Designing, Building & Racing a Miniature F1 Car

Sep 24, 2026 · @Kush

Project Report · F1 in Schools STEM Programme · 2024

A first-person account of one season inside the engineering design cycle — from research and CAD to prototypes, testing and race day.

Author: Pratyaksh Gupta — Grade 9, member of a four-student team

Tutor & Programme Mentor: Mr. Vishal Dutta — remarks included

Cover note

This report documents my participation in the F1 in Schools STEM Programme during 2024, when I was a Grade 9 student. F1 in Schools is an international competition in which student teams design, analyse, manufacture and race miniature Formula 1 cars powered by a compressed CO2 cartridge. I worked as one of four members of our school team. I was not the team leader; my main responsibilities were supporting the CAD design work in Autodesk Fusion 360 and maintaining our testing logs. Throughout this report I have tried to be clear about which achievements belong to the whole team and which lessons were my own.

I chose to document the season carefully because it was the first time I experienced a complete engineering design cycle from start to finish — research, brainstorming, computer-aided design, prototyping, testing and refinement. The sections that follow trace that cycle in order. Short remarks from our tutor, Mr. Vishal Dutta, appear where his feedback shaped my work.

1. Introduction — the Programme & My Place in It

F1 in Schools challenges student teams to engineer a miniature F1 car — CNC-machined from a polymer block, launched by an 8 g CO_2 cartridge down a 20-metre track — and to defend every design decision like a real constructor.

Quick facts	
Team size	4 students
Power source	8 g CO_2 cartridge

Quick facts	
Race distance	20 m straight track
My duties	CAD support · test logs

F1 in Schools is often described as the world's largest STEM competition, and after a season inside it I understand why. Each team must research aerodynamics, design a car in professional CAD software, manufacture it to strict regulations — in our case a CNC-machined polymer body with 3D-printed wings and wheel supports — and race it on a 20-metre track where the difference between cars is measured in hundredths of a second. The car is powered by a single 8-gram CO2 cartridge, which means there is no engine to tune — every gain has to come from physics: less drag, less rolling resistance, better launch stability.

Our team had four members, and I want to be honest about how the work was divided. One teammate led our overall planning, another focused on manufacturing and finishing, a third handled our identity and presentation materials, and I supported the CAD design and owned the testing log. Because we were only four, everyone helped everywhere — I sanded bodies, my teammates checked my CAD dimensions — but those were our centres of gravity.

What drew me in personally was the idea that a shape could be "wrong" in a measurable way. Before this programme, design felt like a matter of taste. F1 in Schools taught me that a design is a hypothesis, and the track is the experiment. That single idea changed how I approached every later stage of the project, and it is the reason my sections of this report lean heavily on recorded numbers rather than impressions.

> "Pratyaksh was the one asking 'why does the shape matter?' before we had even opened the rulebook. A curious, careful starter." — Mr. Vishal Dutta, Tutor

2. Research & Brainstorming

We produced 14 concept sketches and narrowed them to 3 finalists, scored on drag, legality and what our school tools could actually make.

```
flowchart LR
  A[1. Research] --> B[2. Brainstorm & sketch]
  B --> C[3. CAD model<br/>Fusion 360]
  C --> D[4. Prototype]
  D --> E[5. Test on track]
  E --> F[6. Refine & repeat]
  F --> E
```

Fig. 1 — Our engineering design cycle. We looped through Test → Refine three times before race day.

Our first fortnight produced no car at all, and I now think that was the point. The team divided the research: regulations, materials, manufacturing methods, and aerodynamics. I volunteered for aerodynamics because it was the topic I understood least. I learned that drag on a small CO2 car comes mainly from two sources — the frontal area pushing air aside, and skin friction along rough surfaces — and that at our scale, wheels and axles waste more energy than most beginners expect. I condensed my reading into a one-page summary with three recommendations: minimise frontal area, keep surfaces polished, and treat wheel alignment as an aerodynamic problem, not just a mechanical one.

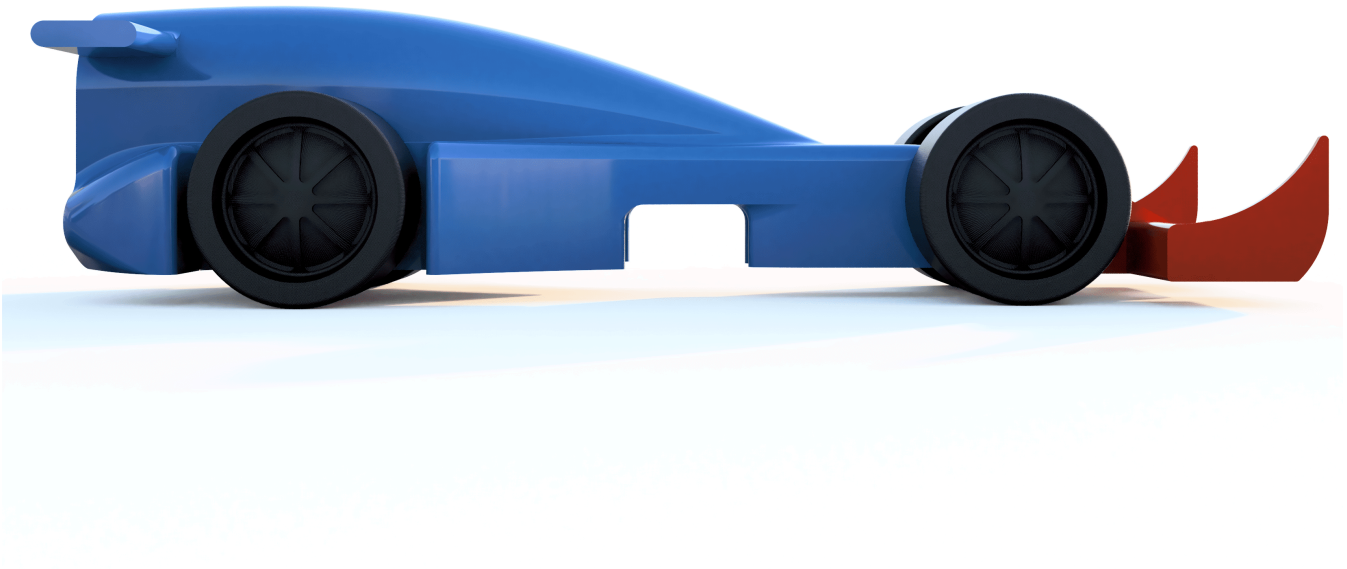
Brainstorming was the most enjoyable stage. We agreed on a rule borrowed from design-thinking articles: no criticism until an idea is sketched, because a bad sketch can still contain one good line. Across two sessions the four of us produced fourteen concept sketches, ranging from sensible teardrop bodies to one frankly impossible twin-hull design. We scored them against three criteria — expected drag, legality under the regulations, and manufacturability with the tools our school actually owns — and kept three finalists.

My personal takeaway from this stage: research is only useful once it is written down and shared. The one-page summary I made was referenced by teammates for months, which taught me that communicating findings clearly is part of engineering, not an extra.

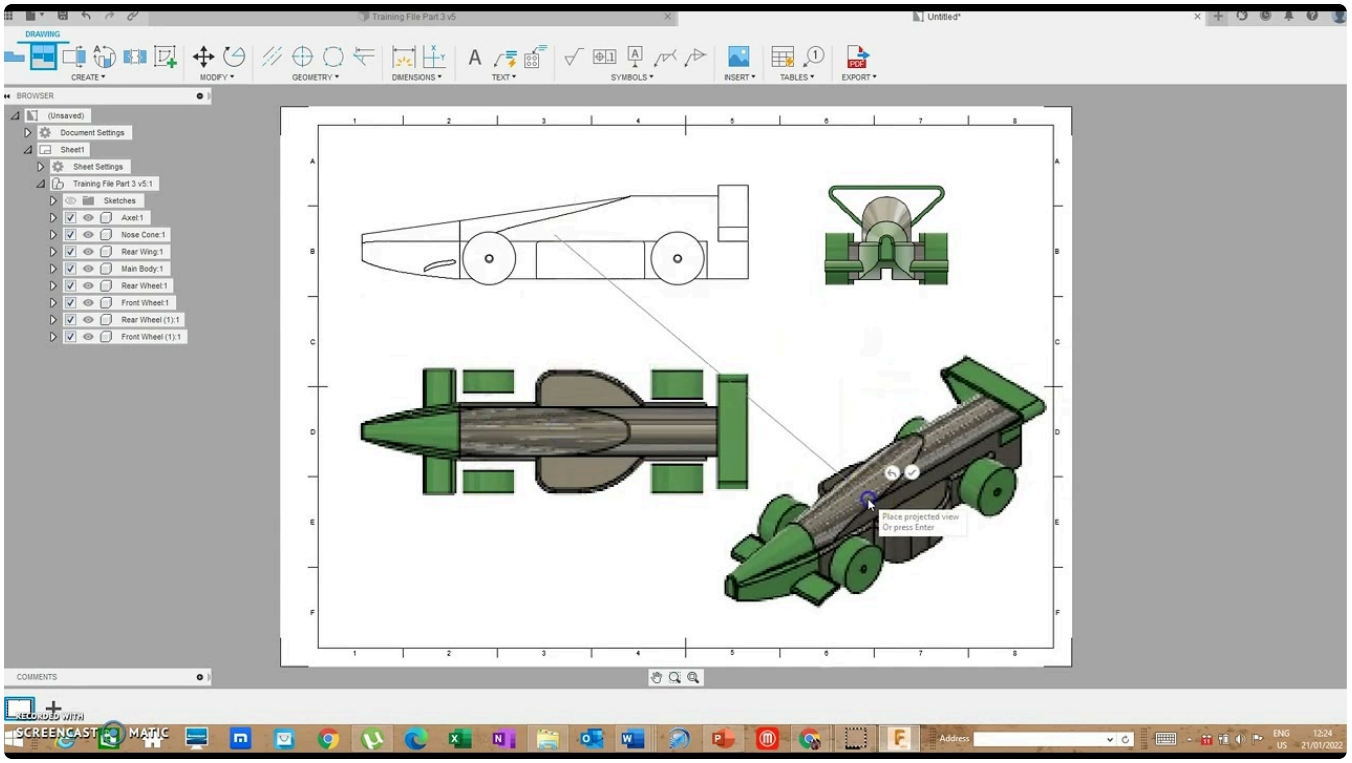
3. Car Design in Autodesk Fusion 360

Final design — key figures	
Body length	205 mm
Race mass	58.4 g
Wheelbase	130 mm
Body	Polymer, CNC-cut

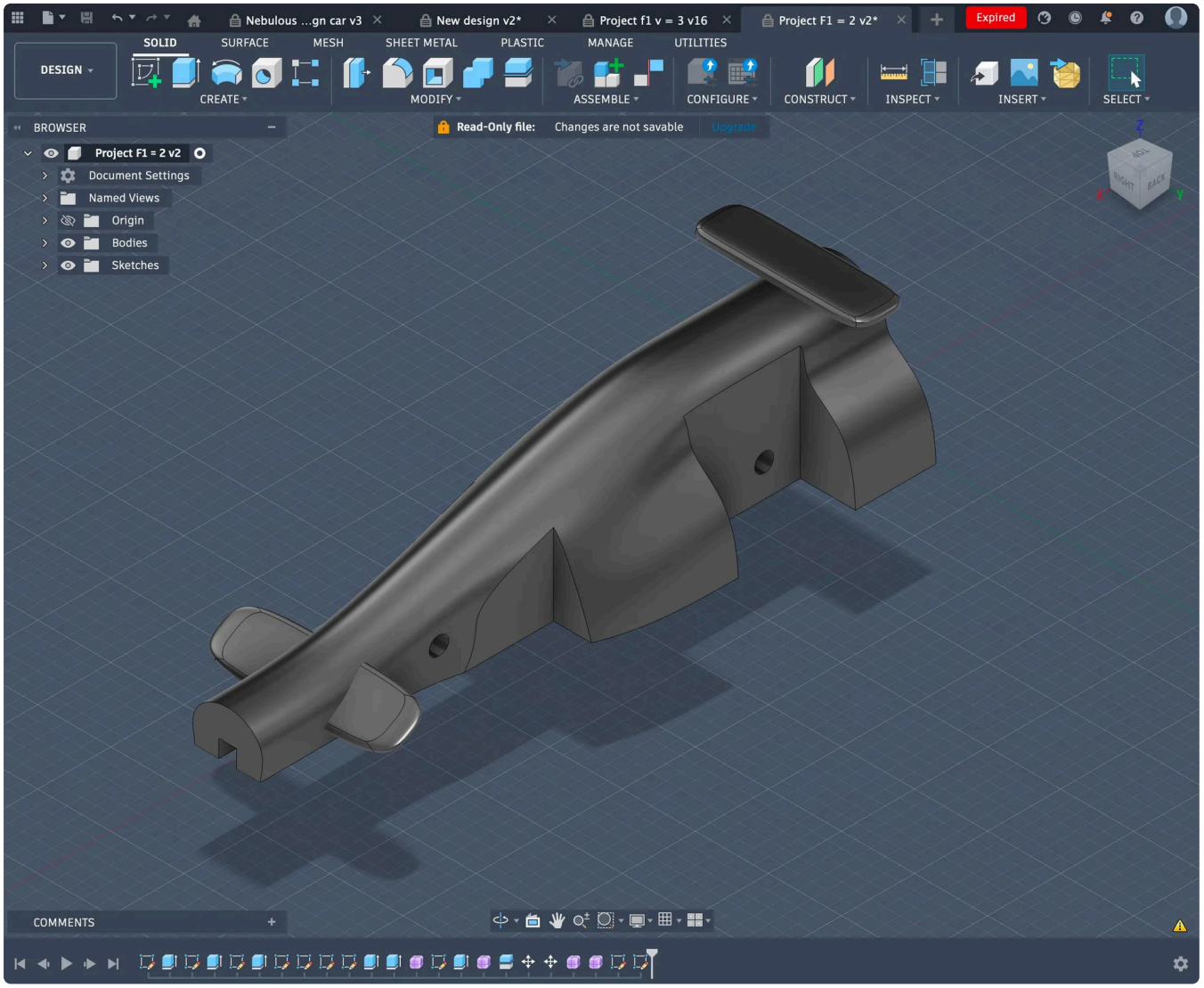
Final design — key figures	
Wings & mounts	3D-printed



CAD render of the final car — Fusion 360.



Fusion 360 drawing sheet — side, front, top and isometric views of the car.



The car body modelled in Fusion 360, showing the axle holes, nose, side pods and rear wing mount.

This was the stage where I contributed most, and where I made the most mistakes. Fusion 360 was completely new to all four of us. I worked through Autodesk's beginner tutorials over one weekend — sketching on planes, extruding, filleting edges — and then attempted to model our chosen concept. My first model looked impressive and was almost entirely illegal: the nose was too fine to survive CNC machining and the side pods intruded into the space the regulations reserve for the CO2 cartridge chamber.

Learning how the car would actually be made changed how I modelled it. The main body was to be CNC-machined from a solid polymer block, which meant every surface had to be reachable by the cutting tool — deep undercuts and hidden pockets were simply impossible, however good they looked on screen. The smaller components — the front and rear wings and the wheel supports — were 3D-printed instead. That split taught me why engineers choose manufacturing methods deliberately: the CNC-cut polymer body gave us a smooth, dense, accurate core, while 3D printing gave us speed and freedom for small complex parts. When our rear wing needed a redesign in September, we reprinted the new version overnight; re-machining a whole body would have taken more than a week.

The most valuable technique I learned was parametric modelling. Instead of typing fixed numbers, I defined key dimensions — wheelbase, body width, wing thickness — as named parameters. When we discovered mid-season that our wheel track had to widen by four millimetres to keep the wheels fully visible from above, I changed one parameter and the whole body updated consistently. Rebuilding the model by hand would have cost us a week.

I want to be accurate about teamwork here: the design was collectively owned. Our planning lead made the final calls on styling, and our manufacturing-focused teammate vetoed any surface the CNC machine could not cut. My role was translating the team's decisions into a clean, legal, machinable file — and I came to see that translation work as real engineering. Before submission, a teammate and I ran a full dimension-by-dimension check against the technical regulations, which caught two violations that would have disqualified the car.

> "His first CAD sketches were over-ambitious, but he learned to respect the rulebook quickly. Strong progress in Fusion 360 for a first-timer." — Mr. Vishal Dutta, Tutor

4. Prototype Development & Project Timeline

Month (2024)	Stage
Apr	Kick-off, rules & research
May–Jun	Concept + CAD in Fusion 360
Jul	Foam & first machined prototype
Aug–Sep	Track testing, 3 refinement loops
Oct	Final car & race day

- We cut a cheap foam mock-up first — holding a full-size shape revealed proportion problems no screen showed.
- The first CNC-machined polymer body taught us tolerances: axle holes 0.5 mm off-centre made the car pull left.
- 3D-printed wings needed light sanding to remove layer lines; the polymer body we wet-sanded to 1200-grit — finishing visibly changed how the car rolled.

Our tutor, Mr. Vishal Dutta, insisted we build a foam mock-up before machining anything, and it was the cheapest lesson of the season. The mock-up took one afternoon and a hot-wire cutter, yet the moment we held it we saw that our rear wing sat too high and the nose looked — and measured — bulkier than the CAD screen suggested. Two of us reworked the profile that same week.

The first real prototype combined our two manufacturing methods: a polymer body cut on the school's CNC machine, plus 3D-printed wings and wheel supports. Watching the CNC machine turn my Fusion 360 file into a physical polymer body was probably the single most exciting moment of the season — and a bigger humbling than I expected. On the bench it looked finished; on a test roll it pulled steadily to the left. We traced the fault to axle holes drilled about half a millimetre off-centre — a mistake nobody could see by eye. That was my introduction to tolerances: in CAD, a hole is exactly where you place it; in a workshop, "exact" costs effort. We built a simple drilling jig for the second prototype and the problem disappeared.

My personal contribution in this phase was mostly patient, unglamorous work: wet-sanding the polymer bodies through progressively finer grits up to 1200, lightly sanding the layer lines off the 3D-printed wings so they would not trip the airflow, measuring each prototype's mass on the science lab balance, and recording every change in the log so we always knew which version we were testing. The timeline above is reconstructed directly

from that log. Looking back, I am glad I kept it — several disagreements about "which change actually helped" were settled by the notebook rather than by memory or by whoever argued loudest.

5. Testing & Practical Learning

Our best 20 m time fell from 1.72 s to 1.39 s across four sessions — a gain of 0.33 s (about 19%).

Session	What changed	Best run time (s)
1	First prototype	1.72
2	Rebuilt axle mounts with the drilling jig — the car finally ran straight	1.58
3	Wet-sanded and polished the body; smoother skin, measurably faster	1.47
4	Trimmed 3.1 g of excess mass and lowered the rear wing (final car)	1.39

Fig. 2 — Data from my testing log: best of five runs per session.

My job: launch checklist, timing, and logging every run — five runs per configuration, best and average recorded.

Testing was where the project stopped being theoretical for me. We ran four formal test sessions on a 20-metre track, and I was responsible for the procedure: a launch checklist, consistent cartridge handling, timing, and the log. We settled on five runs per configuration and recorded both the best time and the average, because a single lucky run can mislead a team into keeping a bad change.

The data above is taken directly from my log. Session 1, with the first prototype, gave a best time of 1.72 seconds — and a car that drifted left on every run. After we rebuilt the axle mounts using our drilling jig, Session 2 improved to 1.58 seconds, and more importantly the five runs clustered tightly together, which told us the car had become consistent. Session 3 tested my aerodynamics reading: the only change was surface finish, wet-sanded and polished, and the best time fell to 1.47 seconds. I had honestly doubted that polishing would show up in the numbers at our scale; being measurably wrong about my own scepticism was one of the most instructive moments of the season. Session 4, with 3.1 grams of excess mass removed and the rear wing lowered, produced our final best of 1.39 seconds.

The practical lesson I value most: change one thing at a time. Early on we bundled changes together and could not tell which one helped. Once we disciplined ourselves to isolate variables, every session taught us something specific — which is, I later realised, simply the scientific method wearing overalls.

> "Kept honest testing logs even when the numbers didn't flatter the design. That's the right instinct." — Mr. Vishal Dutta, Tutor

6. Engineering Concepts I Learned

Concept	What it meant for our car
Aerodynamic drag	Frontal area + surface roughness slow the car; streamlining is measurable, not cosmetic.
Newton's laws	F = ma at launch: same thrust, less mass, more acceleration — why we chased grams.
Friction & rolling	Axle friction and wheel wobble waste energy; alignment is worth more than styling.
Centre of mass	A low, central CoM kept the car stable instead of fishtailing at launch.
Tolerances	±0.5 mm decided whether our car ran straight. CAD is exact; workshops are not.
Iterative design	Design → test → refine beats trying to be right the first time.

The six ideas above are the ones I can now explain without notes, which I have decided is my personal test of whether I truly learned something.

Aerodynamic drag stopped being a vague word and became two specific enemies: frontal area, which we minimised by keeping the body low and narrow, and skin friction, which we fought with sandpaper and polish. Newton's second law explained our obsession with mass — the CO2 cartridge gives every team roughly the same impulse, so the lighter legal car simply accelerates harder. That is why trimming 3.1 grams in our final revision was worth an evening of careful material removal.

Friction and rolling resistance surprised me the most. I had assumed the air did all the slowing; in fact, our biggest single improvement came from fixing axle alignment, a purely mechanical change. Centre of mass mattered for stability: an early prototype with a heavy tail fishtailed on launch until we redistributed material forward and downward.

Tolerances taught me humility about the gap between the digital model and the physical object, and iterative design tied everything together. Our final car was not a stroke of genius; it was version six of an ordinary idea, improved by measurement at every step. I find that genuinely encouraging — it means good engineering is a process a Grade 9 student can actually follow, not a talent you either have or lack.

7. Challenges We Faced

Challenge	How our team responded	What I personally learned
First prototype pulled left on every run	Traced it to off-centre axle holes; built a simple drilling jig	Diagnose with measurement, not guesswork
Fusion 360 learning curve on a deadline	Split tutorials among us and taught each other in 20-minute demos	Teaching a tool is the fastest way to learn it
Mid-season rule check forced a wider wheel track	Parametric model let us update the whole body in one evening	Build flexibility in before you need it
Disagreement over rear-wing height	Ran both versions back-to-back on the track and kept the faster one	Data ends arguments better than voting
Exam weeks collided with test sessions	Rotating pairs kept work moving while others revised	Planning around people is part of engineering

I have listed our five biggest challenges honestly, including the ones caused by our own inexperience. The left-pulling prototype was our first real crisis, and our first instinct — re-sanding the body — was wrong, because we were treating a mechanical fault as an aerodynamic one. Only when we measured the axle holes did the real cause appear. Since then, "measure before you modify" has become a personal rule of mine.

The Fusion 360 learning curve was steep for all four of us. What worked was dividing the official tutorials among the team and then presenting them to each other in short demos. I taught parametric constraints; a teammate taught surface tools. Explaining a feature to three sceptical friends exposes every gap in your own understanding within minutes.

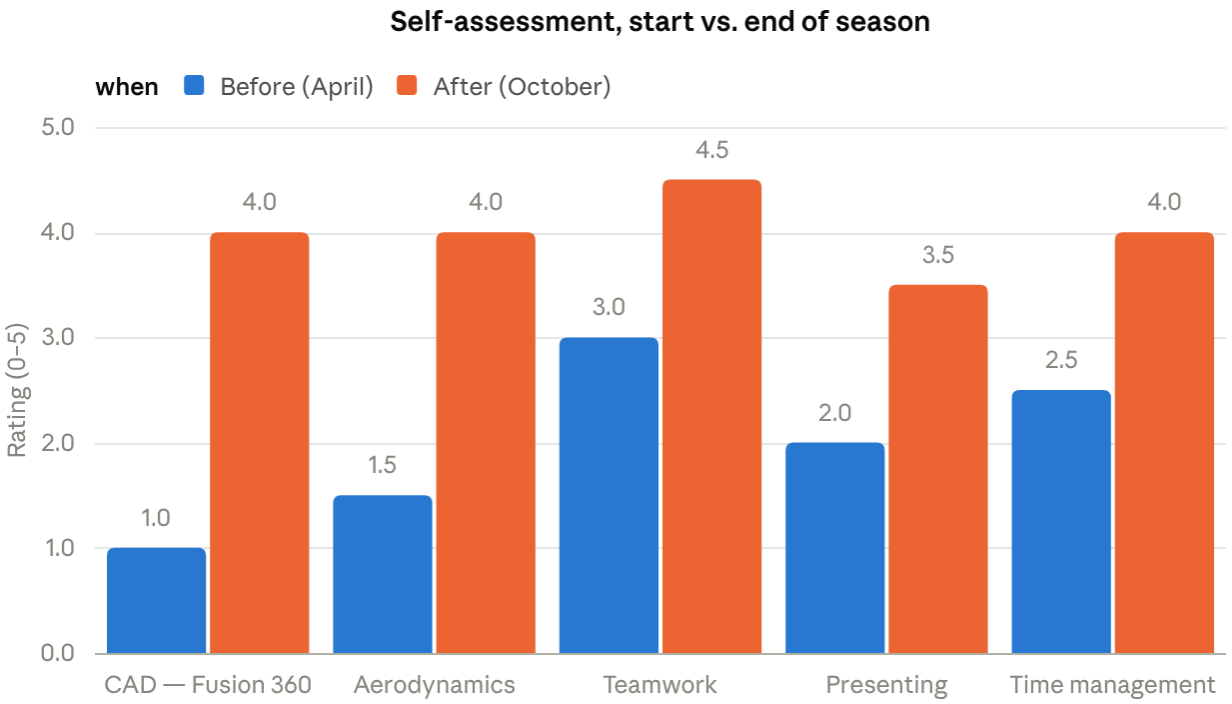
The rear-wing disagreement deserves special mention because it changed how our team made decisions. Two of us were convinced a higher wing looked faster; two suspected it added drag. Instead of arguing, we machined both configurations and raced them back-to-

back. The lower wing won by a repeatable margin, and from that day onward, "let the track decide" became our standard way to resolve design disputes.

Finally, the most ordinary challenge — school exams colliding with the project — taught me something no textbook covers: real projects are done by people with other responsibilities, and a schedule that ignores that fact is fiction.

8. Skills I Developed

CAD and aerodynamics grew the most (each up about 2.5–3 points); presenting grew least, because I only assisted our pit-display talk.



Self-rating on a 0–5 scale

from the slide deck · 5 skills, April vs. October

Fig. 3 — My honest self-ratings.

- **Technical:** parametric CAD, reading technical regulations, basic workshop finishing, structured test logging.
- **Analytical:** isolating variables, averaging runs, trusting recorded data over impressions.
- **Personal:** communicating findings in writing, and contributing reliably without being the leader.

The chart above is a self-assessment, so I want to be transparent about how I made it: I rated myself from 0 to 5 in April and again in October, and I asked a teammate to sanity-check the ratings so they would not just be optimism.

The largest jump was CAD. In April I had never opened Fusion 360; by October I could build a parametric model, repair a broken sketch, and prepare a file for machining. Aerodynamics grew from watching-videos knowledge to something I have physically tested — I know polishing works because I timed it. Teamwork started from a decent base, since I have always enjoyed group projects, but this season taught me a more specific version of it: how to be dependable in a defined role, hand over clean work, and disagree using evidence instead of volume.

Presenting is my honest weak spot. Our presentation lead fronted the pit-display talk, and I only handled the testing-data section. I was audibly nervous, though explaining my own graphs turned out to be far easier than explaining borrowed slides — a hint about how I should prepare in future. Time management improved out of necessity, once exam weeks and test sessions collided and our team moved to a rotating-pairs schedule.

If I had to name the single most transferable skill, it is the habit of writing things down as they happen. Every figure in this report exists because of that habit.

> "Noticeably more confident by October. He should trust his own analysis a little more — the data was usually on his side." — Mr. Vishal Dutta, Tutor

9. Reflection & Key Takeaways

- **A design is a hypothesis.** The track tested our ideas better than any debate. I now want data behind my opinions.
- **Small, measured steps win.** Our car improved 19% through six ordinary revisions — not one brilliant idea.
- **Reliability is a role.** I wasn't the leader, and it didn't matter. Teams run on people who deliver exactly what they promised.

When I signed up for F1 in Schools, I expected to learn about fast cars. What I actually learned is a way of working. The season gave me one complete pass through the engineering design cycle, and the three takeaways above are the parts of that cycle I intend to carry into everything else.

First, a design is a hypothesis. The most freeing idea of the year was that I did not have to be right — I had to be testable. Our rear-wing argument dissolved the moment we let the track decide, and I have started applying the same logic to schoolwork: when I am unsure, I look for a way to check rather than a way to win.

Second, improvement compounds. Our final car was 19% faster than our first, and not one of the six revisions between them was clever on its own. A jig, some sandpaper, three grams, a lower wing — ordinary changes, honestly measured, adding up. That arithmetic of small gains is the most optimistic thing I learned all year.

Third, I discovered what kind of teammate I am. I was not the leader, and this report does not pretend otherwise. I was the one who kept the log, checked the rules, and made sure version six was actually version six. The season taught me that this role has a name — reliability — and that teams cannot function without it.

I am grateful to my three teammates, to our school for the workshop hours, and to our tutor Mr. Vishal Dutta, whose remarks appear through this report and whose insistence on a foam mock-up saved us from our own first design. Next season, I want to move one seat closer to the aerodynamics decisions — and this time, I will arrive with data.

> "Pratyaksh began the season as a quiet observer and ended it as the team's memory and conscience — the log-keeper whose numbers everyone trusted. If he keeps pairing curiosity with this discipline, engineering will suit him very well." — Mr. Vishal Dutta, Tutor, F1 in Schools 2024