

STEM Landscape Study



System Barriers and Support Around Gender-Equitable STEM Education in Patiala, Punjab

Table of Contents

Foreword Note	3
Acknowledgements	4
Abbreviations	5
Executive Summary	6
SECTION 1: Introduction	10
SECTION 2 Methodology	13
SECTION 3 Stakeholder Ecosystem Map	16
SECTION 4 Findings	18
SECTION 5 Barriers Framework	30
SECTION 6 System Readiness	34
SECTION 7 Programmatic Implications	39
SECTION 8 Limitations of the Study	42
SECTION WAY FORWARD A Call to Act on What We Found	44

Foreword Note

Science, Technology, Engineering and Mathematics are not merely disciplines of study; they are among the most powerful drivers of economic transformation, innovation and social progress. If we aspire to build a knowledge-driven and technologically advanced India, it is imperative that every young person—irrespective of gender, geography or socio-economic background- has the opportunity to discover, pursue and realise their potential in STEM.

This makes the STEM Landscape Study - Patiala, 2025–26 both timely and significant.

Its findings remind us that educational choices are rarely determined by academic ability alone. They are shaped by family expectations, financial circumstances, mobility and safety, limited career information, family perceptions, academic preparedness and importantly, the availability of people who can help a young student see a pathway that she may not otherwise imagine. This calls for a shift in perspective—from asking how we can encourage more girls to choose STEM, to asking how we can build an ecosystem that enables every young person to make an informed choice and pursue their potential.

The study importantly highlights that many of the ingredients of such an ecosystem already exist—schools, teachers, laboratories, higher education institutions and support schemes—but the connections between them and the students they are intended to serve need to be strengthened. It provides valuable evidence and an opportunity to explore an approach in which schools, government, higher education, research institutions, industry and other stakeholders work together to strengthen STEM pathways. Patiala can thus become a learning laboratory for an evidence-informed, gender-responsive and ecosystem-led approach to STEM education, with lessons that can potentially inform wider initiatives across Punjab and the region.

I congratulate Sanjhi Sikhiya Foundation for anchoring the STEM Collective and Team PI-RAHI for strengthening it. I hope it serves not merely as a baseline assessment, but as a catalyst for dialogue, partnership and meaningful action.

Dr Jatinder Kaur Arora

Advisor, Northern Region Science & Technology Cluster (PI- RAHI : PU IIT Ropar Accelerator for Holistic Innovation set up by O/o PSA, GoI);

Former Executive Director, Punjab State Council for Science & Technology-cum-Chief Executive Officer, Punjab State Innovation Council-cum-Member Secretary, Punjab Biodiversity Board

Acknowledgements

This study would not have been possible without the generosity of the people who spoke to it. Across five schools in Patiala district, students, parents and guardians, teachers, school principals, district officials, and a faculty member at TIET gave their time, their candour, and in several cases their trust to a researcher they had met for the first time. They spoke about their lives, their constraints, and their aspirations with a directness that made this study what it is. We are grateful to each of them.

Particular thanks are owed to the three principals who opened their schools and their schedules, to the deputy DEO whose thirty years of experience in the government school system shaped our understanding of what system readiness actually means, and to the State Resource Person from the Department of Education, Punjab, whose structural framing of the STEM pipeline challenge sharpened the study's core argument at a critical moment in analysis.

Professor at TIET Patiala gave a perspective that no school-level interview could have provided, the view from the other end of the pipeline, from inside the humanities corridor of an engineering university. His observation that girls are not absent from higher education but from specific STEM disciplines reoriented an entire section of the analysis.

To the teachers and the students in the school focus group, whose voices open this report and whose stories run through it, this study is offered in acknowledgement of what you already know and in the hope that what it documents will contribute, in some small way, to making the system work better for the young women who come after you.

Research and Analysis

This study was designed, conducted, and analysed by the research team, especially Ms. Manmehak Kaur of Sanjhi Sikhiya Foundation (part of Patiala STEM collectives). Field interviews and focus group discussions were conducted between October and December 2025.

Institutional Support

The Patiala STEM Collective acknowledges the support of the schools, teachers, and district education offices in Patiala that enabled access for this study. We are grateful to the PU-IIT Ropar Regional Accelerator for Holistic Innovations Foundation (PI – RAHI) for their engagement with this work and for the institutional conversations that shaped its framing.

This study was supported by Genpact. We are grateful for their commitment to evidence-based work on gender equity in STEM education.

The views expressed in this report are those of the research team and do not necessarily represent the official position of any institution, funder, or partner organisation named herein. All respondents have been anonymised; names used in the report are either pseudonyms or first names shared with explicit consent.

© Patiala STEM Collective, 2025-26. This report may be shared and cited with attribution. For permissions beyond citation, please contact the Patiala STEM Collective.

Abbreviations

The following abbreviations are used throughout this report. They are listed alphabetically.

Abbreviation	Full Form
ADC	Additional Deputy Commissioner
B.Ed	Bachelor of Education
B.Tech	Bachelor of Technology
BA	Bachelor of Arts
BPEO	Block Primary Education Officer
CID	Criminal Investigation Department
DC	Deputy Commissioner
DEO	District Education Officer
F1–F11	Findings 1 through 11 (thematic findings, Section 4)
FGD	Focus Group Discussion
GSSS	Government Senior Secondary School
HE	Higher Education
HEI	Higher Education Institution
ISB	Indian School of Business
IIT	Indian Institute of Technology
JEE	Joint Entrance Examination
MBA	Master of Business Administration
MSc	Master of Science
NEET	National Eligibility cum Entrance Test (medical admissions)
NGO	Non-Governmental Organisation
PSCST	Punjab State Council for Science and Technology
PTM	Parent-Teacher Meeting
RQ	Research Question
SoE	Scheme of Excellence (government school category)
SRP	State Resource Person (Department of Education, Punjab)
SSS	Senior Secondary School
STEM	Science, Technology, Engineering, and Mathematics
TIET	Thapar Institute of Engineering and Technology, Patiala

Executive Summary

Understanding the Conditions That Shape STEM Access and Aspiration in Government Schools

About This Study

This is a qualitative baseline study of the STEM education ecosystem in Patiala district, Punjab. Conducted between October and December 2025, it involved 17 individual interviews and one focus group discussion across five government secondary schools. Respondents included school principals, science and mathematics teachers, parents and guardians, students in Classes 9 and 10, district education officials, a State Resource Person from the Department of Education, Punjab, and a faculty member at TIET and a faculty member at Thapar Institute of Engineering and Technology (TIET). Analysis proceeded through rapid audio synthesis, structured inductive coding, and thematic comparison across stakeholder groups.

The study was commissioned by the Patiala STEM Collective as a programme design baseline, a grounded, field-tested picture of conditions as they are, before interventions begin. It is also intended as the evidentiary foundation for a forthcoming white paper on STEM equity and government school ecosystems in Punjab. A quantitative survey of 2,250 students across 20 schools was conducted alongside **17 focused interviews in 5 schools with 6 stakeholder types. The 11 thematic findings are as follows:**

Table A — Patiala Class 9–12 enrolment, 3-year trend

Class	2023-24 (B/G)	2024-25 (B/G)	2025-26 (B/G)
9th	7,807 / 7,296	7,390 / 7,020	7,434 / 7,034
10th	7,002 / 6,948	6,944 / 6,910	6,472 / 6,573
11th	7,335 / 7,287	7,259 / 7,375	7,226 / 7,149
12th	7,501 / 7,180	6,597 / 6,947	6,458 / 6,765

Source: Punjab State MIS, District Enrolment Data, 2023-24 to 2025-26.

Table B — Patiala Class 11 stream-wise split, 2025-26

Stream	11th grade	% of total 11th (14,375)
Arts	10,418	72.5%
Commerce	1,486	10.3%
Science – Non-Medical (PCM)	1,204	8.4%
Science – Medical	1,016	7.1%
Vocational / Hunar Sikhiya	~251	1.7%

Source: Punjab State MIS, Stream-Wise Enrolment, 2025-26.

The Core Issue: A STEM Pipeline That's Too Narrow for Everyone

The scale of this is sharper than "Science stream" framing alone suggests. Only 8.4% of Patiala's Class 11 students — across both genders — are in the Non-Medical (Physics-Chemistry-Maths) stream and **7.1% into the Medical stream** that feeds engineering, computing, and most STEM higher education pathways (source: State MIS, 2025-26). Girls, notably, are not the ones holding this number down: 20.0% of girls enrolled in Class 11 took up Science in 2024-25, compared to 12.6% of boys — a pattern that has held for at least two consecutive years and is consistent with an independent AISECT/Sattva Consulting study finding roughly similar national uptake levels among girls (source: Sattva Consulting, 2024). This drop-off and low enrollment isn't happening because these young women lack the ability or the desire to succeed — if anything, the data shows they are choosing Science at a higher rate than boys once they arrive at Class 11.

Three premises underpin everything this study found. The barriers are structural: girls are deterred by coaching costs, mobility restrictions, a disruptive Class 10–11 transition, and family assessments of daughters' potential that have been shaped by disrupted schooling rather than actual aptitude. The barriers compound:

financial constraints interact with geographic inequality; absent guidance combines with peer influence; single-level interventions will be insufficient. And the system has unused assets: qualified teachers, existing labs, scholarship infrastructure, what is missing is the connective tissue that would convert these assets into outcomes.

A quantitative survey of 2,250 students across 20 schools conducted alongside this study corroborates these findings: girls at Class 9 outperform boys on most STEM subscales, and the gender gap on aspiration and technology interest is negligible at this stage, confirming that the problem is structural, not motivational.

It is worth situating this local picture against the state trend. Punjab's own transition rate from Class 10 into senior secondary stands at 90.7%, the highest among India's large states, and has been improving steadily since 2022-23 (source: UDISE+ 2021-22 to 2024-25, analysed by Prof. Arun C. Mehta, Education for All in India). This confirms what our fieldwork suggests: Punjab is not losing students at the gate into Class 11. The leak is not about whether students continue their education, it is about which stream they are permitted, prepared, or encouraged to choose once they get there. This distinction matters for how we frame the problem to funders and government partners: the ask is not "keep girls in school," it is "keep capable girls in science."

“Can support someone only if you yourself are capable, and I was not given the chance to become capable. My daughter will be.”, Female Parent, Pheelkhana

Key Findings At A Glance

Eleven thematic findings (F1 to F11) emerged from analysis. Six are summarised here; all eleven are developed in full in Section 4 of the main report.

Finding 1: Career choices are limited by what students see around them (F1 + F11) When families think of science careers, they usually only picture doctors or engineers. Students base their career goals on the jobs they see in their communities, rather than having access to information about all the options available. Because of this narrow view, some students are pushed into science against their will, while others are steered away from it entirely.	Finding 2: High costs and location lock students out of science (F2 + F3) The high cost of private coaching is the biggest roadblock for students, according to every teacher and principal we spoke to. Furthermore, quality coaching centers are almost exclusively located in cities. This creates an unfair, two-tiered system where a student's success heavily depends on their zip code and financial background
Finding 3: Family awareness shapes student confidence, and teachers hold the key (F4) Students are significantly more confident and clearer about their goals when their families understand the different career paths in science. To help families understand these options, teachers are our best and most trusted messengers. Parents listen to teachers for career advice in a way that outside organizations simply cannot match.	Finding 4: The gender gap is a social issue, not a classroom issue (F7) The barriers holding girls back are rooted in family finances, community norms, and safety concerns, rather than direct bias from teachers in the classroom. Girls are not dropping out of education completely. they are still going to college but these external pressures are keeping them out of specific science and technology fields.
Finding 5: We lose students during the jump from Class 10 to Class 11 (F8 + F9) The loss of female students in science happens at multiple stages, not just when they pick their high school streams. The transition between Class 10 and Class 11 is particularly brutal. Without structured support, the sudden increase in academic difficulty and language changes cause many capable students to lose their footing	Finding 6: The system relies too heavily on a few exceptional educators (F10) Right now, positive outcomes are mostly driven by a few highly dedicated teachers and principals going above and beyond their regular duties. Relying on individual heroes is neither fair nor sustainable. A student's chance at quality science preparation should be a guaranteed part of the system, not a lucky draw based on which teacher they happen to get.

Nine Steps for Program Design

Based on the study's evidence, we recommend nine design strategies. These steps are designed to work together to create a stronger, more effective support system for our students

1. Run programs during regular school hours. All main activities must happen during the standard school day. This is an absolute necessity so that girls with travel limits or safety restrictions can actually participate.	6. Use bilingual learning materials. We need to provide science study materials in both Punjabi and English. This helps students understand complex topics in their own language without lowering the academic standards.
2. Strengthen basic math and use active labs. We need to provide extra help with foundational math for Classes 9 and 10, combined with hands-on lab sessions. This directly builds the confidence students need to survive the difficult academic jump to Class 11.	7. Make teachers true partners, but protect their time. Programs should include teachers as co-leaders with clear, manageable roles and proper recognition. We must also protect them from the pressure of meeting school enrollment targets so they can focus purely on helping the students.
3. Help students find their true interests, rather than just pushing science. In Class 9, we should offer career guidance that helps students map out their natural skills across all subjects. We need to support their genuine choices before peer pressure makes the decision for them.	8. Make scholarship support a core part of the school. Getting financial aid shouldn't be a guessing game. Every school should have a trained teacher, a clear step-by-step process, and a parent information session to turn available scholarship funds into real access for students.
4. Bring relatable role models into the classroom. We should invite young professionals and college students from similar backgrounds to speak at the schools. Seeing someone like them succeed makes these career paths feel achievable and realistic, rather than just an abstract dream.	9. Change how families view their daughters' potential. Sometimes families decide a daughter isn't capable of a difficult career based on early school struggles. We need to use trusted teachers to change these early, unfair assessments, because if a family doesn't believe in their child, no other program will work
5. Reach parents through trusted teachers. We should run parent workshops to explain career options and how to access scholarships. These should be led by teachers, because parents already trust them and listen to their advice.	

Partnership Opportunities: Building a Team for Change

No single organization or institution can fix these systemic issues alone. Making real, lasting change requires a coordinated, long-term team effort across the government, colleges, local community groups, and financial backers.

Potential Partner	Here is what a successful team effort could look like
State government & education bodies	Policy anchor for scaling beyond Patiala. Co-development of district STEM models, contribution to state STEM strategy, co-publication of findings. Institutional endorsement that lends programme recommendations credibility with schools, officials, and funders.

Higher education institutions	Near-peer role model pipeline. Research collaboration on language-medium barriers, peer influence dynamics, and emotional regulation frameworks for STEM confidence. Lab visit and Science City programming. Bridge between school-level intervention and HE access.
District education administration	Structural embedding in school timetables and teacher frameworks. Engagement via the district official as primary champion, followed by an evidence-led briefing with the DC and BPEO, framed as partnership and co-ownership, not programme approval.
Civil society and NGO partners	Family-facing awareness and community engagement in peri-urban and rural contexts. Scholarship navigation support. Complementary reach into households and communities the school system does not consistently penetrate.
Funders and impact investors	Sustained multi-year funding matched to the time horizon ecosystem-level change requires. The evidence base this study provides supports investment grounded in field reality. Co-funding of white paper publication as a national knowledge contribution.

Three Immediate Priorities: Regardless of which partnerships are formalised, three actions follow directly from this study and should not wait.

- 1. Initiate district-level liaison and advocacy.** The Deputy DEO is the right entry point, an evidence-led briefing with the DC and BPEO, framed as partnership rather than programme approval, should be initiated before system-level programme architecture is finalised.
- 2. Activate the Class 9 window.** Career guidance, maths bridging, and family sessions must be ready before the next academic year, this is a time-bounded intervention point.
- 3. Make scholarship support easy to access.** Every school should have a trained teacher and a clear process to help students apply for scholarships — and this needs to be set up before the programme begins, not after.

The aspiration is there. The capability is there. The teachers are qualified and the infrastructure exists. What this study documents, across seventeen interviews and the voices of students, parents, teachers, principals, and officials, is the gap between that capability and the structural support available to realise it.

This study is an invitation to close that gap together.

SECTION 1: Introduction

Begin with three moments from the field.

At a parent-teacher meeting in Old Police Line, the interviewer was directed not to the parents she had arranged to meet, but to two young women, aged 23 and 21, who were there as guardians for their younger sisters. Their parents were absent. The first in their family to study beyond school, both had ended up in a computer diploma at a polytechnic college, not by choice but by the direction of teachers and the limits of what their family felt was possible. The elder had already completed a BA and wanted to do a B.Ed — her parents said, 'rehn de, kee karni enni padhayi.' The younger had wanted to pursue nursing. Her uncle said, 'kudi aa ta nai karni' — safety concerns about night duty, and a family of five sisters where the costs simply could not stretch further. Now neither could find work in the field they had trained for. They were at the PTM to make sure their sisters had a different story — one where the door to a real choice stayed open a little longer. - Old Police Line, Patiala

In Pheelkhana, a woman, who had been married off in the first year of her BA when she had wanted to study law, said: 'Education and then a career are the only avenues for women in our society to have a certain level of autonomy and agency. I was not given that chance. My daughter will be.' - Pheelkhana, Patiala

In a focus group in a school, a mixed group of Class 9 and 10 students were asked what they wanted to be. The answers came quickly: CID officer, police inspector, cardiologist, singer, engineer. One student wanted to join the CID but wasn't sure whether to take arts or science and didn't know how to figure it out. No one in the room could tell her. - GSSS, Patiala

The Human Reality Behind the Numbers

These real-life stories are the core of our findings. They show exactly what happens when our system isn't built to support every student. We have young girls who are motivated and ready for science, but when they reach the door, there are no signs and no one there to help them open it. The ambition is there, but the support system is missing.

Our own district data confirms and sharpens this picture. In 2024-25, 20.0% of girls enrolled in Class 11 across Patiala's government schools took up Science, up from 18.3% the year before (source: State MIS, 2023-24 and 2024-25) — figures consistent with a 2024 Sattva Consulting study finding comparably low uptake among girls at the state level. What our data adds is a comparison point: over the same two years, boys took up Science at only 12.0% and 12.6% respectively. Girls are not the underrepresented group within Science; they are, in fact, choosing it more. The system-wide failure this study documents is not that girls are turning away from science. It is that too few students of either gender are being channelled into the specific Non-Medical pipeline that leads to STEM careers — only 8.4% district-wide in 2025-26 — and that even among the girls who do choose Science, the roadblocks this study highlights (coaching costs, mobility restrictions, family assessments of "return on investment") determine how far that early choice actually carries them.

The Patiala STEM Collective was created to fix this gap by providing long-term support in government schools across the district. Before rolling out any new programs, we conducted this study to truly understand the on-the-ground reality by listening directly to the students, parents, teachers, principals, and local officials.

“Can support someone only if you yourself are capable, and I was not given the chance to become capable. My daughter will be.”, Female Parent, Pheelkhana

This report is not about what our communities lack. The people we spoke to are incredibly resilient and driven. We met mothers fighting for their daughters' futures, principals personally driving door-to-door across

villages to enroll students, and young cousins teaching their siblings at home. These are capable people working hard within a system that hasn't caught up to their potential.

Ultimately, our study highlights the gap between what these families can achieve and the lack of structural support holding them back. Closing that gap is exactly what the Collective aims to do

Context: Why Patiala, Why Now

Patiala district sits at a particular intersection of Punjab's educational geography. It has urban anchor institutions — Thapar Institute of Engineering and Technology, Engineering College of Punjabi University, Chitkara University, government senior secondary schools in the city, alongside peri-urban and rural schools where access to quality science preparation is sharply unequal. The coaching economy that has grown around Class 9–12 science preparation is largely urban and largely unaffordable for families whose children attend government schools. The result is a system where geographical proximity to resources determines educational outcomes as much as aptitude does.

Punjab's government schools are not, as one of the district official is insistent to point out, academically weak. Government teachers are qualified, competitive-examination-selected, and in several cases more current in their subject knowledge than their private school counterparts. The infrastructure, labs, buildings, space, exists in most schools. What is missing is not hardware. What is missing is the connective tissue: the structured guidance, the bridging support, the family engagement, the scholarship navigation, and the ecosystem coordination that would convert existing assets into actual outcomes for students who need them most.

About This Study

This study is the Patiala STEM Collective's qualitative baseline. It was conducted between October and January 2026, involving 17 individual interviews and one focus group discussion across five government schools in Patiala district. Respondents included school principals, science and mathematics teachers, parents and guardians, students in Classes 9 and 10, district education officials, and a faculty member at TIET Patiala.

The study was designed as a baseline, a grounded, field-tested picture of conditions as they are, before interventions begin. It is intended to serve three purposes: to inform the Collective's programme design with evidence rather than assumption; to provide a foundation for co-designing interventions with the group of institutions like PI-RAHI, Punjab State Council for Science & Technology (PSCST), TIET, Avanti, Udayan care and other institutional partners; and to contribute to the broader public policy conversation on STEM education and gender equity in Punjab through eventual white paper publication.

Alongside the qualitative fieldwork, the Collective administered a quantitative interest and curiosity survey to 2,250 students across 20 government schools in Patiala district in February 2026. The survey covered seven areas, Physics, Chemistry, Biology, Mathematics, Technology & AI, Exposure & Role Models, and Future Aspirations, and was designed to measure STEM interest and confidence at the Class 9 level, before stream selection pressure peaks.

The survey was not designed to test or validate the qualitative findings, the two instruments were developed independently. What makes the convergence between them significant is precisely that: where the interviews and the numbers point in the same direction, the pattern is harder to dismiss as a feature of one method or one sample. The most important convergence is this, at Class 9, girls in Patiala are not behind. Across most subscales, including Mathematics, Biology, and Chemistry, they outscore boys. On Technology and Future Aspirations, there is no meaningful difference between girls and boys at all. The gender gap that the landscape study documents is not present at the point of aspiration. It arrives later, in the transition that this study is trying to understand.

Survey findings are referenced at specific points in Sections 4, 5, and 7, where they either corroborate a qualitative pattern or add quantitative texture to an observation that the interviews alone could not fully resolve. A full statistical analysis of the survey data, including tests across income groups, parental education, school type, and decision-maker identity, is available to the programme team.

Study Aims

1. To map attitudes, beliefs, and aspirations around STEM education and careers among students, families, school staff, and district stakeholders.
2. To investigate gendered norms and practices that influence subject choice, academic mobility, and occupational aspiration.
3. To identify structural, pedagogical, and economic barriers to STEM uptake, with particular attention to how these are experienced by girls.
4. To assess the readiness and constraints within the local ecosystem for implementing and sustaining the Collective's interventions.
5. To surface evidence-based recommendations for the Collective's programming and for public policy on STEM education in Punjab.

Research Questions

Five research questions structured the fieldwork and analysis. They are listed here as the frame for what follows; each is answered directly in Section 3 and developed fully across Sections 4 through 7.

- RQ1.** What do different stakeholder groups conceive as the value and future of STEM careers?
- RQ2.** How do gender norms and familial expectations shape girls' STEM aspirations and subject choices?
- RQ3.** What are the major academic, economic, and infrastructural barriers to STEM uptake, and how do these manifest differently for girls?
- RQ4.** Which support mechanisms, at the family, school, and community level, currently assist or could amplify girls' participation in STEM?
- RQ5.** How ready are local schools and system actors to integrate and sustain the Collective's activities?

How to Read This Report

The report moves from context to evidence to action. Section 2 describes the methodology. Section 3 maps the stakeholder ecosystem and connects each research question to the finding it generated. Section 4 presents eleven thematic findings, each grounded in field evidence and participant voice. Section 5 organises those findings into a four-tier barriers framework designed as a programme design tool. Section 6 assesses system readiness and the specific opportunity for collaboration with PSCST, PI-RAHI, TIET and IISER. Section 7 translates the evidence into nine programmatic implications. The quant survey findings are referenced at specific points in Sections 4, 5, and 7, where they either corroborate a qualitative pattern or add quantitative texture to an observation that the interviews alone could not fully resolve. Section 8 sets out the study's limitations honestly. The Way Forward section at the close names the concrete next steps this study calls for.

SECTION 2 Methodology

This section sets out how the study was designed, who was involved, how data was gathered and handled, and how analysis proceeded from raw audio to structured findings. It is written to be transparent rather than merely procedural, transparency about methodological choices is what allows a reader to assess how much weight to place on any given finding.

1. Research Design Rationale

A qualitative, interpretive approach was chosen deliberately, not by default. The study's central questions, why families restrict girls' mobility, why teachers deny a gender gap they simultaneously describe, why a student follows friends into the wrong stream and spends a year there, are not questions that surveys can answer. They require conversation: the space for a parent to explain what she meant when she said her daughter is 'not too intelligent,' for a teacher to contradict himself and for that contradiction to become analytically interesting, for a student to say something with hesitation that is more revealing than what she says with confidence.

A quantitative baseline would have told us how many students choose science streams. It could not have told us what it felt like to be a woman, married off in her first year of a BA, redirecting her blocked ambition through her daughter, or what it meant that the Bhadson principal, who manages four schools, was running door-to-door enrolment drives across thirty to forty villages entirely on personal initiative. These stories are not illustrations of statistical findings. They are the findings. They reveal mechanisms, not prevalence.

Semi-structured interview guides were developed specifically for each stakeholder type, students, parents, teachers, principals, district officials, and higher education faculty, probing perceptions of STEM, gendered expectations, resource constraints, and openness to external partnerships. All interviews were audio-recorded with verbal informed consent. A field journal captured non-verbal observations, interviewer reflections, and emergent analytical notes between sessions.

2. Sampling

Respondents were purposively selected to represent the full range of stakeholders in the STEM Collective's ecosystem. Schools were drawn from School of Excellence (SoE) and Senior Secondary School (SSS) categories across urban, semi-urban, and rural locations in Patiala district. A total of 17 one-on-one interviews and 1 completed FGD were conducted between October and December 2025.

Stakeholder Type	Planned	Completed	School / Context
School Principals	4	3	Mohinderganj SoE; Bhadson SSS; Civil Lines
Science & Maths Teachers	4	4	Mohinderganj SoE; Civil Lines SSS; Rural SSS
Parents / Guardians	4+	6	Pheelkhana; Old Police Line; Mixed
Students (Cl. 9–10)	4+	8 + 1 FGD	Mohinderganj SoE; Bahadurgarh SSS; Bhadson SSS
District Officials	3	2	Deputy DEO; State Resource Person (SRP)
HEI Faculty	2	1	Thapar Institute (TIET), Patiala

Table 1: Sampling frame, planned vs. completed interviews by stakeholder type.

3. The Focus Group Discussion

The one completed FGD, held with a mixed-gender group of Class 9 and 10 students at one of the schools, was used differently from the individual interviews, and its data should be read accordingly. Individual interviews are designed to surface the private: what a student thinks when no peer is watching, what a parent says when not performing for a community. The FGD is designed to surface the social: what students say in front of each other, what group dynamics enable or suppress, how aspiration is communicated and received in a peer setting.

The School FGD produced a notable inversion. Girls were more vocal and forthcoming than boys, the opposite of the confidence gap observed in individual student interviews. The researcher's interpretation is that the group setting was enabling for girls: there is a kind of safety in collective speech that individual

interviews, for all their depth, cannot replicate. A girl who hesitates to name her aspiration in a one-on-one conversation may name it readily when others are doing the same. This dynamic is not a distortion of the data, it is itself a finding: confidence for girls in this context is partly social and collective, not only individual.

FGD data is used to triangulate and extend individual interview findings, not to substitute for them. Where the FGD and individual interviews converge, on peer influence, financial barriers, the dominance of medical and engineering as aspirational destinations, the pattern is treated as more robust. Where they diverge, particularly on confidence, both data points are reported and interpreted.

4. Data Handling and Ethics

Verbal consent was obtained and logged at the start of each interview. Recordings are stored securely; transcripts and analytic outputs are held on password-protected drives with access limited to the core research team. Respondent names have been withheld throughout, interviewees are identified by role, school type, and location only. Where direct quotes are used in the findings, they are attributed to role and context rather than name.

5. Analysis Process

Analysis proceeded through four iterative stages. These are described below as stages for clarity, but in practice they overlapped, analytical insights from later interviews were tested against earlier ones, and emerging patterns reshaped how subsequent interviews were conducted.

01 Rapid audio-to-notes: Each recording was reviewed promptly after the interview and synthesised into structured notes capturing key points, direct quotes, field observations, and the researcher's own analytical impressions while the conversation was still fresh. This stage produced the primary working material for all subsequent analysis, the speed of synthesis was deliberate, preserving the texture of what was said before interpretive distance could flatten it.

02 Structured coding: A codebook aligned to the five research question areas was applied to all interview notes. Six primary codes were used: Attitudes & Perceptions Toward STEM; Gender Norms & Gendered Experiences; Barriers & Challenges; Support Systems & Opportunities; Ecosystem Readiness; and Stakeholder-Specific Insights. Sub-codes were developed inductively from the data, the codebook was not fixed before fieldwork but grew alongside it, allowing emergent themes to be captured without forcing them into predetermined categories.

03 Thematic synthesis: Coded extracts were compared across stakeholder types. Consistent patterns across multiple groups, financial barriers named by teachers, parents, principals, and students alike; the coaching geography problem raised in urban and rural contexts, were treated as triangulated and given greater analytical weight. Divergences were treated as analytically significant rather than as data problems: the tension between teachers denying a gender gap while describing its structural conditions is more interesting than either position alone.

04 Auditability: Each finding in Section 4 carries an evidence base line specifying which stakeholder types and how many respondents contributed to it, and at least one anchoring direct quote from the field. The coding schema is reproduced in Appendix B. This structure allows any finding to be traced back to its evidentiary basis.

6. A Note on Interviewer Positionality

The researcher conducting these interviews was a young professional connected to the Patiala STEM Collective, the same organisation whose work this study is designed to inform. This positionality created two tensions worth naming honestly.

First, several principals had been engaged by the Collective before their interviews began. The first interview, with the female principal at Mohinderganj, was conducted after institutional liaison had already taken place. The researcher notes this directly: pre-briefed respondents may frame their answers to align with the organisation's perceived expectations. This risk was most acute with school principals, who had the most to

gain from presenting their schools as ready and receptive partners. The researcher's assessment in each case was that responses appeared genuine, but framing effects cannot be entirely ruled out.

Second, the researcher's perceived identity, young, educated, connected to a civil society organisation with progressive framing, may have influenced how some respondents spoke about gender. Several male respondents demonstrated what the researcher describes as a productive tension: denying a gender gap in STEM while simultaneously describing structural conditions that disproportionately affect girls. Whether this reflects genuine belief or social performance for the interviewer cannot be determined from the interview data alone. Both possibilities are held open in the analysis.

These positionality notes are not offered as reasons to discount the findings. They are offered as the kind of reflexive honesty that makes qualitative research credible, an acknowledgement that the researcher was not a neutral instrument, and that the study is stronger for naming that rather than pretending it away.

SECTION 3 Stakeholder Ecosystem Map

The STEM Collective operates within a multi-layered ecosystem. No stakeholder in this ecosystem acts independently: what a teacher says in a classroom is shaped by what the principal expects; what a parent decides about a daughter's stream is shaped by what a teacher communicates; what a student aspires to is shaped by what her family has seen work and what her peers are doing. Understanding each actor's role, influence level, and the specific themes they raised is the precondition for designing interventions that work with the system rather than past it.

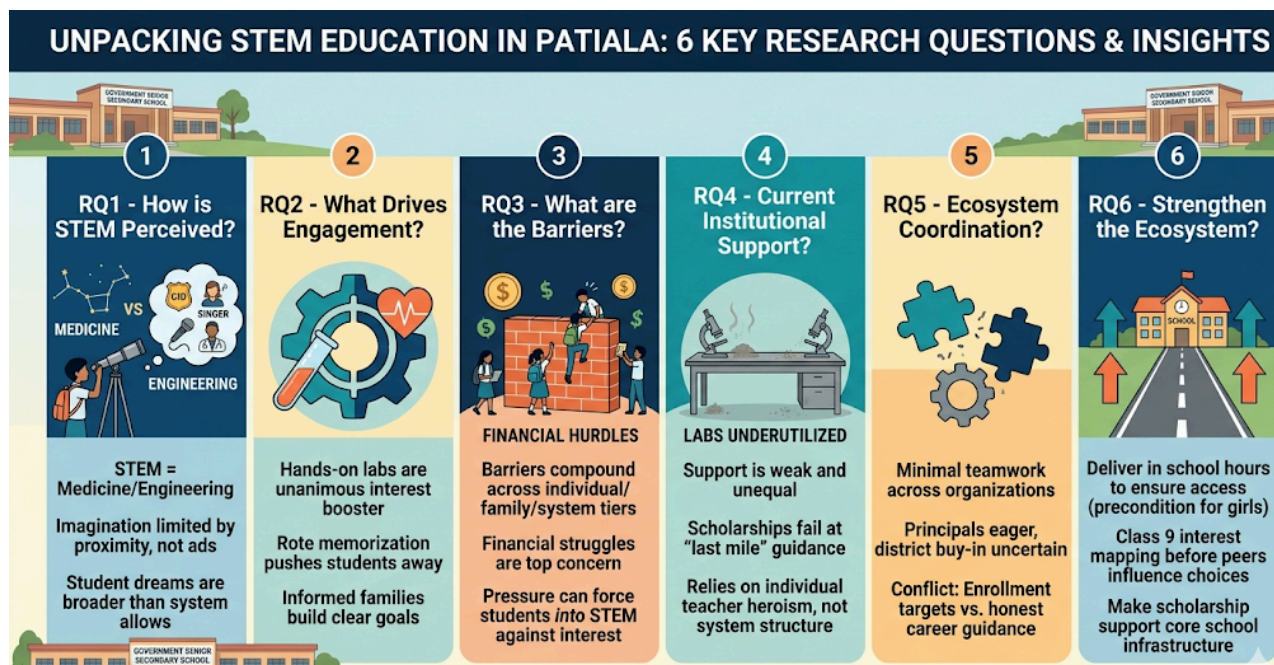
The map below reflects what the study found, not a generic framework. Two stakeholder types absent from conventional ecosystem maps have been added: young women as guardians, a role that emerged unexpectedly at the Old Police Line PTM, and the private coaching sector, which functions as a parallel system that shapes access and aspiration for every student in this study, yet appears in no institutional map of the STEM ecosystem.

Stakeholder	Role in Ecosystem	Influence	Key Themes Raised	What This Study Adds
School Principals	Gate-keepers of school culture, resource allocation, and openness to external partners	High	Infrastructure; teacher motivation; NGO partnerships; community engagement	<i>Individual leadership compensates for structural gaps, but is not a sustainable model. Proactive principals shift outcomes; transferred principals leave gaps.</i>
Science & Maths Teachers	Direct shapers of student interest, confidence, and career orientation	Very High	Pedagogy; coaching gap; gender perceptions; parent mindset; scholarship access	<i>Most trusted channel to parents. Carrying conflicting incentives: enrolment targets vs. honest guidance. Exceptional individuals masking systemic underinvestment.</i>
Parents / Guardians	Primary decision-makers on stream choice, mobility, and education investment	Very High	Finance; safety; marriage expectations; career awareness; role models; perceived intelligence	<i>Career imagination built through occupational proximity, not information. Teacher credibility with parents is the highest-leverage communication channel.</i>
Young Women as Guardians	Emerging decision-influencers for siblings with absent or minimally engaged parents; leaky pipeline exemplars	Moderate–High	Pipeline attrition; guidance failure; STEM-to-employment gap; safety restrictions	<i>NEW. Absent from conventional maps. Represent the pipeline problem in lived form, educated in STEM-adjacent fields, unemployed, still working to keep doors open for sisters.</i>
Students (Cl. 9–10)	Direct beneficiaries; in early aspirational formation	Moderate	Peer influence; career ambiguity; practical science; coaching; aspiration range	<i>Aspiration is broader than the system supports: CID, singer, cardiologist, engineer in the same room. Guidance vacuum filled by peers and family example, not structured support.</i>
District and State Officials	Policy implementers; system-level resource allocators; sustainability arbiters	High	Teacher vacancies; NGO overload; scholarships; language medium; sustainability	<i>District official triple positionality (student → teacher → administrator) gives his caution institutional weight. Sustainability must be designed, not assumed.</i>
HEI Faculty	Role models; research partners; pipeline connectors; discipline-level observers	Moderate–High	Disciplinary gender segregation; aptitude testing; emotional regulation; Punjab cultural attitudes	<i>Girls absent from STEM disciplines, not from HE. Emotional regulation as a lever for STEM confidence development. Last-mile human intermediary is the missing link.</i>
Private Coaching Sector	Parallel system shaping preparedness, aspiration, and access, particularly at Class 9–10 transition	High (de facto)	Coaching cost; geography; urban concentration; perception vs. actual need; coaching as prerequisite belief	<i>NEW. Absent from institutional maps. Functions as an unofficial prerequisite for science streams. Urban concentration creates a two-tiered system that government schools alone cannot equalise.</i>

Table 2: Stakeholder ecosystem map, roles, influence levels, key themes, and what this study adds.

Research Questions and Key Insights

This study was structured around six research questions. Each question, the finding it generated, and the most significant insight it produced are set out below. These are summaries only, the full analytical treatment of each theme is in Section 4.



Question 1: How do students and families view science and math careers?

Families see science careers as desirable but almost always limit their imagination to medicine and engineering. Students' actual aspirations are much wider, but without structured guidance, those aspirations get flattened by peer pressure and family example. See Finding 1 and Finding 11 for the full picture in section 4.

Question 2: What keeps students interested in science?

Three things drive student engagement: teaching that goes beyond memorisation, families who understand career options, and hands-on lab learning. When all three are missing, students disengage. See Finding 4 and Finding 5 for detail.

Question 3: What roadblocks stop students from moving forward in science?

Barriers exist at four levels — student, family, school, and system — and they compound each other. Financial constraints are the most universally named. Two less visible problems also emerged: students being pushed into science against their will, and families underestimating daughters based on past disruptions rather than actual ability. See Finding 2, Finding 3, and the Barriers Framework in Section 5.

Question 4: How well do our schools currently support science students?

Support is weak and uneven. Labs exist but go unused. Scholarships exist but don't reach students. Career counselling happens on paper but not in practice. Positive outcomes currently depend on a few exceptional teachers — which is neither fair nor sustainable. See Finding 8 and Finding 10 for detail.

Question 5: How well are our organizations working together?

Coordination across the system is minimal and informal. School principals are genuinely open to collaboration, but there is a structural conflict: teachers are pressured to meet enrolment targets, which directly works against honest, interest-based career guidance. See Section 6 for the full system readiness assessment.

Question 6: What are our best opportunities to fix this?

The study points to nine design directions, with three being most urgent: delivering programmes within school hours so girls can actually attend, providing career guidance at Class 9 before peer pressure takes over, and making scholarship navigation a core school function. See Section 7 for all nine implications.

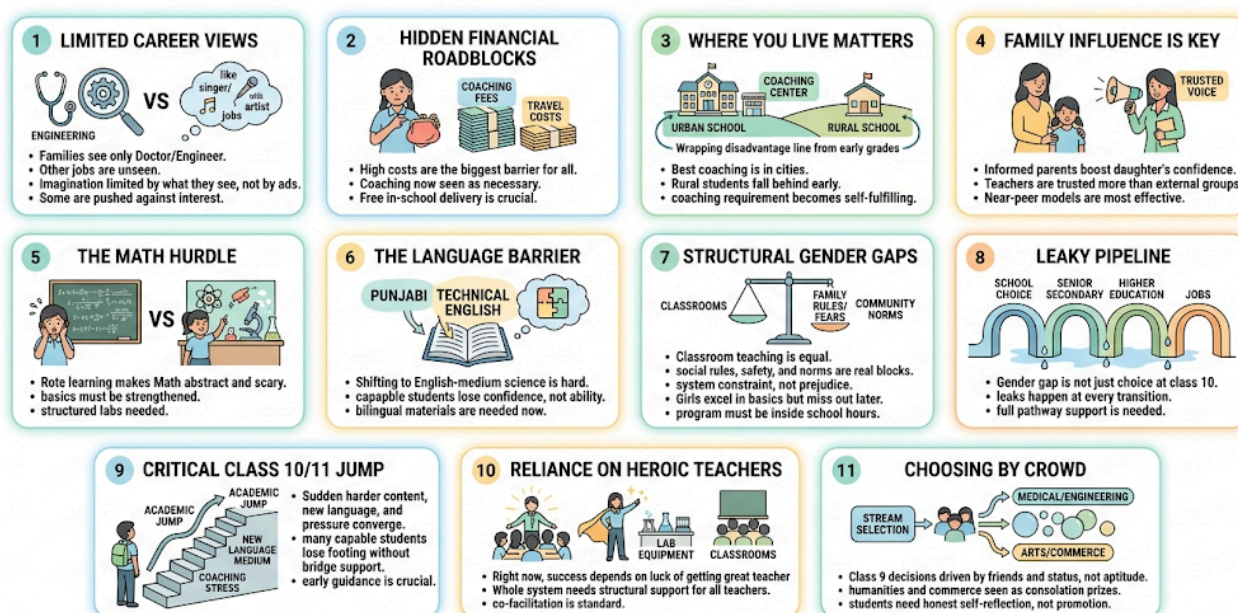
SECTION 4 Findings

Stakeholder interviews and Student Interest Curiosity study findings

The following eleven findings came out of our detailed analysis of interviews and focus group discussions held across five different schools in the Patiala district. We are presenting each finding as a real-life narrative, based on solid evidence from the ground, understood within the bigger picture of how our systems work, and anchored by the actual voices of the people living these realities every single day. When you look at them all together, they do not show a picture of students or teachers failing as individuals. Instead, they show a system that simply has not yet been designed to properly include and support everyone it reaches.

These findings connect directly to our program design recommendations in Section 7, and you will find the evidence sources listed at the end of each point.

'UNPACKING STEM EDUCATION IN PUNJAB: 11 KEY FINDINGS'



Finding 1 - Career Imagination: STEM Means Medicine and Engineering and Little else

Families only see two paths: Doctor or Engineer. Most parents and students don't know about other science jobs because they haven't seen them in their own communities.

When families think about science careers, they usually only picture two options: medicine and engineering. This isn't out of ignorance; it happens because people base their goals on the jobs they actually see succeeding in their own communities. For example, one parent understood that veterinary science was a strong career choice only because he had directly worked alongside vets in his daily life.

The wide variety of dreams that came up during the school focus group perfectly captures this issue. During the discussion, students said they wanted to be CID officers, police inspectors, cardiologists, singers, and engineers. One student specifically mentioned wanting to work in the CID, a career goal that does not neatly fit into one specific academic stream. This student understood the conflict but had no guidance or framework to help figure out how to resolve it. Another student wanted to be a singer, which is a career path completely outside the strict "science versus non-science" choice the school system forces students to make. The students'

career aspirations are genuinely diverse and varied. However, the guidance and support structures needed to help them explore that variety are almost completely missing from the schools.

“I want to be a CID officer. But I also want to take arts, not science. I am not sure if I can do that.”, School FGD

This narrow view of success causes problems in multiple directions. We met a student with a true passion for arts and literature who was being actively pushed into medicine by his family, simply because his brother-in-law is a successful doctor. This student isn't at risk of losing interest in science; he is at risk of being forced into it against his will.

Our larger quantitative survey on student interest and curiosity backs this up. The section measuring "Future Aspirations" scored only 58.6%, which was the lowest score across all seven areas we tested. Furthermore, the item asking if students "Know a woman in STEM" scored very low, at just 2.92 out of 5.

The Takeaway for Our Program: Simply telling students that "science is important" or expanding their imagination isn't enough. We need to provide structured support to help students discover what genuinely interests them and give them the confidence to pursue that path. Expanding their horizons requires connecting them with relatable role models, not just handing them information. **Evidence base:** Students (n=8), Parents (n=6), Teachers (n=4), FGD (school, mixed gr. 9–10)

Finding 2 The Hidden Financial Road block

Money is the single most common barrier mentioned by every single group we spoke with..

Across the board, a lack of finances is the biggest wall our students face. Almost everyone we interviewed, including teachers, parents, school principals, and district officials, agreed on this fact. They pointed out that the high costs of private coaching classes, daily travel, and extra study materials are actively keeping smart, capable students out of the science stream. In this kind of research, getting everyone to agree on one thing is very rare. This tells us it is a massive, undeniable problem, not just an isolated complaint.

“Coaching is not affordable for many families here. And for girls, even where it exists, there is the added issue of having to travel, and parents are not always comfortable with that.”, Female Teacher, Mohinderganj SoE

There is a painful irony here: the families who are the most motivated to choose science because it promises a stable financial future are the exact same families who are priced out of it. In our current system, private coaching is no longer treated as an optional luxury. Instead, it functions as an unofficial requirement to survive the science stream. Because of this, students who cannot afford the fees simply pull themselves out of science, even if they have the natural talent to succeed.

For girls, this barrier is even more complicated. Families view science careers as highly desirable because they offer future independence, but they also see them as structurally out of reach. This is because attending extra coaching requires traveling outside the home, and parents are understandably hesitant to allow that travel due to safety and mobility concerns.

The government does have scholarships available, but they are incredibly difficult for families to actually access. Because of heavy paperwork, confusing application processes, and a general lack of awareness among both teachers and parents, the financial help simply does not reach the students who need it the most. This is a deep flaw in the system that cannot be fixed just by having good intentions.

The Takeaway for Our Program A student's chance to study science is decided just as much by their family's bank account as it is by their intelligence or interest. Any new program that ignores these cost barriers will end up leaving out the exact students it is supposed to help. To fix this, our programs must be designed to run inside the school building, during regular school hours. This ensures that students face absolutely zero

extra fees and no additional travel. **Evidence base:** Parents (n=6), Students (n=8), Teachers (n=4), District officials (n=2)

Finding 3 Where You Live Shapes What You Can Learn

A student's access to quality science and math coaching is deeply unfair depending on where they live, and this gap only gets worse as they grow older

Good, affordable tutoring for science and math is mostly found in city centers. Students living in rural or semi-urban areas who cannot easily get to these centers face a growing, compounding disadvantage. By the time they reach Class 10 and have to choose their future subjects, they have missed out on the extra foundation-building that their city-dwelling peers received. Yet, when moving into Class 11, the system expects these rural students to pick a science stream with the exact same confidence as the students who had years of extra help.

“Coaching is not affordable for many families here. And for girls, even where it exists, there is the added issue of having to travel, and parents are not always comfortable with that.” **Female Teacher, Mohinderganj SoE**

This pattern is well documented beyond our sample. Research on rural school access in India has found that for every additional kilometre between a student's home and her school, girls' enrolment drops by 16%, more than double the 6% drop observed for boys over the same distance (Chaudhary and Verick, 2019). The effect compounds precisely where safety concerns and poor transport infrastructure are already present, which is the exact combination our teacher described. This gives us a quantified basis for the design principle already emerging from the interviews: distance is not a neutral logistical fact, it is a gendered barrier, and it is one that in-school, in-hours delivery directly neutralises.

This reality creates a deeply unfair, two-tiered map of opportunity. Students who live near coaching centers gain a massive advantage, while those who live further away are effectively locked out of the system—even if they are naturally bright enough to succeed. For girls, this problem is even more severe. Even in areas where local coaching is available, going to these classes requires travel. Many parents are understandably hesitant to allow their daughters to travel outside of school hours for safety reasons.

Because of all this, the widespread belief that "you must have coaching to study science" has become a self-fulfilling prophecy. Students who cannot pay for or travel to these extra classes end up voluntarily dropping out of the science stream, even when their natural academic abilities mean they wouldn't actually need the extra help. Simply believing that they need coaching to survive is doing just as much damage as actually needing it.

The Takeaway for Our Program Our current system forces students to begin their education from unequal starting lines. Students with access to tutoring get a clear head start, while others are effectively pushed out before they even try. To fix this structural barrier, we need to bring quality science preparation directly into the local communities through school-based programs. By running these programs inside the school building and strictly during regular school hours, we completely bypass the travel and safety concerns that hold our female students back. **Evidence base:** Students (n=8), Parents (n=6), Teachers (n=4), Principals (n=3)

Finding 4 Family Influence: Families Can Open the Door, or Hold It Shut

When parents know more, their daughters do better. If a family understands the different types of jobs available in the science field, their daughters feel much more confident and have a much clearer plan for their future.

Across all of our interviews with students, a family's actual awareness of careers—not just their general support—was the single biggest factor in building a student's confidence. Students whose families actively knew about different science careers had very specific, strong goals. On the other hand, students whose

families lacked this knowledge still had fierce ambitions, but they didn't have the practical foundation or plan needed to actually achieve those dreams.

Our conversations revealed exactly how families build this career awareness. It almost never comes from formal information like brochures or school talks. Instead, it comes from real-life exposure—what families actually see working in their everyday lives. For example, a father from Pheelkhana knew that veterinary science offered a stable, regular income. No one formally taught him this; he knew it because his agricultural work put him side-by-side with vets. He saw firsthand that they charged a good fee for their consultations. That direct, real-world observation made the career feel real and desirable for his children in a way that no outside program could easily copy.

Our large-scale quantitative survey strongly backs this up. The data shows that a mother's level of education is a massive predictor of her daughter's scores in math, technology, and future aspirations (with high statistical certainty, $p < 0.001$). This proves that a family's awareness is the strongest driver of a student's confidence.

“The medical field gives steady pay. I have seen veterinary doctors charge a good fee per consultation, it is a regular and reliable income. That is what I want for my children.”, Male Parent, Pheelkhana

This gives us a very clear direction for our programs. If families only trust the careers they can physically see, then general "awareness workshops" will not work. Instead, we must introduce families to relatable, real-life examples: people from similar financial and social backgrounds who are actively working in various science roles and can speak plainly about what their lives look like. A parent who ignores an abstract speech about the "importance of science" will listen very closely to a young woman from their own community explaining her job in data science, how she got there, and what she earns.

The interviews also highlighted a second crucial detail: teachers hold an incredible amount of trust and credibility with parents. The father from Pheelkhana explained that his older daughter chose an engineering path (B.Tech) specifically because her teachers guided her, and he trusted their advice. He used the word "confidence," noting that the teacher's involvement gave him confidence in the path his daughter was taking. This is not a minor detail. In communities where families don't have personal experience with higher education, a teacher's voice carries an official authority that outside organizations—no matter how well-meaning—simply do not automatically possess.

From the analysis notes: 'Teachers' word and opinion is heeded to extremely carefully by parents, and can be a good channel of influence to change parental mindset if leveraged properly.'

Role models inside the home—like older siblings in college or parents with professional jobs—act as a ladder, making the future feel real and reachable. When these role models are missing, students have dreams but no clear path to follow. Some of our most powerful interviews were with two young women, aged 21 and 23, who were acting as guardians for their younger sisters. Both had studied in fields related to science, and both were currently unemployed in their fields. Yet, they were still fighting to keep science opportunities open for their younger sisters. They weren't doing this *in spite* of their own struggles, but *because* their difficult experiences showed them exactly what kind of structural support their sisters would need to succeed where they themselves could not.

The Takeaway for Our Program Family awareness is built through real-world closeness to careers, not just through sharing information. Our program designs must prioritize relatable, near-peer role models—people from similar backgrounds who are early in their careers. Crucially, these programs must be delivered through our teachers, because families already trust them. Teachers are not just there to deliver lessons to students; they are our most credible, powerful tool for changing the mindsets of parents. **Evidence base:** Students (n=8), Parents (n=6), Principals (n=3), HEI faculty (n=1)

Finding 5 Mathematics Is the Gate That Stays Locked

Weak conceptual foundations, combined with limited hands-on learning, produce a feedback loop of avoidance that drives students away from STEM.

Teachers and students report uneven conceptual foundations in mathematics and, to a lesser extent, physics. Mathematics is described as abstract and anxiety-inducing, feared before it is encountered. This is not a reflection of student ability. It is a reflection of how mathematics has been taught: as a body of procedures to be memorised rather than a set of ideas to be understood.

“Maths is a bit abstract, so many students find it hard to grasp its concepts. Science is more attractive, you can observe it, relate it to your real life.”, Female Teacher, Mohinderganj SoE

Combined with limited hands-on laboratory exposure, this generates a feedback loop: weak foundations produce low confidence, low confidence produces avoidance, and avoidance produces further weakness. Students who cannot afford external coaching, already excluded from the reinforcement their urban peers receive, have no alternative route to build the conceptual grounding they need.

In the student focus group discussion, students unanimously identified more practicals and visits to Science City and university labs as what would most sustain their interest. The specificity is telling: experiential learning works powerfully when it happens, it simply does not happen often enough.

The Takeaway for Our Program Weak foundations and low confidence can gradually push students away from STEM. Strengthening conceptual understanding and increasing hands-on learning opportunities are critical. A foundational mathematics bridging module for Classes 9 and 10, prioritising conceptual clarity over rote procedure, paired with structured lab sessions using low-cost, repeatable experiments, would directly address this structural barrier. Structured visits to university labs and science centres are a high-demand, high-impact complement. **Evidence base:** Teachers (n=4), Students (n=8), Principals (n=3)

Finding 6 Science in a Language Students Don't Fully Own

The shift to English-medium instruction at higher grades is a hidden barrier that compounds with academic difficulty, especially for high-performing students.

The requirement to engage with science in English, particularly as content becomes more technical at higher grades, emerged as a significant and underexplored barrier. This is not about intelligence. It is a structural mismatch between the medium of instruction and the medium of daily life. Students who are conceptually capable find themselves losing confidence not because they cannot understand the science but because they cannot fully express what they understand.

“If the sciences were taught in Punjabi, I believe most of my students would opt for science. The language is a bigger barrier than most people acknowledge.”, Male Principal, GSSS

The principal stated directly that if science were taught in Punjabi, most students at his school would opt for it. The district official reinforced this from a macro perspective: the shift to technical content, often coinciding with a change in instructional medium at higher grades, triggers confidence loss and disengagement even among academically strong students. This is not a barrier about intelligence, it is a structural mismatch.

This is a system-level policy challenge that no single programme can resolve. But there is space for immediate action: bilingual enrichment materials, key concepts introduced in Punjabi, technical vocabulary built bilingually, would lower the entry barrier significantly without diluting academic rigour.

The Takeaway for Our Program Language can act as a hidden barrier to STEM participation. Supporting bilingual or scaffolded learning can help students better understand and engage with STEM subjects. Developing STEM enrichment materials bilingually positions the programme ahead of slower system-level policy change on language medium, and signals a commitment to inclusion that resonates with both families and school leaders. **Evidence base:** Principals (n=2), District officials (SRP), Teachers (n=2)

Finding 7 Gender and The System: Gender Is a System, Not a Classroom Problem

The real hurdles for girls happen outside the classroom. Teachers treat boys and girls the same, but family rules, safety concerns, and community pressure are what actually stop girls from staying in science.

A consistent pattern runs through the institutional interviews: explicit denial of gender bias at the classroom level, coexisting with detailed description of structural conditions that disproportionately affect girls. Teachers, the district official, and the female science teacher all deny classroom-level gender differences, yet each describes safety restrictions, mobility constraints, family pressures, and community norms that disproportionately shape girls' trajectories. This is not contradiction. It reflects a genuine and important distinction: gender is not operating as individual prejudice in these classrooms. It is operating as a structural condition embedded in family attitudes, community norms, and economic arrangements.

A women's story makes this structural reality human. She was enrolled in a BA degree when she was married off in her first year, moving to Punjab because her husband worked there. She had wanted to study law, specifically, she said, to address the grievances she saw being committed against women in society. That aspiration was ended not by anyone's individual malice but by the accumulated weight of social expectation about when women should marry and what education is for. She is now a domestic worker, fiercely channelling the ambition she was not permitted to pursue into her daughter. Her son, interestingly, was pushed into medicine against his own interest in commerce, because the family's security logic demanded it. She is not a victim of a bad individual. She is evidence of a system working exactly as it was designed to.

“I wanted to study law. I wanted to address the grievances against women. But I was married in my first year of the BA. I can support someone only if you yourself are capable, and I was not given the chance to become capable. My daughter will be.”, Female Parent, Pheelkhana

What Professor perspective adds, from his vantage point as a psychologist embedded in an engineering university, is that the gender gap does not end where school ends. Girls are not absent from higher education in Punjab. They are absent from specific STEM disciplines. The disciplinary gender segregation is observable at the university level and begins forming well before that, in the stream choices made at Class 10–11, in the family deliberations about which kind of education is appropriate for a daughter, in the uneven distribution of coaching access between sons and daughters.

From the analysis: 'Girls are not absent from higher education, they are absent from specific STEM disciplines. The disciplinary gender segregation is observable and documented at the university level, and begins forming well before that.', Professor, TIET Patiala

National data on higher education confirms this precisely. Women make up 50.8% of undergraduate enrolment in Science nationally, meaning there is no gender gap in Science participation at that level. But women are only 29.1% of undergraduate enrolment in Engineering and Technology (AISHE 2021-22, Ministry of Education). Punjab's own higher education picture supports the same reading: female enrolment sits near parity overall (49.4%), so girls are visibly present in the system. What Professor's observation captures, and what this data confirms at scale, is that the gap is not about access to higher education. It is about which doors within it stay open to women and which quietly do not. Our programme's framing should follow this precision: we are not solving an access problem, we are solving a discipline-level segregation problem, and the two require different interventions.

This distinction matters enormously for policy and programme design. If the problem is girls' absence from education, the solution is access. But if the problem is girls' absence from specific disciplines within education

they are already accessing, the solution is something different, it is about what STEM disciplines communicate about who belongs in them, and what structural conditions determine whether girls who could succeed in STEM actually do. The Collective's programme is addressing the second problem. It should name it as such.

For girls, the compounding is also sharper in the mobility dimension: even where local coaching exists, attending it requires movement that families are often reluctant to permit, not because they do not believe their daughters are capable, but because the safety calculus of the environment makes them cautious. The female science teacher at the rural senior secondary school described this not as restriction but as protection; the distinction is analytically significant even if the outcome for the girl is the same. Designing interventions that happen inside school hours, on school premises, dissolves this constraint entirely, it is the most equitable and the most pragmatic design choice simultaneously.

Finally, the female principal's own biography deserves to be named here, not as anecdote, but as compressed evidence. She wanted to teach in higher education. Family constraints redirected her to school-level teaching, which she frames as the sensible choice given the stability of a government job. She is a science teacher, a school principal, and an advocate for girls in STEM. She is also a woman whose own ambitions were bounded by the same structural conditions she now works to address in her students. The system is thoroughly consistent.

In the quant study, girls outperform boys across Biology, Chemistry, Mathematics, and total score. Technology and Future Aspirations show no gender difference at Class 9. This is the single most important survey finding correlate that the gap is structural.

The Takeaway for Our Program Gender inequality in STEM is structural, not individual, embedded in family attitudes, community norms, and economic arrangements that constrain girls' pathways at every stage. It does not end at school; it follows women through higher education and into careers. Programme advocacy must shift the conversation from 'can girls do STEM?' to 'what structural conditions prevent girls who can do STEM from doing it?', and must name the discipline-level gap, not just the access-level gap, as the problem being addressed. **Evidence base:** Teachers (n=4), Principals (n=3), District officials (n=2), Parents (n=6), HEI faculty (n=1)

Finding 8 The Pipeline Leaks at Every Joint

The STEM gender gap is not located at one point of failure, it manifests across multiple transitions, through structural pressure at every junction.

One of the study's most significant insights is that the STEM gender gap is not located only at the point of school-level subject choice. It manifests across multiple transition points: school to senior secondary; senior secondary to higher education; higher education to STEM careers; and within careers, through attrition driven by safety concerns and family pressure.

“She wanted to do nursing. But the uncle said no, a girl cannot do that. The environment these days... So she did a computer diploma instead. Now she cannot find work in that either.”, Female Guardian, Old Police Line

The interviews with two young women acting as guardians for their younger sisters illustrated this vividly. Both had pursued STEM-adjacent education but were unemployed in their fields. One had wanted to pursue nursing; her uncle refused on safety grounds. She completed a computer diploma instead. Now she cannot find work in either. These are women who entered the STEM pipeline and leaked out, not through lack of capacity, but through structural pressure at every junction.

Table C — Patiala Science-stream share of Class 11 population, by gender

Year	Boys in Science / Total Boys	Girls in Science / Total Girls
------	------------------------------	--------------------------------

2023-24	877 / 7,335 = 12.0%	1,337 / 7,287 = 18.3%
2024-25	912 / 7,259 = 12.6%	1,477 / 7,375 = 20.0%

Source: Punjab State MIS, Stream-Wise Data (62-school subset covering most of Patiala's senior secondary schools), 2023-24 and 2024-25.

This is borne out in Patiala's own enrolment data. Girls have taken up Science at nearly double the rate of boys for at least two consecutive years — 18.3% vs. 12% in 2023-24, and 20.0% vs. 12.6% in 2024-25 (source: State MIS, 2023-24 and 2024-25). The leak this finding describes, then, is not a leak of interest. It is a leak of *conversion* — girls arrive at Class 11 choosing Science more readily than boys, and still only one in five of them do so, in a system where only 8.4% of all Class 11 students district-wide are in the Non-Medical stream that would carry that early choice into an engineering or technical career (source: State MIS, 2025-26).

This matters for program design because interventions focused solely on Class 9–10 subject choice are necessary but insufficient. The Collective must map and address the full pipeline, including transition support, higher education access, scholarship navigation, and potentially post-graduation mentoring.

The Takeaway for Our Program The STEM challenge is not only about entry, it is about retention. Interventions must support students across the entire pathway, not just at one stage. The Collective must map and address the full pipeline, including transition support, higher education access, scholarship navigation, and potentially post-graduation mentoring. **Evidence base:** Parents/guardians (n=6), HEI faculty (n=1), District officials (n=2)

Finding 9 Class 10 to 11, The Moment Everything Changes

The transition from Class 10 into senior secondary (Class 11) is a critical breaking point. This is exactly where we lose highly capable students—not just academically, but also due to new language barriers and psychological.

Moving into Class 11 brings a perfect storm of multiplying pressures. The difficulty of the schoolwork takes a massive jump. The language used for teaching often shifts, making the material instantly harder to understand. Students are forced to pick a permanent career stream without any proper advice or guidance. At the same time, the costs for private tutoring increase. For our female students, this is also the exact moment when families start heavily debating whether it is still worth investing their money into a science education. Because of this sudden, overwhelming shift in expectations, students who were highly interested and highly capable in Class 10 frequently lose their footing and fall behind. One of our district officials perfectly described this transition as academically, linguistically, and psychologically disruptive.

“The transition from Class 10 to senior secondary is where many students lose their footing, academically, linguistically, and psychologically. They had the interest. The system did not prepare them for the jump.”- State Resource Person

During our student focus groups, several students openly admitted that they chose their academic streams based purely on peer pressure, rather than understanding their own skills. This is not a personal failure on the students' part; it is simply what happens when adult, structured guidance is missing. When schools do not provide meaningful career counseling, social pressure naturally rushes in to fill that empty space.

The scale of this transition risk is visible in national data too. Only around 42% of rural girls in India complete Class 12, even though rural primary enrolment for girls now approaches 96% (ASER 2023). The gap between these two numbers is almost entirely accounted for by attrition at the secondary stage, the same stage this finding identifies as “academically, linguistically, and psychologically disruptive.” The system does not fail girls at the schoolhouse door. It fails them several years later, at exactly the moment this finding describes.

The solution to this problem is very clear. We need to provide meaningful, interest-based career guidance during Class 9, *before* the pressure reaches a boiling point. We must combine this with active “bridge support” in the months directly before and after they actually choose their streams. Our large-scale survey backs this up with hard data: it shows that girls are significantly more likely to want to study science “if they get help or guidance” (scoring 3.13 vs 2.96, with high statistical certainty, $p=0.003$). This gives us clear, mathematical proof that the Class 9 and 10 window is our absolute best chance to intervene.

The Takeaway for Our Program This Class 10 to 11 transition is our most critical point for intervention. Without proper support, incredibly capable students will drop out of the science path far too early. By providing structured academic, motivational, and informational support to safely "bridge" students through this gap, we can directly stop this leak. Right now, this high-demand, high-impact window of time is left almost entirely ignored by our current system. **Evidence base:** District officials, Teachers (n=3), Students (n=8)

Finding 10 Teacher Initiatives: Teachers Make the Difference, When the System Lets Them

Success shouldn't depend on luck. Right now, a student only gets a great science education if they happen to have an amazing teacher. We need to build a system where every student gets that same support, no matter which teacher they have.

A consistent tension runs through the institutional interviews regarding teacher motivation. Several teachers in this study are clearly exceptional, well-qualified, motivated, and willing to go beyond formal responsibilities. But the one of the schools principal is unambiguous: many colleagues do not take accountability for learning gaps, that labs sit unused for lack of initiative, and that career counselling is largely performative.

"Labs are there. Equipment is there. But no one uses them. It is a question of enthusiasm and initiative, and that is not something you can mandate." - Male Principal, GSSS

What is clear is that individual teacher initiative is currently the most significant variable in whether a student receives meaningful STEM engagement. This is not scalable, and it is not equitable, because a student's access to quality STEM preparation should not depend on the accident of which school they attend or which teacher they happen to have.

The design implication is direct: We want teachers to be our partners. Instead of just giving teachers more work, we want to find 'Teacher Champions' in every school and give them the training and respect they need to lead this program themselves. Augment teacher capacity and motivation without depending on exceptional individual leadership.

The Takeaway for Our Program Reliance on individual teacher initiative is not sustainable. The system needs structured support that enables all teachers to deliver quality STEM learning. Teacher co-facilitation should be structural: teacher champions identified and trained at each school, given meaningful roles, and recognised for their contribution. This distributes ownership without depending on exceptional individual leadership. **Evidence base:** Principals (n=3), District officials (n=2), Teachers (n=4)

Finding 11 Students Choose by Crowd, Not by Calling

Without structured guidance, career choices at Class 9–10 are driven by peer influence and status anxiety rather than aptitude or genuine interest.

Students in Classes 9 and 10 are making consequential decisions, decisions that shape the next decade of their educational and professional lives, within inadequate information and without structured support. The FGD and individual interviews reveal that peer influence is the dominant decision-making mechanism at this stage: more influential than teacher advice, more influential than self-reflection on aptitude, more influential than parental guidance, which is itself often grounded in incomplete information.

The aspiration range in the school focus group illustrates how much genuine variety exists in this group, and how little of it is being supported. Students wanted to be CID officers, police inspectors, cardiologists, singers, and engineers. Several of those aspirations cut across or outside the medical-engineering binary that dominates stream choice conversations. But in the absence of structured guidance, most of those varied interests will be flattened by social pressure into one of two paths, not because students want that, but because no institutional structure exists to help them do otherwise.

“I followed my friends into the medical stream. Did it for a year. Then dropped it and switched. I did not really think about whether it was right for me.”, Female Student, School FGD

The Bahadurgarh arts boy adds a dimension that the original finding did not account for: the pressure to choose STEM is itself a form of misdirection. He is being pushed toward medicine by family, specifically by a brother-in-law who is a doctor and whose professional success has become the household's reference point. The boy is not confused about what he wants. He wants arts. He wants to act. But the environment treats his preference as naivety to be corrected rather than a signal to be taken seriously. The structural absence of meaningful humanities and arts career pathways in the local imagination makes his position almost indefensible within his family's framework.

From the researcher's notes: 'This boy is an outlier. He is interested in arts, not science, and that is rare for young children in this region based purely on interest rather than ease or avoidance. His clarity about his own preferences is striking. What is also striking is that it is being treated as a problem.'

In the local prestige economy, medicine and engineering occupy the stability premium. Arts and commerce are understood as second choices, not second paths, but consolation prizes for those who could not access the first. This pushes students toward STEM not from interest or aptitude but from a fear of occupational ambiguity, fear of being seen to have settled for less. The consequence is predictable: misalignment between stream and genuine interest, followed by the kind of course-correction the female student described, a year spent in the wrong stream, at real cost to momentum and confidence.

What is needed at Class 9 is not a STEM promotion exercise. It is something more honest and more useful: structured support for students to understand their own interests and aptitudes, matched against a genuinely broad picture of what different career paths look like, including paths in arts, humanities, and commerce that are presented as legitimate and valuable, not as fallbacks. A programme that produces more students in the medical stream through peer pressure and family imposition has not improved STEM education. It has reproduced the same coercive dynamic in a new institutional form.

The quant survey confirms no significant gender difference on the Future Aspirations subscale overall, which corroborates qualitative finding that the choices being made are driven by peer pressure and absence of guidance rather than by genuine preference.

The Takeaway for Our Program Peer influence and social pressure operate in all directions, away from STEM and toward it. What students need is not advocacy for any particular path but structured guidance to make informed, interest-grounded choices. Career awareness modules must legitimise a wide range of pathways, including non-STEM ones, or risk becoming another source of misdirection rather than a corrective to it. **Evidence base:** Students (n=8), Parents (n=6), Teachers (n=3), FGD (school, mixed gr. 9–10)

This finding suggests that the challenge is not limited to individual behaviour but reflects a broader system-level gap. Without addressing this issue, students may continue to experience fragmented STEM pathways, where access to opportunities depends on personal networks, financial capacity, or geographic location rather than structured support systems. Addressing this will require coordinated efforts across institutions, including schools, higher education, industry, and government.

Alumni voices:

If ecosystem is provided to the students then they can thrive in STEM. In the following, we are sharing some success stories of girls who have achieved a status in STEM in different fields of career. This includes before and after snapshots of their journey and what factors worked or not worked for them.

Story 1 - Anjali Devi

SMSKW Govt. Sr Sec School, Banuri Village, Palampur, HP. Currently pursuing: M.Ed., Azim Premji University, Bangalore. Supported by: Aavishkaar & Sajhe Sapne

Anjali grew up in a village in Himachal Pradesh, convinced she was not a "maths person" — a belief reinforced by her school years, leading her to drop the subject after Class 10. Financial uncertainty added to her hesitation about higher education. After Class 12, a trusted didi introduced her to Aavishkaar and Sajhe Sapne, where she enrolled in a primary maths teacher training course — reluctantly at first. What followed was a slow but profound transformation: the classroom there asked *how* she thought, not just *what* she answered. She stayed on for years beyond the original course. Today she is pursuing a Master's in Education at Azim Premji University — a path she says she never imagined possible. Her story is one of the clearest illustrations in this study of how pedagogical environment, peer trust, and community support can redirect a young woman's entire educational trajectory.

In her own words (Hindi)

1. गणित से दूरी और आगे बढ़ने की चाहत

इस दौरान मुझे विश्वास था कि मैं अब कभी गणित नहीं सीख पाऊंगी। कुछ ही लोग और बच्चे ऐसे होते हैं जो जिन्हें गणित आता है। मैं उन में से नहीं हूँ। इसीलिए दसवीं के बाद गणित नहीं चुना। मैं 12वीं के बाद किसी अच्छे कॉलेज में जाकर पढ़ना चाहती थी, मेरे परिवार की तरफ से पढ़ने पर कभी कोई रोकटोक नहीं थी, लेकिन मेरा आगे पढ़ने का ख्याल परिवार की आर्थिक स्थिति को देखकर थोड़ा डगमगाता था।

"मुझसे पूछा जा रहा कि आपने कैसे किया? हर किसी के तरीके को ध्यान से सुनकर एहमियत दी जा रही है। जवाब से ज्यादा सोचने के तरीकों पर ध्यान दिया जा रहा है।"

2. आविष्कार की कक्षा — एक अलग अनुभव

12वीं के बाद मुझे मेरे एक दीदी ने साझे और आविष्कार नाम की संस्था के बारे में बताया, जो प्राथमिक गणित अध्यापिका बनने का कोर्स करवा रहे थे। क्योंकि गणित से रिश्ता अच्छा नहीं था तो मैं उस कोर्स को नहीं करना चाहती थी, लेकिन किन्हीं कारणों से कर लिया। जैसे ही कोर्स शुरू हुआ, आविष्कार की कक्षाओं में मैंने महसूस किया कि मुझसे पूछा जा रहा कि आपने कैसे किया? हर किसी के तरीके को ध्यान से सुनकर एहमियत दी जा रही है। जवाब से ज्यादा सोचने के तरीकों पर ध्यान दिया जा रहा है, कैसे किया बताते-बताते मैंने बहुत सारा तर्क देना सीख लिया। जब कहीं अटक जाती, मुझसे सवाल पूछे जाते जिससे मैं खुद ही जवाब तक पहुँच जाती।

Research insight

This describes a classic shift from answer-oriented to process-oriented learning. Anjali's experience suggests that inquiry-based environments — where students are asked to verbalise their reasoning — can dismantle deep-seated subject-level identity barriers ("I am not a maths person") that traditional instruction reinforces.

मुझे धीरे-धीरे महसूस होने लगा कि ओह ये तरीका मेरा अपना बनाया है, मैंने कुछ नई खोज खुद से की है। यह फॉर्मूला मैंने इस तरह से सोच के बनाया है। मैं अलग-अलग तरीकों से गणित के सवाल हल कर सकती हूँ, सवालों पर सोच सकती हूँ। क्योंकि सवाल आसपास की जिंदगी से जुड़े हुए होते थे, तो हर पल उन सवालों के बारे में सोचने का मन करने लगा था। इस तरह गणित इतना पसंद आ गया कि कोर्स तो एक साल का था, पर उसके बाद कुछ साल और आविष्कार में रुक गई।

3. विज्ञान और अंग्रेजी — एक रुकावट

विज्ञान में कर सकती हूँ ऐसा तो लगता था, लेकिन क्योंकि वह 11, 12 में इंग्लिश में होता है, और इंग्लिश-गणित तो मुझे न पसंद थे न आते थे, तो इसलिए विज्ञान और गणित नहीं चुना।

4. काश ऐसा होता — Anjali की सिफारिशें

"मुझे कोई भरोसा दिलाने वाला होता कि तुम कर सकती हो... 11वीं का कोर्स शुरू होने से पहले 1-2 महीने का कोई कोर्स होता जो मुझे विज्ञान गणित लेने के लिए तैयार करता।"

मुझे कोई भरोसा दिलाने वाला होता कि तुम कर सकती हो, किसी ऐसी कहानी के बारे में बताया जाता जहाँ कोई मुझ जैसा था और फिर उसने भी यह चुना था, और उसने कर लिया। हो सकता, तो उससे मिलवाया

जाता। 11वीं का कोर्स शुरू होने से पहले 1, 2 महीने का कोई कोर्स होता जो मुझे विज्ञान गणित लेने के लिए तैयार करता, और फिर एक टेस्ट होता जहां मैं सवाल का जवाब सोचते हुए ही तय कर पाती कि मुझे आगे इसमें जाना है या नहीं।

तब ऐसा लगता था कि काश हिंदी में विज्ञान होता, लेकिन अब यह सोच बदल गई है, क्योंकि कब तक अंग्रेजी से भागना है न, उसको जितना जिंजीगी उसकी जितनी जरूर होगी उसे इस्तेमाल करूंगी तभी तो वो मुझे आएगी। स्कूल में सीमित समय होता है जिससे अध्यापक भी कई बार शायद अलग से सपोर्ट नहीं कर पाएं, तो काश उस समय कोई ऐसी संस्था होती जो 9th और 10th में स्कूल के बाद कुछ सपोर्ट दे पाती।

Programme design note

Anjali names three specific gaps: (1) a trusted peer-mentor who could model the path, (2) a bridge course before Class 11 to reduce the perceived leap into STEM, and (3) after-school support during Class 9–10. These are concrete, implementable asks — not abstract aspirations.

5. संस्था का योगदान

मेरे दीदी ने मुझे आविष्कार और साझे से मिलाया और गणित अध्यापिका के कोर्स में कदम रखने के लिए भरोसा दिलाया कि तुम कर लोगी। आविष्कार और साझे में जुड़ने के बाद मैंने बहुत से कौशल सीखे जैसे लैपटॉप कैसे चलाना है? जीमेल कैसे लिखें, कुछ चीज सीखनी है तो उसकी प्लानिंग कैसे करनी है। कि चाहे कोई सब्जेक्ट हो या अपनी जिंदगी, सोचते कैसे हैं? दूसरों को सुनते कैसे हैं? यह सब करना जरूरी क्यों है?

"हर कोई अलग-अलग होता है और वह नहीं कर सकती/सकता, यह नहीं कहा जा सकता है। बस वह अपने तरीके से कर सकता है — जरूरत है उसे वह माहौल देने की जहां पर वो सवालों से सीख सके, बोल पाए।"

गणित और विज्ञान की कक्षा में मैंने जिन्दगी को इस तरह से देखना और जीना शुरू कर दिया। यह सब बस हो गया, क्योंकि उस कक्षा में कोई नहीं कहता था कि आज तुम यह सीखोगे, वहां एक सवाल होता और उस पर सोचते-सोचते तर्क देते-देते, दूसरों के तरीके सुनते-सुनते, अपनी समझ बताते हुए खुद की गलतियां पकड़ते-पकड़ते सब हो गया।

6. अब और आगे

मैंने कभी नहीं सोचा था कि मैं कभी Masters करने जाऊंगी, और वो भी Education में। पढ़ाने के बारे में पिछले 5 सालों में मेरी समझ थोड़ी बदली है। एक विषय की कक्षा में हर कोई अपनी अलग समझ बनाकर निकलता है, और उस हर किसी एक की समझ उनके आसपास के लोगों पर प्रभाव डालती है, इसलिए कक्षा में यह माहौल बनाना बहुत जरूरी है जहां, हर कोई अपने ख्यालों को चुनौती दे सकें ताकि ज़्यादातर समझें वैसी कक्षा से निकलें जो तैराशी गई हो।

जिस यूनिवर्सिटी में पढ़ने में जा रही हूँ वहाँ की पढ़ाई इंग्लिश में है। इसलिए थोड़ी झिजक है कि कैसे अपनी पूरी बात इंग्लिश में बोलकर किसी के सामने रख पाऊंगी, एक बहुत आत्मविश्वास और उम्मीद है कि जैसे मैंने आसपास के माहौल से इंग्लिश समझना, लिखना और थोड़ा थोड़ा बोलना सीख लिया, वैसे ही पूरा पूरा बोलना भी सीख सकती हूँ।

7. एक संदेश — आगे आने वाली लड़कियों के लिए

"कोई भी विषय आगे चुनने में डर लगे तो मुझसे नहीं होगा यह सोचकर सब एकदम से खत्म मत करना — तरीके ढूँढने की कोशिश करना।"

कोई भी सवाल आपसे पूछा जाए तो आपकी अपनी मर्जी होती है उस पर अपने खयाल साझा करना या नहीं करना। लेकिन न बोलने या साझा करने की वजह कभी यह नहीं होनी चाहिए कि आपने जो सोचा वह गलत हो जाएगा। अगर कुछ समझ नहीं आ रहा तो डर से चुप रहने के बजाय एक और तरीका हो सकता है कि मैं बताती हूँ, मुझे क्या समझ में आया। अपनी दिक्कतें, भावनाएं, उलझनें बताने और दूसरों को समझने का एक बहुत अच्छा ज़रिया सवाल पूछना होता है — कभी भी खुद से और किसी और से सवाल पूछने के लिए झिझकना मत।

SECTION 5 Barriers Framework

The framework below organizes the roadblocks based on how close they are to the student, and who actually has the power to fix them. This is not a document meant to be read once and filed away in a cabinet. It is designed to be a living tool—something we must open and use every single time we sit down to design a new program.

The Universal Hurdle: As a starting point, it is crucial to remember that financial barriers—specifically the costs of coaching, travel, and study materials—were named as the primary roadblock by almost everyone we spoke to (teachers, parents, principals, and district officials). No other problem had this much universal agreement.

How to Read the Framework:

Roadblocks Pile Up None of these barriers happen in a vacuum; they interact and make each other worse. For example, when a family cannot afford private tutoring, a student's normal struggle with math quickly feels like a permanent failure rather than a temporary hurdle. When a school fails to provide adult career guidance, peer pressure easily takes over a student's choices. And when a student lives in a rural area, every single family or school-level problem becomes much harder to overcome.

Single-Level Solutions Will Fail We organized this framework by "tiers" because different leaders have the power to fix different things. However, the most important lesson this tool provides is this: fixing just one level is never enough.

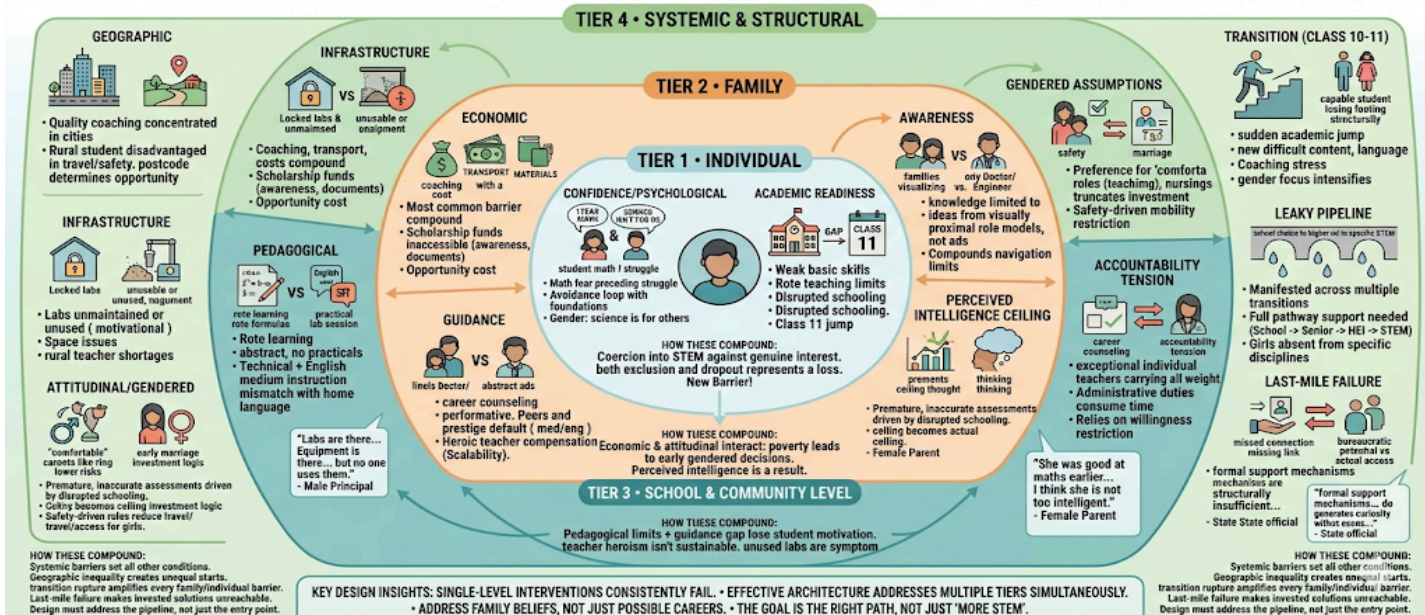
- If a program improves math classes but ignores the high cost of coaching, students will still drop out because of money.
- If a program runs workshops to inspire parents, but doesn't give schools the tools to actually guide the students, we are only building up dreams without providing the structure to make them real. Effective programs must attack multiple levels of the problem at the very same time.

Two Major Game-Changers We have added two crucial new concepts to this framework:

- Two-Way Pressure:** This means our ultimate goal cannot simply be to "push more students into science." Instead, our goal must be to help students find the *right* path for their unique skills, and give them the structured support to actually pursue it. Pushing a student into science against their will is just as harmful as locking them out of it.
- Perceived Intelligence:** We have to deal with what families *believe* their children are capable of, not just what the children are *actually* capable of. Often, because of early school disruptions, a family is led to believe their daughter isn't smart enough for science. Our programs must actively work to fix these false, early beliefs, because a family's belief sets the ceiling for the student.

UNDERSTANDING STEM BARRIERS IN PUNJAB: A 4-TIER FRAMEWORK FOR CHANGE

BARRIERS COMPOUND. FINANCIAL COSTS HAVE HIGHEST STAKEHOLDER CONSENSUS. MULTI-LEVEL SOLUTIONS NEEDED.



Tier 1 · Individual Level

- **Confidence:** Students often fear math before they even try it. Without extra tutoring, struggling students lose confidence and give up, while girls often absorb the cultural message that "science is not for them".
- **Academic Readiness:** Rote memorization leaves students unprepared for complex science. Changing schools or missing class makes it hard to build basic skills, creating a gap that becomes painfully obvious in Class 11.
- **Two-Way Pressure:** Students are not just pushed *away* from science; they are often forced *into* it against their true interests by their families. as seen in the Bahadurgarh student with a clear aptitude for languages and aspiration toward arts, being steered into medicine by family on the strength of a brother-in-law's example. Forcing a student into a subject they dislike is just as damaging as excluding them.

"I want to pursue arts. But my family wants me to take science, my brother-in-law is a doctor and they think that is the right path. I know I am not inclined toward it." **Boy Student, Bahadurgarh**

How These Multiply. Low confidence and a lack of guidance lead students to avoid difficult subjects. When students are pressured into the wrong path, they lose the motivation needed to survive tough classes.

Tier 2 · Family Level

- **Money:** The high cost of coaching and transport is the most common barrier across the board. Scholarships exist, but the confusing application process means the money rarely reaches the students who actually need it.
- **Awareness:** Parents only dream of careers they have physically seen in their communities, like doctors or engineers. If a mother didn't finish her own education, it is incredibly hard for her to guide her daughter through the school system.
- **Gender Expectations:** Families prefer "safe" jobs (like teaching) for girls due to realistic safety and travel concerns. Furthermore, the expectation of early marriage often cuts a girl's long-term educational investments short. A women's story at Pheelkhana illustrates this with painful precision, married off in her first year of a BA, her aspiration toward law permanently redirected.
- **Perceived Intelligence:** Families often mistakenly believe their daughters are "not smart enough" for science just because they struggled after changing schools. If parents don't believe in a child, that false belief becomes their actual ceiling. The Old Police Line parent had not thought about her Class 9 daughter's educational future beyond a tailoring course, because she had concluded the girl was 'not too intelligent.' The daughter had previously been good at maths.

"She was good at maths earlier. But after changing schools she is no longer. I think she is not too intelligent. I have thought of a silai course for her." **Female Parent, Old Police Line**

How These Multiply: Money and family attitudes mix tightly together. Families who cannot afford tutoring make quick, gender-based decisions about their children's futures. "Perceived intelligence" is usually just what financial struggle looks like on the surface..

Tier 3 · School And Community Level

- **Infrastructure:** Schools have science labs, but they stay locked because no one takes the initiative to use them. In rural areas, a lack of specialized teachers makes this problem even worse.
- **Teaching Style:** Science is taught through memorization rather than hands-on learning, making it boring. The sudden shift to English-medium textbooks in higher grades completely disconnects students from the material.
- **Guidance:** Career counseling exists on paper but doesn't actually happen. Without adult guidance, students just copy their friends or chase local prestige (like medicine), regardless of their actual skills.
- **Teacher Accountability:** Right now, the system only works if a heroic, exceptional teacher steps up. Without strong leadership holding everyone accountable, students just get whatever bare-minimum the system provides by default. One of the schools principal describes labs sitting unused for lack of initiative; the district official identifies non-teaching administrative duties as consuming teacher time that should go to students.

“Labs are there. Equipment is there. But no one uses them. It is a question of enthusiasm and initiative, and that is not something you can mandate.”, Male Principal, GSSS

How These Multiply Boring teaching and a lack of career guidance feed off each other. Unused labs are not a sign of missing equipment; they are a symptom of a system where no one is held accountable.

Tier 4 · Systemic And Structural Level

- **Geography:** Quality tutoring is mostly located in cities. Rural students fall behind early, creating a deeply unfair two-tiered system where a child's success is decided by their zip code.
- **The Class 10 to 11 Jump:** This is the breaking point. As the state official describes it as the work gets harder, the language changes, and coaching gets more expensive. This is the exact moment families debate pulling girls out of science, and where many capable students fall off track. Students who were confident and capable at Class 10 frequently lose their footing at Class 11 for structural reasons that no individual effort could prevent.
- **The Leaky Pipeline:** We don't just lose girls at one single point in time. We lose them step-by-step at every transition—from high school, to college, and into jobs—due to safety concerns and family pressure. Girls are not absent from higher education, they are absent from specific STEM disciplines, as Professor observation from Thapar makes clear.
- **Last-Mile Failure:** Government resources (like scholarships) exist, but there is no human guide to help families apply for them. Without a person to help navigate the bureaucracy, these resources are

useless. As Professor frames it: the last mile is the missing link. Structural resources without structural navigation support are not resources, they are bureaucratic potential.

“Scholarships and support schemes exist on paper, but they don't reach the students who need them most. And programs that only inspire students without following through on the practical barriers will create curiosity, but not change.” State official, Dept. of Education

The following are key national and state scholarships available to students in Classes 9–12 in Punjab.

Scholarship	Eligibility	Amount (approx.)*
National Means-cum-Merit Scholarship (NMMS)	Class 8 pass, continuing to Class 9	₹12,000/year
Pre-Matric Scholarship (SC/ST/OBC)	Classes 9–10	₹3,500–₹7,000/year
Post-Matric Scholarship (SC/ST/OBC)	Classes 11–12	Up to ₹15,000/year
Pragati Scholarship (AICTE)	Class 12 pass girls entering technical education	₹50,000/year
Punjab Ashirwad Scheme	Girls from low-income families	To be verified
Dr. Ambedkar Post-Matric Scholarship	SC students Classes 11–12	To be verified

* Amounts listed are indicative

Despite these schemes being available, the study found that most families and teachers in Patiala were unaware of eligibility criteria or how to apply. The barrier is not the absence of funding — it is the absence of a structured process and a human guide to help families navigate it. This is what the State Official's observation points to.

How These Multiply: The broader system sets the rules for everything else. Geographic disadvantages mean some students never get a fair start, and the brutal Class 11 jump makes every other family and school-level problem much harder to overcome. Last-mile support failure means that even where the system has invested in solutions, those solutions are unreachable. Programme design must address the pipeline, not just the entry point

SECTION 6 System Readiness

Understanding barriers and designing interventions is only part of the challenge. The other part is understanding whether the system, its schools, its administrators, its teachers, and the institutions above them, is ready to be a partner in change. This section assesses what the study found about system readiness across five dimensions: willingness to collaborate, teacher availability, infrastructure, sustainability, and district-level buy-in. It also sets out the specific opportunity for collaboration with the PU-IIT Ropar Regional Accelerator for Holistic Innovations Foundation (PI-RAHI) which this study positions as a natural institutional anchor for the work ahead.

A note on scope: system readiness was identified as an underexplored area during analysis. Findings below draw on available evidence from the district and state officials, and principal interviews. Formal interviews with some district officials were not completed within the study window, which limits what can be said about district-level institutional buy-in.

1. Willingness to Collaborate

The signals from school leadership are encouraging. All three principals interviewed expressed genuine openness to external involvement, not the polite receptivity that often masks indifference, but engagement grounded in a clear-eyed understanding of what their schools lack and what a well-designed partnership could provide. One of the schools principal, who manages four schools and has received training at ISB, had already approached local NGOs proactively before this study began. His is not a school waiting to be found, it is a school looking for the right partner.

The district official position is more cautious, and that caution is worth taking seriously rather than dismissing. His concern is not about the value of external programmes, it is about the burden they can place on already-stretched teachers and the pattern of NGOs arriving with short-term commitments and leaving without sustainable handovers. This is a legitimate institutional memory, and any programme design that ignores it will struggle to build the trust needed for sustained collaboration.

“We have had NGOs come before. They run a programme for six months and leave. The teachers are left holding something they were never trained to sustain. I need to know this is different.”, District official, Patiala District

The district official’s credibility on this question is worth understanding properly. He is not a policy official speaking from institutional distance. He occupies what the interview notes describe as a triple positionality: he was a rural government school student himself, spent thirty years as a science teacher and then principal in the same system he now administers, and only recently moved into district-level implementation. His caution about external partnerships is not scepticism in the abstract, it is the accumulated memory of programmes that arrived with energy and left without handovers, and of teachers who were left holding something they were never trained to sustain. Any collaboration that takes his concern seriously will be stronger for it.

The State official offered the clearest endorsement of sustained multi-stakeholder partnership models, explicitly contrasting them with the episodic programming that has characterised much of the sector. His framing, that meaningful change requires working simultaneously with students, teachers, and parents over time, aligns directly with the programme architecture this study’s findings point toward.

2. Teacher Availability and Competing Priorities

Teachers are the programme’s most critical delivery asset, and the most constrained. Across all school interviews, teacher time emerged as significantly consumed by administrative duties, non-teaching responsibilities, and the relentless pressure of board exam preparation. At Classes 10 and 12, the academic calendar leaves almost no space for enrichment activity; anything that cannot be embedded within the formal timetable is effectively out of reach.

Teacher willingness, however, varies sharply by school culture. In schools where leadership is proactive, where the principal models initiative and creates space for it, teachers follow. In schools characterised by compliance-oriented administrative cultures, teacher engagement with anything beyond the prescribed curriculum is much harder to unlock. This matters because it means programme design cannot assume uniform teacher availability. It must be built to work within the tightest constraints, not the most favourable ones.

The interview data surfaces a more troubling dimension of teacher overload that deserves naming directly. The Civil Lines teachers described being under active administrative pressure to meet enrolment targets, to urge, and in their words almost force (phar-phar ke), village children to attend school. This is a system incentive that runs in precisely the wrong direction for the kind of programme the Collective is designing. Teachers measured on enrolment numbers cannot simultaneously be the agents of honest, interest-based career guidance. A programme built on aptitude-matched stream choices sits in direct structural tension with an administrative culture that rewards bodies in classrooms regardless of fit. Programme design must anticipate this tension and build in enough structural protection, through in-school hour delivery, through teacher co-facilitation that is bounded and not evaluative, to prevent it from distorting outcomes.

Table D — Patiala PCM teaching posts, 2025-26

Subject	Total working staff	Schools with the post but 0 staff in position
Physics	48	16 of 52 schools (30.8%)
Chemistry	53	6 of 46 schools (13.0%)
Mathematics	77	3 of 57 schools (5.3%)

Source: Punjab State MIS, Staff Data, 2025-26.

Teacher vacancy is not evenly spread across subjects. In nearly a third of Patiala schools with a sanctioned Physics-lecturer post, that post is currently vacant — more than double the vacancy rate for Chemistry, and six times the vacancy rate for Mathematics. This has a direct bearing on the Non-Medical stream specifically, since Physics is a compulsory subject for it: a school can have a functioning lab and enrolled students, and still be unable to teach the subject properly if the lecturer post sits empty.

The study also found, clearly, if quietly, that several teachers in this sample are exceptional. Well-qualified, motivated, willing to go well beyond their formal responsibilities. They are a genuine asset. But a programme that depends on them to sustain itself is a programme that will not survive their transfer, retirement, or burnout. Teacher co-ownership must be built into programme structure as a system feature, not recruited as a personal favour.

“Labs are there. Equipment is there. But no one uses them. It is a question of enthusiasm and initiative, and that is not something you can mandate.”, Male Principal, GSSS, Patiala

Design signal: All core student-facing programming should be designed for delivery within school hours, embedded in the timetable, and requiring no additional teacher time beyond what is structured into the programme itself. Teacher co-facilitation roles should be meaningful, bounded, and recognised.

3. Infrastructure Readiness

The physical infrastructure picture is better than expected, and more complicated than it appears. Labs exist in most schools visited. Equipment is present. The problem is not absence but disuse: labs sit locked or under utilised, not because the tools are unavailable but because the culture and accountability structures that would put them to work are absent. One principal described functional equipment gathering dust because no one had been given, or had taken, responsibility for using it.

Table E — Patiala lab infrastructure, Senior Secondary schools, 2025-26 (n=125)

Lab type	% of schools with it
Integrated Science Lab (shared/generic)	83.2%

Computer Lab	100%
Mathematics Lab	45.6%
Dedicated Physics Lab	22.4%
Dedicated Chemistry Lab	22.4%
Have all three (Physics + Chemistry + Integrated Science)	15.2%
Have neither dedicated Physics nor Chemistry lab	76.0%

Source: Punjab State MIS, School Infrastructure Data, 2025-26.

At the district level, 83.2% of Patiala's senior secondary schools report an Integrated Science Lab, which likely explains why fieldwork visits consistently found some lab space present. But only 22.4% have a dedicated Physics lab and 22.4% a dedicated Chemistry lab, and just 15.2% of schools have all three lab types together. Three in four schools rely entirely on a single shared, general-purpose lab for all science practicals — a very different infrastructure reality than "STEM labs" implies, and one that constrains the kind of subject-specific, hands-on practice that Non-Medical stream students need most.

Physical space for large-group enrichment events is more constrained. At least one school in the sample has limited room for gatherings beyond standard class sizes, which affects how certain programme components can be designed. This is a manageable constraint, it argues for smaller-cohort, more intensive programme models over large-scale events, but it needs to be factored into design.

The key insight here is that the infrastructure gap in these schools is primarily motivational and organisational, not physical. The resources to deliver better STEM learning are largely already present. What is missing is the structure, the accountability, and the support that would put those resources into regular use. This is a more solvable problem than a capital investment gap, and it is one that a well-designed external partnership is particularly well-positioned to address.

4. Sustainability

The district official's framing of sustainability is revealing: he locates it in teacher ownership and student intrinsic interest, not in policy directives or institutional mandates. This is not skepticism; it is grounded experience of what happens when programmes end and all that remains is a policy requirement that no one has the capacity or motivation to fulfil.

The State official offers a complementary but more structural perspective: sustained programming must work simultaneously with students, teachers, and parents. Each group reinforces the others. A student whose family understands and values STEM is more likely to persist through difficulty. A teacher whose school leadership actively supports enrichment is more likely to sustain it. A parent who has attended a career awareness workshop is more likely to support their child's unconventional subject choices. Sustainability is an ecosystem property, not a programme feature.

Individual principal initiative, evident and impressive in this sample, is not a sustainability model. The school principal's proactivity is an asset to be supported and built upon, not a foundation to build on alone. When proactive leaders are transferred or replaced, programmes that depend on them collapse. System-level sustainability requires that programme components be embedded in institutional routines that outlast individuals.

The female science teacher at the rural senior secondary school offered a concrete illustration of where the pipeline breaks down even when the programme has done its job. One of her students prepared diligently for NEET. She was ready. But she could not get admission anywhere, not because of lack of preparation, but because of finances. The student had done what the system asked of her. The system had not done what it implicitly promised in return. This is not an isolated story; it is what last-mile support failure looks like at the individual level. A sustainable programme cannot treat scholarship navigation as a peripheral add-on. It must be structural, a trained teacher, a documented process, a parent session, because without it, students who persist through every other barrier will encounter this one at the point of maximum cost.

Design signal: Sustainability planning should begin at programme design, not at programme close. Build teacher co-ownership, family engagement, and school leadership accountability into programme architecture from the start. Any component that cannot survive a principal transfer is a component that needs to be redesigned.

5. The PI-RAHI collaboration: A Case for Institutional Partnership

The findings from this study point clearly toward an intervention model that no single organisation can deliver alone. What is needed is an ecosystem of support, coordinated across schools, higher education, civil society, and government, sustained over a period long enough to produce measurable change in student trajectories. These institutions are, by mandate and by positioning, the natural institutional anchor for exactly this kind of ecosystem.

They existing remit, supporting scientific awareness, promoting STEM education, enabling partnerships between schools, universities, and industry, maps directly onto the gaps this study has identified. The Council has the institutional legitimacy to convene stakeholders across sectors, the reach to support district-level initiatives at scale, and the policy nearness to help translate field-level evidence into state-level strategy. What this study provides is the evidence base: a grounded, field-tested picture of what the barriers look like in Patiala, what the system is ready to receive, and what programme architecture the evidence points toward.

A collaboration between these institutes and the Collective could operate across three levels simultaneously. At the district level, piloting an ecosystem-based STEM intervention in Patiala, built on this study's findings, using the school relationships already established, and designed with the sustainability principles the state and district official have outlined. At the state level, contributing to the evidence base for STEM policy design and supporting PSCST in developing scalable models for other districts once the Patiala pilot has been tested and refined. And at the knowledge level, co-publishing the findings of this and future studies as white papers that place Punjab's STEM challenges in the broader national and international policy conversation.

Co-publication, including the foreword from PI-RAHI, would signal the institutional seriousness of the partnership and lend the report the government credibility it needs to influence policy beyond the programme team. This is not a symbolic gesture. It is a signal to schools, district officials, and higher education institutions that this work has the backing of the state's apex science body, and that the recommendations it contains are worth acting on.

Collaboration Level	What It Could Look Like
District Level	Pilot an ecosystem-based STEM intervention in Patiala schools, designed from this study's findings, co-designed with PI-RAHI, testing the programme architecture before scaling.
State Level	Support PSCST in developing replicable district models and contributing field evidence to state STEM policy development and strategy in collaboration with PI RAHI.
Knowledge Level	Co-publish findings and white papers, positioning Punjab's STEM evidence in the national policy conversation, with institutional endorsement from PI-RAHI

6. District-Level Buy-In: The Honest Gap

Formal interviews with some district officials were not completed within the study window, and rather than treating this as a research gap to fill, the Collective's immediate next step is to use it as an opening for structured liaison and advocacy. District-level officials are not research subjects to be interviewed; they are institutional partners whose endorsement determines whether school-level programmes get structural support or polite tolerance. The question is not how to study them, it is how to bring them in.

The district official's cautious-but-supportive position is the right starting point. His triple positionality, rural school student, thirty-year science teacher and principal, now district implementer, means his backing carries more institutional weight than a formal letter of support from most officials would. A targeted engagement with him, followed by a facilitated introduction to the DC and BPEO framed around the study's evidence

rather than a programme pitch, is more likely to build genuine buy-in than a cold interview request. The goal is not a data point. It is a relationship that survives a principal transfer.

System-level programmes that lack district-level buy-in tend to operate at the margins, welcomed in schools but unable to access the formal structures, timetables, and resource channels that allow them to embed properly. The door is open; what is needed now is a deliberate, evidence-led advocacy strategy to walk through it.

Immediate next step: Initiate structured liaison with the Deputy DEO as the primary district-level champion. Use the study's findings as the basis for a facilitated briefing with the DC and BPEO, framing the ask as partnership and co-ownership, not programme approval. District-level endorsement should be built before programme architecture is finalised, not sought as an afterthought once design is complete.

System Readiness Summary

Area	Status	Design Signal
School Leadership	<i>Actively receptive</i>	Engage schools as co-designers early; formalise participation before programme launch.
Teacher Availability	<i>Constrained + conflicting incentives</i>	Embed in school hours; insulate guidance work from enrolment-target pressure; bound and recognise teacher roles.
Infrastructure	<i>Present, underutilised</i>	Programme should activate existing labs, motivational/org gap, not capital gap.
Sustainability	<i>Ecosystem-dependent</i>	Design for sustainability from day one; make scholarship navigation structural, not peripheral.
PI-RAHI Partnership	<i>Strong opportunity</i>	Formalise collaboration proposal; explore co-publication and co-design of pilot.
District Buy-In (DC/BPEO)	<i>Engagement underway, advocacy priority</i>	Initiate via Deputy DEO; frame as evidence-led partnership briefing with DC/BPEO before system-level components are finalised.

SECTION 7 Programmatic Implications

The design directions below emerge directly from the findings, the barriers framework, and the system readiness assessment. They are cross-referenced to findings and organised to reflect both the level at which each intervention operates and the sequence in which components should be activated. This is not a complete programme design, it is an evidence-based priority signal for the Collective's programme team, grounded in what this study actually found.

How to Read These Implications Together

These nine implications are not independent activities to be selected from a menu. They form a mutually reinforcing architecture. In-school, school-hour delivery (1) is the structural precondition for most of the others without it, girls with mobility constraints cannot access any of them. Mathematics bridging (2) and career guidance (3) must both be active before the Class 10–11 transition, which means Class 9 is the critical activation window. Role model exposure (4) and family workshops (5) reinforce each other: a parent who has met a relatable woman in STEM is more likely to support their daughter attending in-school sessions featuring similar role models.

Teacher co-ownership (7) is the mechanism that makes all other components sustainable but only if it is designed to protect teachers from the conflicting incentive structures the system currently places on them. Scholarship navigation (8) and perceived intelligence work (9) address the parts of the problem that sit upstream of programme engagement: a student whose family has already decided she is not capable, or who cannot access the higher education she has prepared for, will not be reached by any programme that begins at school-level interest.

The State official's caution that exposure-based interventions without structured follow-through risk generating curiosity without conversion applies to this set of implications as much as to any individual component. The programme must be designed to convert, not just to inspire. That means tracking students through the Class 10–11 transition, not just to it.

PROGRAMMATIC IMPLICATIONS: 9 PRIORITIES FOR CHANGE

EVIDENCE-BASED DESIGN DIRECTIONS GROUNDED IN STUDY FINDINGS. ACTIVATED SEQUENTIALLY TO CREATE A MUTUALLY REINFORCING ARCHITECTURE. NO PROGRAM LOGO. SIMPLE ENGLISH. LIGHT COLORS.

Phase 3: TRUSTED CHANNELS & SYSTEMIC ACCOUNTABILITY (Trust & Believes Activation)

5. FAMILY AWARENESS VIA TEACHERS. (F2, F4, F7)

- workshops broader careers ideas
- addresses safety with facts, not abstract reassurance
- scholarship navigation knowledge
- Key: delivered through trusted teachers, not external groups

credibility logic

7. TEACHER CO-OWNERSHIP. (Findings: F10, S6)

- STRUCTURALLY INTEGRATE TEACHER CHAMPIONS: training, meaningful co-facilitation roles, recognition, MUST INSULATE from enrollment target pressure, honest guidance separate from quantitative enrollment numbers.

separation of quantitative enrollment metrics from qualitative career guidance

9. PERCEIVED INTELLIGENCE INTERVENTION. (F4, F7, B-Family)

- change premature parent assessments of daughters potential logic: modify written off daughter based on disrupted schooling logic
- uses trusted intermediaries
- lifts believes ceiling
- modify parent logic

Phase 2: PALPABLE PATHWAYS & RESOURCES (Path Exposure & Navigation Activation)

4. RELATABLE ROLE MODELS & NEAR-PEER. (Findings: F1, F4)

- Flowing walkable path connecting student to young women professionals and university
- Roster of relatable women in STEM
- in-school talks & structured mentoring
- imagination built through visibility ('proximity')
- supplement with university lab visits
- walkable paths.

delivered in-school

8. SCHOLARSHIP NAVIGATION. (Findings: F2, F3, S6)

- DEDICATE NAVIGATION COMPONENT
- trained teacher intermediaries, documented process, parent sessions on documentation
- converts bureaucratic potential into actual access.
- not peripheral.
- trained guides

Phase 1: STRENGTHENING THE BASE (Confidence & Rupture Window Activation)

1. IN-SCHOOL, SCHOOL-HOUR DELIVERY. (Findings: F3, F7, F8)

- All core student programs inside schools, regular hours. avoids fees or travel.
- solves safety and mobility barriers for girls.
- direct response to girls' safety and mobility barriers.
- circumvents enrollment pressure.
- PRE-CONDITION for student programs.

pre-condition icon

2. MATH BRIDGING & ACTIVE LABS. (Findings: F5, F9)

- CONCEPTUAL MATH BRIDGE
- pairs core math ideas with hands-on labs (low-cost, repeatable).
- strengthens foundations & builds confidence before Class 11 jump.
- complementing university visits and Science City visits.

Science City complement

3. INTEREST MAPPING, NOT STEM PROMOTION. (Findings: F1, F9, F11)

- MEANINGFUL CAREER GUIDANCE
- maps Class 9 APTITUDE & INTEREST across all disciplines, not just promoting STEM.
- includes legitimate paths in Arts/Commerce.
- delivered before peer pressure fills vacuum.
- CATCH RUPTURE window structurally.

catch rupture window

6. BILINGUAL LEARNING MATERIALS. (Findings: F6)

- Develop bilingual STEM enrichment materials in Punjabi and English.
- INCREMENTALLY BUILDS vocabulary.
- mismatch barrier is key.
- simple, low-cost, high-impact.
- low-cost, high-impact

#	Direction	Findings	Rationale and Design Guidance
1	In-School, School-Hour Delivery	F3, F7, F8	All core student-facing programming must be designed for delivery within school hours, on school premises, requiring no additional fees or travel. This is the single most structurally effective response to the mobility and safety barriers that prevent girls from accessing after-school or off-site enrichment, and the most direct counter to the enrolment-pressure dynamic identified in revised Section 6, which makes teacher-managed out-of-school activities doubly problematic.
2	Mathematics Bridging and Active Lab Programming	F5, F9	A foundational mathematics bridging module for Classes 9 and 10 prioritising conceptual clarity over rote procedure, paired with structured lab sessions using low-cost, repeatable experiments. The confidence deficit that drives the Class 10–11 rupture (F9) is rooted in abstract instruction without practical grounding (F5). Both must be addressed simultaneously. Structured visits to Science City and university labs are a high-demand complement, students in the FGD named these specifically as what would most sustain their interest.
3	Interest Mapping, Not STEM Promotion	F1, F9, F11	Meaningful career guidance at Class 9, before stream selection pressure peaks, must be explicitly framed as interest and aptitude mapping across all disciplines, not STEM promotion. Revised F1 and F11 show that pressure toward STEM is as distorting as pressure away from it. A student coerced into science who drops out at Class 11 is a failure in two directions. Guidance must include legitimate, well-articulated pathways in arts and commerce alongside STEM, and must be delivered before peer influence fills the vacuum. The quant survey shows no gender difference on Future Aspirations or Technology at Class 9. The case for guidance over promotion is now quantitatively grounded: you are not filling a motivation gap, you are catching a structural one.
4	Role Model and Near-Peer Exposure	F1, F4	Build a roster of relatable women in STEM, university students, young professionals from similar socioeconomic backgrounds, for in-school talks and structured mentoring. Career imagination is built through proximity, not information (revised F4): the most effective role models are not inspirational figures from distant contexts but people close enough in background to make the path feel walkable. Supplement with structured visits to university labs. Deliver in-school to eliminate mobility constraints for girls. The quant study acknowledge that "knowing a woman in STEM" scores 2.92/5 across the full sample (2250). Girls are significantly more motivated to meet STEM professionals than boys ($p < 0.001$). SoE girls score 3.10 vs non-SoE girls at 2.87 on this item, a measurable differential.
5	Family-Facing Awareness via Teacher Channels	F2, F4, F7	Workshops for parents and guardians of Class 9–10 students that broaden career imagination beyond medicine and engineering, address safety concerns with practical information rather than abstract reassurance, and equip families with scholarship navigation knowledge. The critical design decision: deliver through teachers, not external facilitators. The Pheelkhana father trusted his daughter's B.Tech path because teachers recommended it (revised

			F4). Teacher communication channels carry institutional credibility that external organisations do not automatically possess.
6	Bilingual and Scaffolded Learning Materials	F6	Develop STEM enrichment materials introducing key concepts bilingually, Punjabi and English, with technical vocabulary built incrementally across both languages. The language-medium barrier is named by both the GSSS principal and the State official as underexplored and potentially decisive; it compounds directly with the confidence drop at the Class 10–11 transition. Bilingual materials are low-cost, high-impact, and position the Collective ahead of slower system-level policy change on instructional medium.
7	Teacher Co-Ownership, Structurally Protected	F10, S6	Build teacher co-facilitation into programme delivery structurally, not as an optional add-on. Identify and train teacher champions at each school; give them meaningful, bounded co-facilitation roles; build in recognition mechanisms. Critically, co-facilitation design must insulate teachers from the enrolment-target pressure identified in revised Section 6: teacher roles within the programme must be clearly separate from the administrative expectations that currently push teachers toward quantity over quality. A teacher asked to deliver honest career guidance cannot simultaneously be measured on enrolment numbers.
8	Scholarship Navigation as a Structural Component	F2, F3, S6	Scholarships exist in the system but do not reach students who need them. The NEET-prepared student who could not access higher education due to finances (revised Section 6) is the clearest possible evidence of what last-mile support failure costs. A dedicated navigation component, a trained teacher at each school, a documented application process, a parent session on eligibility and documentation, would convert existing resources into actual access. This is not a peripheral add-on; it is the difference between a student who prepared and a student who got through.
9	Perceived Intelligence and Family Mindset Intervention	F4, F7, B-Family	Families make premature and often inaccurate assessments of daughters' academic potential, assessments driven by disrupted schooling or inconsistent performance rather than actual aptitude. The Old Police Line parent had written off her Class 9 daughter's educational future to a tailoring course because she had concluded the girl was 'not too intelligent,' despite the daughter having previously been strong at maths. Family mindset interventions must address not only career awareness but also parents' beliefs about what their children are capable of, and must do so through trusted intermediaries, particularly teachers.

Forward research signals: Several further research directions emerged from the interview data that should inform the white paper and future study design: (1) the role of language medium in STEM uptake in Punjab, is there existing literature or policy, and what specifically causes the confidence drop at the linguistic transition point? (2) peer influence as a stream-choice determinant in Indian secondary education, what interventions have been shown to counteract it? (3) disciplinary gender segregation in Indian higher education, is psychology's female skew documented nationally, and what does the literature offer? (4) emotional regulation frameworks and their applicability to STEM confidence development in adolescent girls, following Professor's research at TIET. (5) the impact of single-parent households on educational and career trajectories.

SECTION 8 Limitations of the Study

This study is based on qualitative fieldwork—meaning it is grounded in real conversations, the way people talk about their lives, what they eagerly share, and what they hesitate to say. That depth is our greatest strength, but it also creates natural limits. We offer the following points not as excuses, but as honest navigational tools for anyone using this study to design policies or programs.

1. **Sample Size and Focus** Because we conducted 17 in-depth interviews and one group discussion across five schools, this study cannot claim to represent every single person in Patiala mathematically. We designed this study to get deep, diverse perspectives, not broad percentages. Our findings identify patterns and highlight real mechanisms at work. Rather than discounting these findings because the sample is small, they should be used as a solid, grounded starting point for larger, numbers-based surveys in the future.
2. **The "Best Student" Bias** During our visits, several school principals and teachers deliberately chose to send us students from their "Scheme of Excellence" (SoE) sections. Because we interviewed the top-performing students, our data likely shows higher levels of student confidence, family awareness, and career clarity than what actually exists in the general student body. (Our larger quantitative survey later confirmed this bias, showing that SoE schools don't actually have a massive advantage over non-SoE schools). When reading this report, keep in mind that the reality for the average, non-SoE student is likely much tougher than these specific interviews suggest.
3. **Pre-Briefed Principals** We had already engaged with some of the school principals before we interviewed them. For example, the principal at our very first school knew about our organization's goals beforehand. While we believe her answers were genuine, there is always a risk that she framed her responses to match what she thought we wanted to hear, rather than showing us the unguarded reality of her school. In the future, we need to conduct all baseline interviews before forming official partnerships.
4. **The Missing District-Level Voices** We were not able to complete interviews with top district officials, like the Deputy Commissioner (DC), during this study's timeframe. Because these officials control the administrative rules and funding that determine if a school program succeeds or fails, not having their full perspective is a significant gap. Securing their official buy-in is an absolute requirement before we design our final program, not something we can figure out later.
5. **Missing the Single-Parent Perspective** One teacher pointed out that single-parent households face uniquely severe challenges when it comes to keeping kids in science—such as students taking on part-time work or families struggling to survive on one income. Unfortunately, we did not interview enough single parents to fully map out how this specific household structure changes a student's path. Given how heavily money impacts education, studying single-parent households must be a priority for our future research.
6. **Did People Tell Us the Truth About Gender?** When interviewing people about sensitive topics, it is sometimes hard to know if they are being fully honest. For example, several male teachers explicitly denied that there was any gender gap in their classrooms, but then went on to describe structural rules and safety concerns that clearly hold girls back. We cannot fully tell if they genuinely don't see the bias, or if they were just trying to sound "progressive" for the interviewer. We must keep this in mind when using their quotes as evidence.
7. **Group Dynamics vs. Private Thoughts** During our student focus group, the girls were incredibly vocal and outgoing—which was the exact opposite of the quiet lack of confidence we saw during one-on-one private interviews. This tells us that the group setting, surrounded by peers, made the girls feel safe enough to speak up. While this is a wonderful insight, it

means that group data is heavily shaped by social dynamics. We have to read the group findings side-by-side with the private interviews to get the full truth.

8. **Gender Split Within Non-Medical vs. Medical Streams Could Not Be Verified** State MIS data allows us to split Class 11 Science enrolment by gender (Table C), and separately to split Science into Non-Medical and Medical (Table B), but not both together. 93% of Patiala's Non-Medical students (1,123 of 1,204) are enrolled in co-educational schools where trade-wise enrolment is not recorded by gender in the data available to us. The only gender-disaggregated Non-Medical/Medical figures come from Patiala's 27 girls-only schools, which are not representative of the district's girls overall, most of whom study in co-educational settings. This is a genuine data gap rather than an omission, and closing it would require either a direct request to the MIS team for gender-disaggregated trade data in co-ed schools, or primary data collection in future rounds of this study.

The Bottom Line on Our Evidence

These limitations do not ruin the value of this study; they simply show us exactly where our evidence is strongest and where it needs backup.

Our findings are **highly reliable** when multiple different groups across multiple different schools all agreed on the exact same problem—like the crushing cost of coaching, the brutal transition into Class 11, the lack of career guidance, and the unfairness of where coaching centers are located.

Our findings are **more tentative** when they rely on just one person's view or one single school's experience. Our future work must prioritize filling these gaps: interviewing top district officials, talking to average (non-SoE) students, understanding single-parent homes, and running large-scale surveys to put hard numbers behind the barriers we have uncovered here.

SECTION WAY FORWARD A Call to Act on What We Found

What we can do together. This is a big challenge, and we can't fix it overnight, but we know it can be done if we work as a team.

We started this study to answer one question: what does it really take for a girl in a Patiala government school to choose science in Class 11?

Here is the truth: the girls have the ambition. They have the ability. Our teachers are highly qualified, and our schools have the physical infrastructure, including buildings and science labs. What is missing is the structural support to actively connect these eager students to the resources right in front of them.

This is a problem we can solve. It will not be easy or quick, and no single group can do it alone, but it is entirely solvable. We have laid out the evidence, the roadblocks, the readiness of our schools, and the clear paths forward. This final section outlines exactly what needs to happen next, who needs to take action, and what a true partnership between the Patiala STEM Collective and the PI-RAHI can achieve.

What This Study Shows: Three Core Truths

Looking at all eleven of our findings, three major arguments stand out. Any new program or policy must be built on these three-starting premises:

1. **The barriers are in the system, not the students.** Girls are not avoiding science because they lack ambition or intelligence. They are stopped by tutoring fees they cannot afford, travel rules that keep them home after school, a brutal jump in academic difficulty during Class 11, and families who unfairly judge their potential based on past schooling struggles. We do not need to build programs to "motivate" these girls; we need to fix the system around them.
2. **The roadblocks multiply.** These problems do not happen one at a time; they combine to make things much worse. A lack of money combined with living in a rural area creates a massive, unfair disadvantage. When schools fail to provide adult career guidance, peer pressure easily takes over a student's choices. Even a family's premature belief that their daughter is "not too intelligent" is usually just the result of long-term financial and mobility struggles wearing them down. Because these problems pile up, trying to fix just one issue while ignoring the rest will fail.
3. **We already have the tools, we just aren't using them.** Our system has incredible assets that are sitting completely unused. Our government school teachers are highly qualified, motivated, and deeply trusted by parents in a way that outside organizations are not. Most of our schools already have science labs, even if they currently sit empty. Scholarship money exists, but it fails to reach students simply because there is no human guide to help families fill out the paperwork. The program we need to build is not about bringing brand-new resources into a poor system. It is about activating the amazing resources we already have, and building the connections that are currently missing.

"Exposure-based interventions without structured follow-through risk generating curiosity without conversion. The programme must be designed to convert, not just to inspire.", State official, Dept. of Education

Concrete Next Steps

Immediate Actions: Our Minimum Required Response

These actions are the absolute minimum steps we must take based on our findings. They are organized by who needs to act and how quickly. These are not just hopes for the future; they are the required next steps to fix the system.

- **Fix the Class 9 window before it closes** Career guidance, foundational math support, and family awareness sessions must be in place before Class 11 pressure hits. This is the single most time-sensitive intervention point the study identified.
- **Embed scholarship navigation in every school** Every school needs a trained teacher, a clear process, and a parent session to help families access existing scholarship schemes. Funding exists — what is missing is the human support to reach it.
- **Secure district-level partnership before programme design is finalised** District officials — particularly the Deputy DEO, DC, and BPEO — must be engaged as co-owners, not approached for approval after decisions are made. Their buy-in determines whether school-level work gets structural support or polite tolerance.
- **Work across institutions, not in silos** Lasting change requires coordinated effort across government, higher education, civil society, and funders. Any single organisation working alone will hit the same walls this study documents.
- **Build on what already exists — teachers, labs, and trust** The system has qualified teachers, functional labs, and deep parental trust in school staff. The priority is activating these assets through structured support, not importing new ones from outside.
- **Empower "Teacher Champions" to Lead the Ecosystem.** Our government schools already have incredible talent; we just need to scale it. We have seen firsthand that when highly motivated teachers are given proper support, they don't just teach their own classes—they build their own unique identities in science and influence the entire education ecosystem around them. Look at real-life examples like Jaswinder Sir, who successfully runs the "Science on Wheels" YouTube channel, or Gagan Mam. They prove that our teachers can be powerful innovators. Instead of relying on these exceptional teachers to act as isolated heroes, we need to actively organize them into a structured leadership team.

To make this happen, we will focus on three key steps:

- **Role Modeling:** We will position these successful teachers as visible role models and mentors for other teachers across the district, proving what is possible within a government school setting.
- **Building a Master Trainers Cadre:** We will elevate these Teacher Champions into a dedicated group of "Master Trainers." Instead of bringing in outside consultants, these local experts will lead the training and skill-building for their fellow teachers.
- **Documenting the Reality:** We will task this cadre with testing new ideas and honestly documenting effective practices—writing down exactly what actually works in our local classrooms, and just as importantly, what does not.

A Conclusion, or a Starting Point

During our research, we met two young girls at a Parent-Teacher Meeting who were there to make sure their younger sisters had a different story than their own. They had already lost years to a system that gave them neither the guidance nor the financial support to land where their hard work actually deserved. But they were

still there—standing in a school they no longer attended, advocating for sisters whose parents couldn't come, using whatever limited resources they had to hold open a door that had nearly closed on them.

That is the fierce level of commitment this ecosystem is currently working against, and working with. The ultimate question this study asks is whether our education system can be redesigned to match their dedication. This study is our starting point. The Patiala STEM Collective invites PI-RAHI to join us in building what comes next—as an institutional anchor, a co-designer, a co-publisher, and as the powerful state-level voice that can take what we learn in Patiala and ask what it means for the future of Punjab.