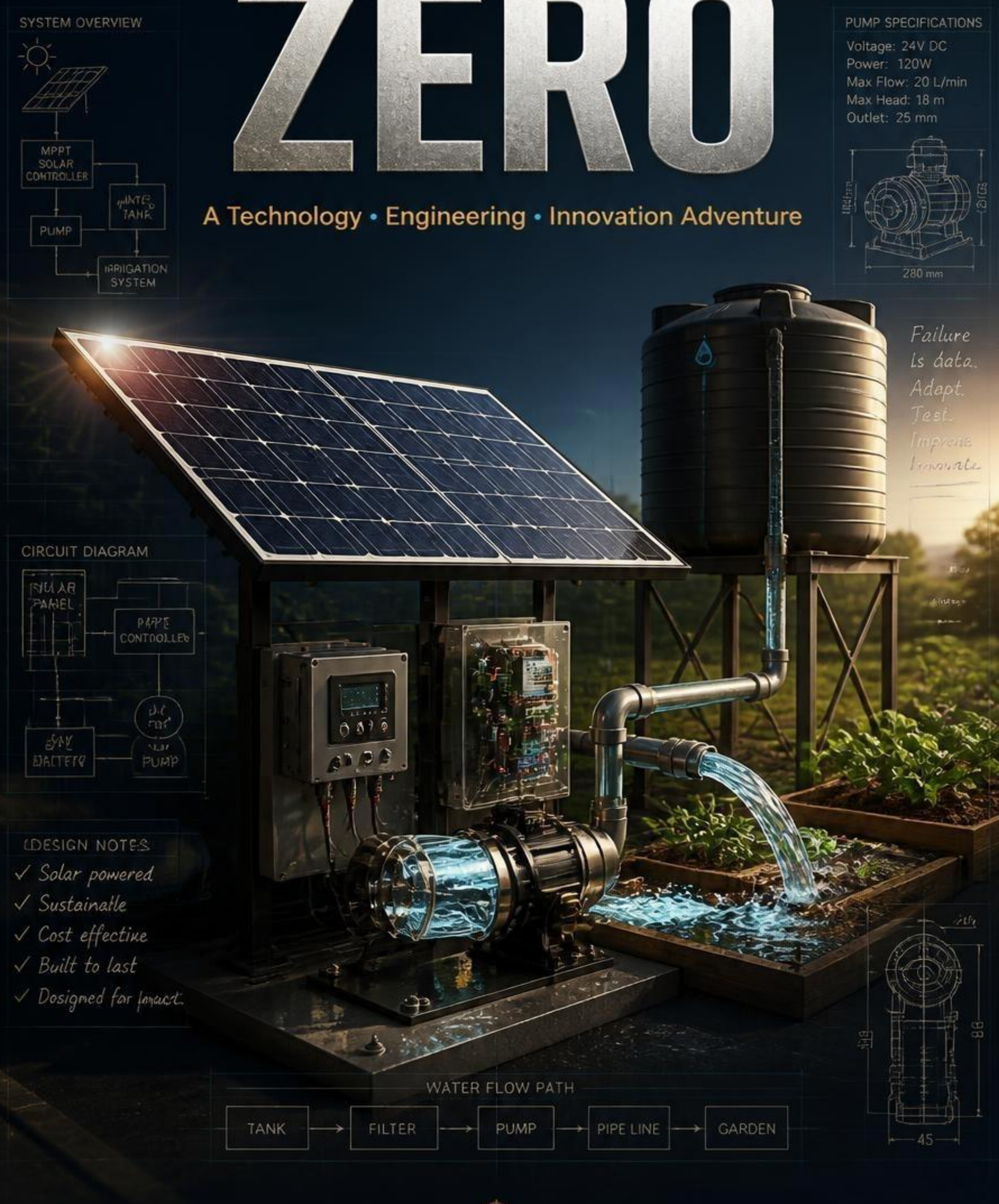
THE ACADEMY SERIES

BOOK 5

PROJECT ZERO

A Technology • Engineering • Innovation Adventure



PRESENTED BY HIRRA ACADEMY

Genre: *Educational Fiction / STEM Adventure (Basic Technology & Engineering)*

Junior Secondary Level

About This Book

Every year, Hirra Academy's Young Innovators Competition asks one simple question: can you solve a real problem, not just imagine one? For Tariq, Zainab, Fatima, and Chinedu, the answer starts under a mango tree with a sketch of a solar-powered water pump for the school garden, and it does not go smoothly. Wires fail. Pipes trap air. A frame that held perfectly still collapses the moment the machine actually runs. Project Zero is Book Five in The Academy Series, and it follows the team through every measurement, failure, and redesign that stands between a good idea and a working invention. This is a story about technology, but more than that, it is a story about what engineering really looks like: not a single flash of genius, but the patience to test, to fail, and to understand exactly why something finally works.

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Book 5 *Project Zero*.

CHAPTER ONE — THE ANNOUNCEMENT

The assembly hall was louder than usual, the kind of noise that came from something genuinely exciting rather than the usual restlessness before morning announcements. Mr. Musa waited at the front, arms folded, letting the noise run its course before raising a single hand for quiet.

“This year’s Young Innovators Competition,” he said, once the hall had settled, “will be the biggest this school has held.”

A murmur of approval rippled through the rows.

“You will work in teams,” he continued. “You will identify a real problem not an imaginary one, but a real problem in this school or this community and you will design something, using basic technological principles that actually solves it.”

He let that sink in.

“Not a drawing of a solution,” he said. “A working prototype, something that does what you say it does, in front of judges, on the day.”

Tariq Ibrahim stood near the back though the assembly hadn’t technically called for note-taking. He’d been sketching since the moment Mr. Musa mentioned “problem” a rough shape already forming in the margin, half bicycle wheel, half something he didn’t have a name for yet.

Beside him, Zainab leaned over. “You’re drawing already?”

“I draw when I’m listening,” Tariq said. “It helps me think.”

At the front, Mr. Musa was still speaking. “You will be judged,” he said, “on whether you understand *why* it works or why it doesn’t.”

Chinedu, snorted quietly. “Why would it not work? If you build it right, it works.” Fatima muttered. After assembly, the four of them gathered under the mango tree near the workshop block, the unofficial meeting spot for anyone in Mr. Musa’s Basic Technology class with an idea worth arguing about.

“So,” Zainab said, notebook ready, pen uncapped. “Real problem. What do we actually have around here that needs solving?”

Chinedu had an answer before she'd finished the sentence. "The generator, half the time it doesn't start. We could build something to fix that."

"Too big," Fatima said. "And too electrical for what we're allowed to touch this term."

"The gate," Chinedu tried again. "It's always squeaking. We could design a better hinge."

"That's not a problem," Zainab said. "That's an annoyance."

Tariq, still sketching, hadn't said anything and the others turned to him.

"What about you?" Fatima asked. "You've been drawing something since assembly. What is it?"

Tariq turned the notebook around slowly and showed them the rough sketch of a tank, a slanted panel, a scatter of arrows he hadn't labelled yet but the shape of an idea was clearly there.

"The garden," he said. "Have you seen how the students on watering duty carry those buckets every single morning? Even during the dry season, when the tank runs low, they're hauling water from the borehole all the way across the compound."

"So?" Chinedu said. "That's just how it's always been done."

"That's exactly the problem," Tariq said quietly. "Nobody questions it because it's always been done that way but there's a solar panel sitting unused behind the workshop store. There's a small pump in the equipment room nobody's used since last term. What if we didn't need buckets at all?"

For a moment, nobody spoke.
"A solar-powered water system," Zainab said slowly, writing as she spoke. "For the garden."

"It's real," Fatima said, warming to it. "It solves an actual daily problem and it uses everything Mr. Musa's been teaching us, energy, structures, circuits and materials."

Chinedu grinned, already picturing it built. "I like it," he said. "What do we call it?"

Tariq looked down at his sketch, the tank, the panel, the pump, the arrows showing water finally moving on its own, without a single bucket in sight.

"Project Zero," he said. "Because right now, it's nothing but just an idea and everything after this is us finding out if it can become something real."

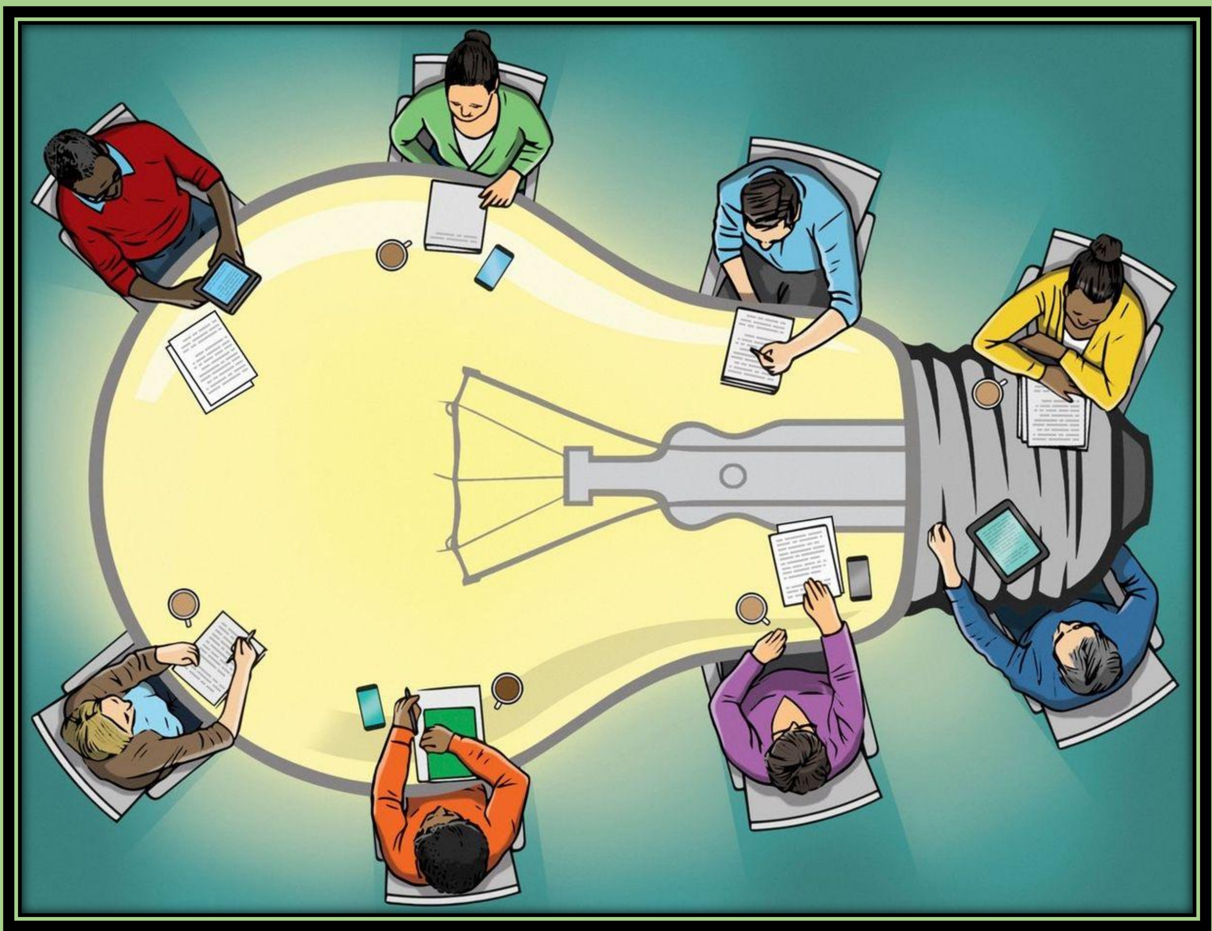
WHAT DID WE BUILD?

The team identifies a genuine daily problem, manual watering of the school garden and proposes a solar-powered pumping system as their solution. Tariq's idea shows the first step of the engineering process: noticing a real inefficiency.

TECHNOLOGY TERMINOLOGY

Prototype — an early working model of a design, built to test whether an idea functions in reality.

Engineering process — the sequence of steps (Problem → Design → Build → Test → Improve) used to develop a working solution.



CHAPTER TWO — FIRST SKETCHES

Mr. Musa's workshop smelled the way it always did, sawdust, machine oil, and the faint metallic tang of solder from the last class that had used the workbenches. The four of them spread Tariq's notebook open across a table, along with a fresh sheet of paper Zainab insisted on starting properly, ruled and labelled before anyone touched a pencil to it. "Before we build anything," she said, "we need a real design, a technical drawing, dimensions, materials, everything."

"It was never just a doodle," Tariq said, mildly offended, though he slid the notebook toward her without complaint.

Fatima had already claimed one corner of the table with three library books on solar energy and basic irrigation, spread open at different pages. "Before we draw anything," she said, "we need to understand what we're actually working with. How much water does the garden need? How high does it need to travel? How much energy can the solar panel actually produce?"

"Why does it matter how high?" Chinedu asked, already itching to start cutting wood for a frame.

"It matters a lot," Fatima said, tapping the page in front of her. "Pumping water uphill takes more energy than pumping it along flat ground. If the tank is higher than the pump, or the pipe has to climb before it reaches the garden beds, the pump has to work harder. If we don't account for that, the pump might not have enough power to move the water at all."

Chinedu frowned, clearly hearing this for the first time. "So height matters as much as distance?"

"Sometimes more," Fatima said.

Zainab was already sketching the outline of their prototype on the fresh sheet, a support frame, slanted mount for the solar panel, storage container and pump connected by piping toward the garden. "We need real measurements," she said. "How tall is the water tank we're using? How far is it from the garden? How much of a slope is there between them?"

"I'll measure it after school," Chinedu volunteered.

"Bring a proper tape measure," Zainab said with a smile on her face and Chinedu smiled too.

Mr. Musa appeared at the workshop door, unannounced as always, and looked over their shoulders without a word for a long moment.

"Solar water pump," he said finally. "For the garden."
"Yes, sir," Tariq said.

“Good problem,” Mr. Musa said. “Real one.” He tapped the edge of Zainab’s sketch. “What’s this measurement?”

“The height of the tank stand,” Zainab said.

“Measured, or estimated?”

The four of them exchanged a glance.

“Estimated,” Tariq admitted. “For now.”

Mr. Musa nodded slowly, “remember this moment,” he said. “Estimated measurements are how good ideas quietly become broken machines, not because the idea was wrong. Because the numbers were.”

“We’ll measure everything properly,” Fatima said. “Before we build anything.”

“Good,” Mr. Musa said. He turned to leave, then paused at the door. “One more question. What problem are you actually trying to solve?”

“Getting water to the garden without buckets,” Chinedu said, as if it were obvious.

Mr. Musa shook his head slightly. “I love the idea” he said. “Once you understand your system better. You’ll find the real answer is a little more precise than that.”

He left before anyone could ask what he meant.

“What does that mean?” Chinedu asked, once the door had closed.

Tariq was staring at his sketch, turning the question over. “I think,” he said slowly, “he means there’s a difference between wanting water to move, and understanding exactly what has to happen — how much energy, how much lift, how much flow to make it more reliably. We haven’t answered that yet. We’ve just drawn a picture of what we want.”

Zainab looked at her half-finished technical drawing with new eyes. “Then we’d better go measure everything,” she said, “before we draw one more line.”

WHAT DID WE BUILD?

The team begins the design process properly, learning that a workable prototype starts with accurate measurements and real understanding. Mr. Musa's question, "What problem are you actually trying to solve?" pushes them to think more precisely about their goal than they initially realize.

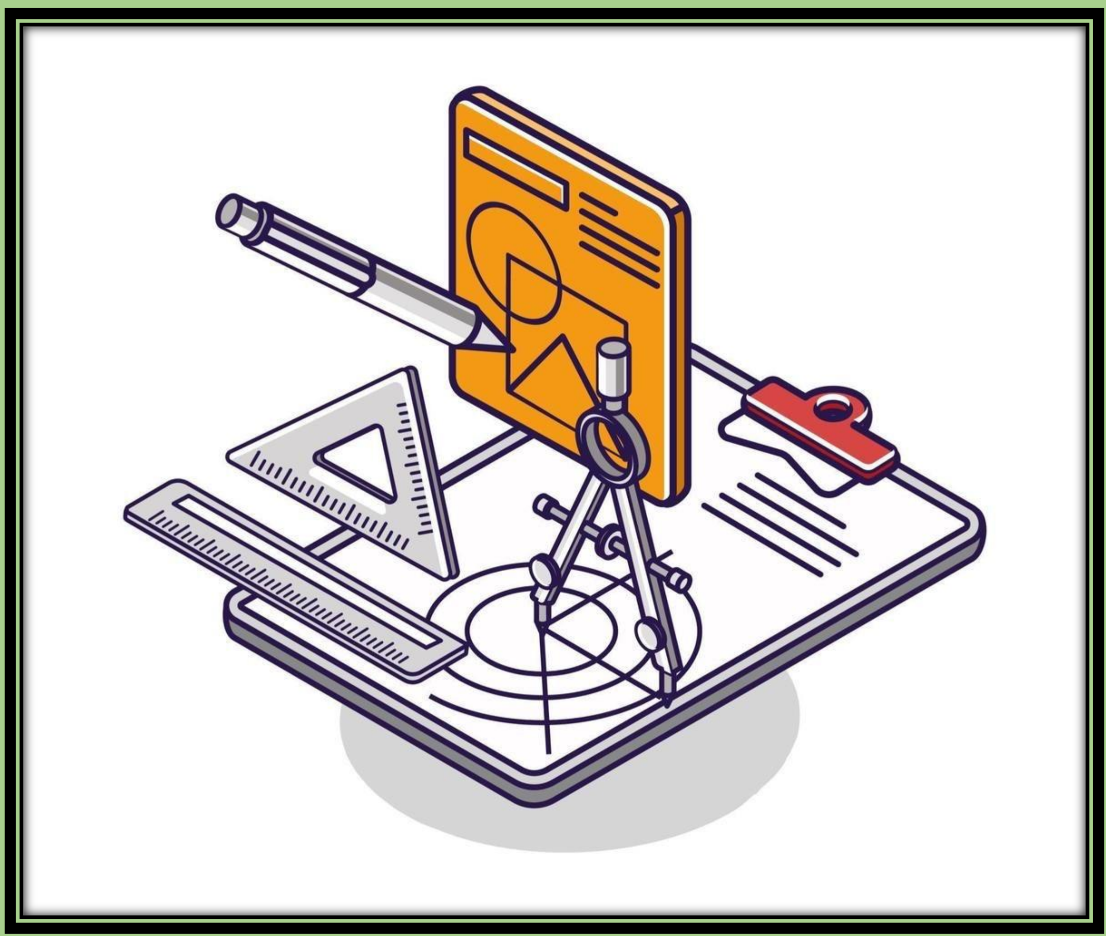
TECHNOLOGY TERMINOLOGY

Technical drawing — a precise, labelled sketch showing the exact dimensions and structure of a design, used to guide construction.

Energy transfer — the movement of energy from one form or place to another, such as solar energy powering a pump to move water.

SAFETY FIRST

Before cutting or measuring in a workshop, always confirm tools are being used correctly and under supervision. Careless handling of tools during measuring can also lead to accidents.



CHAPTER THREE — MEASURING EVERYTHING

They met after classes the next day, armed with a tape measure Chinedu had properly borrowed this time, along with a notebook Zainab had already divided into careful columns:

COMPONENT, MEASUREMENT, NOTES.

The water tank stood on a raised concrete platform behind the workshop, its stand slightly taller than Tariq had guessed from memory.

“One point four meters,” Chinedu called out, reading the tape. “To the base of the tank.” “And the tank itself?” Zainab asked, pen ready.

“Another meter, roughly. So the water surface, when full, sits about two point four meters above the ground.”

Fatima was crouched near the garden beds on the far side of the compound, holding the other end of a long string they were using to estimate the horizontal distance. “Twenty-two meters,” she called back. “From the tank to the nearest garden bed.”
“And the ground between them?” Zainab asked. “Is it flat?”

Fatima walked the distance slowly, eyes on the earth. “Mostly,” she said. “There’s a slight rise about halfway, maybe knee height at its highest point.”

Tariq recorded it in his own notebook, sketching a rough side view of the entire path the water would need to travel: down from the tank, briefly uphill over the rise, then along flat ground into the garden.

“So the pump isn’t just fighting the height of the tank,” he said slowly, working it out as he wrote. “It’s also fighting that rise in the middle.”

“Exactly,” Fatima said. “This is what I meant before, it’s not just distance. It’s total lift. Every point where the water has to go up, even briefly, adds to what the pump has to overcome.” Chinedu, testing the solar panel’s mounting bracket nearby, looked up. “How do we even know if our pump is strong enough for all that?”

“We check its rating,” Fatima said, pulling a spec sheet from her folder, details she’d copied from the equipment room’s storage label. “It says here it can lift water up to three meters, at a certain flow rate.”

“Then we’re fine,” Chinedu said. “The tank’s only two point four meters, plus a small rise.

We’re under three.”

“Barely,” Zainab said, frowning at the numbers. “And that’s assuming the pipe is smooth, the connections are tight, and nothing else is working against us. Real systems rarely perform exactly like the specification sheet promises.”

“So we build in a safety margin,” Tariq said. “Don’t push the pump right up to its limit, give it room.”

Zainab nodded, writing it down as a design principle rather than a passing comment: **DESIGN WITH MARGIN. DO NOT RELY ON MAXIMUM RATED PERFORMANCE.**

By the time they finished, the notebook held a full page of real numbers: tank height, garden distance, ground slope, pump rating, pipe diameter, and solar panel output. Nothing estimated or guessed.

Mr. Musa found them packing up as the sun began lowering behind the workshop roof.

“Well?” he asked.

“We measured everything,” Tariq said, holding up the notebook. “Real numbers, not guesses.”

Mr. Musa flipped through the pages slowly, nodding once or twice. “Better,” he said. “Now, the question I asked yesterday. What problem are you actually trying to solve?” Tariq thought about it properly this time, the numbers still fresh in his mind. “Moving a measured volume of water,” he said slowly, “up a height of roughly two and a half meters, across twenty-two meters of ground, using only solar-generated energy. Reliably, every day, without needing more power than our panel can realistically produce.”

Mr. Musa allowed himself something close to a smile. “Now that,” he said, “is a problem you can actually design for.”

WHAT DID WE BUILD?

By taking precise measurements, height, distance, slope, and equipment ratings, the team transforms a vague idea into a specific, solvable engineering problem. Zainab's "design with margin" principle introduces an important real-world lesson: relying on a component's absolute maximum rating leaves no room for error.

TECHNOLOGY TERMINOLOGY

Lift — the total height water (or any load) must be raised against gravity, a key factor in choosing a suitably powered pump.

Safety margin — extra capacity built into a design beyond the minimum requirement, to allow for real-world imperfections.

DESIGN QUESTIONS

1. Why does Fatima say total lift matters more than simple distance?
2. What might happen if the team had designed the system using the pump's absolute maximum rating, with no safety margin?

CHAPTER FOUR — THE FIRST BUILD

Building Project Zero took longer than any of them expected, not because the components were complicated, but because Zainab refused to let anyone attach a single piece without first confirming it matched the drawing exactly.

"It's just a frame," Chinedu said, holding two lengths of wood at an angle he was fairly confident looked right. "We don't need to measure the angle. I can see it's square."

"Seeing isn't measuring," Zainab said, holding out the set square without further argument.

Chinedu sighed but checked it anyway. The corner was, in fact, very slightly off.

"See?" Zainab said, not smugly, just matter-of-fact. "This is why we check."

The frame came together over two afternoons: a simple wooden stand angled to hold the solar panel at what Fatima's research suggested was the most effective tilt for their location, sturdy enough, they hoped, to support the panel's weight and withstand wind.

The pump was mounted at the base of the tank stand, wired to a small battery meant to store the solar panel's energy for use even when clouds passed overhead. Chinedu handled the wiring with visible enjoyment, twisting connections together with practiced fingers.

"Should we solder these?" he asked, tools already in hand.

"Not yet," Fatima said. "Let's test the connections first, loosely. If something's wrong, we don't want to have to de-solder everything to fix it."

Tariq, meanwhile, worked on the piping, running it from the pump, along a route he'd sketched to minimize unnecessary turns, up over the small rise Fatima had identified, and down into the garden beds.

By late afternoon on the second day, Project Zero stood assembled for the first time: solar panel angled toward the sky, frame steady beneath it, pump connected to tank and pipe, and wires running to the small battery pack.

It looked, Chinedu said proudly, stepping back to admire it, "like something out of a real workshop."

Tariq had to agree. Compared to the rough sketch in his notebook, the machine standing in front of them looked almost professional: clean lines, careful joints, wiring tucked neatly along the frame.

"Ready for the first test?" Fatima asked.

Zainab checked her notebook one final time, comparing the finished build against the technical drawing, component by component. "Frame matches, pipe route matches, pump position matches." She looked up. "Ready."

Mr. Musa arrived just as they were preparing to switch it on, drawn, he admitted, by the sight of four students crowded excitedly around something in the workshop yard.

"First test?" he asked.

"First test," Tariq confirmed, a nervous energy in his voice he couldn't quite hide.

"Then let's see it," Mr. Musa said, stepping back to observe rather than intervene.

Chinedu flipped the switch connecting the battery to the pump.

Nothing happened.

No sound, no movement in the pipe, no flicker of life from the small indicator light Fatima had wired in to show power flow.

The four of them stared at the still, silent machine.

“That’s not supposed to happen,” Chinedu said quietly.

Tariq felt something drop in his stomach, not panic exactly, but the particular disappointment of watching an idea, built carefully over days, simply refuse to work.

Mr. Musa, watching from the side, didn’t look surprised, disappointed, or even particularly concerned. If anything, his expression looked like that of a teacher who had expected exactly this, and was waiting patiently to see what his students would do next. “Well,” he said calmly, into the silence. “Now the real project begins.”

WHAT DID WE BUILD?

The team completes their first full prototype, only to have it fail completely on the first test. No movement, no power. Mr. Musa's calm reaction signals an important idea the students haven't yet grasped: failure isn't the end of the engineering process. It's often where the real learning starts.

TECHNOLOGY TERMINOLOGY

Circuit — a complete path that allows electrical current to flow from a power source, through components, and back again.

Component testing — checking individual parts of a system separately, to identify exactly where a problem is occurring.

CHAPTER FIVE — NOTHING HAPPENS

Nobody spoke for a long moment after the switch was flipped. The garden hose lay motionless. The small indicator light stayed dark.

“Check the battery,” Fatima said finally, breaking the silence.

Chinedu crouched by the frame, following the wire from the panel to the battery pack.

“Panel’s connected,” he said. “Battery’s connected. Should be getting power.”

“Should be,” Zainab repeated, unimpressed by the word. “Let’s not guess. Let’s check.” Mr. Musa, still watching from the edge of the yard, said nothing, offering neither hints nor reassurance. Tariq glanced at him once, half hoping for a clue, and found only the same patient, waiting expression.

“We need a way to actually see what’s happening,” Fatima said.

“There’s a multi-meter in the equipment room,” Zainab said. “We could check whether current is actually reaching the pump.”

“I’ll get it,” Chinedu offered, already moving.

While he was gone, Tariq crouched beside the panel, running his fingers gently along its surface, checking for anything obviously wrong: cracks, loose mounting screws, anything visible.

“Panel looks fine,” he said. “No damage.”

“Maybe it’s just not producing enough power right now,” Fatima said, glancing up at the sky. Thin clouds drifted overhead, not heavy, but enough to soften the afternoon sun. “Solar panels don’t produce a fixed amount. It depends on sunlight, angle, even temperature.” “So it might just be cloudy?” Tariq asked, a flicker of hope returning.

“Maybe,” Fatima said carefully. “But we shouldn’t assume that’s the whole answer. It’s too easy an explanation.”

Chinedu returned with the multimeter, and Zainab, who had used one before in a previous term’s project, took it carefully, touching the probes to different points along the wiring as the others watched.

“There’s some voltage coming from the panel,” she said, reading the small display. “Not a lot, but something.”

“Battery?” Fatima asked.

Zainab moved the probes. “Getting a reading here too. Lower than I expected, but not zero.”

“So power’s getting through,” Chinedu said. “Then why isn’t the pump running?”

Zainab moved the probes a final time, to the wires leading directly into the pump itself. The display flickered, then settled on a number noticeably lower than the reading at the battery. “Something’s losing power along the way,” she said slowly. “Between the battery and the pump.”

Tariq leaned in, studying the length of wire running from the battery pack, along the underside of the frame, down to the pump housing. “The connection here,” he said, pointing to a spot where two wires had been twisted together rather than properly joined. “Chinedu, is this one of the connections we said we’d solder later?”

Chinedu winced. “Yes.”

“It might be loose,” Tariq said. “Enough current getting through to register on the meter, but maybe not enough to actually start the pump.”

“That’s one possible answer,” Fatima said, careful as always not to declare victory too early. “But it might not be the only problem. We assumed one thing was wrong. There could easily be more than one.”

Mr. Musa finally spoke, quietly, from where he stood. “How would you find out?” The four of them exchanged a look.

“Test each part separately,” Zainab said slowly, working it out as she said it. “Not the whole system at once.

The panel alone, the battery alone, the connection alone, the pump alone, with a direct power source, to make sure the pump itself even works.”

“Isolate the variables,” Fatima said, nodding. “Instead of guessing at the whole machine.” Mr. Musa allowed the smallest nod of approval. “Now you’re thinking like technologists,” he said. “Not like people who simply build things and hope.”

Tariq looked at Project Zero, silent and still on its frame, and felt the disappointment from earlier begin to shift into something else, a kind of stubborn curiosity he hadn’t expected to find on the other side of failure.

“Then let’s take it apart,” he said. “Piece by piece. Until we know exactly what’s wrong.”

WHAT DID WE BUILD?

Faced with total failure, the team resists the urge to guess and instead uses a multi-meter to trace power step by step through the system, discovering a loose connection along the way. Crucially, Fatima and Mr. Musa both caution against assuming this is the *only* problem, a key engineering habit: isolate and test each variable rather than accepting the first explanation.

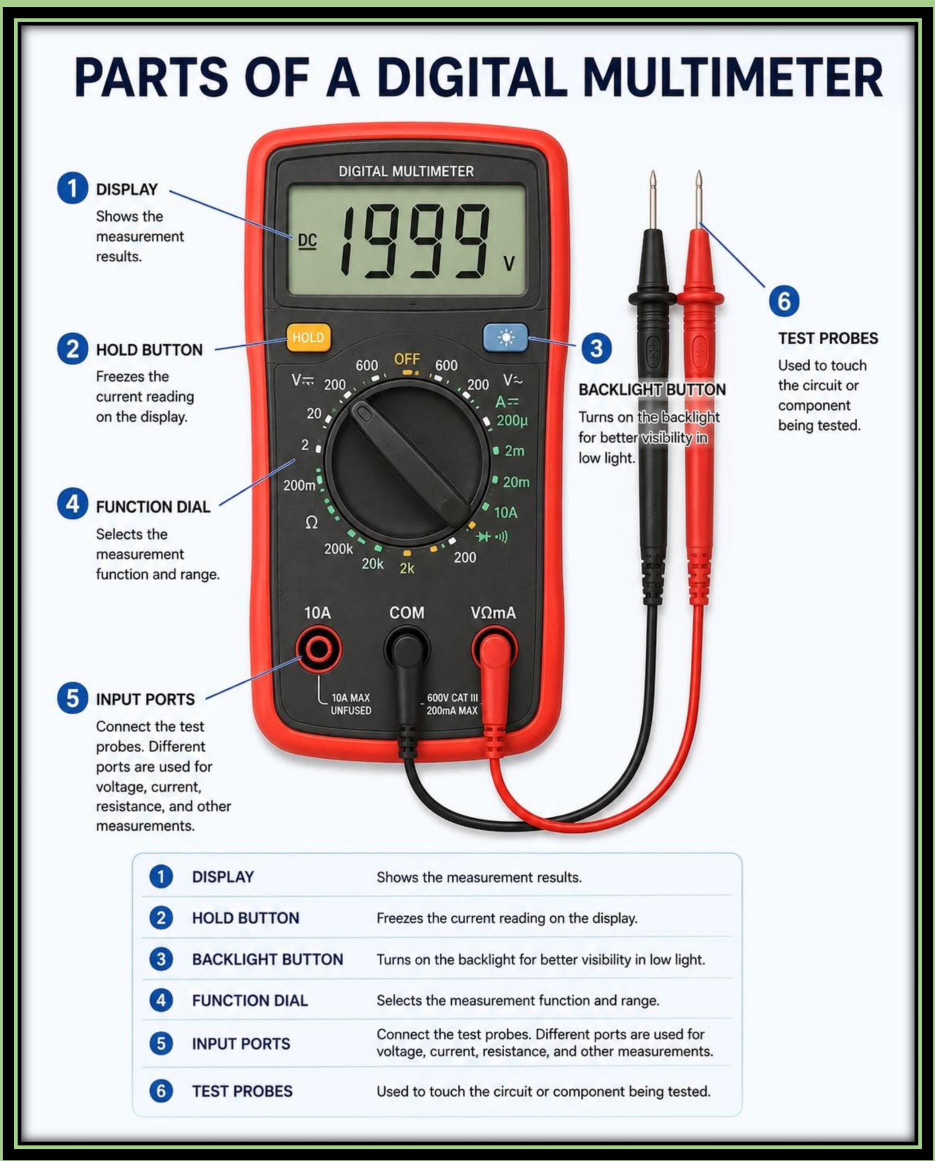
TECHNOLOGY TERMINOLOGY

Multimeter — a tool used to measure electrical properties such as voltage and current, helping diagnose faults in a circuit.

Isolating variables — testing one part of a system at a time, so that the cause of a problem can be identified precisely.

SAFETY FIRST

When testing electrical connections, always ensure hands are dry and tools are used as instructed by a supervising teacher. Never test a circuit you're unsure about without guidance.



CHAPTER SIX — TAKING IT APART

They spent the next afternoon dismantling Project Zero as carefully as they had built it, each piece labelled, each connection photographed before it was separated, Zainab insisting that nothing be removed without a note of exactly where it had come from.

“We’re not destroying it,” she reminded Chinedu, who looked faintly pained every time a screw came loose. “We’re studying it.”

They tested the solar panel first, disconnected entirely from the rest of the system, wired directly to the multi-meter under the open sky.

“Panel’s fine,” Fatima said, reading the display. “Producing exactly what the spec sheet says it should, given the current light.”

Next, the battery, tested alone, charged separately, then checked under load.

“Battery’s fine too,” Zainab said. “Holds charge, releases it steadily.”

Then the pump, disconnected from the piping entirely, wired directly to a fresh power source Mr. Musa allowed them to borrow from the equipment room.

The pump whirred to life immediately, smooth and strong, water pulled up through a test tube and out the other side without hesitation.

“Pump works,” Chinedu said, relief clear in his voice. “So it’s not the pump.”

“Which means,” Tariq said slowly, “it really was that connection. The one we twisted instead of soldering.”

They rebuilt the wiring path from battery to pump, this time properly soldering every joint, wrapping each connection in insulating tape the way Mr. Musa had shown them weeks earlier in a lesson none of them had thought much about at the time.

By late afternoon, Project Zero stood reassembled, wiring clean and secure.

“Second test?” Fatima asked, though nobody quite matched the excitement of the first attempt. Caution had replaced it.

Chinedu flipped the switch.

This time, the indicator light flickered on immediately. A soft hum came from the pump.

Then, after a pause, water began moving through the pipe, slow at first, then steadier.

“It’s working!” Chinedu said, forgetting his caution entirely, grinning as the water climbed the pipe toward the small rise Fatima had marked weeks before.

Tariq watched, holding his breath, as the water continued down the far side, toward the garden beds.

Then, without warning, the flow stuttered, slowed then it stopped.

The pump was still running, they could hear it, still humming steadily, but no water was coming out.

The brief celebration died as quickly as it had started.

“What happened?” Chinedu asked, staring at the pipe.

Tariq crouched beside it, following its length with his eyes. “It’s running,” he said, “but nothing’s coming out the end. The pump’s working, the connection’s fixed. So why did it stop?”

Mr. Musa, observing quietly from his usual spot near the workshop door, said nothing, but Tariq noticed, for the first time, something like genuine interest in his expression, rather than simple patience.

“One problem solved,” Fatima said, staring at the stalled pipe. “And already, another one waiting behind it.”

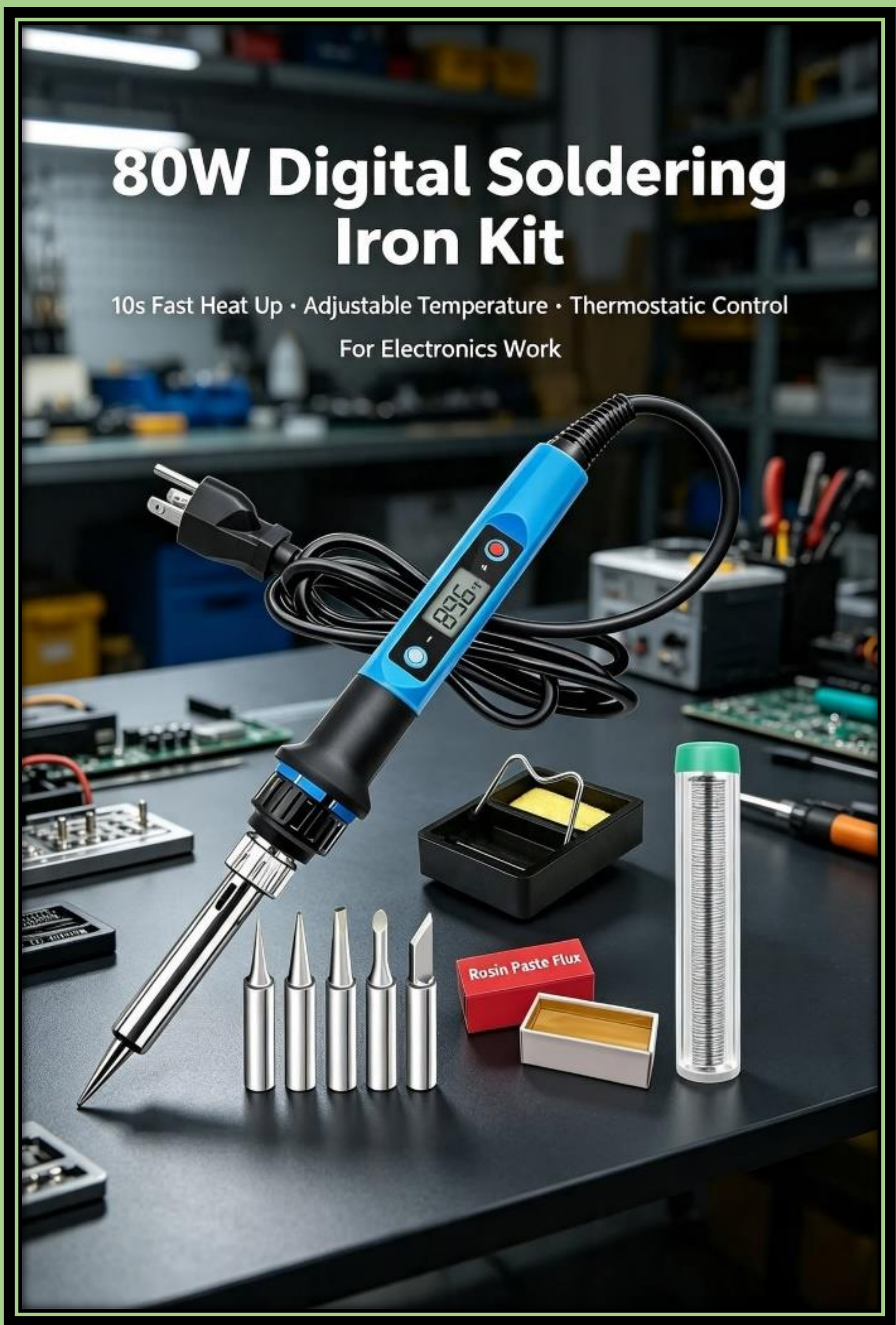
WHAT DID WE BUILD?

By isolating and testing each component separately, the team confirms their earlier suspicion, the loose connection was a real problem, and fixes it properly through soldering. But solving one issue reveals a second: the pump runs, yet water still fails to reach the garden. This teaches an important lesson about complex systems: fixing one fault doesn't guarantee the whole system will work.

TECHNOLOGY TERMINOLOGY

Soldering — a method of permanently joining electrical wires using melted metal, creating a stronger and more reliable connection than twisting wires together.

System failure — a breakdown that can result from the interaction of multiple components, not just a single faulty part.



CHAPTER SEVEN — THE STUTTERING PIPE

“Air,” Fatima said the next morning, arriving at the workshop with a library book already open to a marked page. “I think its air in the pipe.”

“Air?” Chinedu repeated. “It’s a water pipe. Why would air be the problem?”

“If there’s a pocket of trapped air somewhere along the route,” Fatima explained, “especially near the top of that rise, it can block the water behind it. The pump keeps pushing, but instead of moving water forward, it’s just compressing air that has nowhere to go.”

Zainab was already tracing the pipe’s route on her diagram, marking the exact point of the rise. “That’s the highest point in the whole system,” she said. “If air’s going to get trapped anywhere, it would be there.”

They disconnected the pipe at the peak of the rise and found, to Fatima’s evident satisfaction, a visible gap where the pipe had been assembled from two shorter sections, joined at a slight angle rather than a perfectly straight line.

“There,” Tariq said, examining the joint closely. “The pipe isn’t running smoothly through here. It dips slightly before rising again, right at the connection. That’s probably where air’s collecting.”

“So we need a straighter route,” Zainab said, already sketching an adjustment.

“Or a way to let trapped air escape,” Fatima added. “Some systems use a small valve at the highest point specifically for that.”

Mr. Musa, passing through the workshop with a stack of materials for another class, paused at their table. “Problem?” he asked, though his tone suggested he already suspected the answer.

“Air pocket,” Tariq said. “In the pipe. At the highest point.”

“How do you know?” Mr. Musa asked, not doubtful, simply testing whether they could explain it.

“The pump runs fine on its own,” Tariq said, working through it aloud. “The connection’s fixed. But right where the pipe rises and dips slightly at the joint, water would naturally struggle to push trapped air out. It would just get stuck there, blocking anything behind it.”

Mr. Musa nodded slowly. “That’s a reasonable hypothesis,” he said. “How will you test it?”

“Fix the joint,” Zainab said. “Make the route smoother, no dip then test again.”

“And if that doesn’t solve it?”

“Then we’ll know the air pocket wasn’t the only cause,” Fatima said, “and we keep looking.” They spent the rest of the afternoon reworking the pipe’s path, replacing the awkward joint with a single continuous length wherever they could, and where a joint was unavoidable, angling it carefully so no low dip could trap air on the way up.

By the time they reassembled everything, the sun had dropped low enough that Mr. Musa reminded them, not unkindly, that a third test could wait until morning.

“We’re so close,” Chinedu said, reluctant to stop.

“Close and rushed is how mistakes happen,” Zainab said, though even she looked disappointed at the delay.

Tariq lingered a moment longer than the others, running his hand along the newly smoothed pipe route, remembering his own first sketch, a single confident line from tank to garden, with no rises, no joints, no thought given to any of this at all.

The real machine, he was beginning to understand, was a much more complicated conversation with the world than his drawing had ever suggested.

WHAT DID WE BUILD?

Fatima's research points the team toward a specific, testable hypothesis, a trapped air pocket at the pipe's highest point, rather than a vague guess. The chapter reinforces the engineering habit of forming a clear hypothesis, explaining the reasoning behind it, and designing a specific test to confirm or rule it out.

TECHNOLOGY TERMINOLOGY

Hypothesis — an explanation proposed based on available evidence, which can then be tested to see if it holds true.

Air pocket — a trapped pocket of air within a pipe or system that can block or disrupt the flow of liquid.

DESIGN QUESTIONS

1. Why does Mr. Musa ask "How do you know?" instead of simply confirming their idea?
2. Why is it important to test a hypothesis rather than assume it's correct once it sounds reasonable?

CHAPTER EIGHT — THE THIRD TEST

Morning testing brought a different kind of nervousness than the first two attempts, not the wide-eyed hope of day one, nor the shaken confidence after Chinedu's rushed frame corner. This time, it was something closer to careful expectation, four students who had earned every piece of understanding they now carried.

Mr. Musa arrived just as Chinedu reached for the switch, saying nothing, simply watching. The pump hummed to life. The indicator light glowed steady.

Water began climbing the pipe.

This time, it didn't stutter at the rise. It crested smoothly, continuing down the far side without hesitation, following the route exactly as Tariq's revised sketch had shown it. "It's past the rise," Fatima said, unable to keep the excitement fully out of her voice despite her usual caution.

The water continued along the flat stretch, approaching the garden beds.

Then the frame shuddered, enough that all four of them turned toward it instantly. The support structure, holding both the solar panel and the tank stand, swayed slightly under a strain nobody had anticipated.

"What's happening?" Chinedu asked, already moving toward it.
"Don't touch it yet," Zainab said sharply. "Just watch." The frame steadied, briefly, water still flowing.

Then one of the joints near the base gave way with a sharp crack, and the entire structure tilted, the solar panel sliding several degrees off its mount before Chinedu managed to catch it, wincing as its edge dug into his palm.

The pump kept running for a moment longer, water spraying from a pipe now disconnected from its proper alignment, before Fatima lunged for the switch and cut the power. Silence returned to the workshop yard, broken only by the drip of water from the now crooked pipe.

Chinedu, still holding the panel upright by sheer effort, looked around at the others. "A little help," he said, strained.

They steadied the frame together, easing the panel back into a stable resting position before finally stepping back to survey the damage.

"Solved one problem," Fatima said quietly, staring at the tilted frame. "Found a bigger one." Tariq crouched by the base of the structure, examining the joint that had failed. It was the same wooden frame Zainab had insisted on checking with a set square weeks earlier, square, by measurement, but clearly not strong enough to bear the combined weight and vibration of a fully running system.

"It held when it was still," he said slowly. "It held during the first test, when nothing was flowing. But once water started actually moving through it, vibration from the pump, the weight of water in the pipe, it wasn't strong enough."

Mr. Musa, who had watched the entire sequence without a single word of warning or intervention, finally spoke.

"You built a frame," he said, "for a machine that wasn't moving then you asked it to hold a machine that was."

The four of them absorbed that quietly.

“We didn’t design for vibration,” Zainab said, half to herself, already writing in her notebook. “Or for the weight of water actually inside the pipe while it’s running. We only measured the static weight, before.”

“So the frame needs to be stronger,” Chinedu said, still nursing his scraped palm. “Not just square. Stronger.”

“And probably braced differently,” Tariq added, studying the failed joint. “This corner took all the strain. If the weight had been distributed more evenly across the frame, maybe it wouldn’t have failed here specifically.”

Mr. Musa allowed a small, approving nod. “Now,” he said, “you’re finding problems the machine itself is showing you. Not problems I’m pointing out for you.”

WHAT DID WE BUILD?

The team's second failure, a structural collapse under the added strain of a running system, teaches them that a frame strong enough to hold a still machine isn't necessarily strong enough for a working one. This introduces an important structural engineering concept:

Designs must account for dynamic forces such as vibration and moving weight.

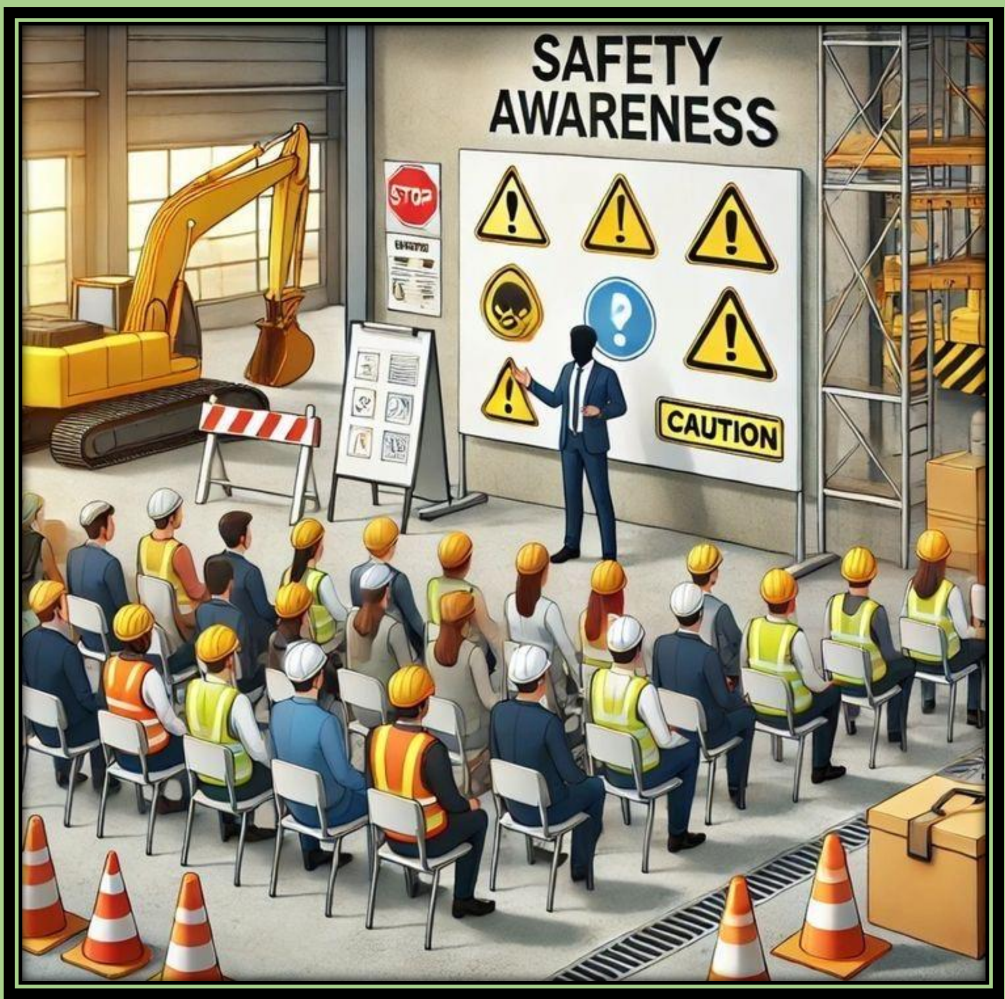
TECHNOLOGY TERMINOLOGY

Static load — the weight or force on a structure when it is not moving.

Dynamic load — the additional force placed on a structure by movement, vibration, or flowing weight, often greater than the static load alone.

SAFETY FIRST

Chinedu is injured slightly catching the falling panel. In a real workshop, sudden structural failures can cause serious harm. Structures being tested under new conditions should always be approached cautiously, with a safe distance kept where possible until stability is confirmed.



CHAPTER NINE — REBUILDING THE FRAME

Nobody suggested giving up, though the thought crossed Tariq's mind more than once as they cleared away the damage. It was Fatima, of all people, usually the most measured of the group, who voiced what he'd been feeling.

"I keep thinking we're close," she admitted, sitting on an overturned crate while Chinedu cleaned the scrape on his palm. "And then something else breaks."

"That's not a reason to stop," Zainab said, though her voice was gentler than her words. "It's just what building something real looks like. We just haven't seen it before."

Mr. Musa, sorting through spare timber with them after class, overheard this without turning around. "Your first project that means anything," he said, "will always feel like this. The ones that come easily rarely teach you very much."

They redesigned the frame from the ground up this time: wider at the base for stability, cross-braced at the corners rather than relying on simple right-angle joints, and reinforced specifically at the point where the previous joint had failed.

Chinedu, working alongside Tariq's revised sketch, built more carefully than before, checking each angle without needing to be reminded.

"Bracing here," he said, fitting a diagonal support across the corner that had given way. "So the weight isn't all resting on one joint anymore."

"And here," Tariq added, marking a second point along the base, "in case the vibration puts strain somewhere we haven't thought of yet."

Zainab tested the new frame's stability before a single wire was reconnected, pressing against it from different angles, checking that it didn't sway or shift under deliberate pressure the way the old one had.

"Better," she said, satisfied. "Much better."

They reconnected the piping, the wiring, the solar panel, working with a quiet efficiency that hadn't been there during the first build. Nobody rushed. Nobody skipped a check.

"This feels different," Chinedu admitted, tightening a final bolt. "Not exciting like the first time. But steadier."

By the time they were ready for a fourth test, the afternoon light had turned gold, throwing long shadows across the workshop yard. Mr. Musa had stayed later than usual, though he said nothing about why.

Tariq stood before the switch, hand hovering over it, feeling none of the nervous excitement from the very first attempt weeks earlier. What he felt instead was something steadier, not certainty that it would work, but confidence that whatever happened next, they would actually understand it.

"Ready?" he asked.

"Ready," the others answered, almost in unison.
He flipped the switch.

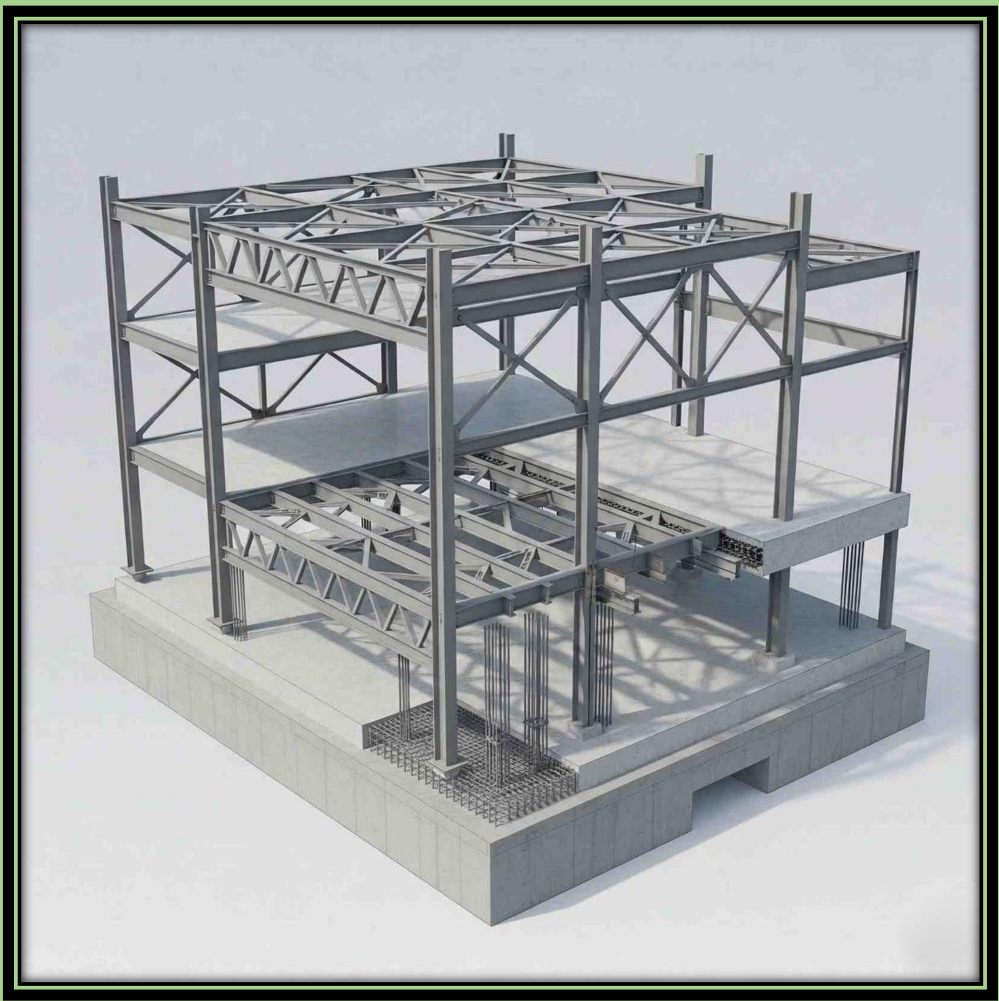
WHAT DID WE BUILD?

Rather than rushing to fix the visible damage, the team redesigns the frame with structural principles in mind, a wider base, cross-bracing, and reinforcement at the previous failure point.

TECHNOLOGY TERMINOLOGY

Bracing — additional structural supports, often diagonal, added to a frame to distribute force and prevent it from concentrating at a single weak point.

Structural stability — a structure's ability to remain steady and intact under expected forces, including weight, vibration, and movement.



CHAPTER TEN — CLOSER

The pump hummed to life, steady and familiar now. Water began its climb up the pipe, crested the rise without hesitation, and continued along the flat stretch toward the garden beds.

The frame held.

Water reached the first garden bed and began to fall, gently, exactly where Tariq's original sketch had imagined it weeks earlier, though the machine delivering it looked almost nothing like that first rough drawing anymore.

For a long moment, nobody spoke, as if speaking might somehow break the fragile success unfolding in front of them.

Then Chinedu let out a whoop that startled a bird from the nearby tree, and the spell broke into genuine celebration, Fatima laughing despite herself, Zainab allowing a rare, wide smile, Tariq simply standing very still, watching the water fall exactly where it was supposed to. "It's working," Fatima said, as if she needed to say it aloud to fully believe it. "It's actually working."

Mr. Musa let them enjoy the moment for a full minute before stepping closer, studying the system with the same careful attention he'd given its failures.

"How long can it sustain this?" he asked.

The celebration paused.

"We haven't tested that," Zainab admitted, already reaching for her notebook. "Only that it starts correctly."

"Then test it," Mr. Musa said. "A machine that works for thirty seconds isn't the same as a machine that works for an hour, under changing sunlight, day after day."

They let it run, watching closely, timing it, checking the water level in the tank, the flow rate at the garden end, the temperature of the pump housing after sustained use.

Twenty minutes in, the flow began to slow but noticeably weaker than when it started.

"Battery's dropping," Fatima said, checking the multi-meter. "As the sun moves and clouds pass, the panel's not producing quite as much, and the battery's supplementing it. But it can't do that forever."

"So even a working system," Tariq said slowly, "still has limits we haven't fully mapped yet."
"Exactly," Mr. Musa said. "You've solved the failures you could see. Now you're finding the ones that only show up over time."

Zainab was already sketching a new column into her notebook: **SUSTAINED PERFORMANCE.**

TIME, FLOW RATE, BATTERY LEVEL.

"We have three weeks until the competition," she said, checking the school calendar pinned inside her folder. "We need to understand this well enough to explain it confidently, not just show it working once."

Tariq looked at Project Zero, water still trickling steadily into the garden bed, the frame solid beneath it, and felt something settle in his chest that hadn't been there at the very first, hopeful, ultimately silent test weeks ago.

It wasn't finished. He understood that now, clearly, in a way his first sketch had never accounted for.

But it was real. And for the first time, he understood exactly why it worked, and exactly what still needed to be tested before he could truly trust it.

“Then let’s keep going,” he said. “We’re not done. But we’re close.”

WHAT DID WE BUILD?

The team achieves their first genuine success, water reaching the garden, but Mr. Musa immediately reframes the moment: working once isn’t the same as working reliably.

TECHNOLOGY TERMINOLOGY

Sustained performance — how consistently a system continues to function correctly over an extended period, rather than in a single short test.

Flow rate — the volume of liquid moving through a system in a given amount of time, an important measure of a pump system’s real-world usefulness.

THINK LIKE AN ENGINEER

The system works for the first several minutes, then begins to weaken. Why might a machine that works perfectly at first still fail to be a reliable, finished design?

CHAPTER ELEVEN — THE THINGS THAT DON'T SHOW ON THE FIRST DAY

The three weeks before the competition became, in Zainab's words, "the part nobody tells you about when they talk about inventions."

There was no single dramatic failure anymore, no cracked joint or silent switch. Instead there was a slow, patient list of smaller problems, the kind that only revealed themselves once the system had to run for longer than a few triumphant minutes.

"Flow rate drops every afternoon," Fatima reported, comparing three days of notes. "Not because anything's broken. The panel just produces less as the sun moves lower." "So we need the battery to carry more of the load later in the day," Zainab said. "Which means we need to know exactly how much charge it's storing each morning, and how fast it drains."

Chinedu, who had grown steadily more careful since the frame collapse, spent an entire afternoon simply timing charge and discharge cycles, writing each result down without embellishment. "It's not exciting work," he admitted, "but I get why we're doing it now."

Tariq split his attention between two things: refining the pipe route further after noticing a second, smaller air pocket near a joint they'd previously judged "good enough," and reworking his own sketches to properly document every version of the machine so far. "Why keep the old drawings?" Chinedu asked, watching him carefully copy a failed early design into a fresh notebook page. "The frame's already fixed. Nobody needs to see the version that broke."

"Mr. Musa keeps saying the judges won't just want to see it work," Tariq said. "They'll want to know how we got here. If I only show them the final version, it looks like we got it right by luck. If I show them everything, they'll see we got it right by understanding."

Mr. Musa, passing through the workshop that same afternoon, paused at Tariq's open notebook, flipping slowly through pages of failed frames, disconnected joints, and the small, hand-drawn air pocket diagram Fatima had insisted on labelling precisely. "This," he said, tapping the notebook, "is worth more than the machine itself."

"Why?" Chinedu asked, half joking. "The machine's the part that actually works."

"The machine will eventually wear out," Mr. Musa said. "Parts fail, panels crack, and pumps break down after enough seasons. But this," he tapped the notebook again, "this is the part that stays with you. Anyone can copy a working machine. Not everyone can explain why it works." By the final week, Project Zero could run a full ninety minutes under real conditions, morning sun through afternoon cloud, without a stutter, a shudder, or a silent switch. The flow rate still dipped in weaker light, but Zainab had built a simple chart predicting exactly how much, and exactly why.

"We're not claiming it's perfect," she said, reviewing their final notes with the others the night before the competition. "We're claiming we understand it completely. That's different, and it's better."

Tariq closed his notebook, the collection of sketches now thick with crossed-out failures, corrected measurements, and small triumphant notes in the margins where something had finally worked.

"Then I think we're ready," he said.

WHAT DID WE BUILD?

With the major failures behind them, the team shifts to a subtler kind of engineering work: understanding *why* performance varies under changing real-world conditions, rather than simply celebrating that the system runs.

TECHNOLOGY TERMINOLOGY

Documentation — the recorded history of a design's development, including failures, changes, and reasoning, used to explain and improve a project over time.
Performance variation — differences in how a system operates under changing real-world conditions, such as shifting sunlight or temperature.

THINK LIKE AN ENGINEER

Tariq keeps every failed sketch instead of throwing them away. Why might showing your mistakes, not just your final success, make your work more convincing to someone judging it?

CHAPTER TWELVE — COMPETITION DAY

The school hall had been rearranged into rows of tables, each holding a different team's project, each surrounded by a small, hopeful crowd of classmates and a handful of visiting judges moving slowly from table to table with clipboards.

Project Zero stood near the end of the row, solar panel angled toward the light streaming through the hall's tall windows, tank filled, and pipe running to a small demonstration garden bed Mr. Musa had allowed them to set up especially for the day.

"They're impressive," Fatima murmured, glancing at the neighboring tables, one displaying a brightly painted model bridge, another a complicated-looking alarm system wired with flashing lights. "Ours looks so plain next to them."

"Ours works," Zainab said simply. "That's not nothing."

When the judges finally reached their table, three of them, notebooks ready, expressions carefully neutral, Tariq felt his nerves rise and steady in the same breath, the way they had on the morning of the fourth test.

"Tell us about your project," the lead judge said.

Tariq didn't reach for the working machine first. Instead, he opened his notebook to the very first sketch, the confident single line from tank to garden with no rise, no joints, nothing accounted for.

"This is where we started," he said. "We wanted to move water to the school garden using solar energy instead of buckets. We thought it would be simple."

He turned the page, to the first failed test. "It wasn't."

He walked them through it in order: the silent first attempt, the loose connection found through careful testing, the stuttering pipe traced to a trapped air pocket, the frame that had held while still but failed once the system was actually running, and the redesign that finally let it hold.

One of the judges, an older woman with sharp, interested eyes, interrupted partway through.

"Why did you keep all these failed versions?" she asked, gesturing at the notebook's crossed-out sketches. "Most teams only show us what works."

"Because they showed us what we needed to fix," Tariq said. "Each failure told us something specific. If we'd thrown them away, we'd have thrown away the reasons we understand the final version at all."

The judge nodded slowly, writing something down.

"Show us it working," the second judge said.

Chinedu flipped the switch.

The pump hummed. Water climbed the pipe, crested the small rise without hesitation, and fell steadily into the demonstration garden bed, exactly as it had every day for the past week. "How long can it sustain this?" the lead judge asked, echoing, almost word for word, the same question Mr. Musa had asked weeks earlier.

Zainab answered without hesitation, turning her notebook to the chart she'd built. "Ninety minutes continuously under full conditions," she said. "Flow rate decreases predictably as sunlight weakens, here, exactly by this much, and recovers fully once the battery recharges.

We've tested it across five separate days."

The judges exchanged a glance that Tariq couldn't quite read.

“And if it failed right now,” the older judge asked, “in front of us, what would you do?”

Tariq didn’t hesitate. “Check the connections first,” he said. “Then the pipe route for trapped air. Then the frame for strain. We know this system now. If it fails, we’d know where to look.” The judge smiled, the first real smile any of them had offered all day. “That,” she said, closing her notebook, “is the answer we were hoping to hear.”

WHAT DID WE BUILD?

On competition day, the team demonstrates not just a working machine but a complete understanding of it, including its failures, its limits, and how they would respond if something went wrong. The judges' questions echo Mr. Musa's earlier lessons exactly, showing how thoroughly the team has absorbed them.

TECHNOLOGY TERMINOLOGY

Demonstration — presenting a working prototype to an audience, showing both its function and the reasoning behind its design.

Reliability — a measure of how consistently and predictably a system performs, especially under real-world conditions.

DESIGN QUESTIONS

1. Why might a judge be more convinced by a team who can explain what they'd check if their machine failed, rather than a team who simply says it works?

CHAPTER THIRTEEN — WHAT THE MACHINE TAUGHT THEM

The results were announced at the end of the day, the whole school gathered back in the hall, the row of competing projects still standing on their tables like quiet witnesses to weeks of work.

When Project Zero was called, Tariq barely registered the applause at first, caught somewhere between disbelief and the particular, quiet satisfaction of watching something finally land exactly where months of failure had been pointing all along.

Afterward, once the noise had settled and most of the hall had emptied out, Mr. Musa found the four of them still standing beside their machine, packing away notebooks and tools with the unhurried care of people who no longer needed to rush.

“Anyone can build something that works once,” he said, looking at Project Zero rather than at them. “An engineer asks why it works, and how to make it better.”

“We didn’t win because it worked perfectly,” Zainab said. “We won because we understood it.”

“That’s the part most people miss,” Mr. Musa said. “They think invention is about getting something right the first time. It rarely is. It’s about staying curious enough, through every version that doesn’t work, to find the one that finally does.”

Tariq looked down at his notebook, still open to the very first sketch he’d drawn weeks ago under the mango tree, that single confident line from tank to garden.

It looked nothing like the machine standing in front of him now, braced properly, wired carefully, its pipe route smoothed against every trapped pocket of air they’d learned to notice.

“The first drawing was wrong about almost everything,” he said, not with disappointment, but with something closer to quiet amusement. “The height. The frame. The pipe route. All of it.”

“But it wasn’t a failure,” Fatima said. “It was a starting point. You needed the wrong drawing before you could find the right one.”

Chinedu, already looking ahead the way he always did, glanced toward the garden beds outside the hall’s windows, where the real, permanent version of Project Zero still stood, water still moving quietly through it in the last of the afternoon light.

“So what do we build next?” he asked.

Tariq considered the question for a long moment, thinking not of a new sketch, but of everything the old one had taught him, patience over excitement, evidence over assumption, and the understanding that a good idea only truly becomes something real once it’s been allowed to fail, carefully, and often enough to be trusted.

“I don’t know yet,” he said finally. “But whatever it is, I know how to find out if it actually works.”

Mr. Musa, closing the workshop door behind them as they left, allowed himself one last, small smile.

“That,” he said, “is the whole lesson.”

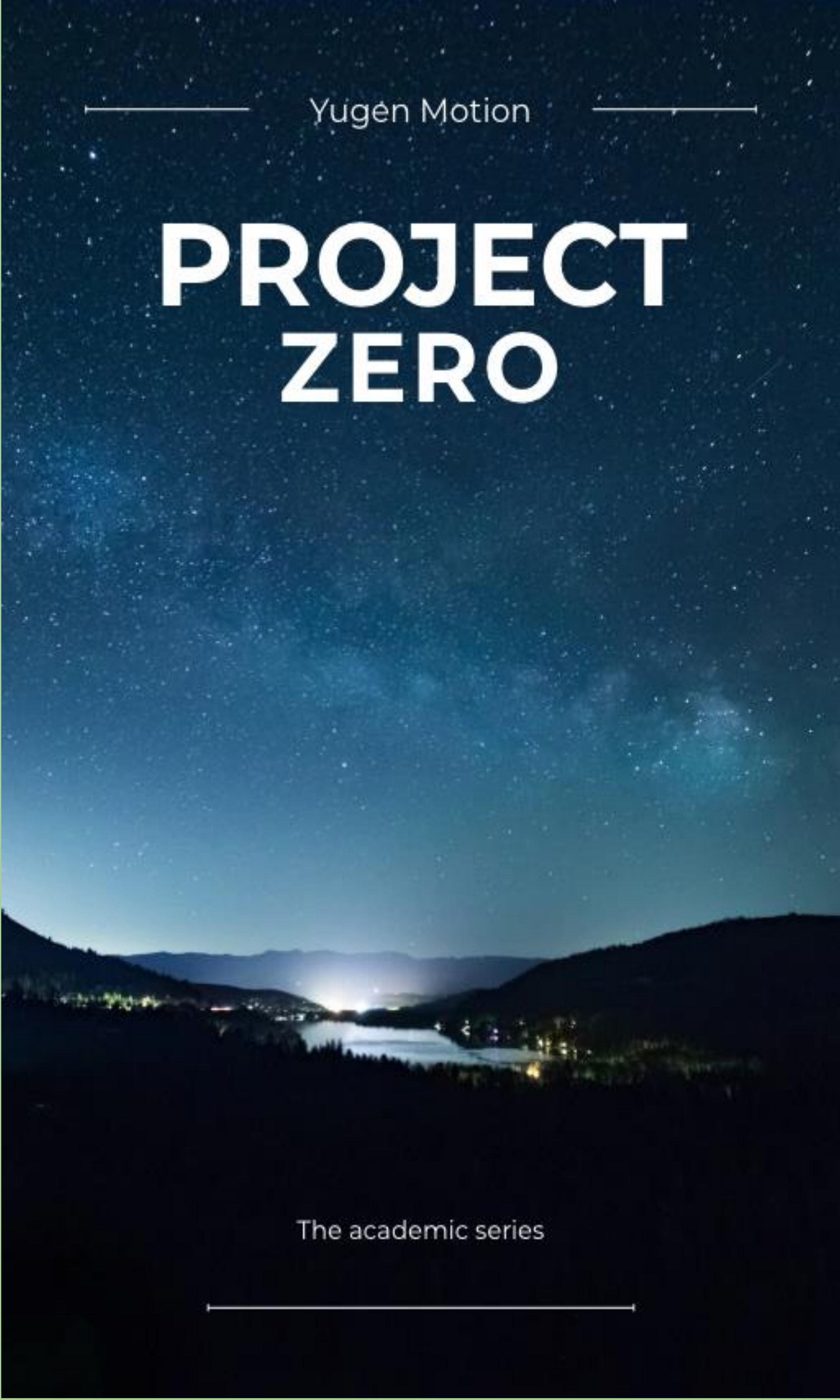
WHAT DID WE BUILD?

The book closes not on the trophy, but on what the process left behind: a team that no longer measures success by whether something works the first time, but by whether they understand it well enough to trust it. Tariq’s final line, admitting he doesn’t yet know what to build next but knows how to find out if it works, captures the story’s central transformation.

FINAL DESIGN CHALLENGE

YOUR COMMUNITY OR SCHOOL HAS A PROBLEM THAT TECHNOLOGY COULD HELP SOLVE.

1. Identify the problem clearly.
2. Sketch a first design, without worrying about it being perfect.
3. List what you would need to measure it.
4. Predict at least two ways it might fail.
5. Explain how you would test and improve it after each failure.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