate energy, for one, has no count to take.

QUESTION 2 OF 3

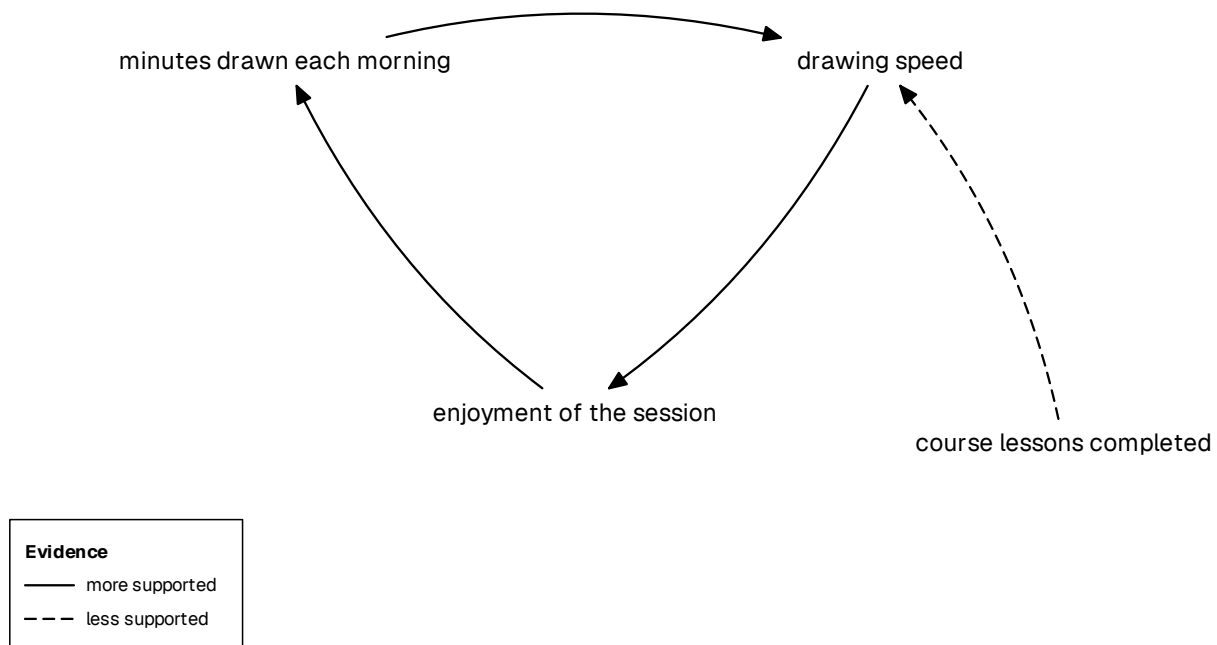
In the source, twelve of these effects are dotted lines ending in a square. What did that line mean there, and why are those effects drawn solid here?

- a That the effect was less supported, as a dash means here.
Not quite. The source's legend reads Negative Influence for that line: the second variable moves opposite to the first. Drawn dashed, the twelve would read as less supported, which the source never says.
- b A weaker effect than a solid line.
Not quite. No line in the source's legend marks how strong an effect is. That line is a negative influence: the second variable moves opposite to the first.
- c A negative influence, the second variable moving opposite to the first; here a dash means less supported, a hypothesis, so they are drawn solid, with no polarity.
Yes. In a causal loop diagram that direction is a – polarity; here no effect carries one. A dash means only that its author judges an effect less supported.

QUESTION 3 OF 3

No effect here is dashed. Which of the solid effects did the atlas's authors judge more supported?

- a Nobody can tell from the lines: a diagram with no dashed effect carries no coding.
Yes. Its solid effects are its authors' claims, their evidence unrecorded. Which rest on counts is a question for the atlas's text and its sources, not for the drawing.
- b All of them: a solid effect is more supported.
Not quite. A solid line reads as more supported only beside a dashed one. With none dashed, the diagram carries no coding.
- c None of them: with no legend, a solid effect is a hypothesis.
Not quite. A hypothesis is drawn dashed. With no dashed effect, the lines say nothing either way.

DF 01 Greta's morning drawing

This is one defensible answer, not the only one. Yours can differ and still hold up: the lab's checks show whether it has the brief's structure.

The minutes Greta draws each morning change her drawing speed, her speed changes her enjoyment of the session, and her enjoyment changes the minutes she draws: three effects whose changes she timed, marked or logged side by side, closing a circle, and she draws each solid. The lessons of the online course change her speed too, an effect she believes and hasn't counted alongside her times, so she dashes it, and the legend lists the dashed line as less supported.

Why it works

- Four quantities, each able to rise or fall
- Three effects Greta draws solid close a circle, each a change she logged alongside another
- Greta's one belief, course lessons completed → drawing speed, dashed
- Legend on, listing the dashed line as less supported

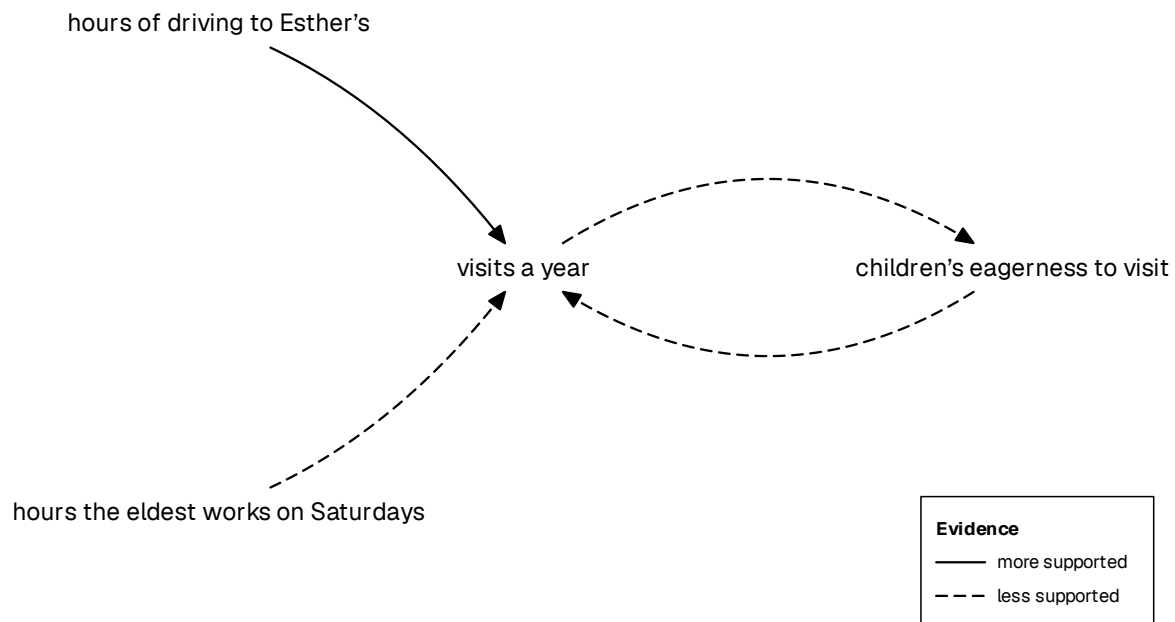
Step by step

1. Minutes drawn each morning and drawing speed, with an effect between them that Greta draws solid: her log opens with her times beside the weeks she drew longest and the fortnight she barely drew.
2. Enjoyment of the session, with a solid effect into it from drawing speed and another from it to minutes drawn each morning, which closes the circle before anything is dashed: her one-to-five marks and her longer mornings are in the log too, so she draws both solid.
3. Course lessons completed, with a dashed effect on drawing speed, and the legend with it, since this is the one dashed line: Greta has no count of lessons beside her times, so she dashes it.

What another defensible answer might vary

Another answer might close the circle from drawing speed straight back to minutes drawn each morning, since Greta's faster mornings are also her longer ones, and leave enjoyment of the session an effect of speed alone. With a fifth variable, beyond this brief's four, another might add sleep the night before as a second dashed effect

on drawing speed. What stays is a circle of solid effects through the minutes she draws, and the course's effect on her speed dashed, with the legend on.

DF 02 Esther's grandchildren's visits

This is one defensible answer, not the only one. Yours can differ and still hold up: the lab's checks show whether it has the brief's structure.

The hours of driving to Esther's changed the visits a year, from twelve to four, from the first month after the move: her calendar counts the change in the visits alongside the move, so she draws the effect solid, and her son agrees with it. She dashes her three beliefs, which no count supports and her son rejects: the hours the eldest works on Saturdays changing the visits, and a circle in which fewer visits lower the children's eagerness to visit and lower eagerness means fewer visits. The legend lists the dashed line as less supported.

Why it works

- Four quantities, each able to rise or fall
- The one effect Esther draws solid, on the calendar's count of the visits alongside the move: hours of driving to Esther's → visits a year
- Esther's three beliefs dashed, the two that close a circle among them
- The solid effect is the one Esther and her son agree on; every dashed one is hers alone
- Legend on, listing the dashed line as less supported

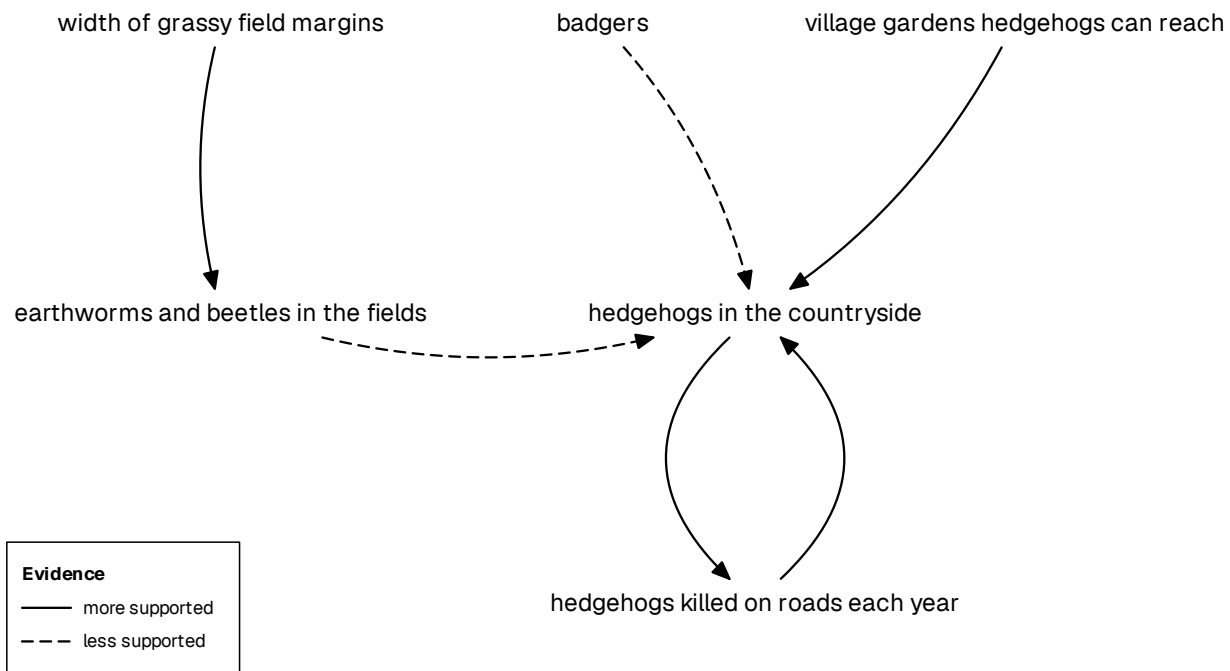
Step by step

1. Hours of driving to Esther's and visits a year, with a solid effect between them, before anything dashed: the calendar is the one count in the paragraph, and Esther draws the effect solid on it.
2. Hours the eldest works on Saturdays, with a dashed effect on visits a year, and the legend with this, the one dashed line so far: Esther hasn't set the calendar beside the bakery shifts, so she dashes it.
3. Children's eagerness to visit, with a dashed effect into it from visits a year and another from it back to them, the circle drawn whole in one step because Esther believes it both ways at once; she hasn't asked the children, so she dashes both.

What another defensible answer might vary

Another answer might draw the Saturday job's effect on the children's eagerness to visit instead of on the visits, still dashed, since Esther hasn't asked the eldest either. What stays is one solid effect from the drive to the visits, every one of Esther's beliefs dashed, and the legend on.

DF 03 Hedgehogs in Britain's countryside



This is one defensible answer, not the only one. Yours can differ and still hold up: the lab's checks show whether it has the brief's structure.

This answer draws its line at a count. Four effects have a change counted alongside another and are drawn solid: wide, grassy field margins hold more earthworms and beetles; the more village gardens hedgehogs can reach, the more hedgehogs, since they are densest there; and hedgehogs and the hedgehogs killed on roads, counted falling together since 1990, change each other. Whether road deaths are behind the hedgehogs' fall, which the authors call unclear, is a question for reading that solid effect. The badgers' effect on the hedgehogs rests on the authors' word that it is likely, weaker support than a count, and the prey's on a question they are still studying, so both fall below the line and are dashed. The legend lists the dashed line as less supported.

Why it works

- Six quantities, each able to rise or fall
- Solid effects where a change was counted alongside another, the line drawn at a count: field margins on prey, gardens on hedgehogs, and hedgehogs and road deaths each on the other
- Dashed effects where the newsletter reports no count: badgers and prey, each on the hedgehogs
- Road deaths drawn both ways, both solid on the one count: which changes which is the question the authors leave unclear
- Legend on, listing the dashed line as less supported

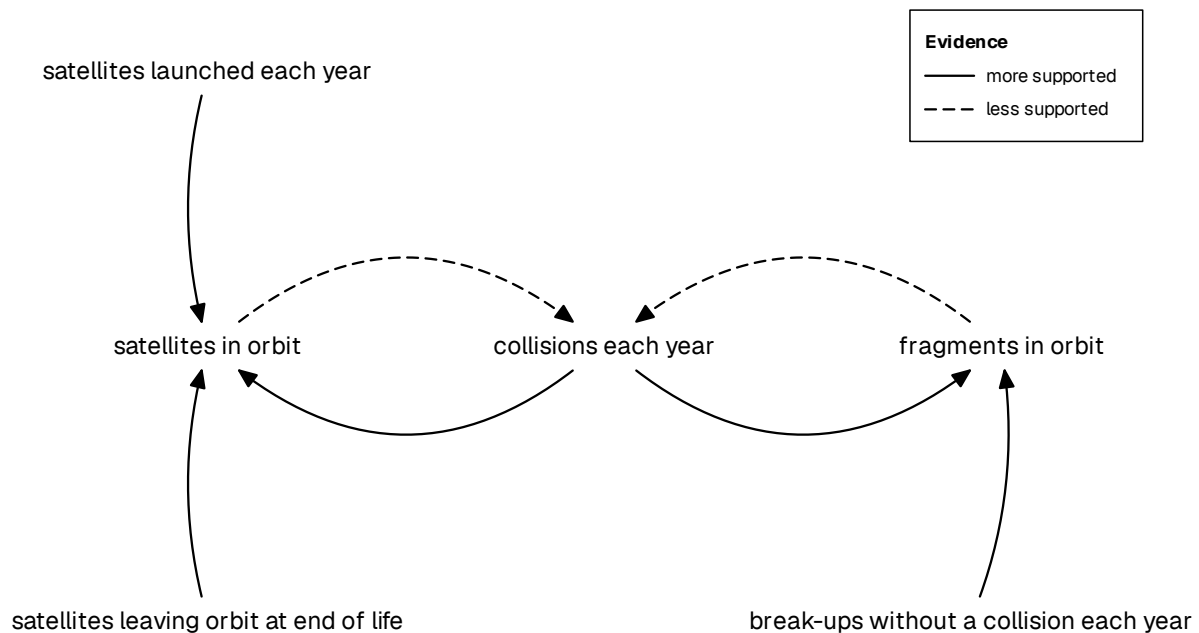
Step by step

1. Hedgehogs in the countryside and hedgehogs killed on roads each year, with a solid effect each way, the line drawn at a count: the newsletter opens with these two counts, both falling.
2. Width of grassy field margins and earthworms and beetles in the fields, with a solid effect between them from the studies of margins; nothing counted joins the prey to the hedgehogs, so no solid effect does.

3. Village gardens hedgehogs can reach, with a solid effect on the hedgehogs, from the researchers' count of hedgehogs densest in village gardens on arable land.
4. Badgers, with a dashed effect on the hedgehogs, and the legend with this, the one dashed line so far: the authors call the effect likely, testimony weaker than a count, so it falls below the line.
5. A dashed effect from earthworms and beetles to the hedgehogs joins the field margins to the rest of the drawing, on a question the authors list as still being studied.

What another defensible answer might vary

Another answer might dash the gardens' effect, since the studies found where hedgehogs feed and are densest, not how many more a hole in a fence adds. Another might add badgers → earthworms and beetles in the fields, dashed, for the food the two compete for, which the newsletter doesn't count. What stays is the badgers' and the prey's effects dashed, and the legend on.

DF 04 Objects in orbit

This is one defensible answer, not the only one. Yours can differ and still hold up: the lab's checks show whether it has the brief's structure.

Five effects rest on counts and are drawn solid: satellites launched each year add to the satellites in orbit, and satellites leaving at the end of their life take from them; collisions each year take satellites out and add fragments, as Iridium 33 and Cosmos 2251 did; and break-ups without a collision each year add more fragments. Two effects come from models, Kessler and Cour-Palais's in 1978 and ESA's now: more satellites and more fragments in orbit bring more collisions. Those two dashed effects close both circles through collisions, so the cascade in the models runs on two less supported effects. The legend lists the dashed line as less supported.

Why it works

- Six quantities, satellites in orbit and fragments in orbit apart
- Five effects the counts support, solid: launches, departures at end of life, the collision's two, and break-ups
- The two modelled effects, satellites in orbit → collisions each year and fragments in orbit → collisions each year, dashed
- Each circle closes through a dashed effect
- Legend on, listing the dashed line as less supported

Step by step

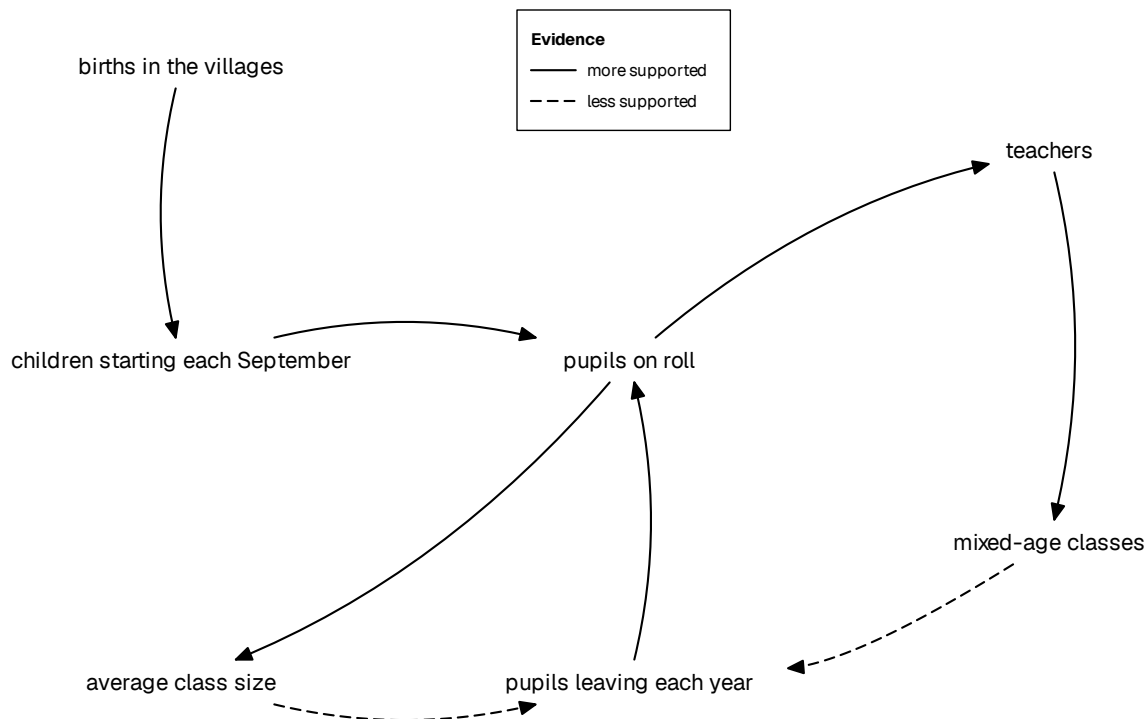
1. Satellites in orbit, with solid effects from satellites launched each year and satellites leaving orbit at end of life, the two counts the notes open with.
2. Collisions each year and fragments in orbit, with solid effects from collisions to satellites in orbit and to fragments in orbit: Iridium 33 and Cosmos 2251 broke apart into 823 catalogued fragments.
3. Break-ups without a collision each year, with a solid effect on fragments in orbit: ESA counts them as the largest source of fragments today.

4. Dashed effects from satellites in orbit and from fragments in orbit to collisions each year, with the legend, after every solid effect: these two alone turn the chain of counts into two circles.

What another defensible answer might vary

Another answer might draw one variable, objects in orbit, for satellites and fragments together, with one dashed effect on collisions; this brief keeps the two apart, since launches and departures change the satellites and break-ups the fragments. Another might leave out collisions each year → satellites in orbit, since one collision took out two satellites. What stays is the effects on collisions dashed, the rest solid, and the legend on.

CS 01 Kelsham Primary School: the head teacher's letter



This is one defensible answer, not the only one. Yours can differ and still hold up: the lab's checks show whether it has the brief's structure.

Six effects rest on counts and are drawn solid: the births in the villages changed the children starting each September four years later; the starters and the pupils leaving each year changed the pupils on roll; the roll, through the funding each October's count sets, changed the teachers, and fewer teachers made Years 3 and 4 one mixed-age class; and the roll in four classes set the average class size. The parents' two reasons, mixed-age classes and average class size each changing the pupils leaving each year, rest on their word and are dashed, and each closes a circle back through the pupils on roll. The legend lists the dashed line as less supported.

Why it works

- Seven quantities, the starters and the pupils leaving each year apart
- Six effects the counts support, solid: births on the starters, the starters and the leavers on the roll, the roll on teachers and on average class size, and teachers on mixed-age classes
- The parents' two reasons dashed: mixed-age classes → pupils leaving each year, and average class size → pupils leaving each year
- Each circle through the pupils on roll closes through a dashed effect
- Legend on, listing the dashed line as less supported

Step by step

1. Births in the villages, children starting each September and pupils on roll, with a solid effect from each to the next, the first counts in the letter: the county council's records and the roll.
2. Pupils leaving each year, with a solid effect on pupils on roll: each October's roll is the last one's plus the starters, less those who left.

3. Teachers and mixed-age classes, with solid effects from the roll to teachers and from teachers to mixed-age classes: in 2023 the roll paid for four teachers, and Years 3 and 4 became one class.
4. Average class size, with a solid effect from the roll: 88 pupils in four classes, counted this October.
5. Dashed effects from mixed-age classes and from average class size to pupils leaving each year, with the legend, after every solid effect: the parents' two reasons, resting on their word, close both circles.

What another defensible answer might vary

Another answer might draw school funding between the pupils on roll and the teachers, since the count sets the funding and the funding pays the teachers, or draw the parents' reasons on the children starting each September as well, still dashed. What stays is the counts' effects solid, the parents' reasons dashed, and the legend on.