DESIGN STUDIO

Catalog

Learning objectives and activities

Ideas you can hold.

219 activities · 652 learning objectives
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How to read this catalog

Every activity is listed with its **learning objectives**: what a pupil can do or explain afterwards. The line under them names the **idea it replaces**, the misconception the activity is built to collide with.

Paper activities print and go. **Paper + GRID** activities have a pupil sheet and run in GRID, Vonk's own spreadsheet in the browser. **Digital lab** activities run in the browser after the paper lesson they belong to: hands first, screen second.

Nothing needs an account, and nothing a pupil does online is stored or sent anywhere.

Level colors groep 5–6 · Basic | groep 7 · Intermediate | groep 8 · Advanced | secondary · Challenge

Paper lessons and lab activities are colored by the youngest group they are for; Working with Data by its level.

1	AI, step by step	Paper lessons for groep 6 to secondary, one toy machine at a time. Each series is a ladder: sheet 1 for groep 6, sheet 4 for secondary.	35
2	Working with Data	148 spreadsheet exercises for secondary, in one numbered route. Each topic teaches its skills first, then lets pupils use them.	148
3	The digital lab	Browser activities that go where paper cannot: more cases, more rounds, the real thing at scale.	32
4	Assessment	Paper assessments that ask pupils to predict, find the fault and explain, never to define a word.	4

1

AI, step by step

Paper lessons for groep 6 to secondary, one toy machine at a time. Each series is a ladder: sheet 1 for groep 6, sheet 4 for secondary.

When does the machine say yes?

Four sets, ten short lessons, one toy machine that keeps getting more real: count, move the threshold, weigh, let a learning rule set the weights. Every collision asks who decided; every change is tested on new cases.

WS-L1-1

Count the features

groep 6 (ages 9–10) · 2 short parts: 25 + 25 minutes · Free download

LEARNING OBJECTIVES

- A feature is one thing the machine can check: yes or no.
- The machine counts features and compares the count with a threshold. It does not look at the animal.
- A correct count can still give a wrong answer. The mistake is in what gets counted, not in the counting.
- People choose the features, and a new feature has to be tested on cases it was not chosen for: "works on the animals tested so far".

Replaces the idea: That a machine that sorts things correctly must know what the things are, and that a fix is proven once it works on the examples it was made for.

Parts: 1A Count the features · 1B New animals

WS-L1-2

Shifting thresholds

groep 7 (ages 10–11) · 2 short parts: 25 + 20 minutes · Free download

LEARNING OBJECTIVES

- The threshold is the number the machine needs for YES. Change it, and the same animals get different answers.
- There are two kinds of mistake: a wrong YES and a wrong NO. Raising the threshold never makes more YESes; it can swap one kind of mistake for the other.
- A threshold only sees the count. Two things with the same count always get the same answer.
- Which threshold is best depends on what each mistake does to the people and animals involved, and the people affected should have a say.

Replaces the idea: That a machine's mistake can always be fixed by adjusting a setting, and that there is one correct setting.

Parts: 2A Move the line · 2B Which mistake is worse?

WS-L1-3

Not every feature weighs the same

groep 8 (ages 11–12) · 3 short parts: 20 + 25 + 20 minutes · Free download

LEARNING OBJECTIVES

- A weight says how much a feature counts. The machine multiplies each feature by its weight and adds up the points. Weight 0 means the feature is ignored.
- Weights can separate things a plain count cannot, like a chick and a butterfly.
- A heavy weight lets one feature almost decide on its own, which is how the shuttlecock gets through.
- In this toy people write the weights; in learning systems training adjusts them and people choose the examples and the goal. Several rules can fit the same examples, so you test on cases they were not made from.

Replaces the idea: That a machine which weighs features knows which features really matter, and that a rule is correct because it fits the examples in front of you.

Parts: 3A Weigh the features · 3B Change the rule, then test it · 3C The message filter

WS-L1-4

Write down the rule

secondary years 1–3 (ages 12–15)

3 short parts: 30 + 25 + 25 minutes | Free download

LEARNING OBJECTIVES

- A threshold machine is an inequality: each feature (0 or 1) times its weight, added up, compared with a threshold t.
- A learning rule adjusts the weights after every wrong answer on a labeled example. The result depends on the examples, their labels and order, the starting weights, the threshold and the rule.
- A rule can fit every example and still be wrong on new cases: it picks up whatever the examples happen to share.
- Two inputs with the same features always get the same answer; only a new feature separates them. Responsibility for the result is shared by everyone who built, fed and deployed the rule.

Replaces the idea: That a rule learned from data is neutral, or correct because it fits the data.

Parts: 4A Weights from examples · 4B Same features, same answer · 4C Same examples, different order

Words in pieces

Four sheets, split into nine short parts, one question that keeps getting sharper: how does a machine cut up words? Freely and losslessly, then with a list and a rule, then with two lists, then with a list you count yourself. Carpet takes an extra piece in 2A and is explained in 4B.

WS-L2-1

Chop the word up

groep 6 (ages 9–10) · 2 short parts: 20 + 20 minutes · Free download

LEARNING OBJECTIVES

- A chopper (tokenizer) turns text into pieces from a fixed list, and every piece has an ID number.
- The number is a label, not an amount: it says which piece, not how big.
- Chopping is reversible: with the list, the numbers turn back into exactly the same text. Different lists chop differently and still give the same word back.
- The part that makes the answer works with whole pieces, so jobs that need the letters inside them (count them, reverse them) take an extra step and can go wrong.

Replaces the idea: That a chatbot reads a word letter by letter the way you do, or that chopping a word into numbers throws its letters away.

Parts: 1A Numbers for pieces · 1B Cards, not letters

WS-L2-2

Greedy matching

groep 7 (ages 10–11) · 2 short parts: 25 + 20 minutes · Free download

LEARNING OBJECTIVES

- A tokenizer chops text with a fixed list of pieces (a vocabulary) and a rule for using it.
- Greedy longest-match: always take the longest piece that fits, from left to right, and never go back. Real tokenizers such as BERT's WordPiece also match longest-first, with their own way of handling words the list cannot build.
- Following the rule perfectly can still give more pieces than needed. 'Better' needs a goal, such as fewest pieces.
- Trying every split is much more work (the number of ways doubles with every letter), which is why a fast rule can still be worth using. The same trap appears outside words, for example when paying with coins.

Replaces the idea: That a machine following its rule correctly must give the best answer, or that trying every possibility is always practical.

Parts: 2A Longest piece first · 2B Why not try every way?

WS-L2-3

Compare two splits

groep 8 (ages 11–12) · 2 short parts: 25 + 25 minutes · Free download

LEARNING OBJECTIVES

- There is more than one way to split the same text, and you can compare splits by counting pieces, which is one of several things builders care about.
- A list of whole words gives few pieces on familiar text, but falls apart on a word that is not on its list.
- A list of reusable pieces handles new words, because new words are mostly made of old pieces.
- A list counted mostly from one language chops other languages into more pieces; a fair test holds word length constant and runs both lists on both languages.

Replaces the idea: That fewer pieces always means a better split, that a machine treats every language the same, or that Dutch costs more only because its words are long.

Parts: 3A Whole words or pieces? · 3B Two lists, two languages

WS-L2-4

Build your own vocabulary

secondary, years 2–3 (ages 13–15) · 3 short parts: 30 + 30 + 30 minutes (4C optional) · Free download

LEARNING OBJECTIVES

- A tokenizer's vocabulary can be built by counting: the most frequent pair of neighboring pieces is glued into a new piece, again and again (BPE). People choose the text, the rules and when to stop.
- Frequent words end up as one piece; rare words stay in several pieces.
- The merge list has an order, and replaying it in that order chops new words; greedy longest-match on the same list can give a different split with more pieces.
- A list counted from one language's text chops another language into more pieces, even for words of the same length.

Replaces the idea: That someone picked the pieces a chatbot uses one by one, that they are chosen for their meaning, or that no human choices shape them.

Parts: 4A Count the pairs · 4B Greedy or replay? · 4C Two texts, two lists

Where does it belong?

In these toy models every thing becomes a point and 'similar' means 'near on the chosen axes'. Four rungs add axes one at a time; each collision shows that what counts as near depends on people's choices.

WS-L3-1

Everything on one line

groep 6 (ages 9–10) · 2 short parts: 25 + 20 minutes · Free download

LEARNING OBJECTIVES

- A machine does not get a word or a picture. It gets numbers, here chosen by a person.
- With one feature, every word becomes a point on a line; close means alike in that feature only.
- Two things on the same spot are the same for the machine: that feature leaves out what tells them apart.
- A number can keep every thing apart (an ID) and still say nothing about which things are alike.

Replaces the idea: That the computer sees the thing itself, or that one number is only a problem because there are too few spots.

Parts: 1A Twins on the line · 1B Apart or alike?

WS-L3-2

Two axes

groep 7 (ages 10–11) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- Two numbers turn a thing into a point on a map with two axes.
- People see groups by eye; a machine needs a stated rule, and a different rule gives different groups.
- Close on the map means alike on the chosen axes; you can count it in steps, pair by pair or against everyone.
- The axes and their scale are chosen by a person; each map suits a different question.

Replaces the idea: That a computer groups things by what they really are, or that groups simply appear, instead of following the numbers and rules someone chose.

Parts: 2A Shark or cow? · 2B Change one axis

WS-L3-3

Who is the neighbor?

groep 8 (ages 11–12) · 2 short parts: 27 + 28 minutes · Free download

LEARNING OBJECTIVES

- Distance between two points can be counted: steps across plus steps up. A ruler's straight line is another rule.
- A nearest-neighbor recommender suggests the point with the smallest distance; it is one simple design among many.
- What is nearest can differ from what feels most similar, because the machine only has its chosen scores.
- Adding an axis can fix one case and break another, so a change must be tested on cases it was not made for.

Replaces the idea: That a 'more like this' suggestion knows what things are, or that adding a feature always makes it better.

Parts: 3A The snack machine · 3B Fix it, then test it

WS-L3-4

Three axes and coordinates

secondary years 1–3 (ages 12–15) · 2 short parts: 27 + 29 minutes · Free download

LEARNING OBJECTIVES

- A vector (a point with one coordinate per axis) can represent a word or thing; in this model, similar means a short distance.
- Distance in 3D can be counted as steps or as squared distance; the smallest is the nearest.
- A flat view leaves an axis out and can put the wrong things next to each other.
- The axis with the biggest range dominates the distance; in learned embeddings people choose data, scaling, measure and tests rather than each axis.

Replaces the idea: That a computer stores what a word means, or that a person hand-picks every axis of a real embedding.

Parts: 4A The hidden axis · 4B Who decides what is near?

Everything is on or off

Four rungs, one idea: everything a screen shows is stored as on and off. Each rung ends in a result pupils did not expect.

WS-L4-1

On or off

groep 6 (ages 9–10) · 2 short parts: 25 + 25 minutes · Free download

LEARNING OBJECTIVES

- A bit is anything with two states, like a lamp that is on or off.
- Several lamps together make patterns. The pattern carries the message, not a single lamp.
- Every extra lamp doubles the number of patterns: 2, 4, 8, 16.
- A pattern means nothing on its own. People agree what it means: that agreement is a code.
- A code that works for the messages tested so far can still break when a new message arrives.

Replaces the idea: That a computer stores pictures and words as pictures and words, and that each extra lamp adds just one more message.

Parts: 1A Only two lamps · 1B Every lamp doubles

WS-L4-2

Binary numbers

groep 7 (ages 10–11) · 2 short parts: 25 + 25 minutes · Free download

LEARNING OBJECTIVES

- In binary every lamp is worth double the lamp to its right: 1, 2, 4, 8, 16, like our places worth 1, 10, 100.
- A binary number is read by adding the values of the lamps that are on.
- Position matters more than how many lamps are on: 10000 is bigger than 01111.
- A fixed number of lamps has a largest number: five lamps stop at 31, and each extra lamp doubles the range.
- Computers use binary because two states are easy to tell apart reliably, not because binary is shorter.

Replaces the idea: That binary is a secret computer language, and that more lamps on must mean a bigger number.

Parts: 2A One lamp against four · 2B How far can five lamps count?

WS-L4-3

Encoding a picture

groep 8 (ages 11–12) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- A black-and-white picture can be stored as a grid of pixels, one bit each (color pixels need more bits).
- Run-length coding counts how many pixels of the same color follow each other.
- A code only works if sender and receiver use the same agreement.
- Fewer numbers is not the same as fewer bits: every stored number costs bits.
- The run code only saves space on pictures with long runs; a busy picture gets bigger.

Replaces the idea: That a computer stores a picture as a picture, that compressing always makes a file smaller, and that writing fewer numbers means storing fewer bits.

Parts: 3A Your own picture code · 3B Fewer numbers, fewer bits?

WS-L4-4

Compression and catching errors

secondary years 1–3 (ages 12–15) · 3 short parts: 25 + 20 minutes, plus an optional 30 · Free download

LEARNING OBJECTIVES

- A parity bit makes every row and column even, so a single flipped bit shows up as one odd row and one odd column.
- Parity can detect two errors but not locate them, and it misses any pattern with an even number of flips in every row and column, such as four in a rectangle.
- Run-length compression stores each run length in a fixed number of bits; it pays off only when runs are long.
- In a simple run code without row markers, one flipped bit can shift everything after it.
- Systems generally compress first and then add error-catching, so the protection covers the bits that actually travel.

Replaces the idea: That a check which passes proves the data is correct, and that smaller data is always better data.

Parts: 4A The parity trick · 4B When the check says OK · 4C Squeezing, in real bits

What comes next?

Four rungs, four toy machines that get closer to a real language model each time: guess, count, the follow-on table, roll. Together they show why generated text can be fluent and false, and why a draw can make the same start come out differently twice.

WS-L5-1

What comes next?

groep 6 (ages 9–10) · 15 minutes · Free download

LEARNING OBJECTIVES

- A text machine makes its answer one piece at a time: what comes next?
- This tiny machine picks the word it has seen most often after the word before; real systems are far bigger, use much more context and often make a weighted draw.
- It does not look at what the sentence means, so a well-counted answer can still be nonsense.

Replaces the idea: That the machine is working from what the sentence means, rather than from counts of what came next.

WS-L5-2

Count how often

groep 7 (ages 10–11) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- This toy machine gets its choices by counting which word follows which in its text.
- It picks the word with the highest count, whatever the rest of the sentence says; a tie goes to the word it met first.
- A different text gives different counts, so a different answer to the same sentence.
- This table machine can only say words that are in its counts. Real language models are not tally tables, but the text they are made from still shapes what comes out.
- A fix tested only on the case it was made for can break another case.

Replaces the idea: That the machine's answer comes from knowing about the world, rather than from the text it counted, and that a fix that works once works everywhere.

Parts: 2A Count how often · 2B Fix it for one sentence

WS-L5-3

The follow-on table

groep 8 (ages 11–12) · 2 short parts: 27 + 25 minutes · Free download

LEARNING OBJECTIVES

- A follow-on table (a bigram model) records, for each word, which words came right after it and how often.
- This toy machine writes by looking up the last word and picking a follower, again and again, until the sentence ends.
- Every pair can be supported by the text while the whole claim is not. Checking pieces is not checking the claim.
- Nothing in the table records what is true, and nothing shows a purpose: the sentence is false, not a lie. Fluent is not the same as true.

Replaces the idea: That a fluent, confident sentence from a machine must be true, that checking its pieces is enough, or that a false one means the machine lied.

Parts: 3A The follow-on table · 3B Check the whole claim

WS-L5-4

Rolling dice on probability

secondary years 2–3 (ages 13–15) · 2 short parts: 29 + 29 minutes · Free download

LEARNING OBJECTIVES

- A language model gives probabilities for the next token; a separate decoding step chooses one, by a weighted draw (sampling), by always taking the most likely (greedy), or by searching.
- With sampling, the same input can give different outputs. That is not a mistake or a choice; in real chats other differences can also play a part.
- Always taking the most likely word can loop, and it can miss the most likely sentence.
- The probability of a sentence is the product of the probabilities of its steps.
- Temperature, in many samplers, changes how flat the probabilities are. Consistent is not the same as correct.

Replaces the idea: That a computer always gives the same answer to the same question, that a different answer means the machine made a mistake or decided something, and that the same answer every time must be the right one.

Parts: 4A Roll for the next word · 4B No dice: always the most likely

Why are you seeing this?

One mechanism in four steps: match words, rank by a rule, add points for clicks, optimize a feed for one number. At every step a toy machine does exactly what it was told, and that is what surprises pupils; every sheet then tests a fix on a case it was not built for.

WS-L6-1

Catching keywords

groep 6 (ages 9–10) · 2 short parts: 30 + 20 minutes · Free download

LEARNING OBJECTIVES

- An exact-word search machine checks whether your words are on a page. It does not read what the page means.
- A wrong find: a page can have all your words and still be about something else.
- A missed page: a good page can be missed because it uses other words for the same thing.
- A machine with wider word lists finds more: more useful pages and more wrong ones. Test a fix on a new search before you trust it.
- Real search engines use more than exact words, and still make both kinds of mistake.

Replaces the idea: That a search engine understands your question and finds the page that answers it, or that a cleverer matching rule fixes every mistake.

Parts: 1A The exact-word machine · 1B The word-family machine

WS-L6-2

Who comes first?

groep 7 (ages 10–11) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- Ranking is putting the found pages in order by a rule.
- A rule uses signals that can be counted: matching words, age, likes.
- Different rules give different orders for the same search.
- A rule that sounds reasonable can put the best answer at the bottom, because these numbers do not fully capture whether a page is correct and clear.
- Combining better signals can improve the order, and still has blind spots, such as new pages nobody has rated yet.
- Real rankings mix many signals and are often learned from examples; people choose the goal, the data and the signals.

Replaces the idea: That the page at the top of the results is there because it is the best or the most true, or, the other way round, that rankings are useless.

Parts: 2A Who comes first? · 2B A better rule?

WS-L6-3

Why do you see something else?

groep 8 (ages 11–12) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- Personalization: the machine adds points based on what you clicked before.
- The same search can give different people different results.
- Position bias: people click the top more, partly just because it is on top.
- It is a loop: what is on top gets clicked, and every click pushes that topic further up. A small difference at the start can grow.
- A rule can be changed to weaken the loop; a fix must be tested on new cases, and has its own costs.

Replaces the idea: That everyone sees the same results, that what you see first is there because it is best for you, or that every app must trap you in a loop.

Parts: 3A Same search, different screens · 3B Change the rule

WS-L6-4

Who pays for your result?

secondary years 1–3 (ages 12–15) · 3 short parts: 30 + 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- A system can meet its metric and still fail its purpose.
- A feed optimized for one number, here watch time, does exactly that; in this toy rule it narrows round by round into a filter bubble.
- Under a rule with no exploration, a category that gets no slots produces no data, so it can never come back. Real feeds often add variety and exploration.
- A constraint can protect what users need; a fix built for one user must be tested on another.
- Paid slots marked Ad are sold by auction; in a simplified model, score = bid × relevance, and the platform sets relevance.
- You pay with time and attention; advertisers pay the platform for it.

Replaces the idea: That a feed which hits its numbers is working well, that the feed and the top results are neutral or arranged for your benefit, or that every feed must collapse into a bubble.

Parts: 4A Hit the number, miss the point · 4B A fix for Sam, tested on Noor · 4C Who buys the top?

From idea to thing

Each rung puts a design in front of something it did not plan for, and each time you look at the design first, change it, and try the change on someone new.

WS–L7–1

Sketch it and try it

groep 6 (ages 9–10) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- A clickable prototype is screens plus a rule for which screen comes next when you press. A real app does more, but this is enough to test where people press.
- A button needs a link (a number), or nothing happens.
- You cannot test your own design: you already know where to press.
- When a tester gets stuck, look at the design first.
- A fix is only known to work once someone new has tried it.

Replaces the idea: That a design that is clear to the designer is clear to everyone, and that a fix works because the designer made it.

Parts: 1A Will they get stuck? · 1B Fix it and try again

WS–L7–2

Requirements and constraints

groep 7 (ages 10–11) · 2 short parts: 27 + 27 minutes · Free download

LEARNING OBJECTIVES

- A must is what the design has to do; a nice-to-have can be dropped; a limit (constraint) is a rule about how it may be made, set by the users and the place. The labels vary; the reasoning matters more than the box.
- A good requirement can be tested: you could try it with a real user and see yes or no.
- A requirement list is a check: go through every line, limits included, and look for clashes.
- A check mark on paper is not a test with people: a feature can exist and still not be found.
- When a must and a limit clash, design around it, ask the client, or move a wish down.

Replaces the idea: That the design that does the most things is the best design, and that a design that checks every line on paper works for its users.

Parts: 2A Check every line · 2B One button, two choices

WS–L7–3

Test and improve

groep 8 (ages 11–12) · 5 short parts: 30 + 25 + 25 + 30 + 20 minutes · Free download

LEARNING OBJECTIVES

- A user test gives a mission and watches; it does not only ask whether people like the design.
- What testers do, say while testing and say afterwards answer different questions. To find what to fix, compare them and look at what they did.
- Fewest presses is one measure, not the definition of usable.
- The worst problems can be ones testers never notice.
- A fix is only supported by a retest with someone new, it can create a new problem, and one retest is one case.

Replaces the idea: That asking people if they like a design tells you whether it works.

Parts: 3A Watch what they do · 3B Same place, different person? · 3C Which problem first? · 3D Fix it, then test on someone new · 3E Show the evidence

WS–L7–4

From paper to working thing

secondary · 10 parts of 20–30 minutes (265 in all) · Free download

LEARNING OBJECTIVES

- A simple clickable prototype can be written as a transition table: from screen, element, to screen.
- A paper test is only as strict as the person playing the computer; the table is the specification that makes it strict.
- Unreachable means no chain of rows from the start screen leads there; a dead end is a screen with no way out that is not meant as an end screen.
- A link check shows the rows work; a user test shows whether people can use them. Neither proves the app complete.

Replaces the idea: That a design that passed a paper test is ready to build, and that a build where every link works is usable.

Parts: 4A From screens to a table · 4B The human computer · 4C Brief and paper screens · 4D A strict paper test · 4E Our own table · 4F Build it from the table · 4G The link check · 4H The user test · 4I Fix it and retest · 4J Show what the tests found

Keeping secrets

Four codes, each cracked by the class. Pupils leave with a test, not a code: a secret is only as safe as the ways to work it back.

WS–L8–1

Secret writing

groep 6 (ages 9–10) · 2 short parts: 25 + 25 minutes · Free download

LEARNING OBJECTIVES

- A secret alphabet (monoalphabetic substitution) swaps every letter for one fixed sign. The key is the list that says which sign belongs to which letter.
- The signs hide the letters, but not the pattern: the same letter always gets the same sign.
- Guessable words, such as a greeting or a name, give away letters, and those letters work everywhere in the note. That is a foothold, not always the whole message.
- Leaving out greetings or spaces makes cracking slower, not safe. You only know a code is strong when someone has tried to crack it.

Replaces the idea: That a code is safe because it looks strange and only you know the key.

Parts: 1A A note from Noor · 1B Swap and crack

WS–L8–2

The Caesar shift

groep 7 (ages 10–11) · 2 short parts: 25 + 30 minutes · Free download

LEARNING OBJECTIVES

- A Caesar shift moves every letter the same number of places along the alphabet. That number is the key.
- There are only 25 useful keys, so trying them all (brute force) always cracks it.
- The shift hides each letter, but not how often it appears. In long English text E is usually the most common letter, so the most common secret letter is a good guess for E, never a certainty.
- A guessed key must be checked: a second letter and a readable word. A longer message makes the count clearer; it does not change the number of keys.

Replaces the idea: That a code is safe as long as nobody has the key, that the most common letter is always E, and that a longer secret is a safer one.

Parts: 2A Only 25 keys · 2B Count the letters

WS–L8–3

Exchanging keys

groep 8 (ages 11–12) · 2 short parts: 25 + 25 minutes · Free download

LEARNING OBJECTIVES

- The key exchange problem: to send secrets you need a shared key, but how do you share it without meeting?
- With two locks, a secret can travel three times and never be open on the way, with no lock key shared in advance.
- Hiding is not enough: if Eve can put on her own lock and pretend to be Bob, Alice must be able to check who is on the other end (authentication).
- A computer sends numbers, not padlocks. A usable lock must be easy to close and far too slow to work back from what an eavesdropper sees. Adding and multiplying are not. (Real computers use a different method, in which the secret is never sent at all.)

Replaces the idea: That a secret has to be sent openly at least once, that anything that looks locked is locked, and that keeping a secret hidden is all that security needs.

Parts: 3A The double-locked envelope · 3B Locks made of numbers

WS–L8–4

A lock anyone may close

secondary years 2–3 (ages 13–15) · 2 short parts: 30 + 25 minutes · Free download

LEARNING OBJECTIVES

- A key pair: the public key closes, the private key opens. Closing is allowed for everyone; opening only for the owner.
- Because anyone may close, anyone may close every likely message and compare (a dictionary attack). A bigger key does not stop this.
- Random filler (randomized padding) makes the same message close differently each time, which is what stops the table.
- Huge numbers stop a different attack: splitting the public number to work out the private key. The textbook RSA on this sheet is a toy for learning, never used this bare way for real.

Replaces the idea: That a public key means anyone can read the message, and that a big enough key makes any message safe.

Parts: 4A A lock anyone may close · 4B A bigger lock?

Where it came from

WS-L9-1

Rule or example

groep 7–8 (ages 10–12) and vo klas 1–3 · 30 minutes

Free download

LEARNING OBJECTIVES

- Written (rule-based): a person decided the behavior and encoded it. You can point at the line.
- Learned (statistics-based): a process adjusted numbers until the outputs matched a pile of examples.
- Where the knowledge sits decides how you fix a wrong answer: edit one line, or change the examples and train again.
- Impressive is not the same as learned. A calculator is written; a photo tagger is learned.

Replaces the idea: That AI is the impressive end of a scale running from dumb software to smart software.

Generative AI

WS-CF-1

Confident and wrong

groep 7–8 (ages 10–12), secondary years 1–3 (ages 12–15)

2 short parts: 25 + 25 minutes (optional extension for secondary: +15 minutes)

Free download

LEARNING OBJECTIVES

- A chatbot writes one piece at a time, choosing what is likely to come next after the words before it. Fitting what came before is not the same as being checked.
- Invented sentences can sound just as confident and specific as true ones: exact numbers, real names, a book title.
- Checking means comparing each sentence with a source: does it say the same, something different, or nothing at all?
- A named source is a claim too. Even when a chatbot shows a link, open it and see whether it exists and says the same.

Replaces the idea: That a chatbot answer which sounds sure and specific must be correct, and that its mistakes are rare glitches.

Parts: 1A Confident and wrong · 1B Fitting is not the same as true

WS-VF-1

Check it before you use it

groep 8 (ages 11–12), secondary years 1–3 (ages 12–15)

2 short parts: 25 + 25 minutes

Free download

LEARNING OBJECTIVES

- A chatbot answer is a starting point, not a source. Every fact in it still needs checking in a source you open and read.
- Checking means finding the fact somewhere else, not asking the chatbot again.
- A source is strong or weak for a particular claim: who made it, when, what it is based on, and could they know this?
- Counting agreeing sources is not enough: copies count once, and one strong source can outweigh many weak ones.
- Every fact gets a decision: use it, adjust it, or drop it.

Replaces the idea: That a fact is checked as soon as you find one website that says the same, that more agreeing sites always means more certain, and that asking the chatbot again counts as checking.

Parts: 1A Found it, checked it? · 1B Copies count once

2

Working with Data

148 spreadsheet exercises for secondary, in one numbered route. Each topic teaches its skills first, then lets pupils use them.

Tables and cells

Exercise 0–9

0 How to use GRID WD-T0

- Click a cell, type a number or a word, and press Enter.
- Find a cell by its address, such as B4: column letter, then row number.
- Type a formula that starts with =, fill it down, and add a column up with SUM.
- Switch between sheets, and check your work.

Basic
10–15 minutes
Free download

1 What belongs in a cell? WD-T1

- A cell holds a type: number, date, or text.
- A spreadsheet guesses the type from what you type, without telling you.
- You calculate with numbers and dates; codes made of digits are text.

Replaces the idea: That a spreadsheet stores exactly what you type.

Basic
15–20 minutes
Free download

2 Fix the messy table WD-T2

- One variable per column, one observation per row, one header row.
- Merged cells, subtotals and blank rows break calculations, sorting and filtering.
- A correct formula over a messy table can give a wrong total.

Replaces the idea: That a table which is easy to read is easy to calculate with.

Basic
15–20 minutes
Free download
After: T1

3 Make it readable WD-T3

- A number format changes the display, not the stored value.
- A number too wide for its column shows ####.
- Totals use stored values, so rounded parts need not add up to the rounded total.

Replaces the idea: That what a cell shows is what it holds.

Basic
15–20 minutes
Free download
After: T1

4 Sort without breaking the data WD-T4

- A row is one record and must move as a whole.
- Sorting one column alone mixes up the records without any error.
- The sort warning offers to expand the selection for this reason.

Replaces the idea: That a sorted table that looks neat is still correct.

Basic
15–20 minutes
Free download
After: T2

5 Filter a question WD-T5

- A filter is a question written precisely: year = 2 and km > 8.
- Hidden rows are still in every formula; SUBTOTAL and the status bar leave them out.
- "More than 8" and "8 or more" are different filters.

Replaces the idea: That what you filter away is gone.

Basic
15–20 minutes
Free download
After: T2

6 Turn a range into a table WD-T6

- A plain range ends where it was typed.
- A table grows with a row typed under it.
- Formulas that read a whole table column follow it.

Replaces the idea: That a total that was right stays right as the data grows.

Intermediate
15–20 minutes
Free download
After: T5

7 Write a data dictionary WD–T7

- A number does not say what it means.
- A data dictionary gives each column a meaning, a unit and its allowed values.
- Evidence in other columns can test a reading.

Replaces the idea: That a column's name says what it means.

Intermediate
15–20 minutes
Free download
After: T6

8 Import a CSV WD–T8

- A CSV file is text cut by a separator.
- The decimal mark decides whether 3.5 is a number, text or a date.
- Count the rows, check a total and check the types after every import.

Replaces the idea: That an import that shows no error worked.

Advanced
15–20 minutes
Free download
After: T7

9 Challenge: the bike shed WD–TX

- Tidying comes first, because sorting and filtering need one kind of row.
- Information held only by position (a week heading) is lost when rows move.
- A question becomes a filter.

Replaces the idea: That you can sort or filter any table as it is.

Challenge
15–20 minutes
Free download
After: T1–T5

Formulas

Exercise 10–20

10 First formulas WD–F1

- A formula starts with = and calculates from other cells.
- A reference (B2) keeps the link to the data; a typed number does not.
- Fill down copies a formula to every row.

Replaces the idea: That a formula that gives the right answer is a right formula.

Basic
15–20 minutes
Free download
After: T1

11 Relative references WD–F2

- A copied formula moves its references by the same number of rows and columns.
- Filling down works because each row needs its own cells.
- Reading the copied formula, not just its result, shows what it really calculates.

Replaces the idea: That a copied formula is the same formula.

Basic
15–20 minutes
Free download
After: F1

12 Absolute references WD–F3

- $ fixes a column, a row, or both, when a formula is copied.
- An empty cell counts as 0 in arithmetic.
- A rate kept in one cell can be changed in one place.

Replaces the idea: That a formula that is right in its first row is right in every row.

Intermediate
15–20 minutes
Free download
After: F2

13 Percentages WD–F4

- Percentage change = (after − before) / before.
- The same amount is a different percentage of a different start.
- Percentage points compare two percentages; percent compares to the start.

Replaces the idea: That going up and down by the same percentage brings you back.

Intermediate
15–20 minutes
Free download
After: F1

14 Decide with IF WD–F5

- IF(test, value if true, value if false).
- > and >= differ exactly at the boundary.
- Boundary cases are where a rule is tested.

Replaces the idea: That a formula with the right idea has the right comparison.

Intermediate
15–20 minutes
Free download
After: F2

15 Working hours WD–F6

- A spreadsheet stores a time as a part of a day.
- Hours = time × 24, before any rate per hour.
- A time past midnight needs a day added: MOD(end − start, 1).

Replaces the idea: That a time that shows 8:30 is the number 8.5.

Intermediate
15–20 minutes
Free download
After: F3

16 Audit a formula WD–F7

- A formula can be valid and still read the wrong cells.
- Trace precedents outlines the cells a formula reads.
- Checking one row by hand catches what looking at the totals does not.

Replaces the idea: That a formula with no error message is right.

Advanced
15–20 minutes
Free download
After: F6

17 Separate input and output WD–F8

- A sheet has input, calculation and report areas.
- Only input is typed; every output is a formula.
- Show formulas tells typed numbers and formulas apart.

Replaces the idea: That a number which is right now will stay right.

Advanced
15–20 minutes
Free download
After: F7

18 Names for ranges WD–F9

- A name makes a formula say what it means.
- A name points at fixed cells and does not grow.
- A table column grows with the list.

Replaces the idea: That a named range follows the data.

Advanced
15–20 minutes
Free download
After: F8 and T6

19 Lists that update themselves WD–F10

- A spilling formula fills the cells below it from one formula.
- Anything in the way, even a space, gives #SPILL!.
- UNIQUE compares text without capitals.

Replaces the idea: That a formula writes its answer wherever it needs to.

Advanced
15–20 minutes
Free download
After: F9

20 Challenge: the class trip budget WD–FX

- References and $ make a sheet that recalculates.
- IF turns a comparison into an answer.
- A share of a budget is a percentage.

Replaces the idea: That a budget has to be recalculated by hand for every change.

Challenge
15–20 minutes
Free download
After: F1–F5

Summaries and statistics

Exercise 21–37

21 Sum and count WD-S1

- SUM adds numbers; COUNT counts numbers; COUNTA counts filled cells.
- A number stored as text is skipped without warning.
- Comparing COUNT with COUNTA finds the gap.

Replaces the idea: That COUNT counts the rows of a table.

Basic
15–20 minutes
Free download
After: T1

22 The average WD-S2

- AVERAGE skips blanks and counts zeros.
- Blank and zero mean different things.
- Cleaning data is a judgement about what is true.

Replaces the idea: That an empty cell can always be filled with 0.

Basic
15–20 minutes
Free download
After: S1

23 Mean, median or mode? WD-S3

- The mean is pulled by extreme values; the median is not.
- The mode is the most common value, and the only one for categories.
- Choosing the measure is part of the answer.

Replaces the idea: That "the average" always means the typical value.

Basic
15–20 minutes
Free download
After: S2

24 What kind of variable? WD-T9

- Categorical, ordinal, discrete and continuous variables.
- A spreadsheet calculates with any number, codes included.
- The kind of variable decides the summary: most common, median or average.

Replaces the idea: That a column of numbers can always be averaged.

Basic
15–20 minutes
Free download
After: S3

25 Minimum, maximum and range WD-S4

- MIN, MAX and the range.
- The range depends only on the two extremes.
- An implausible range is a fast check for typos.

Replaces the idea: That one wrong value can only cause a small error.

Basic
15–20 minutes
Free download
After: S1

26 Compare two groups WD-S5

- Mean and median can rank groups differently.
- A few extreme values move the mean.
- An honest comparison says which measure it uses.

Replaces the idea: That one number can say which group did better.

Intermediate
15–20 minutes
Free download
After: S3

27 Counts against rates WD-S6

- A count grows with the size of the group.
- A rate shares the count out over the size: per pupil, or per 100.
- Count and rate answer different questions.

Replaces the idea: That the group with the most cases has the biggest problem.

Intermediate
15–20 minutes
Free download
After: S5

28 Not everyone is average WD-S7

- The same mean can come from very different distributions.
- COUNTIF per value gives the distribution; a column chart shows it.
- A mean or median can sit where no one is.

Replaces the idea: That the mean tells you what a typical person thinks.

Intermediate
15–20 minutes
Free download
After: S5

29 Is the die fair? WD-S14

- A chance is the share something gets in a very long run.
- A short run wobbles far from that share; a long one settles near it.
- A simulation imitates a real process with random numbers (RANDBETWEEN).

Replaces the idea: That a fair die gives about the same count of every face in a short run.

Intermediate
15–20 minutes
Free download
After: S7; a die for each pair

30 Quartiles WD-S8

- Quartiles split ordered data into four quarters.
- A quartile often falls between two values; methods place it differently.
- A reported quartile needs its method.

Replaces the idea: That every statistic has exactly one right answer.

Advanced
15–20 minutes
Free download
After: S7

31 Box plot and IQR WD-S9

- The box is the middle half; the IQR is its width.
- The 1.5 × IQR rule flags values far from the middle half.
- A flag starts an investigation; evidence decides.

Replaces the idea: That an outlier is an error to delete.

Advanced
15–20 minutes
Free download
After: S8

32 What one value can do WD-S10

- The mean uses every value's size.
- The median uses only the middle position.
- A resistant measure is not dragged by one extreme value.

Replaces the idea: That the mean and the median always move together.

Advanced
15–20 minutes
Free download
After: S9

33 The average of averages WD-S11

- AVERAGEIFS averages one group in a list.
- Groups of different sizes need a weighted mean.
- SUMPRODUCT ÷ SUM gives a weighted mean.

Replaces the idea: That the average of averages is the overall average.

Advanced
15–20 minutes
Free download
After: S10

34 Spread on skewed data WD-S12

- The standard deviation is a typical distance from the mean.
- Skewed data pulls the mean and the SD towards the long tail.
- Median and IQR describe skewed data; mean and SD describe evenly spread data.

Replaces the idea: That mean ± SD always describes where most values lie.

Advanced
15–20 minutes
Free download
After: S11

35 Small numbers swing WD-S13

- A rate from a small group swings with one case.
- Small groups fill both ends of a ranking by chance.
- Show the group size beside a rate.

Replaces the idea: That the top of a ranking is the best.

Advanced
15–20 minutes
Free download
After: S12

36 Is the difference big? WD-S15

- Side-by-side box plots compare two distributions.
- A difference is measured against the spread: difference ÷ spread.
- The same difference can be big or small.

Replaces the idea: That a difference in averages says on its own how different two groups are.

Advanced
15–20 minutes
Free download
After: S12

37 Challenge: the canteen's Monday WD-SX

- Check the data before summarizing it.
- Each question needs its own measure.
- A real extreme value can stay in the data and still not describe the typical case.

Replaces the idea: That one summary number answers every question.

Challenge
15–20 minutes
Free download
After: S1–S5

Charts

Exercise 38–48

38 Choose the chart WD-C1

- A line is read as a story over time, so its points must be in time order.
- Sorting by name puts months and weekdays out of time order.
- Things with no order get bars; parts of one whole get a pie.

Replaces the idea: That a chart with the right numbers tells the right story.

Basic
15–20 minutes
Free download
After: T4

39 Label the chart WD-C2

- A chart title says what is shown.
- An axis title says the unit.
- Two charts can only be compared in the same unit.

Replaces the idea: That a chart speaks for itself.

Basic
15–20 minutes
Free download
After: C1

40 Read the chart WD-C3

- A chart shows only what was measured.
- A likely explanation is not a finding.
- Each claim needs its own data.

Replaces the idea: That what sounds true about a chart is in the chart.

Basic
15–20 minutes
Free download
After: C2

41 Pie or not? WD-C4

- A pie needs parts of one whole.
- Multiple answers per person make shares add to more than 100%.
- A spreadsheet draws a pie of anything, without checking.

Replaces the idea: That a pie chart can show any set of percentages.

Basic
15–20 minutes
Free download
After: C1

42 Fix a misleading chart WD-C5

- A bar's length stands for its amount, so bars need 0.
- A spreadsheet's automatic axis can start above 0.
- 3D and a loud title add nothing the data says.

Replaces the idea: That a misleading chart needs someone who meant to mislead.

Intermediate
15–20 minutes
Free download
After: C2

43 Highlight without a rainbow WD-C6

- A color scale is relative to its own range.
- A rule highlights against a fixed value.
- Color should mean something the reader needs.

Replaces the idea: That red in a spreadsheet means bad.

Intermediate
15–20 minutes
Free download
After: C5

44 Group into classes: the histogram WD-C10

- A histogram counts values per class; the bars touch.
- Class width and starting point are choices.
- The same data can look like one peak, a block or two peaks.

Replaces the idea: That the shape of a histogram is a fact about the data alone.

Intermediate
15–20 minutes
Free download
After: C2

45 Scatter plots WD-C7

- A line chart spaces its categories evenly.
- A scatter plot puts numbers at their real distance.
- Speed = change ÷ time between.

Replaces the idea: That the steepness of a line chart always shows the speed of change.

Advanced
15–20 minutes
Free download
After: C1

46 Trendlines WD–C8

- R^2 measures fit to the points used.
- Overfitting: a flexible curve fits noise.
- A forecast is tested on data it was not fitted on.

Replaces the idea: That the trendline with the highest R^2 gives the best forecast.

Advanced
15–20 minutes
Free download
After: C7

47 Chart for an audience WD–C9

- A chart answers one reader's question.
- A title can state the finding.
- Detail serves checking; summary serves deciding.

Replaces the idea: That there is one correct chart for a set of data.

Advanced
15–20 minutes
Free download
After: C2

48 Challenge: chart the survey WD–CX

- Chart type, order, title, unit and axis are each a decision.
- Sorting helps a reader compare.
- Honest charts start bars at 0.

Replaces the idea: That a chart is done once the spreadsheet has drawn it.

Challenge
15–20 minutes
Free download
After: C1–C5

Data quality and privacy

Exercise 49–60

49 Missing values WD-Q1

- A blank can mean zero, unknown or not applicable.
- AVERAGE skips blanks and counts zeros.
- The meaning of a blank comes from how the data was collected.

Replaces the idea: That an empty cell is the same as 0.

Basic
15–20 minutes
Free download
After: S2

50 Personal or anonymous? WD-Q10

- Ordinary details together can identify a person.
- A unique row is a person.
- Remove what is not needed; generalize the rest.

Replaces the idea: That deleting the names makes data anonymous.

Basic
15–20 minutes
Free download
After: Q1

51 May we use this? WD-Q11

- Data is collected for a purpose.
- Keep only what the purpose needs, only as long as needed.
- Only those who need it may see it; your own data is yours to see.

Replaces the idea: That true, freely given data may be used for anything.

Basic
15–20 minutes
Free download
After: T4

52 Duplicates WD-Q2

- A duplicate is the same record.
- Remove duplicates compares only the chosen columns.
- An ID column identifies a record; a name does not.

Replaces the idea: That two rows with the same name are the same person.

Intermediate
15–20 minutes
Free download
After: Q1

53 Impossible values WD-Q3

- A rule finds questions, not answers.
- Correct only what you can be sure of.
- Unusual is not impossible.

Replaces the idea: That every flagged value is an error to delete.

Intermediate
15–20 minutes
Free download
After: Q2

54 Control data entry WD-Q4

- Validation checks typing, not pasting.
- Rows from before the rule stay unchecked.
- Circle invalid data inspects what is already there.

Replaces the idea: That a drop-down list keeps a column clean.

Intermediate
15–20 minutes
Free download
After: Q3

55 Odd in combination WD-Q5

- Some errors only show in a combination of values.
- A derived column can make a combination checkable.
- A combined flag cannot say which value is wrong.

Replaces the idea: That data is clean when every value is in range.

Intermediate
15–20 minutes
Free download
After: Q3

56 Is the outlier an error? WD-Q6

- An outlier is a question, not an error.
- Error codes are not values.
- Removing a real extreme can make a summary false.

Replaces the idea: That outliers should be removed to get a better average.

Intermediate
15–20 minutes
Free download
After: Q3

57 Keep a cleaning log `WD-Q7`

- Cleaning involves choices that can be defended differently.
- A log makes every choice visible and checkable.
- A reason must be checkable by someone else.

Replaces the idea: That cleaning data has one right answer.

Intermediate
15–20 minutes
Free download
After: Q6

58 Check a control total `WD-Q8`

- A control total checks the sum, not the rows.
- Errors can cancel out.
- Reconciling compares record by record.

Replaces the idea: That a matching total means the list is correct.

Intermediate
15–20 minutes
Free download
After: Q7

59 A quality check that's tested `WD-Q9`

- A check is tested on data it was not built on.
- New data brings new kinds of error.
- "Works" means "works on the cases tested so far".

Replaces the idea: That a check which passes its own examples is finished.

Advanced
15–20 minutes
Free download
After: Q8

60 Challenge: clean the canteen week `WD-QX`

- Check and clean data before summarizing it.
- Each problem needs its own decision.
- A log makes a cleaned dataset trustworthy.

Replaces the idea: That data from a machine is ready to use.

Challenge
15–20 minutes
Free download
After: Q1–Q7

Groups and pivot tables

Exercise 61–70

61 Count one group WD-G1

- COUNTIF counts the cells in a range that match a value.
- It compares the whole cell: capitals are ignored, spaces are not.
- LEN shows characters you cannot see.

Replaces the idea: That a spreadsheet reads a cell the way a person does.

Intermediate
15–20 minutes
Free download
After: T5

62 Add up one group WD-G2

- SUMIF adds the values whose row matches a condition.
- * stands for any letters, or none.
- A rule is tested on a case it was not made for.

Replaces the idea: That a rule which gives the right answer on the data it was built on is a right rule.

Intermediate
15–20 minutes
Free download
After: G1

63 Two conditions WD-G3

- Two column filters mean AND.
- OR(...) tests each row for either condition.
- COUNTIFS counts rows where every condition holds.

Replaces the idea: That adding a filter can widen a selection.

Intermediate
15–20 minutes
Free download
After: G2

64 Several conditions WD-G4

- COUNTIFS counts rows where every condition holds.
- Adding two counts counts their overlap twice.
- A OR B = A + B − (A AND B).

Replaces the idea: That counts of groups can always be added.

Intermediate
15–20 minutes
Free download
After: G3

65 Totals by month WD-G5

- SUMIFS adds values where every condition holds.
- A date with a time is the date plus a part of a day.
- Months are checked against the total.

Replaces the idea: That "up to March 31" includes all of March 31.

Advanced
15–20 minutes
Free download
After: G4

66 Your first pivot table WD-G6

- A pivot table adds up rows per group: Rows, Values, Summarize by.
- Empty cells become a (blank) group.
- A pivot does not update by itself: refresh it.

Replaces the idea: That a pivot's (blank) row can be ignored.

Intermediate
15–20 minutes
Free download
After: G1–G5

67 Turn the pivot around WD-G7

- A pivot can show values as % of the row or column total.
- The same count gives different shares of different wholes.
- A percentage needs its base.

Replaces the idea: That a percentage from a table has only one reading.

Intermediate
15–20 minutes
Free download
After: G6

68 Group by month WD-G8

- A pivot can group dates by month, month and year, or year.
- Months alone merges the same month of different years.
- Check what a group holds before ranking it.

Replaces the idea: That a pivot's month row is one month.

Advanced
15–20 minutes
Free download
After: G6

69 A pivot chart WD–G9

- A PivotChart follows its pivot, filters included.
- A filter is visible on the pivot's sheet, not on the chart.
- A title describes the data; it does not change it.

Replaces the idea: That a chart's title decides what the chart shows.

Advanced
15–20 minutes
Free download
After: G6

70 Challenge: the canteen pivot WD–GX

- Check the data before you trust a pivot.
- Blank and near-duplicate labels make groups of their own.
- Choose Sum or Count for the question.

Replaces the idea: That a pivot's top row is the answer.

Challenge
15–20 minutes
Free download
After: G1–G7

Lookups and joining tables

Exercise 71–76

71 Look it up WD-L1

- XLOOKUP finds a value in one column and brings back the value beside it.
- It returns the first match from the top.
- A total is checked against a number from outside the spreadsheet.

Replaces the idea: That a lookup without an error has found the right row.

Advanced
15–20 minutes
Free download
After: G4

72 Why did the lookup fail? WD-L2

- A lookup matches exactly: text is never a number, a space counts.
- IFERROR hides a failure; it does not repair it.
- Repair data where it starts.

Replaces the idea: That a sheet with no errors showing has no errors.

Advanced
15–20 minutes
Free download
After: L1

73 Join two tables WD-L3

- A lookup joins two tables on a key.
- One order, many lines: a join repeats the order's values on every line.
- Amounts are added up where one row is one of them.

Replaces the idea: That joining two tables cannot change a total.

Advanced
15–20 minutes
Free download
After: L2

74 Who went missing? WD-L4

- Rows with no match drop out of group totals.
- COUNTIF of a key, or ISNA on the lookup, finds them.
- Check a join both ways.

Replaces the idea: That a total with no errors includes every row.

Advanced
15–20 minutes
Free download
After: L3

75 Analyze two tables WD-L5

- A summary over two tables needs the key that links them.
- Join first (XLOOKUP into the detail table), then pivot.
- Check the Grand Total against the source.

Replaces the idea: That a pivot's total is right because the pivot added it up.

Advanced
15–20 minutes
Free download
After: L1–L4 and G6

76 Challenge: orders and customers WD-LX

- A failed lookup has a cause: text, a space, or a missing key.
- Repair at the source; flag what cannot be repaired.
- Parts must add up to the whole.

Replaces the idea: That a join without errors showing is complete.

Challenge
15–20 minutes
Free download
After: L1–L4

Questions, evidence and conclusions

Exercise 77–90

77 Make it measurable WD-E1

- A topic is not a question until it says what is counted.
- Two honest counts can give opposite answers.
- SUMIF adds up one group.

Replaces the idea: That a question like "is it healthy?" has one answer in the data.

Basic
15–20 minutes
Free download
After: S5 and F5

78 Observation or explanation? WD-E2

- An observation is what the data shows.
- An explanation says why, and needs more than the data.
- A statement can sound like data and still need data that isn't there.

Replaces the idea: That anything said in the language of facts is an observation.

Basic
15–20 minutes
Free download
After: E1

79 Write the survey question WD-E11

- Answer boxes must not overlap and must leave nobody out.
- Pick one or pick all: say which.
- A fair question does not tell you what to think.

Replaces the idea: That a survey simply records what people think.

Basic
15–20 minutes
Free download
After: S1

80 Collect your own data WD-E12

- A plan says what, in which unit, how, who and how many times.
- Two groups can only be compared if they followed the same plan.
- More measurements give a steadier average.

Replaces the idea: That data is just what was measured, and the way it was measured does not matter.

Basic
15–20 minutes
Free download
After: E11; needs a 30 cm ruler per group

81 A conclusion with a limitation WD-E3

- A conclusion says what the data shows, about whom.
- A useful limitation is specific to how this data was collected.
- AVERAGEIF compares groups.

Replaces the idea: That "more research is needed" is a limitation.

Intermediate
15–20 minutes
Free download
After: E2

82 One recommendation WD-E4

- A total is only fair when everything had the same chance.
- COUNTIF and SUMIF by group.
- A recommendation is an action, a figure and a limitation.

Replaces the idea: That the biggest total is the best seller.

Intermediate
15–20 minutes
Free download
After: E3

83 Correlation or cause? WD-E5

- CORREL measures how closely two columns move together.
- A common cause can make two things correlate.
- Correlation is not causation.

Replaces the idea: That a strong correlation shows a cause.

Advanced
15–20 minutes
Free download
After: E4

84 Who did you ask? WD-E6

- Where and how you ask chooses who answers.
- A random draw gives everyone the same chance.
- The average of a 1/0 column is a share.

Replaces the idea: That more answers always make a survey better.

Advanced
15–20 minutes
Free download
After: E5

85 Who is missing? WD-E7

- Who could answer decides who did.
- A missing respondent leaves no blank cell.
- Check the answers against the full list.

Replaces the idea: That data with no blanks has nobody missing.

Advanced
15–20 minutes
Free download
After: E6

86 Can this data answer it? WD-E8

- What one row is decides what the data can answer.
- Group averages say nothing certain about individuals.
- "Partly" is a real verdict.

Replaces the idea: That a strong pattern between groups holds for the people in them.

Advanced
15–20 minutes
Free download
After: E7

87 Audit a conclusion WD-E9

- Audit a claim by reproducing it.
- SUBTOTAL follows a filter; AVERAGE does not.
- A figure must say who it is about.

Replaces the idea: That a number from the data is a true claim about everyone in it.

Advanced
15–20 minutes
Free download
After: E8

88 Write a source note WD-E10

- Published figures can be revised.
- A source note says who, what and when.
- The date tells which version you used.

Replaces the idea: That two copies of the same table must match.

Advanced
15–20 minutes
Free download
After: E9

89 Better in every group, worse overall WD-E13

- An overall rate is a weighted mean of the group rates.
- Groups made up differently can flip a comparison (Simpson's paradox).
- Compare like with like: group by group.

Replaces the idea: That winning in every group means winning overall.

Advanced
15–20 minutes
Free download
After: S11

90 Challenge: from question to answer WD-EX

- A measurable question says what is counted.
- Compare per day when periods differ.
- Every change to the data goes in a log.

Replaces the idea: That answering a question means finding one number.

Challenge
15–20 minutes
Free download
After: E1–E4 and Q7

Dashboards and work

Exercise 91–97

91 Revenue, cost and margin WD-D1

- Revenue = price × quantity.
- Markup = profit ÷ cost; margin = profit ÷ revenue.
- A percentage needs its base.

Replaces the idea: That a profit percentage is one fixed number.

Intermediate
15–20 minutes
Free download
After: F4

92 Time to reorder? WD-D2

- IF decides from exactly what it is given.
- A reorder test counts stock plus open orders.
- A rule is tested on cases it was not built on.

Replaces the idea: That a formula without errors gives the right decision.

Intermediate
15–20 minutes
Free download
After: F5

93 The number behind the number WD-D3

- A KPI has a base and a period.
- A rate over a period divides totals, not averages of rates.
- & joins numbers and text in a formula.

Replaces the idea: That a high percentage is good news on its own.

Intermediate
15–20 minutes
Free download
After: D1

94 Hit the number, miss the point WD-D4

- AVERAGE skips blank cells.
- A KPI can be met while its purpose is missed.
- A sturdier KPI counts every case, including failures.

Replaces the idea: That a KPI on target means the work is going well.

Advanced
15–20 minutes
Free download
After: D3

95 Filter the dashboard WD-D5

- A selector is a data-validation list cell.
- Only what reads the selector follows it.
- SUMIFS on the selected value feeds KPIs and charts.

Replaces the idea: That a filter on a dashboard filters everything on it.

Advanced
15–20 minutes
Free download
After: D3

96 Clear the clutter WD-D6

- A dashboard answers a stated question.
- A shared axis can flatten a small series.
- Removing is a design decision.

Replaces the idea: That more charts and colors give a reader more information.

Advanced
15–20 minutes
Free download
After: C6

97 Build an interactive dashboard WD-D7

- A selector, KPIs and a chart wired to it.
- $ keeps the selector fixed when filling down.
- A dashboard is tested on cases it was not built on.

Replaces the idea: That a dashboard that works on its example works.

Advanced
15–20 minutes
Free download
After: D5

Automation (VBA)

Exercise 98–135

98 Your first script WD-P1

- A script follows its lines in order, exactly.
- Range("B1") without a sheet is the open sheet.
- Naming the sheet makes a script safe to run from anywhere.

Replaces the idea: That a script knows where its result belongs.

Intermediate
15–20 minutes
Free download
After: F1

99 Name the sheet WD-P2

- A Range with no sheet named is the open sheet, for reading as well as writing.
- A wrong 0 gives no error.
- Test a fix on a case it was not made for.

Replaces the idea: That naming the sheet once makes a script safe.

Intermediate
15–20 minutes
Free download
After: P1

100 Read a value WD-P3

- A value read from a cell keeps its type.
- For two Strings, + joins.
- Val() turns text into a number.

Replaces the idea: That + always adds.

Intermediate
15–20 minutes
Free download
After: P2

101 Variables WD-P4

- A variable is a named box for a value.
- Without Option Explicit a typo makes a new variable.
- Option Explicit checks every name before the script runs.

Replaces the idea: That a script with no error message has no mistakes.

Intermediate
15–20 minutes
Free download
After: P3

102 Text or number? WD-P5

- Text is compared character by character.
- Numbers stored as text sort as 1, 10, 2.
- Val() makes the comparison numeric.

Replaces the idea: That 10 is always more than 9 to a computer.

Intermediate
15–20 minutes
Free download
After: P4

103 Big enough? WD-P6

- Dim ... As sets a variable's type.
- An Integer holds whole numbers up to 32,767; a Long up to about 2.1 billion.
- A test only proves the sizes it tried.

Replaces the idea: That a script that passed its test will work on the real data.

Intermediate
15–20 minutes
Free download
After: P5

104 If, else if WD-P7

- If and ElseIf are tried in order; the first true one wins.
- Overlapping conditions: strictest first.
- Check the edges: exactly 8, exactly 5.5.

Replaces the idea: That every line of an If is checked.

Intermediate
15–20 minutes
Free download
After: P6

105 Loop through the rows WD-P8

- For r = 2 To 30 runs 29 times.
- After the loop the counter is one step past the end.
- A fixed end number breaks when the list grows.

Replaces the idea: That a loop to 30 covers 30 rows.

Intermediate
15–20 minutes
Free download
After: P7

106 Delete while you loop WD-P9

- Rows(r).Delete moves the rows below up one.
- A top-down loop then skips a row.
- Step -1 loops from the bottom up.

Replaces the idea: That a loop sees every row of a list it is changing.

Intermediate
15–20 minutes
Free download
After: P8

107 Where does the data end? WD-P10

- End(xlDown) stops at the last filled cell before a gap.
- Cells(Rows.Count, 1).End(xlUp).Row finds the real last row.
- Ctrl+Down and Ctrl+Up show the same jumps.

Replaces the idea: That a script finds the end of a list by itself.

Intermediate
15–20 minutes
Free download
After: P9

108 Empty or not? WD-P11

- IsEmpty is True only for a cell that holds nothing.
- A formula returning "" is empty text, not Empty.
- Value = "" catches both.

Replaces the idea: That a cell that looks empty is empty.

Intermediate
15–20 minutes
Free download
After: P10

109 Totals per group WD-P12

- A value no Case matches falls through, with no error.
- Compare the parts with the whole.
- Case Else catches what nobody named.

Replaces the idea: That a script would warn you about data it does not expect.

Intermediate
15–20 minutes
Free download
After: P11

110 Step through it WD-P13

- Stepping shows which lines run, how often, with which values.
- A right output can hide a wrong route.
- Test on a case the script was not checked on.

Replaces the idea: That a script which gives the right answer works.

Intermediate
15–20 minutes
Free download
After: P12

111 Check the script against your hand WD-P14

- Check a script with an independent hand calculation.
- When they disagree, trace both.
- The average of averages is only right for groups of equal size.

Replaces the idea: That when a script and a person disagree, the script is the one to fix.

Intermediate
15–20 minutes
Free download
After: P13

112 Is it worth automating? WD-P15

- Pay-back = build time ÷ time saved per year.
- How often a task runs matters more than one run's saving.
- A rule like "within a year" is a choice, and can be argued.

Replaces the idea: That automating a task always saves time.

Intermediate
15–20 minutes
Free download
After: P14

113 Say what it should do WD-P16

- Input, process, output make a request checkable.
- Two correct scripts can answer a vague request differently.
- A script is checked against its spec, not against a feeling.

Replaces the idea: That a script that runs without an error does what was wanted.

Advanced
15–20 minutes
Free download
After: P15

114 Flowchart first WD-P17

- A flowchart shows every decision before the code exists.
- An empty input is a case, not an accident.
- 0 ÷ 0 stops a VBA script with an error.

Replaces the idea: That a script tested on full data works on all data.

Advanced
15–20 minutes
Free download
After: P16

115 Split it into pieces WD-P18

- Copy-pasted code is one idea in several places.
- A Function returns a value and can be called from many places.
- A change made in one place cannot be missed elsewhere.

Replaces the idea: That code that runs without an error is up to date.

Advanced
15–20 minutes
Free download
After: P17

116 What a procedure can change WD-P19

- A procedure is called with arguments.
- ByRef (VBA's default) passes the variable itself; ByVal passes a copy.
- Stepping and the variables panel show a value change where no line in the caller changed it.

Replaces the idea: That a procedure can only change what it returns or writes.

Advanced
15–20 minutes
Free download
After: P18

117 Functions that return WD-P20

- A VBA Function returns by assigning to its own name.
- A Function that never does returns Empty, with no error.
- Empty written into a cell leaves it blank.

Replaces the idea: That a Function that runs without an error gives back its answer.

Advanced
15–20 minutes
Free download
After: P19

118 Constants and comments WD-P21

- A named constant says what a number is.
- A comment should say why, not repeat the code.
- A rate written once can be checked once.

Replaces the idea: That a number in code explains itself.

Advanced
15–20 minutes
Free download
After: P20

119 Find columns by name WD-P22

- A column position is a fact about one file.
- Search the heading row, and handle a heading that is missing.
- Test a fix on a case it was not written for.

Replaces the idea: That a script that worked last month reads the same data this month.

Advanced
15–20 minutes
Free download
After: P21

120 Reset the counter WD-P23

- An accumulator needs a reset where each new count starts.
- The parts must add up to the whole: a control total.
- In VBA a Dim inside a loop does not reset a variable.

Replaces the idea: That a total that looks plausible is right.

Advanced
15–20 minutes
Free download
After: P22

121 Bike or bike? WD-P24

- Text comparison in VBA is exact by default.
- A key must be cleaned the same way every time.
- Cleaning fixes typing, not different words.

Replaces the idea: That the computer sees "Bike" and "bike" as the same answer.

Advanced
15–20 minutes
Free download
After: P23

122 Hidden rows still count WD-P25

- A filter hides rows; it does not remove them.
- A loop over row numbers sees hidden rows.
- Rows(r).Hidden or SpecialCells(xlCellTypeVisible) lets a script skip them.

Replaces the idea: That a script works on what is on the screen.

Advanced
15–20 minutes
Free download
After: P24

123 Rules for bad data WD-P26

- Rules catch the errors their writer imagined.
- A held-out sheet tests a check honestly.
- A new rule must not break the old cases.

Replaces the idea: That a check that passed once will catch every error.

Advanced
15–20 minutes
Free download
After: P25

124 "0 problems" WD-P27

- A For loop whose start is past its end never runs.
- A count of 0 can mean clean or unchecked.
- A report should say how much it checked.

Replaces the idea: That "0 problems" means everything was checked and fine.

Advanced
15–20 minutes
Free download
After: P26

125 One read, not ten thousand WD-P28

- Each read, write or Select is a trip to the sheet.
- Range.Value of many cells is one read into a 2-D array.
- Work inside the script, write once.

Replaces the idea: That a script which gives the right answer is a good script.

Advanced
15–20 minutes
Free download
After: P10

126 Run it twice WD-P29

- A script that adds to its output depends on the last run.
- Clear the output, then build it.
- Repeatable: twice gives the same as once.

Replaces the idea: That running a script again is harmless.

Advanced
15–20 minutes
Free download
After: P28

127 Charts from a script WD-P30

- ChartObjects.Add always adds a chart.
- A range in the code does not grow.
- Find the last row with End(xlUp).

Replaces the idea: That a chart made by a script updates itself.

Advanced
15–20 minutes
Free download
After: P29

128 Same scale for comparison WD-P31

- Automatic axes fit each chart to its own data.
- Small multiples compare only on one shared scale.
- Take the scale from the data, not from a typed number.

Replaces the idea: That charts side by side can be compared by bar height.

Advanced
15–20 minutes
Free download
After: P30

129 Errors you can't see WD-P32

- Resume Next skips the failing line and nothing else.
- A script that succeeds can still be wrong.
- Test values, and name what you cannot use.

Replaces the idea: That a script that does not crash has worked.

Advanced
15–20 minutes
Free download
After: P31

130 Messages people can act on WD-P33

- VBA's errors describe VBA, not your file.
- Check before you use: the sheet, the data.
- A message names the problem and the action.

Replaces the idea: That an error message is for the user.

Advanced
15–20 minutes
Free download
After: P32

131 Three nasty files WD-P34

- Each nasty file breaks a different assumption.
- Unchecked problems come back as answers.
- Keep test files; test on ones you did not design for.

Replaces the idea: That a script tested on the normal file is tested.

Advanced
15–20 minutes
Free download
After: P33

132 Write down your assumptions WD-P35

- Assumptions on a sheet can be read and checked.
- Unwritten assumptions are never checked.
- Report nothing while an assumption is broken.

Replaces the idea: That a script whose checks pass is right.

Advanced
15–20 minutes
Free download
After: P34

133 Review a partner's script WD–P36

- A passing test proves one case.
- Authors test around their own blind spots.
- Review from the rule: test the boundaries.

Replaces the idea: That a script whose tests pass is correct.

Advanced
15–20 minutes
Free download
After: P35

134 A rule for every pupil, every week WD–P37

- An automated rule is applied to everyone, every time, unread.
- Counts without the denominator compare unfairly.
- A list for a person, not a label on a child.

Replaces the idea: That a rule is fair because a machine applies it the same way to everyone.

Advanced
15–20 minutes
Free download
After: P36

135 Capstone: an automated report WD–PX

- Design before code: input, process, output, checks.
- Repeatable output, data-driven groups and ranges.
- Test on held-out files; messages people can act on.

Replaces the idea: That a script which works on your file is finished.

Challenge
15–20 minutes
Free download
After: P37

The Canteen case

Exercise 136–147

136 The canteen: repair five problems WD-K1

- A check against an independent count (reconciling).
- Some errors leave no trace in money: names, categories.
- A strange value is not always a wrong one.

Replaces the idea: That cleaning data means changing everything that looks odd.

Intermediate
15–20 minutes
Free download
After: T2, G1

137 The canteen: mean or median wait? WD-K3

- The mean is pulled by extreme values; the median is not.
- AVERAGEIF to leave one day out.
- A real outlier is reported, not hidden.

Replaces the idea: That "the average wait" is what a typical pupil waits.

Intermediate
15–20 minutes
Free download
After: S3, S5

138 The canteen: the most popular product WD-K4

- SUMIF per product.
- Count and value rank differently.
- A claim needs its unit.

Replaces the idea: That "most popular" has one answer.

Intermediate
15–20 minutes
Free download
After: G2

139 The canteen: a sales chart WD-K6

- AVERAGEIF per category.
- The automatic axis need not start at 0.
- A bar's length stands for its amount.

Replaces the idea: That a default chart is a neutral chart.

Intermediate
15–20 minutes
Free download
After: C5

140 The canteen: two conclusions WD-K9

- A share per week.
- Observation against explanation.
- Two changes at once cannot be separated.

Replaces the idea: That a change in the data explains itself.

Intermediate
15–20 minutes
Free download
After: E2, E3

141 The canteen: two limitations WD-K10

- Who a denominator covers.
- Coverage of a dataset.
- Specific against generic limitations.

Replaces the idea: That "more data is needed" is a limitation.

Intermediate
15–20 minutes
Free download
After: E3, E6

142 The canteen: a pivot WD-K11

- A pivot: rows, values, sum.
- Empty cells make a (blank) group.
- A pivot is refreshed, not live.

Replaces the idea: That a pivot's rows are the categories you meant.

Intermediate
15–20 minutes
Free download
After: G6

143 The canteen: plan the automation WD-K12

- Break-even = time to build ÷ time saved each run.
- IF against a limit.
- A plan before a script.

Replaces the idea: That the most annoying job is the best one to automate.

Intermediate
15–20 minutes
Free download
After: F5, G2; before P15

144 The canteen: revenue per sale `WD-K2`

- XLOOKUP finds a value; it does not know when it was valid.
- A total checked against an independent count.
- IF to choose between two price lists.

Replaces the idea: That a lookup that returns a price returns the right price.

Advanced
15–20 minutes
Free download
After: K1, F3, L1

145 The canteen: margin by category `WD-K5`

- Margin = (revenue − cost) ÷ revenue.
- A weighted result from totals.
- An average of percentages ignores size.

Replaces the idea: That a category's margin is the average of its products' margins.

Advanced
15–20 minutes
Free download
After: F4, S11

146 The canteen: a weekly trend `WD-K7`

- COUNTIF for the days open.
- A rate per day makes unequal weeks comparable.
- A trendline fits the numbers it is given.

Replaces the idea: That a trendline shows what is happening.

Advanced
15–20 minutes
Free download
After: C7, C8, K6

147 The canteen: one indicator `WD-K8`

- A rate (per meal) against a total (per day).
- Percentage change.
- An indicator needs a counterweight.

Replaces the idea: That a target met is a goal reached.

Advanced
15–20 minutes
Free download
After: F4, D3

3

The digital lab

Browser activities that go where paper cannot: more cases, more rounds, the real thing at scale.

AI

TL-008 tool

Train It Yourself

groep 7–secondary · 20–30 min · vonkdesign.studio/lab/train.html

WHAT PUPILS DO

- Teach SORT-1 to find an animal in pictures. Check its answers, train it again, and test it on new pictures. Covers kerndoel 21D: training an AI system.

TL-001 tool

Threshold Machine

groep 6–8 · 5–10 min · vonkdesign.studio/lab/tally.html

WHAT PUPILS DO

- TALLY gives points for each feature a card has and says YES when the total reaches the line. Pick birds, fish, insects or mammals. Set the points so every card on the board is right, then solve one more card.

TL-003 tool

Splitter

groep 6–8 · 15–25 min · vonkdesign.studio/lab/splitter.html

WHAT PUPILS DO

- Chatbots chop words into numbered pieces. SNIP does the same, with a list of pieces it counted from text. Guess how it chops, beat it with fewer pieces, and find out which language costs more pieces.

TL-002 tool

Prediction Machine

groep 7–8 · 15–20 min · vonkdesign.studio/lab/next.html

WHAT PUPILS DO

- NEXT finishes a sentence with the word that came next most often in a real book. Guess what it will say, change what it says, and catch it writing a false sentence made of true pieces.

TL-013 simulation

Feed Simulator

groep 8–secondary · 15–25 min · vonkdesign.studio/lab/feed.html

WHAT PUPILS DO

- LOOP fills a feed with more of what was clicked and watched. See two pupils' feeds grow apart, see a feed win more watch time but lose variety, and test a fix on 50 made-up users.

TL-009 tool

Map Maker

groep 7–8 · 10–20 min · vonkdesign.studio/lab/map.html

WHAT PUPILS DO

- PLOT puts 40 animals or 40 snacks on a map using two numbers, and counts the steps to the nearest one. Place them, find the nearest, then swap one axis and see every neighbor change.

TL-004 tool

Cloud Explorer

secondary · 15–20 min · vonkdesign.studio/lab/cloud.html

WHAT PUPILS DO

- Turn a 3D cloud of 24 words. Two words that look close from above can be far apart in depth. Find these traps, then see how one unit or one extra axis changes who is nearest.

GM-014 game

Reward Robot

groep 7–secondary · 15–20 min · vonkdesign.studio/lab/reward.html

WHAT PUPILS DO

- ROVER has no map. It learns the way to its dock from the points you give it, and its whole score table is on screen. Set points for mud, a hole and a coin, and catch it learning the wrong thing.

GM–015 game

Fool the Machine

groep 8–secondary · 15 min · vonkdesign.studio/lab/fool.html

WHAT PUPILS DO

- Paint on the 256 squares SORT-1 compares until it gives the wrong answer: a cat it calls DUCK because of the water, or a duck it misses in evening light. Then add your trick picture to its memory and try to fool it again.

GM–016 game

Memorize or Learn

groep 8–secondary · 15 min · vonkdesign.studio/lab/memorise.html

WHAT PUPILS DO

- MEMO remembers the practice cards. TALLY learns a rule from them. Both get 100% on practice. A test with new cards shows which one really learned something. Then beat a machine that learned a shortcut.

PZ–001 puzzles

Threshold puzzles

groep 6–8 · 10 min · vonkdesign.studio/lab/thresholds.html

WHAT PUPILS DO

- Eight short puzzles about TALLY's rule: add up the points, move the line, find the card that breaks a rule, and set the points in as few clicks as you can.

PZ–002 puzzles

Chop puzzles

groep 7–8 · 10 min · vonkdesign.studio/lab/chops.html

WHAT PUPILS DO

- Eight short puzzles about SNIP's rule: always take the longest piece first. Find words where that uses more pieces than needed, beat it, see why trying every way takes too long, and find the same trap with coins.

PZ–003 puzzles

Nearest-neighbor puzzles

groep 7–8 · 10 min · vonkdesign.studio/lab/neighbours.html

WHAT PUPILS DO

- Who is nearest? And does that change when the axes change? NEAR counts steps on the animal and snack maps from the worksheets. Swap, squeeze or add an axis and see what happens.

TL–014 tool

Source Checker

groep 7–secondary · 20 min · vonkdesign.studio/lab/sources.html

WHAT PUPILS DO

- SHELF shows the source lines that share words with a claim. You decide for each claim: the same, different, or not in the sources. You practice on example chatbot answers written by Vonk, then weigh search results.

TL–005 tool

Ranking Sandbox

groep 6–secondary · 10–20 min · vonkdesign.studio/lab/ranking.html

WHAT PUPILS DO

- RANK finds pages with your search words and puts them in order by counting. Search 300 pages, move sliders and watch 40 results change places, find the page no rule can move up, and run the auction for the top spot.

SC–001 teacher script

Same prompt, twice

groep 8–secondary · 10 min · vonkdesign.studio/lab/twice.html

WHAT PUPILS DO

- A script for the teacher, for the school's own approved chatbot. Ask the same question in two new chats and get two different answers, explained with the dice from worksheet L5-4A. For the projector or on paper.

SC–002 teacher script

Ask it for sources

groep 8–secondary · 15 min · vonkdesign.studio/lab/ask-sources.html

WHAT PUPILS DO

- A script for the teacher, for the school's own chatbot. Ask it for facts and sources, then check each source: does it exist, and does it say what the chatbot claimed?

Working with data

GM–018 game

Tidy Up

secondary · 10–20 min · vonkdesign.studio/lab/tidy.html

WHAT PUPILS DO

- Eight tables made for people to read. Tidy each one so a computer can use it. Then four tests check it: shape, SUM, sort and filter.

GM–017 game

Data Detective

secondary · 5–8 min · vonkdesign.studio/lab/detective.html

WHAT PUPILS DO

- Eight headlines from a made-up newspaper. Use the data in GRID to find what went wrong, then pick the honest headline. Each solved case gives you a code, so nothing needs to be saved.

GM–019 game

Mean Machine

secondary · 10 min · vonkdesign.studio/lab/mean.html

WHAT PUPILS DO

- Drag the points and watch the mean, median and mode change. Puzzles like: make the mean 30 but keep the median at 12.

GM–020 game

Chart Doctor

secondary · 10–15 min · vonkdesign.studio/lab/chart-doctor.html

WHAT PUPILS DO

- First make an honest chart support a false headline, just by changing its settings. Then fix charts that other people twisted.

GM–021 game

Reference Runner

secondary · 10 min · vonkdesign.studio/lab/refs.html

WHAT PUPILS DO

- Predict where a copied formula will point. Lock parts of it with $ and watch the copy. Then copy it in a new direction to test your answer.

GM–022 game

Lookup Lock

secondary · 10 min · vonkdesign.studio/lab/lookup.html

WHAT PUPILS DO

- Look up values between two tables. Every match is drawn as a line. Find out why a line is missing: text versus a number, a hidden space, two matches where only the first counts, or a 0 that hides an error.

GM–023 game

Cause or Coincidence?

secondary · 10–15 min · vonkdesign.studio/lab/cause.html

WHAT PUPILS DO

- Guess how strongly two things go together. Then see the real number (r) and the hidden third thing. Is it cause, a shared cause, or chance?

GM–024 game

Sample Trap

secondary · 10–15 min · vonkdesign.studio/lab/sample.html

WHAT PUPILS DO

- Survey a made-up school of 1,000 pupils, a thousand times over. Asking only in the canteen gets it wrong every time. Random samples land close to the truth.

GM–025 game

Dirty Data

secondary · 10–15 min · vonkdesign.studio/lab/dirty.html

WHAT PUPILS DO

- Find the wrong rows by hand. Then write a rule that finds them for you, and test it on new rows it has never seen.

Codes and bits

TL-010 tool

Bit Lab

groep 7–secondary · 15–20 min · vonkdesign.studio/lab/bitlab.html

WHAT PUPILS DO

- BITBOX zooms in on a picture until you see its pixels and their numbers. It measures how much smaller your drawing gets when it is packed. Then it sends 10,000 grids down a line that flips some bits, with and without a check bit.

TL-011 tool

Crack Lab

groep 7–secondary · 10–15 min · vonkdesign.studio/lab/crack.html

WHAT PUPILS DO

- Break a secret code (a Caesar shift) by trying every key, then by counting letters. CRACK attacks 1,200 messages: counting works on long messages and fails on short ones.

TL-012 tool

Lock Lab

groep 8–secondary · 15–20 min · vonkdesign.studio/lab/lock.html

WHAT PUPILS DO

- Checking a code takes no time, but guessing it gets ten times slower with every extra digit. Multiplying and splitting a number work the same way. Your browser times it live. Then see how Eve attacks with a table, and how random padding stops her.

PZ-004 puzzles

Lamp puzzles

groep 6–7 · 10 min · vonkdesign.studio/lab/lamps.html

WHAT PUPILS DO

- How high can a row of lamps count? Three short puzzle sets with LAMP-5: each lamp is worth double the one before, lamps make numbers, and a counter runs out of lamps.

PZ-005 puzzles

Find the flip

groep 8–secondary · 10 min · vonkdesign.studio/lab/flip.html

WHAT PUPILS DO

- EVEN adds a check row and a check column to a grid. One square flips: find it. Then catch EVEN saying OK when the grid is wrong.

More

TL-006 tool

Prototype Studio

secondary | 30 min | vonkdesign.studio/lab/prototype.html

WHAT PUPILS DO

- Write a table of screens and what each tap does, and PROTO turns it into an app you can click. It follows the table exactly: if a tap is not in the table, nothing happens. Check every link, find screens nobody can reach, then build your own app and share it as a link.

4

Assessment

Paper assessments that ask pupils to predict, find the fault and explain, never to define a word.

AS-001

Assessment: Band C

groep 5–6 (ages 8–10)

two sittings of 25 minutes (or one sitting of 50) · On request

LEARNING OBJECTIVES

- A machine that learned from examples copies its examples, including their gaps.
- Data, steps and computers are separate parts, and a fault usually lives in one of them.
- A dataset is a slice of the world, chosen by people: who was asked decides the answer.
- A machine can sound like a kind person without feeling or knowing anything.
- What you type into a chatbot, and what you believe from it, are your choices.

Replaces the idea: That you can assess AI understanding by asking pupils what AI words mean.

AS-002

Assessment: Band D

groep 7–8 (ages 10–12)

two sittings of 25 minutes (or one sitting of 50) · On request

LEARNING OBJECTIVES

- A written rule can be read and checked; a learned pattern came from examples and has no single rule to point at; many systems combine both.
- A system that learned from examples copies their mistakes: one wrong label gives a wrong answer, done perfectly.
- Who is missing from the data is who the system is most likely to fail, and what has to be tested, whatever the box says.
- A text generator picks likely words by chance, so it can be different each time and confidently wrong.
- Detail and confidence are not evidence; checking outside the chatbot is.

Replaces the idea: That knowing the words 'algorithm' and 'training data' shows you understand AI.

AS-003

Assessment: Band E

secondary years 1–2 (ages 12–14)

two sittings of 25 minutes (or one sitting of 50) · On request

LEARNING OBJECTIVES

- Rule-based and statistics-based systems fail differently, and only one of them can show you the rule that decided about you.
- A trained model learns whatever separates its examples, which is not always what its makers meant.
- A percentage correct hides which mistakes a system makes; choosing a setting is choosing who pays for them.
- An official with two minutes and a risk score on screen is not the same as human oversight.
- A language model's probabilities follow patterns in text, not truth, so the most frequent answer need not be the true one.

Replaces the idea: That a VO AI unit can be assessed with a definitions quiz.

AS-004

Assessment: Band F

secondary year 3, havo/vwo (ages 14–15)

two sittings of 25 minutes (or one sitting of 50) · On request

LEARNING OBJECTIVES

- An expert system follows its rules in order; a fix is a rule in the right place, and you can read whether it worked.
- Training is repeatedly adjusting numbers to make an error smaller.
- A model with zero error on its training data can be the worse one; only data it never saw tells you how well it generalizes.
- A reward is a number to maximize, so a system does what scores, not what was meant.
- Word positions record how words were used in the training text, including its biases; a toy map shows the idea, real embeddings are messier.

Replaces the idea: That knowing the names of machine-learning techniques shows you understand what they can and cannot do.