

Case Study of Maker Spaces

in Andhra Pradesh, Karnataka and Telangana

Understanding Stakeholder Experiences



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List of Abbreviations

AIM	Atal Innovation Mission
ANOVA	Analysis of Variance
AP	Andhra Pradesh
ATL	Atal Tinkering Lab
CI	Confidence Interval
CMS	Centre for Media Studies
DEO	District Education Officer
DSO	District Science Officer
FGD	Focus Group Discussion
GoI	Government of India
HEI	Higher Education Institution
HM	Headmaster
IDI	In-Depth Interview
IoT	Internet of Things
IRB	Institutional Review Board
ITI	Industrial Training Institute
ITS	Implementation & Technical Skills
KII	Key Informant Interview
MCQ	Multiple Choice Question
NEP	National Education Policy
NITI	National Institution for Transforming India
PR	Presentation & Reflection
PUP	Problem Understanding & Planning
SD	Standard Deviation
SDG	Sustainable Development Goal
STEAM	Science, Technology, Engineering, Arts and Mathematics
STEM	Science, Technology, Engineering and Mathematics
ToC	Theory of Change
UNEG	United Nations Evaluation Group
UNICEF	United Nations Children's Fund
VA	Vigyan Ashram
ZPHS	Zilla Parishad High School
IPS	Iteration & Problem Solving
df	Degrees of Freedom
α	Alpha

Executive Summary

Background

Maker spaces have emerged globally as transformative ecosystems where students design, tinker, and build, applying knowledge to real-world challenges (Papert & Harel, 1991). These spaces, ranging from Fab Labs in the United States to community innovation hubs in Africa and Asia, are widely recognized for fostering agency, interdisciplinary learning, and innovation-driven mindsets (Gershenfeld, 2005; Dougherty, 2012). In India, Atal Tinkering Labs (ATLs), established under Atal Innovation Mission (AIM), cultivate innovation and design thinking among students in grades 6–12. Each ATL is equipped with digital fabrication tools, robotics kits, and open-ended resources to promote hands-on learning, problem-solving, and creativity.

Despite their rapid expansion, ATLs face challenges in practice. These include: top-down implementation (a direct implementation by AIM using an online application and selection process in which schools took part, bypassing state school education departments in the establishment and implementation of the first phase of 10,000 ATLs), limited teacher training, low utilization of lab equipment, uncertain long-term funding, lack of curricular integration etc. Recognizing these gaps, UNICEF partnered with Vigyan Ashram and State Governments in Andhra Pradesh, Karnataka, and Telangana to strengthen ATLs in the states. This collaboration introduced a *"hub-and-spoke" model* wherein select hub schools received intensive training and resources and, in turn, mentored nearby spoke schools in effective ATL usage. A case study across these states was conducted to generate insights on how UNICEF's interventions were functioning, their perceived value, and the conditions that enable or hinder their sustainability.

Key Findings

Student skills: The study administered hands-on problem-solving tasks to students to evaluate four domains: *Problem Understanding & Planning (PUP)*, *Implementation & Technical Skills (ITS)*, *Iteration & Problem Solving (IPS)*, and *Presentation & Reflection (PR)*. Student performance was strong overall – average scores were above 3.5 on a 1-5 scale for all domains, indicating that many students achieved a basic or proficient level on these open-ended challenges. Students scored highest in understanding and planning the problem (mean = 4.2), and slightly lower in technical implementation and iterative problem-solving. Students in Karnataka outperformed their peers, with average scores ranging from 4.2-4.4 on the 5-point scale across the four competencies. Gender-wise disparities were observed in the scores wherein boys scored higher than girls on all four domains, with the gap most pronounced in ITS and IPS.

Design thinking skills (self-reported): Alongside the observed tasks, students answered a Likert-scale survey on key design thinking practices – Empathize, Define, Ideate, Prototype, and Test. The self-reported results were overwhelmingly positive, indicating a high uptake of design-thinking mindsets. Nearly 90% of students agreed or strongly agreed that they take time to understand others' needs and actively seek feedback to improve solutions, with mean ratings of 4.37 and 4.41 out of 5 respectively. A similarly high proportion (85%+) felt confident in clearly defining problems and building prototypes to test ideas (means ~4.3). Students from Andhra Pradesh and Karnataka reported the strongest uptake of design thinking skills. On average, female students gave themselves a slightly higher

composite score (mean 4.33 vs. 4.19 on the 5-point scale) and showed more consistency in responses.

Teacher assessments and capacity: The study examined teacher's skills and perceptions through both practical assessments and in-depth interviews (IDIs). ATL teachers took the same problem challenge as students and scored very high, averaging 4.4 to 4.5 out of 5 in all competency domains. Multiple Choice Questions (MCQs) were also administered to teachers of spoke schools – 71% of teachers said they conduct ATL sessions *weekly or more often*, typically in class periods of 40 to 120 minutes. 82% of spoke teachers reported linking ATL activities to their textbook lessons or curriculum, showing that many are already integrating tinkering projects with what students learn in science, math, etc.

Other student learnings: MCQs were also administered to students to understand their overall experience of ATLs. Almost all students (96%) felt encouraged to work on real-life problems after participating in ATL. Hands-on learning also seems to be reinforced in classroom education. Around 93% of students agreed that working on ATL projects helps them understand their school subjects better. Many teachers and headmasters confirmed this, observing improvements in students' performance and interest in STEM subjects due to ATL exposure. About 90% of students believed ATL activities were preparing them for future careers and opportunities. When asked what skills they have improved through ATL, students most frequently cited technical skills (61% of students), creativity (57%), teamwork (55%), and problem-solving (55%). Many also reported gains in self-confidence (47%) and communication skills (42%).

Other qualitative insights: Students consistently described ATL sessions as *"more engaging than regular classes"* and as opportunities to *"learn by doing"* which made even difficult subjects fun. Many ATL teachers noted that ATLs have helped shift pedagogical mindsets away from rote teaching. They noted that they no longer see ATL as limited to science class and now find ways to use it in other subjects.

A recurring theme that emerged from qualitative interviews was that consistent support and resources are critical to ATL's success. Stakeholders pointed to factors like active involvement from district officials, supportive principals, training opportunities, and interest of mentors. Common barriers identified included: lack of dedicated staff (most ATL in-charge teachers have to juggle ATL on top of full teaching loads), insufficient time during the school day for ATL, limited materials or poorly maintained equipment, and funding delays or gaps for consumables and upgrades.

Recommendations

The case study outlines a set of key recommendations to enhance the effectiveness and sustainability of ATLs. These are presented below:

- Ensure that lab equipment is better maintained and larger spaces provided for ATL activities to prevent overcrowding.
- Ensure that dedicated staff/teachers are assigned for ATL labs and regular ATL periods are provided every week within the timetable.
- Train all science teachers (tiered training pathway) on ATL equipment and ensure that ATL is integrated into all subjects, not just science.
- Map ATL activities to state-board curriculum for better integration.
- Develop a dashboard for tracking ATL lab usage, monitor safety protocols, and ensure regular equipment maintenance and audits.

- Address barriers to girls' participation by promoting female leadership and ensuring safety, transport, and after-school access.
- Introduce parents' engagement in ATLs through community activities/events.
- Create an innovation pathway with Higher Education Institutions (HEIs) adopting ATLs as their extension labs or centres.

The case study shows that when students are given the tools and guidance to *learn by making,* they develop critical thinking, creativity, and confidence. Teachers, once trained and supported, become champions of this new pedagogy, blending it with the curriculum to enhance overall education quality. The ATL programme aligns strongly with India's educational goals and has already begun to produce change, from more engaged classrooms to actual community innovations by students. However, reaping its full benefits requires continued commitment and scaling up of support. By integrating curriculum, building teacher capacity, improving infrastructure, innovating staffing, engaging the community, and solidifying policy support, ATLs can move from a novel experiment to a permanent, self-sustaining feature of India's school system.

1 Introduction

1.1. Background

The past decade has witnessed a paradigm shift in school education, moving away from rote learning towards experiential and learner-centred approaches that emphasize creativity, collaboration, critical thinking, and technological fluency (Halverson & Sheridan, 2014; Sheridan et al., 2014). Maker spaces have emerged globally as transformative ecosystems where students design, tinker, and build, applying knowledge to real-world challenges (Papert & Harel, 1991). These spaces, ranging from Fab Labs in the United States to community innovation hubs in Africa and Asia, are widely recognized for fostering agency, interdisciplinary learning, and innovation-driven mindsets (Gershenfeld, 2005; Dougherty, 2012).

India's response to this global movement was the establishment of the Atal Innovation Mission (AIM) in 2016 under NITI Aayog, with the Atal Tinkering Labs (ATLs) as its flagship school-based programme. ATLs are "state-of-the-art" maker spaces set up in middle and secondary schools to cultivate innovation and design thinking among students in grades 6–12. Each ATL is equipped with digital fabrication tools, robotics kits, and open-ended resources to promote hands-on learning, problem-solving, and creativity (AIM, 2021). By 2025, more than

Each Atal Tinkering Lab is equipped with digital fabrication tools, robotics kits, and open-ended resources to promote hands-on learning, problem-solving, and creativity.



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An additional 50,000 ATLs will be established as per the Union Finance Minister's budget announcement in February 2025. This process has already begun and indicates the government's emphasis on using maker spaces to promote innovations in schools through 'learning by doing'.

10,000 ATLs have been established across 722 districts in India, reaching an estimated 11 million students, including those in rural and tribal areas (AIM, 2024; UNICEF, 2025). An additional **50,000** ATLs will be established as per the Union Finance Minister's budget announcement in February 2025. This process has already begun and indicates the government's emphasis on using maker spaces to promote innovations in schools through 'learning by doing'.

The initiative is strongly aligned with the National Education Policy (NEP) 2020, which emphasizes scientific temper, inquiry-based learning, creativity, problem-solving, and digital literacy as essential 21st century skills (Government of India [GoI], 2020). It also supports India's commitment to the Sustainable Development Goals (SDGs), particularly SDG 4 on inclusive and equitable quality education. ATLs have already produced notable student innovations such as AI-enabled health monitoring systems, flood-warning devices, and low-cost agricultural tools, reflecting their potential to bridge school learning with community problem-solving (UNICEF, 2025).[1]

Despite their promise, several challenges hinder ATL effectiveness. The funding and application processes are centralized under AIM, which limits involvement from state education departments, resulting in weak systemic integration and oversight. Teachers often perceive ATL responsibilities as additional workload and without adequate training or incentives, labs risk underutilization (Athena Infonomics, 2023; UNICEF, 2025). Moreover, evidence on long-term learning outcomes, inclusivity, integration of ATLs with the school curriculum, and sustainability of ATLs remain limited. Recent data from the Unified District Information System for Education (UDISE) and other studies also highlight a persistent digital readiness gap in Indian schools, financing constraints, digital inequities, and teacher preparedness which could significantly slow or unevenly enable NEP 2020 implementation (UDISE, 2024; Mili et al., 2025).

The UNICEF supported intervention to strengthen ATLs included regular face-to-face teacher training, student bootcamps, 'make-a-thons', online demo sessions, and the involvement of engineering students as 'ATL mentors' (only in AP), aimed at embedding design thinking in classroom practices and ensuring broader systemic ownership.

To address these challenges, UNICEF partnered with Vigyan Ashram (a constituent of the Indian Institute of Education, Pune) to support the school education departments of the state governments in Andhra Pradesh, Karnataka, and Telangana to strengthen ATLs through a hub-and-spoke model between end 2021 and 2025[2]. As part of this model, a sub-set of ATL schools were designated as 'hub schools' which received intensive training and support; these hubs in turn mentor and support. The objective was to develop these hubs as district level training and resource centres – they, in turn, were expected to mentor and support the surrounding spokes' ATL schools in their vicinity. A total of 86 hubs were identified across the three states (31 each in AP and Telangana, and 24 in Karnataka). Each hub was tagged with 5-8 spokes, ATLs in the same district.

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[1] Reference to UNICEF generally refers to Inception Report, RFP documents or other background documents shared from UNICEF/VA.

[2] The UNICEF engagements first began in AP towards the end of 2021, followed by Karnataka (second half of 2022) and Telangana (early 2023).

practices and ensuring broader systemic ownership (UNICEF, 2025). Further, both education department officials from the state and districts as well as hub teachers visited Vigyan Ashram's maker space facility in Pune for in-depth sessions. Further, a state training centre was established in each state to ensure that hub teachers had access to training facilities within the state itself. The overall objective of providing this range of inputs was to help build in-house capacities of the school education departments in each state.

Furthermore, as part of the range of inputs related to this engagement, UNICEF and Vigyan Ashram supported the education departments of the three states to develop a handbook for teachers on strengthening the ATLs. This handbook has a section on design thinking besides containing sample lesson plans to guide the teachers to integrate regular curricular topics with activities in the ATLs.

Rationale for the study

While ATLs represent one of the largest school-based maker space initiatives globally, systematic evaluations remain scarce. Previous assessments, including NITI Aayog's 2023 review, largely examined compliance and infrastructure but did not capture shifts in pedagogy, student skill development, or systemic integration in detail (Athena Infonomics, 2023). There is limited understanding of how ATLs are being experienced by teachers and students in diverse contexts—especially rural schools—or how sustainable practices are being built at the school and state levels. UNICEF's interventions provide a unique model of capacity building and systemic engagement; however, there is a need for evidence on their effectiveness, scalability, and alignment with NEP 2020. This study seeks to fill that gap by documenting stakeholder experiences, analyzing pedagogical changes, and identifying enablers and barriers to sustainable integration of ATLs in Andhra Pradesh, Karnataka, and Telangana.



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UNICEF's engagement with the ATLs in states of AP, Telangana and Karnataka is closely aligned to national priorities, aiming to strengthen STEM learning in middle and secondary grades, with an emphasis on 'learning by doing' and 'learning for innovation'.

UNICEF's engagement with ATLs in the states of AP, Telangana and Karnataka is closely aligned to national priorities, aiming to strengthen STEM learning in middle and secondary grades, with an emphasis on 'learning by doing' and 'learning for innovation'. UNICEF believes that this work is foundational from the point of view of developing effective pathways for adolescents on 'skills for life, work and sustainable development.'

This study is particularly timely in light of broader shifts in NEP, which now explicitly encourage experiential, project-based learning and innovation, as outlined in NEP 2020. It will not only document outcomes, but also help inform future models for scaling maker spaces, ensuring they are both impactful and inclusive.

Ultimately, this case study will serve as a vital tool for UNICEF, state governments (Samagra Shiksha), and their partners to refine strategies, advocate for necessary policy changes, and promote more effective, equitable, and sustainable integration of maker spaces within India's schools.

1.2. Literature review[3]

Global evidence on maker spaces in education

The maker movement has emerged as a significant educational reform, reshaping the way students engage with knowledge. Rooted in *constructionist* learning theory (Papert & Harel, 1991), maker spaces emphasize "learning by doing", where students actively construct meaning through problem identification, design, experimentation, and creation. Studies show that maker spaces build *agency* by positioning learners as innovators rather than passive recipients of knowledge, thereby fostering

[3] See Annexure 6 for detailed Literature Review.

creativity, critical thinking, and problem-solving skills (Halverson & Sheridan, 2014; Sheridan et al., 2014).

Global initiatives such as Fab Labs in the United States and Europe, and Do-It-Yourself (DIY) or mobile maker hubs in Africa and Latin America, have demonstrated that hands-on innovation environments can expand STEM learning, promote teamwork, and inspire entrepreneurial thinking (Gershenfeld, 2005; Dougherty, 2012). A 2023 mixed-methods study found that 9th grade science students who learned through maker-centred projects showed significantly better learning outcomes than those in standard science classes, highlighting that students had better learning outcomes in science class when learning occurred through maker technologies than the school's standard curriculum (Tofel-Grehl et al., 2023). Maker spaces also provide opportunities for cross-disciplinary learning, combining science, engineering, arts, and design (STEAM). At the same time, scholars caution that unless supported by adequate teacher training, institutional backing, and inclusivity frameworks, maker spaces risk becoming peripheral or elitist initiatives (Sheridan et al., 2014).

Maker education and equity

Equity and inclusion are recurring concerns in the literature on maker space education. International studies reveal that participation often reflects broader structural inequalities, with girls and students from marginalized communities less likely to dominate technical tools and prototyping activities (Vossoughi et al., 2016). Access is also uneven as maker spaces tend to cluster in urban and better-resourced contexts, potentially widening gaps between schools and learners (Halverson & Sheridan, 2014). This raises questions about sustainability and whether maker initiatives can scale equitably in diverse socio-economic and geographic settings.



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The Indian experience with ATLs

In India, the launch of ATLs under AIM in 2016 marked an ambitious attempt to mainstream maker spaces within the public education system. ATLs are equipped with cutting-edge resources such as 3D printers, robotics kits, sensors, and open-source electronics to nurture innovation among students in grades 6–12 (AIM, 2021). With over 10,000 labs established across 722 districts by 2025, ATLs constitute one of the world's largest school-based maker space networks, reaching an estimated 11 million children (AIM, 2024).

ATLs align strongly with the NEP 2020, which emphasizes 21st century skills, creativity, problem-solving, and inquiry-based learning (Government of India, 2020). Case studies have documented how students in ATL schools have developed innovative solutions to local challenges, such as low-cost medical devices, flood warning systems, and agricultural automation prototypes (UNICEF, 2025). Participation in ATL innovation challenges has also provided students with exposure to national and international platforms, further shaping their aspirations in STEM and entrepreneurship (NITI Aayog, 2023).

STEM Education India

The NEP recognizes that rapid technological progress in areas such as artificial intelligence, data science, and automation is reshaping the world, and education must prepare young people to respond thoughtfully to these changes. It promotes the integration of STEM with arts, humanities, and social sciences to build creativity, problem-solving skills, and clear communication. NEP 2020 also emphasizes early exposure to mathematics, scientific exploration, and digital learning through activities such as coding and design-based projects. By embedding STEM within a broader and balanced learning framework, the policy aims to nurture individuals who are not only technically skilled but also ethical, adaptable, and capable of applying knowledge responsibly to meet the challenges of the 21st century.

However, students' STEM exposure in middle and secondary school remains uneven. The National Achievement Survey (NAS) 2021 assessed classes 3, 5, 8 and 10 across core subjects, highlighting the need to strengthen applied understanding and problem-solving rather than just recall. Infrastructure and teacher support also vary widely. Moreover, only about half of secondary schools are reported to have integrated science laboratories, which constrains practical work central to STEM (MoE, 2023).

According to UDISE 2023-24 report, only **32.4%** of India's 14.7 lakh schools had access to functional computers. Furthermore, **24.4%** of schools had smart classrooms, and **24.2%** relied on mobile phones for teaching purposes. Thus, financial constraints, digital inequities, faculty readiness gaps, governance complexities, and wide variation across institutions pose significant risks that could hinder the effective implementation of NEP 2020 objectives (Mili et al., 2025).

Emerging challenges and limitations

While ATLs have achieved remarkable scale, studies highlight several critical challenges:

- **Curricular integration:** ATLs may be treated as add-on or extracurricular activities, limiting their pedagogical impact within the mainstream classroom (Athena Infonomics, 2023).
- **Teacher preparedness:** ATLs do not have full time/separate instructors. Teachers, who are given the additional role of managing the ATL, are those who are already engaged in full time teaching, mostly at the secondary level. Their sustained professional development is lacking, resulting in uneven implementation quality and low confidence in facilitating design thinking (UNICEF, 2025).
- **Equity gaps:** Gendered participation patterns persist, with boys more likely to dominate technical tasks, while girls often take on supportive or documentation roles (UNICEF, 2025). In tribal and rural schools, infrastructure and resource gaps exacerbate these inequities. UNESCO's State of the Education Report 2025 states that there is an urgent need for

targeted policy interventions such as improved secondary infrastructure in tribal districts, language-responsive pedagogy, gender-sensitive facilities, and economic support measures to ensure quality learning and the successful transition of Scheduled Tribe (ST) students across all stages of schooling and higher education (UNESCO, 2025).

- **Systemic ownership:** Since ATLs are centrally funded and managed by AIM, state governments and district education departments often have limited involvement, undermining sustainability and systemic integration.

- **Assessment and monitoring:** Current metrics largely emphasize number of labs established or prototypes built, with limited evidence on how ATLs influence deeper skill acquisition or long-term career outcomes (Athena Infonomics, 2023).

- A systematic literature review of 40 empirical studies showed that design thinking is most commonly implemented using adapted versions of the Stanford d.school model, operationalized through empathy-driven tools, inquiry-based tasks, and iterative prototyping (Saseendran and Thomas, 2025). The review notes that while design thinking helps in forming a broad range of cognitive, creative, and socio-emotional competencies, its implementation is often hindered by teacher readiness, curriculum rigidity, and insufficient assessment mechanisms (Saseendran and Thomas, 2025).

These limitations mirror global concerns about sustainability and inclusivity in maker education, reinforcing the need for systemic reforms (Halverson & Sheridan, 2014; Sheridan et al., 2014).

Gaps in the evidence base

Although ATLs represent one of the largest government-supported maker space initiatives worldwide, the evidence base remains fragmented. Previous studies in India have focused primarily on infrastructure readiness and basic usage patterns, rather than capturing nuanced shifts in pedagogy, teacher agency, or student learning trajectories (Athena Infonomics, 2023). Longitudinal research on how ATLs influence higher education choices, entrepreneurship, or employability is particularly scarce.

Moreover, there is limited documentation of how ATLs function across diverse school contexts—urban vs. rural, government vs. private, tribal vs. non-tribal—and how systemic partnerships can strengthen ownership at state and district levels. The UNICEF-supported hub-and-spoke model in Andhra Pradesh, Karnataka, and Telangana represents a novel approach by embedding teacher training, mentorship, and systemic collaboration into ATL implementation (UNICEF, 2025). Studying this model offers an opportunity to address existing evidence gaps by analyzing how such interventions enhance sustainability, inclusion, and relevance within the Indian school system.

1.3. Overview of technical assistance to strengthen ATLs in Andhra Pradesh, Telangana and Karnataka

Before detailing out the scope, methodology and results of the study, the following section presents an overview of technical assistance facilitated by UNICEF to strengthen STEM learning through the ATLs in Andhra Pradesh, Telangana and Karnataka. The range of technical inputs provided were to strengthen a 'hub and spokes' model in which 86 ATLs across the three states were selected as 'hub ATLs'. The premise was that these ATLs, once developed as resource centres and as master trainers, would then go on to support other ATLs (the spokes) in their district and vicinity, thus setting off a larger process of capacity building in their state. UNICEF partnered with the Pune based Vigyan Ashram (part of the Indian institute of Education) for the planning, design, and implementation of various capacity building inputs. These inputs, which were jointly developed with the School Education Department, included face-to-face training of teachers, district and state level officials, exposure visits to Vigyan Ashram's maker space facility in Pabal near Pune, online sessions (for both hub and spokes ATLs), bootcamps (especially during the summer school break), monitoring checklists, teacher handbooks to link the ATLs with the curriculum and on learning design thinking, among others. These inputs are presented in detail below.

Face-to-face training of hub school teachers: The face-to-face training focused on the 'what, why and how' of the ATLs, enabling teachers to understand how the ATLs can be integrated into the school routine, how they can be made functional, and how the school curriculum can be integrated with the learning activities at the ATLs.

Further, an important aspect of the face-to-face trainings was the emphasis on 'Design Thinking' methodologies. This is seen as a tool to enable teachers and children to learn to identify daily problems that need solutions and use the ATL resources to design, iterate and develop these solutions. There are several examples of teachers and children using design thinking principles to develop ideas that address some or the other daily problem, ranging from agriculture to road safety, to potential solutions to challenges faced in the context of disability. Some of these ideas, which have emerged from the hub schools with whom this programme has worked, have also been selected for prestigious competitions such as 'Seed the Future' by Dassault Foundation and the ATL Marathon of the AIM (now known as the School Innovation Marathon). About 25-30 such ideas have been identified as deserving further support for development. As a result of UNICEF engagement, government schools have started participating in the Seed the Future programme which earlier saw participation from only private schools.

Online sessions for hubs and spokes: Online sessions have been used to demonstrate various learning activities that can be easily undertaken in the ATLs. Teachers as well as children attend online sessions from their schools. In Karnataka, the online sessions have been conducted on the state's '*Gnanadeepa*' channel of the DSERT (Department of State Education Research and Training). The online sessions have received positive feedback from the teachers. In Andhra Pradesh, the online sessions are done via the SCERT's Diksha channel. The outreach (both for teachers and children) of the abovementioned training inputs is summarized in the table below:

Table 1.1: **Number of teachers in hub schools who have received continuous training**

State	No. of hub teachers trained (includes new teachers who have been transferred to the ATLs)			No. of days – face-to-face training	No. of online sessions (conducted over state platform)	No. of hours (online sessions)
	Male	Female	Total			
Karnataka	16	12	28	22 days over two academic years	42	42
Telangana	37	18	55	16 days over two academic years	24	24
AP	42	15	57	21 days over two academic years	93	93

Table 1.2: **Number of boys and girls accessing the ATLs in hub schools**

State	No. of hub schools	No. of children accessing the ATLs (grades 6-9)			No. of children getting additional inputs (grades 6-9)		
		Boys	Girls	Total	Boys	Girls	Total
Karnataka	24	1152	768	1920	265	291	556
Telangana	31	1860	1240	3100	372	248	620
AP	31	1632	1568	3200	306	294	600

As a result of UNICEF's advocacy with the school education departments in three states, the departments have issued circulars to all ATLs to include 'ATL periods' as part of the timetable. This has created the opportunity for a larger group of children to access the ATL resources (see Table 1.3).

Table 1.3: **Children accessing ATLs across the state due to state directive on including ATL periods in the timetable (UNICEF advocacy)**[4]

Telangana	Karnataka	AP
384 ATLs X 80 children (20 each from grades 6-9) = 30720 children	305 ATLs X 80 children (20 each from grades 6-9) = 24400 children	545 X 80 children (20 each from grades 6-9) = 43600 children

[4] All ATL schools have received the state directives in both states on introducing 1-2 periods per class per week for the ATL activity. However, this does not necessarily mean that all these ATL teachers are capable of doing activities in the ATL. Where vendor support is strong, one can expect some activity in the ATL. Where the teachers are interested, they often find ways of using the ATLs. We have included these numbers to indicate that there is an administrative breakthrough as a result of UNICEF efforts – this has resulted in the space being created in the school routines for the ATLs.

'Make-a-thons'/Summer camps: Summer school breaks have been used to host 'make-a-thons' or bootcamps which have been attended by teachers as well as children. Hosted often by the hub ATL schools, the summer camps have provided learning spaces in which children and their teachers have undertaken many an activity, using the modern as well as conventional tools available in the ATLs.

Additional support to select schools: Selected schools have been supported to register for prestigious competitions like 'Seed the Future' (organized by Dassault Foundation) and the School Innovation Marathon (organized by AIM). Hub schools as well as spokes schools have participated in these competitions, with all selected schools receiving grants from Dassault Foundation to further develop their ideas. Table 1.4 provides these details. Similarly, the top 100 schools in the nationwide School Innovation Marathon get further support from AIM.

Departmental reviews and monitoring: When UNICEF began engaging with the school education department to strengthen the ATLs, it was clear that the department was not aware of the initiative, as the ATLs had been established through a central online process in which the AIM was directly linking with the schools, bypassing the structures of the department. Upgrading the skills of the teacher through continuous training as well as monitoring of the ATLs did not take place for a long time, resulting in

Table 1.4: **Hub ATL schools' participation in national competitions**

State	Competition	Academic year and number of ATL schools which participated in and were recognized in national competitions*		
		2023-24	2024-25	2025-26
Karnataka	Seed the Future*	4	6	3
	ATL Marathon (top 100 schools)	14	11	Yet to happen
	ATL Marathon (top 500 schools)	82	46	Yet to happen
Telangana	Seed the Future**	3	4	5
	ATL Marathon (top 100)	9	10	Yet to happen
	ATL Marathon (top 500 schools)	20	30	Yet to happen
AP	Seed the Future	4	6	5
	ATL Marathon (top 100)	2	2	Yet to happen
	ATL Marathon (top 500)	29	19	Yet to happen

*All Seed the Future schools received a grant from Dassault Foundation for developing their ideas.

** Prior to UNICEF engagement, there were no ATLs from government schools which were selected for this prestigious competition. This engagement has changed that, to some extent, and it is very encouraging to see an increasing number of schools getting selected for this competition. Vigyan Ashram has provided mentoring support to the ATLs in government run schools.

dysfunctional ATLs. Over a period, this has changed, and there is greater involvement of the education department in the support and review of ATL functioning. Nationally, the taking over of the ATL initiative by the Ministry of Education has also helped. The appointment of nodal officers, regular communication through circulars, the institutionalization of periods in the timetable for the ATLs along with teacher training have all contributed to a gradual activation and integration of these maker spaces in the schools. With the addition of nearly 600 ATLs in 2025, Telangana has now developed a digital platform with UNICEF's help to streamline ATL monitoring. This is part of the Telangana School Education App. In Andhra Pradesh, ATL monitoring is being done using the LEAP (Learning Enhancement Andhra Pradesh) platform. Karnataka is using Google forms to elicit information from the ATLs.

Integrating ATLs with the school curriculum: UNICEF and Vigyan Ashram developed a three-volume handbook for teachers (shared with the education department for dissemination to all ATLs, online and through physical copies) to respond to teacher's concerns that the ATLs are 'outside the syllabus'. The handbook contains 40 sample lesson plans, indicating to the teacher how core curricular concepts across science and mathematics can be brought alive through activities in the ATLs. Further, the handbook has a section on the 'why, what and how' of Design Thinking. AIM has uploaded this handbook on their website. It is an important step in bringing the ATLs closer to the school and at the same time providing the impetus for school-based innovation.



These engagements have resulted in greater ownership of the ATLs by the school education department, leading to improved monitoring and review; integration of ATLs within the school routine and timetable; regular teacher training (face-to-face and online); efforts at curriculum integration; expansion of the ATLs to cover more schools, among others.

1.4. Objectives of the case study

The rapid scale-up of ATLs across India has created opportunities for fostering creativity, design thinking, and 21st century skills among students. Yet, evidence on how ATLs are integrated into school systems, experienced by different stakeholders, and sustained over time remains limited. In Andhra Pradesh, Karnataka, and Telangana, UNICEF supported ATLs through a hub-and-spoke model, which emphasizes teacher capacity-building, student mentorship, and systemic engagement. This study is designed to generate insights on how these interventions are functioning, their perceived value, and the conditions that enable or hinder their sustainability.

Objectives

The study is guided by the following objectives:

Explore the experiences of stakeholders (teachers, students, and administrators) involved in UNICEF-supported engagements to strengthen maker spaces in Andhra Pradesh, Karnataka, and Telangana, particularly in the context of design thinking and the development of 21st-century skills.

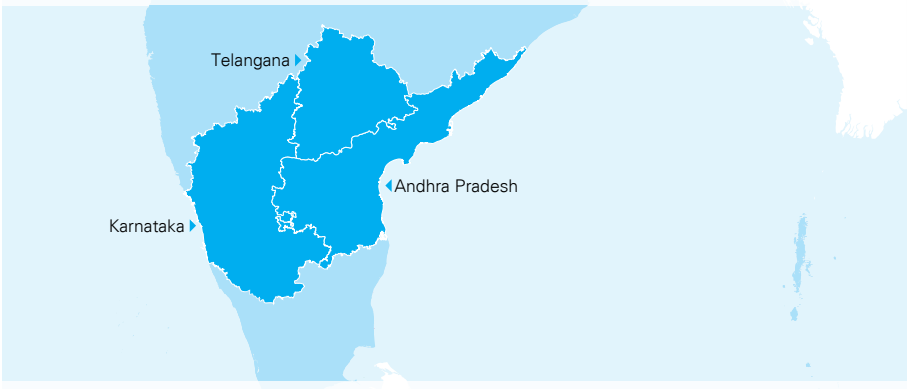
Understand how UNICEF's initiatives in maker spaces are perceived by local stakeholders, focusing on their alignment with educational needs and priorities, and identifying key challenges or gaps in implementation and understanding.

Document the role of maker spaces in shaping pedagogical practices and teacher capabilities, particularly through stakeholder perspectives on changes in teaching methods and attitudes towards learning.

Through these objectives, the study seeks to go beyond infrastructure assessments and capture the lived experiences of stakeholders, the pedagogical transformations emerging from maker space interventions, and the systemic conditions that shape their sustainability. In doing so, the study is expected to contribute actionable insights for policymakers, educators, and development partners working to strengthen ATLs and advance innovation-driven education across India.

1.5. Scope of the study

The scope of this study is defined by the dual purpose of generating insights into the functioning of ATLs and examining the contributions of UNICEF-supported interventions in three Indian states–Andhra Pradesh, Karnataka, and Telangana. Rather than just focusing on measuring impact in a statistical sense, the study is designed as a case-based exploration, enriched with quantitative scores, to capture depth, nuance, and contextual variation.



Coverage of stakeholders and geographies

The study engages a broad spectrum of stakeholders across multiple levels:

School-level actors: Students, ATL teachers and headmasters

System-level actors: District and state education officials, and representatives from technical support agency (Vigyan Ashram)

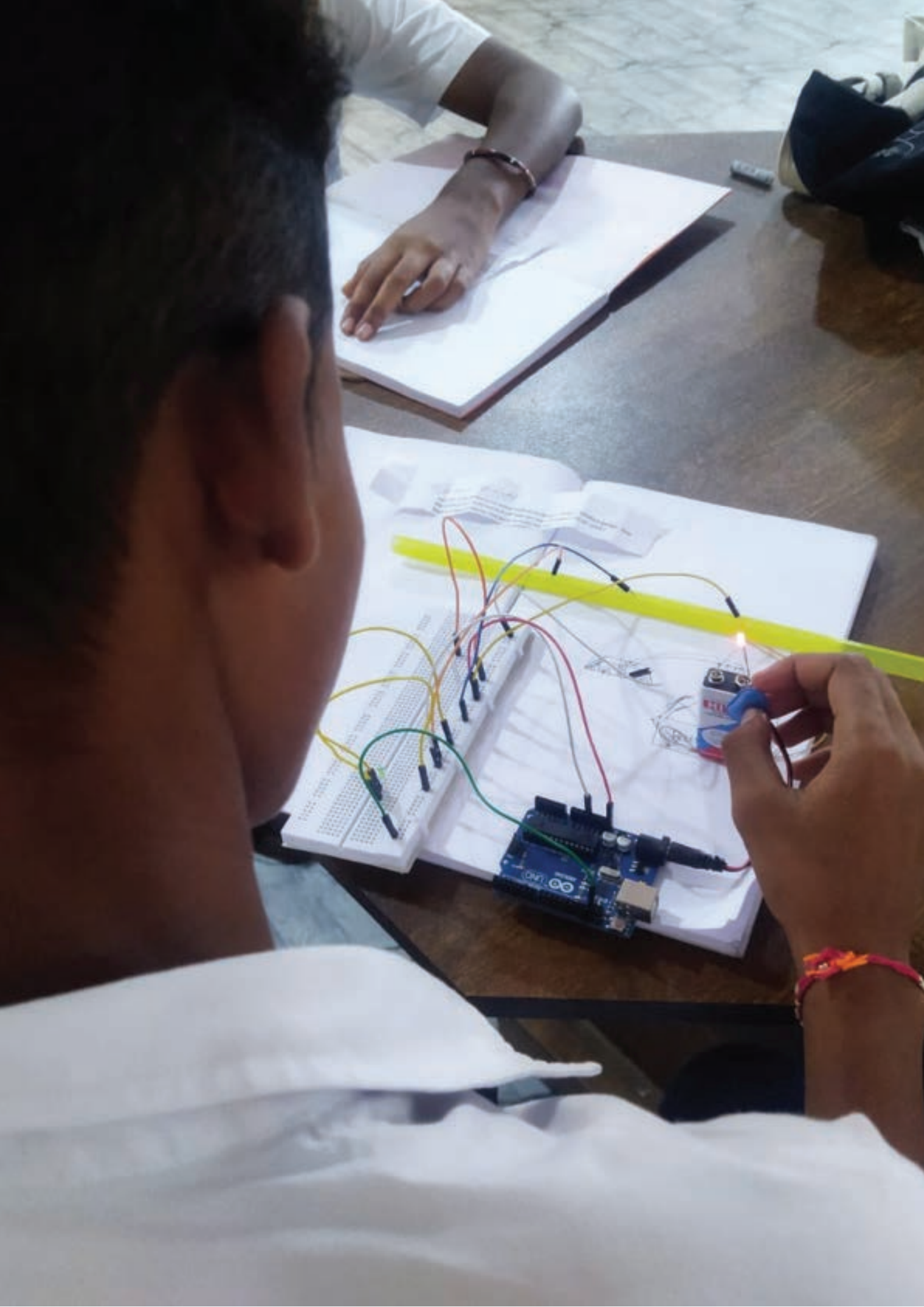
Ecosystem actors: UNICEF staff, engineering faculty and students involved in mentorship, and representatives of the Atal Innovation Mission

Geographically, the study covered 22 out of the 86 hub (about 25% of the hub schools) schools distributed across urban and rural areas in the three states. The inclusion of diverse school settings allows the study to reflect on how context shapes ATL experiences and sustainability.

The study focuses on four interlinked domains:

1. Stakeholder experiences of engaging with ATLs
2. Relevance and fit of ATLs with NEP 2020 and local educational priorities
3. Pedagogical change and skill development (among children and teachers) emerging from ATL practices
4. Systemic enablers and barriers influencing sustainability

While quantitative survey and problem solving are part of the methodology, the study does not aim to establish statistically generalizable results across all ATLs or measure long-term causal impacts. Instead, it emphasizes transferable insights and practical lessons.



2 Methodology

2.1. Study criteria and questions

The study is guided by a set of criteria that reflect the theory of change, study objectives, and stakeholder priorities. The study addresses questions of relevance, effectiveness, efficiency, and sustainability. It explores how ATLs are enhancing 21st-century skills, what pedagogical shifts have occurred, and how interventions align with local priorities. Rather than applying a standardized framework, the criteria are tailored to the context of ATLs and UNICEF-supported interventions in Andhra Pradesh, Karnataka, and Telangana. They focus on capturing the relevance of ATLs within policy and school systems, the experiences of stakeholders, the pedagogical and skill-related outcomes, the inclusiveness of participation, and the systemic factors influencing sustainability. These criteria are translated into guiding questions that shape both data collection and analysis.

Criteria and guiding questions

1. Stakeholder Experiences

- What are the experiences of various stakeholders (teachers, students, education department officials, UNICEF and the technical agency) involved in the engagement to strengthen maker spaces?

2. Student Skill Development

- In what ways have UNICEF-supported maker space interventions influenced student learning outcomes, vis-a-vis design thinking, conceptual understanding, and applicable 21st-century skills?

3. Relevance and Alignment

- According to local stakeholders such as teachers and students as well as administrators, how relevant are the initiatives undertaken by UNICEF in the area of maker spaces?

4. Pedagogical Change and Teacher Capacity

- How have teachers adapted their pedagogical approaches as a result of UNICEF's support? What are the stakeholder perspectives in this regard?

5. Systemic Enablers and Barriers

- What resources were allocated to support maker spaces, and how effectively have these been managed to maximize impact?
- What insights (in terms of challenges and gaps in implementation) have been gained from the implementation of maker spaces that can inform future projects?
- What is the potential for adapting and scaling UNICEF's model of support to other contexts or regions within India?
- What are the lessons learned and best practices emerging from the intervention?

2.2. Conceptual framework: Theory of Change

The Theory of Change underpinning this study reflects UNICEF's engagement with ATLs as part of a broader effort to nurture innovation, design thinking, and 21st-century skills in India's school system. It captures the pathways through which inputs such as infrastructure, training, mentoring, and systemic partnerships are expected to lead to improved student learning experiences, pedagogical transformation, and sustainable institutional ecosystems.

Problem statement: Despite the rapid establishment of ATLs nationwide, several constraints have limited their effectiveness in schools:

- Teachers often lack training in design thinking and hands-on pedagogy.
- ATLs are insufficiently integrated into school timetables and curricula.
- Vendors provide equipment but little capacity support for teachers.
- Rural and government schools, in particular, struggle to operationalize labs due to limited technical support.

The Theory of Change assumes that when teachers are equipped, students are mentored, and systemic buy-in is secured, ATLs can function not merely as technology hubs but as catalysts of experiential, inclusive, and innovative learning.

Inputs and activities: UNICEF, in partnership with Vigyan Ashram and the education department, has introduced a hub-and-spoke model in Karnataka, Andhra Pradesh, and Telangana. The model designates hubs as demonstration and training centres, each linked to 5–10 spoke schools. Activities include:

- Teacher training and mentoring (online and offline).
- Classroom integration of ATL activities.
- Student projects, make-a-thons, bootcamps, and participation in state and national level competitions and exhibitions.
- Establishment of a state training centre to anchor state-wide capacity-building.
- Linkages with HEIs, students to mentor school students in ATL projects (only in Andhra Pradesh).

Outputs: From these inputs, the model anticipates the following immediate outputs:

- Teachers demonstrate confidence in using ATL equipment and design thinking approaches.
- Students engage in tinkering, collaborative problem-solving, and innovation projects.
- Schools integrate ATLs into timetables and recognize ATL teachers.
- Spoke schools begin replicating and adapting hub practices.

Outcomes: In the medium term, the Theory of Change envisions:

- Enhanced student skills – creativity, critical thinking, teamwork, and innovation mindsets.
- Pedagogical change – teachers adopt experiential learning strategies, moving beyond rote instruction.
- Inclusive participation – ATLs are accessible to girls, rural students, and marginalized learners.
- Systemic strengthening – state and district institutions embed ATLs into mainstream education processes.

Long-term impact: If these pathways hold, ATLs will contribute to:

- Embedding design thinking and problem-solving in India's secondary education system.
- Strengthening employability and entrepreneurship among youth.
- Building a culture of innovation that aligns with NEP 2020's vision of holistic, skills-based education.

Assumptions

- Teacher workload and staffing remain stable enough for designated ATL teachers to run regular sessions.
- Equipment remains available and functional for labs and timely access to maintenance support is available.
- Minimum enabling infrastructure including reliable electricity, secure space, and basic digital/internet access remain available at schools.

The Theory of Change thus situates ATLs not as stand-alone labs but as transformative learning ecosystems. Through strategic inputs—teacher training, mentoring, systemic linkages, and student projects—the initiative aspires to generate sustained pedagogical and institutional shifts. This study is structured to test the plausibility of these pathways, explore enabling and constraining factors, and distil lessons for future scaling.

2.3. **Study design**

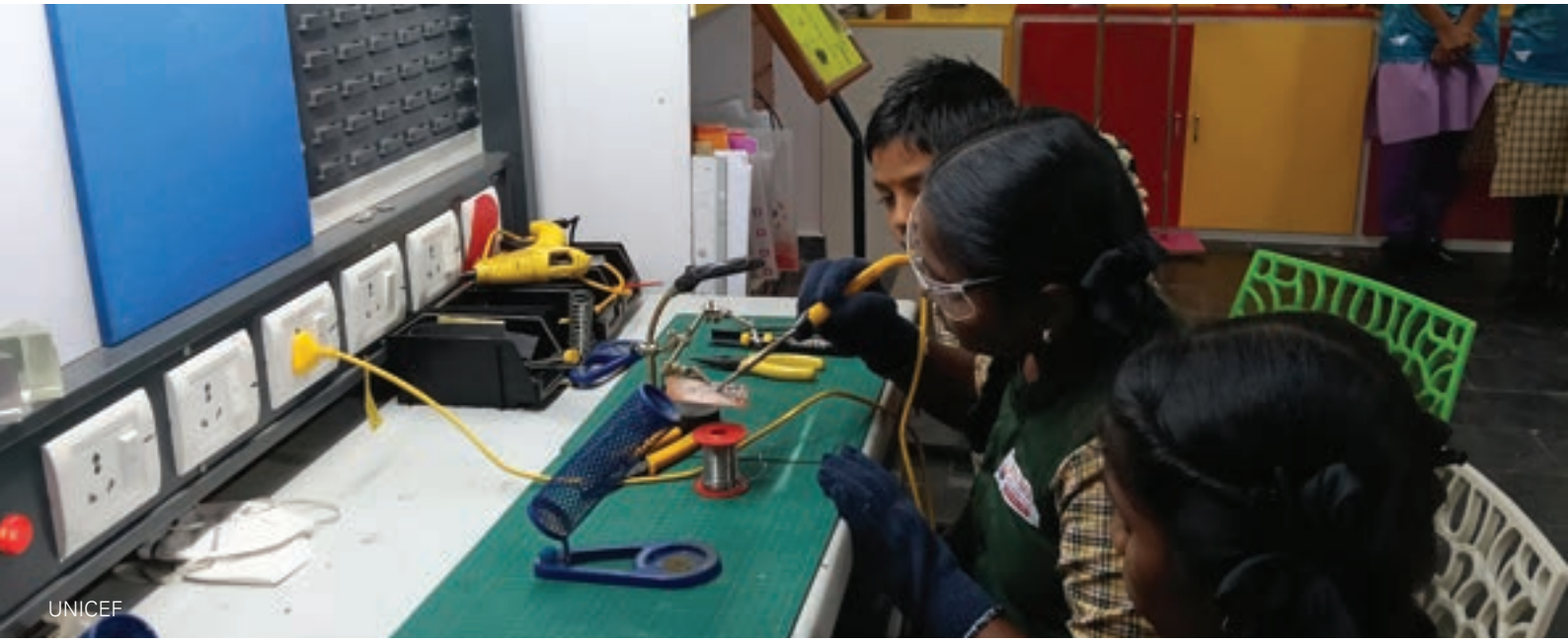
The study is conceived as a case study enriched with quantitative components. This approach is well-suited to capturing the complexity of ATLs, which operate at the intersection of pedagogy, student experiences, and systemic structures. The design emphasizes contextual depth, stakeholder perspectives, and transferable insights across three states—Andhra Pradesh, Karnataka, and Telangana. It has the following features:

Case study orientation: The study is structured as a multiple-case study, with 22 hub schools serving as focal units of analysis. Each case represents a school-level ecosystem where ATLs are implemented, while also reflecting broader district and state dynamics. Comparative insights across schools and states enable the study to identify patterns, variations, and context-specific enablers or barriers.

Mixed-method approach: The design combines qualitative and quantitative methods to generate a holistic picture of ATL functioning:

- Qualitative methods (FGDs, IDIs) capture rich narratives on experiences, perceptions, and systemic processes.
- Quantitative methods (student questionnaires, student and teacher skill rating using structured rubrics) provide descriptive evidence on participation, usage patterns, and skill outcomes.

This combination allows triangulation of data sources and strengthens the validity of findings.



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Embedded systems perspective: The design extends beyond school-level analysis to capture insights from district and state officials, implementing partners, and ecosystem actors. This embedded perspective allows the study to examine how policies, partnerships, and systemic support influence ATL sustainability and integration.

The study design reflects a fit-for-purpose approach that is sufficiently rigorous to provide credible insights, yet flexible to accommodate contextual diversity across three states. By combining case-level narratives with structured observations, the study balances depth and breadth, offering evidence that is both analytically robust and practically relevant for scaling and strengthening ATLs.



2.4. Sampling design

The sampling strategy for this study is guided by the case study design and the objective of capturing rich, contextual insights across diverse geographies and stakeholder groups. A statistically valid sample of students from hub schools was taken for the study.[5] The sample was divided geographically across three States- Andhra Pradesh, Telangana, and Karnataka. For each state, 25% of the hub schools were selected for data collection to ensure equitable distribution across states. Thus, total schools from Andhra Pradesh, Telangana, and Karnataka were 8, 8 and 6 respectively. A purposive sampling strategy was used to select the schools and participants, after discussions with UNICEF. The schools were selected keeping in view that all the intervention activities of the programme were covered in the selected schools. In each school, it was ensured that that all genders are appropriately represented in the study.[6] (See Table 2.1 below)

Table 2.1: **Sample size for the case study**

Stakeholder group/Sample element	Andhra Pradesh	Telangana	Karnataka	Total
Hub schools	8	8	6	22
Quantitative				
Students	166	149	122	437
Qualitative				
ATL teachers and Headmasters (IDIs)	16	16	12	44
Student FGDs	8	8	6	22
District-level officials (IDIs)	8	6	6	22
Other ecosystem actors (UNICEF, Vigyan Ashram, AIM, HEI mentors, etc.)				15

[5] 327 or more measurements needed to have a confidence level of 95% that the real value is within ±5% of the measured/surveyed value (assuming that there are about 25 active students who attend ATL sessions/activities in 86 hub schools, which gives a population of 2150 students across three states).

[6] The final sample distribution is based on the students who actively participate in the ATL sessions. This varies from state to state. The sample will reflect the enrollment/attendance of the students in the ATL sessions.

School selection

- A total of **22** hub schools were purposively selected across Andhra Pradesh, Karnataka, and Telangana. The schools were identified in consultation with the school education department, UNICEF and Vigyan Ashram.

Student sample

- ATL students: Responses from **437** students were recorded using a structured rubric to rate on problem understanding, ideation, iteration, and presentation skills. Responses from **335** students were also taken for MCQs.
- Students also participated in FGDs to capture experiences, perceptions, and gendered dynamics of ATL participation.

Teacher sample

- **22** ATL teachers (one from each hub)
- IDIs were conducted with **22** teachers and **22** headmasters to explore pedagogy, confidence in design thinking, and challenges in operationalizing ATLs.

Administrators and officials

- Key Informant Interviews (KIIs) were conducted with key district and state-level education officials.
- These interviews provided insights into systemic support, ownership, and policy alignment.

Ecosystem actors

- The sample also included ecosystem actors, such as UNICEF staff, Vigyan Ashram team members, AIM representatives, and engineering college faculty and students linked to ATL mentoring. Their perspectives shed light on the broader ecosystem, including technical mentorship, partnerships, and sustainability strategies.

2.5. **Data collection methods**

Data collection for this study was designed to capture both breadth (patterns across multiple schools and stakeholders) and depth (rich narratives of experiences and perceptions). A mixed-method approach was therefore adopted, combining structured quantitative tools with qualitative techniques. This combination allows for triangulation of findings, ensuring credibility and richness of insights.

Student and teacher responses through problem solving

Students and teachers selected one problem statement through a draw of lots and then were given 45-60 minutes to solve the problem and present their solutions.

Focus Group Discussions

Student FGDs: Conducted in all 22 hub schools to explore participation dynamics, perceived benefits, and challenges.

Each FGD followed a semi-structured guide, with participatory techniques (e.g., ranking exercises, innovation storytelling) to encourage dialogue.

Secondary data review

Relevant programme documents, assessment report, training handbook, and ATL monitoring records were reviewed. This helped contextualize primary data and identify consistency or divergence with official records.



In-depth Interviews

Teachers: Conducted with 22 ATL teachers and 22 Headmasters to explore experiences, challenges, and professional growth.

Key Informant Interviews

Conducted with district officials and state officials (District Science Officers/Nodal Officers, State Officials).

These provided insights into leadership support, systemic alignment, and sustainability perspectives.

KIIs were also conducted with ecosystem actors such as UNICEF staff, Vigyan Ashram mentors, AIM representatives, and higher education partners.

Data quality and validation

During data, the Senior Field Research Managers conducted daily debriefing with researchers to understand challenges and resolve any issues. They, along with the Senior Resource Person and Project Manager, conducted monitoring visits to six schools across the three states. The quantitative data obtained through Google forms was cleaned and incomplete entries were removed. The Statistician also carried out one level of data review at their end to identify any anomalies.

For qualitative data, the field notes were reviewed by the Senior Field Research Managers and Project Manager before uploading to Atlas.ti for analysis.

2.6. Analytical approaches

The approach was designed to provide both statistical summaries of participation and outcomes and in-depth insights into stakeholder experiences, while ensuring credibility through triangulation.

The analysis was carried out using a mixed-method framework, combining quantitative and qualitative techniques to address the research questions. The approach was designed to provide both statistical summaries of participation and outcomes and in-depth insights into stakeholder experiences, while ensuring credibility through triangulation.

Quantitative analysis

- Data from the student and teacher rubrics were cleaned, coded, and entered into statistical software (STATA).
- The analysis primarily relied on descriptive statistics (percentages, means, and frequency distributions) to summarize patterns in student skill levels and teacher competencies.
- Disaggregation by gender and state enabled examination of equity and contextual variation.

Qualitative analysis

- Notes from FGDs, IDIs, and KIIs were systematically coded in Atlas.ti using a thematic framework aligned to the criteria.
- An inductive approach was also applied, allowing themes to emerge from stakeholder narratives, particularly around challenges, motivations, and systemic enablers.
- Special attention was paid to gendered participation and variations across states ensuring contextual nuance.

Triangulation

- Findings from different methods and sources were triangulated to strengthen validity. For example, student self-reports were cross-checked with responses in MCQs, while official perspectives from state/district officials were compared against school-level realities.

2.7 Tool finalization and orientation of researchers

A two-day tools finalization was held in UNICEF Hyderabad office on 2-3 July 2025. The workshop was attended by representatives from UNICEF, Vigyan Ashram, and New Concept. The ATL State Nodal Official (Andhra Pradesh) also attended the workshop. During the workshop, the following decisions were taken:

- The schools will be selected purposively by UNICEF and Vigyan Ashram.
- The quantitative tool would be divided into two parts – Problem Statements for Students and MCQs.



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- For the problem statements, the students would randomly choose one problem through a draw of lots. They would be given about 45-60 minutes to work on the problem and then present the solution to the researchers. Similarly, teachers will also be given a problem statement from the lot, and expected to follow a similar process.
- It was decided that both quantitative and qualitative interviews in the school will be completed in two days.
- It was also decided that engineering students will be hired for data collection as they would be better positioned to understand various aspects of ATLs. Researchers well versed with local languages (Telugu and Kannada) were hired for the study.

After selection and on-boarding of researchers, a five-day orientation of researchers was organized in Hyderabad from 28 July to 1 August 2025. This also included one day pilot of tools in Hyderabad and Raichur. Day 1 included an introduction to the study and a hands-on session in the ATL lab in Hyderabad, followed by discussions on key equipment and topics. Day 2 focused on quantitative research tools, with facilitators introducing the research objectives, quantitative and qualitative tools, and scoring methods. Day 3 delved into MCQs, qualitative tools, and ethical guidelines, with a detailed walkthrough and mock sessions. Day 4 included pilot testing of the tools in schools in Telangana and Karnataka. Finally, Day 5 offered reflections from the pilot, tool adjustments, and final clarifications for data collection.

Once the tools were finalized, they were submitted for IRB approval to the Centre for Media Studies (CMS), New Delhi. Inputs from CMS in the tools were incorporated and finalized. The IRB approval certificate is enclosed as Annexure 3.

2.8. **Limitations of the study**

Like all case studies, this study was subject to certain risks and limitations. While mitigation measures were employed, it is important to acknowledge these boundaries to situate the findings appropriately.

- **Representativeness:** The study was based on purposive sampling of 22 hub schools across three states and is designed to follow a case study approach. Findings, therefore, may not be statistically generalizable to all ATLs nationwide.
- **Attribution:** Given the complexity of school ecosystems and the role of multiple actors (government, AIM, NGOs, private mentors), it is not possible to isolate the contribution of UNICEF-supported interventions with certainty. The study instead focuses on plausible contribution and stakeholder perceptions. However, triangulation of rubric scores with MCQs and qualitative interviews has minimized this limitation.

- **Time constraints:** Fieldwork was conducted within a limited time window during the academic year, restricting the ability to capture longitudinal effects or seasonal variations in ATL functioning.

Despite these limitations, the mixed-method, multi-stakeholder design provided credible, contextually rich insights. By explicitly recognizing these risks, the study ensures transparency and supports careful interpretation of findings.

2.9. **Ethics**

Strict ethical protocols were followed while conducting the study. A five day orientation with researchers was conducted which included a session on ethical protocols. All field staff were trained in ethics in evidence generation and child safeguarding protocols during the training/field orientation. Key ethical principles followed were:

- **Informed consent and assent:** Adults provided consent, while students participated with school administration's consent and their own assent.
- **Voluntary participation:** Respondents could withdraw at any time without consequence.
- **Do no harm:** Discussions were conducted in safe, respectful environments.
- **Inclusiveness:** The sample included girls, rural schools to ensure diverse representation. The tools were translated in local languages and researchers administered them in the language comfortable for the respondents.

The research design and tools were reviewed by CMS under UNICEF's quality assurance process.



3 Findings

The following section presents findings from the study. Insights from both quantitative and qualitative tools have been brought together, as and when required. The findings have been organized as per the study criteria and guiding questions listed under Chapter 2:

Stakeholder experiences | Student skill development | Relevance and alignment | Pedagogical change and teacher capacity | Systemic enablers and barriers



3.1 Stakeholder experiences

This section explores the experiences of various stakeholders (students, teachers, education department officials, UNICEF and Vigyan Ashram) involved in the engagement to strengthen ATLs across the states.

3.1.1 Student experience

The experiences of students are broadly categorized in the following areas:

- **ATL usage and participation** includes awareness of ATL, frequency of visits, inclusion in timetable or voluntary participation, types of activities, guidance received, session duration, participation in online sessions, and other engagement forms.
- **Skills and problem-solving** presents findings from the problem statements administered to all students along with relevant findings from MCQs.
- **Perceptions and attitudes** cover aspects like engagement compared to regular classes, perceived burden, gender equality in participation, peer sharing of learnings, challenges faced, availability of materials, and teacher support.
- **Safety and access** include experiences of minor injuries, responses to accidents, permissions to stay back after school, reasons for missing ATL sessions, and willingness to recommend ATL to peers.

Figure 3.1
How did you come to know about the ATL?

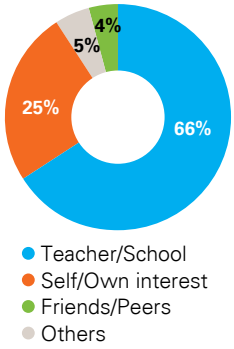


Figure 3.2
How often do you go to the ATL?

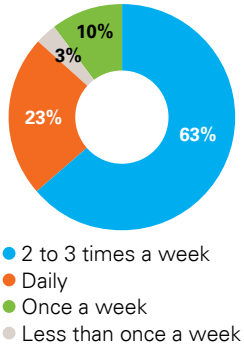
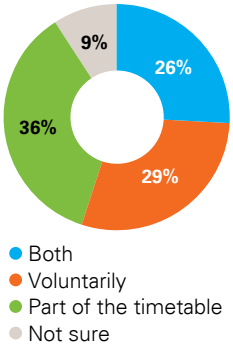


Figure 3.3 **Is ATL included in your timetable or do you go voluntarily?**



ATL usage and participation

A majority of students (65.8%) reported first learning about ATL through their teachers or schools, followed by self-interest (24.8%), while only a small share heard about it through peers, alumni, family, or events. In terms of frequency, two-thirds (63.3%) of students visited ATLs 2-3 times a week, and about one in four (23.3%) reported daily visits, reflecting a high level of engagement.

Regarding scheduling, 36.4% indicated that ATL was part of their timetable, while others participated voluntarily (29.0%) or in combination with scheduled classes (25.7%). Participation in activities was broad-based, with the highest engagement in electrical circuits (86.0%), followed by robotics (39.4%), 3D designs (40.0%), art and design (35.8%), science experiments (34.3%), and coding/programming (31.6%). Most students reported participating in multiple activities, with nearly 30% involved in three activities and another 28% in two activities.

Teachers remained the primary guides (65.8%), though nearly a quarter of students (24.8%) also engaged out of self-interest. The typical session length was 45 minutes (48.7%) or 1–2 hours (31.6%), indicating structured and manageable learning blocks. Participation in online sessions was reported by 43.6% of students, while more than half had not attended ATL-related online sessions.

> **When I came to this school, I wasn't very familiar with the ATL lab. I got to know about it after coming here. We have a period for it every Thursday, and we come and work then. We also come during any free periods. [....] sir helps us with whatever we want to do.**
>
> *- Student, Karnataka*

Figure 3.4

What activities do you participate in at the ATL?

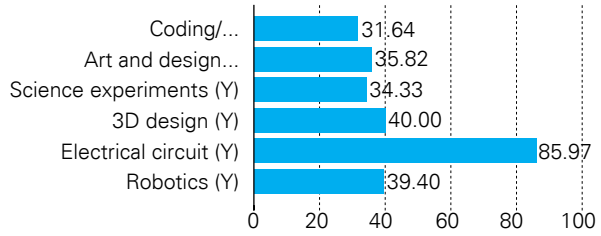
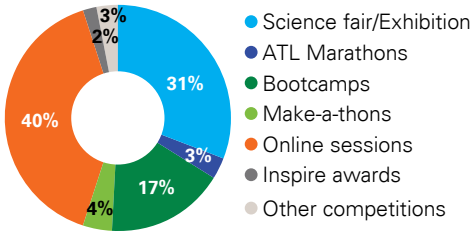


Figure 3.5

Have you participated in any of the event?



Event participation was moderate, with online sessions (40.0%) and science fairs/exhibitions (31.1%) being most common, followed by bootcamps (16.9%). In contrast, ATL marathons, make-a-thons, inspire awards, and other competitions saw lower levels of participation.

State/Gender comparisons

Across the dimensions of state and gender, the data shows that teachers and schools are the dominant channel through which students learn about ATL.

In Andhra Pradesh, the majority of students reported visiting the ATL 2-3 times a week (66.9%), with females slightly more represented (53.0%) than males (47.0%). Daily attendance was more common among boys (81.5%) than girls (18.5%). The Chi-square test ($p = 0.003$) indicates a statistically significant gender difference in visit frequency, with boys more likely to attend daily.

In Karnataka, the 2-3 times per week category again dominated (58.1% of students), and here girls made up two-thirds (66.7%) compared to boys (33.3%). However, daily attendance was skewed towards boys (66.7%). The Chi-square test ($p = 0.001$) confirms significant gender differences, with patterns showing girls, more consistent weekly attendance, whereas boys made more frequent daily visits.

In Telangana, 75 students (63.6%) reported attending 2-3 times weekly, with a nearly equal gender split (49.3% girls, 50.7% boys). Daily attendance was higher among boys (66.7%) than girls (33.3%). Here, however, the Chi-square test ($p = 0.527$) shows no significant gender differences, suggesting visit frequency is more balanced between boys and girls.

Across all three states, more participation was reported by male students in robotics, 3D printing/design, coding, and science experiment. Some activities, such as electronic circuit building, show balanced participation. The Chi-square results highlight that gender differences are most pronounced in areas like robotics, coding, 3D printing, science experiments. In terms of participation in number of activities, a consistent pattern emerges across all states: girls are more likely to engage in one activity, while boys

tend to show multi-activity involvement. This gap is most pronounced and statistically significant in Andhra Pradesh, less in Telangana, and absent in Karnataka. This suggests that while ATL participation is accessible to both genders, sustained and deeper engagement may require more encouragement and support for girls, particularly in Andhra Pradesh and Telangana.

Online engagement varied by state, with highest participation in Telangana (60.2%), moderate in Karnataka (46.2%), and lowest in Andhra Pradesh (25.8%). Across all three states, gender differences were negligible and statistically insignificant.

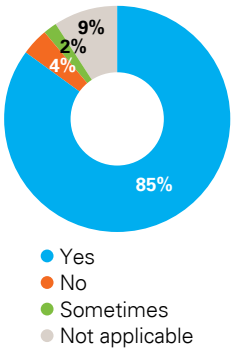
Key Highlight: Across all three states, most students visited ATLs 2-3 times per week, but the gender dynamics varied by state. Andhra Pradesh and Karnataka showed significant differences: boys tended towards daily attendance, while girls were more regular in weekly visits. Moreover, in terms of participation in number of activities, girls are more likely to engage in one or two activities, while boys tend to show multi-activity involvement.

Attitudes and perceptions

The section below presents students' perceptions and attitudes towards participation in ATL sessions, gender inclusivity, challenges, resources, and teacher support.

Nearly all students (95.5%) felt that ATL sessions were more engaging than regular classes, with only 4.5% disagreeing. Regarding workload, a large majority (79.7%) did not consider participation a burden, while 14.3% reported it as burdensome, and about 6% felt it was sometimes or conditionally so. About 84.2% agreed that boys and girls are equally encouraged to participate in ATLs, while only a small share (3.6%) said no.

Figure 3.6
Are boys and girls equally encouraged to participate in ATL?



On peer learning, 89.3% reported sharing their ATL learnings with classmates, 8.7% shared sometimes, and just 2.1% did not share at all. When asked about challenges in using ATLs, the vast majority (93.1%) reported facing few (1–2) challenges, while 6.3% cited multiple (3–5) issues, and almost none reported no challenges.

Teacher support was reported as strong: 84.5% said teachers "always" supported them in projects, with an additional 6.6% saying "often". A small minority noted limited support (rarely 3.0%, sometimes 5.7%, and not at all 0.3%).

State/Gender comparisons

Across all three states, the majority of students felt that ATL participation was equally encouraged for both boys and girls, and they regularly shared their ATL learnings with classmates.

Across all three states, lack of materials, components, and equipment emerged as the most significant challenge, especially in Andhra Pradesh and Telangana. Teacher availability and overcrowding in labs were also notable constraints, particularly in Telangana. Gender differences were generally minimal across states.

> **Sometimes equipment works, sometimes it doesn't. This causes problems when we are programming. They need to check and maintain the equipment annually, see what's not working, and replace whatever is broken.**
>
> *- Student, Karnataka*

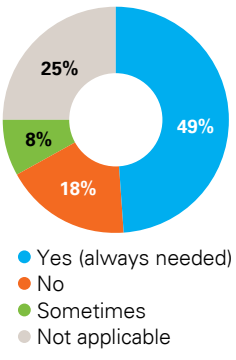
Across all three states, teacher support in ATL projects was rated highly, with "always supportive" being the dominant response, especially in Andhra Pradesh and Karnataka. In Telangana, however, a noticeable proportion of students (25%) reported inconsistent support (sometimes or rarely). Gender differences were not significant in any state, suggesting that teacher support was broadly equitable across male and female students.

Key Highlight: Across all three states, ATL participation was equally encouraged for both boys and girls. However, students in Telangana reported noticeable inconsistent support from their teachers.

Safety and access

While the majority of the students (77.6%) did not encounter any safety issue or injury, a notable 22.9% of students reported facing a minor injury or safety-related issue while working in ATLs.

Figure 3.7 **Are you allowed to stay back after school to attend ATL sessions?**



The female students were specifically asked about permission to stay back after school for ATL sessions. About half (49.4%) said they were always allowed, 25.3% indicated it was not applicable (meaning ATL lab was not available after school hours), 17.5% said they were not allowed, and 7.8% could stay back only sometimes. This suggests that while many students had consistent access, restrictions remained for a substantial minority of female students.

The most common causes of injuries reported were burns from soldering irons and glue guns, followed by minor electric shocks while handling live circuits or batteries, and small cuts from tools such as cutters, mechanical devices, or LED pins. A few students also reported injuries from broken bulbs, falling hammers, and burns from heat guns. In most cases, injuries were minor and managed with immediate first aid (burn treatment, cleaning cuts, etc.), though some students reported not taking any action for very small injuries.

Almost all students expressed a positive outlook towards ATL, with 98.2% recommending ATL to friends or peers, indicating high levels of satisfaction and perceived value despite challenges with safety and access.

While safety-related issues were reported in all three states, they are most frequent in Karnataka (28%) and least frequent in Telangana (16%).

The reasons for not being allowed to stay back for ATL activities ranged from safety and transport concerns, academic pressure/ workload, and household chores.

Key Highlight: Safety concerns, transport issues, and academic pressure, along with the responsibility of household chores, emerge as the key reasons for girl students not staying back after school for attending ATL activities.

3.1.2 Other stakeholders' experiences

Teachers' perspectives

Interviews with teachers across Andhra Pradesh, Telangana, and Karnataka show that the ATLs had become both a catalyst for pedagogical change and a source of strain, depending on the extent of systemic support. Teachers consistently appreciated the opportunities that ATLs created for practical, project-based learning, while also highlighting recurring operational bottlenecks such as staffing, timetabling, fund flows and maintenance.

Pedagogical shifts

Teachers widely agreed that ATL engagement had shifted their practice from rote, lecture-based teaching to hands-on, inquiry-driven pedagogy. Several noted that ATL activities allowed them to make abstract concepts tangible, particularly in physics and science subjects. Teachers said they had started to:

- set up small, syllabus-aligned demonstrations and experiments;
- facilitate student teams and peer tutoring rather than delivering content top-down; and
- encourage iterative problem-solving and tolerance for failure.

Teachers also described adopting more facilitative roles, encouraging peer collaboration, and iterative problem-solving. Weekly online sessions, for instance, helped them structure regular innovation time.

ATL functioned as both a pedagogical tool and a mindset trigger for teachers — where conditions were favourable (time, mentors, functioning equipment), the shift from transmission to facilitation was noticeable and sustained.

Curriculum enrichment

Teachers described ATLs as complementary to the curriculum, especially in STEM subjects. Many examples were given where ATL tools made textbook concepts easier to grasp.

> **ATL has made teaching my Physics subject much easier. Instead of sticking only to textbooks, I now encourage students to think differently, experiment, and link theory with practical applications.**
>
> *- ATL Teacher, Andhra Pradesh*

> **It was initially very scary even to connect a bulb with batteries, but the fears have been overcome because of ATL. Now we demonstrate circuits live.**
>
> *- ATL Teacher, Karnataka*

> **Sessions are structured around generating and implementing own ideas. The Zoom meeting really helps us keep momentum.**
>
> *- ATL Teacher, Telangana*

> **It is mainly helpful for Physics teaching... earlier we used to explain Newton's laws in theory, now we do it practically.**
>
> *- ATL Teacher, Karnataka*

> **There is collaboration between the school and UNICEF. The UNICEF-supported curriculum, introduced by Vigyan Ashram and UNICEF, seems to align with the goal of teaching students about microcontrollers, sensors, and prototypes.**
>
> *- ATL Teacher, Andhra Pradesh*

Teachers described tangible ways in which ATL had supported curriculum goals:

- ATL projects were continually used to demonstrate and rehearse syllabus concepts—notably in Physics (circuits, optics, mechanics) and to a lesser extent in Chemistry and Biology.
- Several schools produced projects that directly benefited the school (e.g., automatic bell, smart attendance), which reinforced the relevance of ATL to enhanced school functioning.
- Teachers reported anecdotal improvements in students' conceptual understanding and examination readiness when ATL activities were aligned with the syllabus.

Projects also served practical school functions, such as an automatic bell or smart attendance systems, making ATL visibly relevant to both academics and school operations.

Capacity-building and training

Teachers valued the exposure from UNICEF- and Vigyan Ashram supported trainings but called for more applied, hands-on support.

> **The support from Vigyan Ashram has been instrumental. I consistently learn new topics from each training session.**
>
> *- ATL Teacher, Telangana*

Karnataka teachers described how refresher workshops and mentorship visits boosted their confidence.

> **Online workshops are conducted regularly and every year, face-to-face refreshers are held. Selected people go to Pune for more exploration.**
>
> *- ATL Teacher, Karnataka*

Teachers credited UNICEF, Vigyan Ashram, and Samagra Shiksha for training, mentorship, and exposure to competitions.

> **Vigyan Ashram and UNICEF gave us training and technology support. Engineering student mentors provided through Samagra Shiksha were very effective.**
>
> *- ATL Teacher, Telangana*

> **There were many activities that have been amazingly conducted with the collaboration of UNICEF and Vigyan Ashram. We were also taken to Pune to be given adequate training along with constantly clearing our doubts. These training sessions and resources have been of utmost help to all of us in furthering our scientific temperament.**
>
> *- DSO, Andhra Pradesh*

In some instances, the institutional push came from school leadership. Recognition from government officials, such as the Deputy Chief Minister's appreciation of an ATL student project in Andhra, further boosted morale.

> **The principal informed in 2019 that there is an ATL Lab and I, being a science teacher, needed to take charge. Support from SRF Foundation and later UNICEF made this possible.**
>
> *- ATL Teacher, Karnataka*

Systemic barriers and constraints

Despite enthusiasm, teachers also faced challenges that constrained ATL's potential. Teachers identified structural constraints that limited ATL's effectiveness:

- Projects required extended, uninterrupted time blocks, which clashed with syllabus completion and exam schedules. Teachers reported difficulties in protecting ATL time, without affecting core subject coverage.
- The ATL teacher role was typically an add-on for a subject teacher. Teachers asked for dedicated, technically trained ATL instructors or rotating technical mentors (engineers/ STEM trainers) to reduce overload and improve technical quality.
- Multiple responses referenced outdated or non-functional components (Node MCU, Bluetooth modules, servo motors, 3-D printers), slow fund disbursements, and inadequate maintenance plans—especially in remote schools.

> **Project activities take a lot of time. There is a time-problem between the regular curriculum and ATL lab activities.**
>
> *- ATL Teacher, Andhra Pradesh*

Teachers also acknowledged gender disparities in access. However, some teachers actively sought to challenge stereotypes.

> **Girls are often not allowed to participate in after-school activities. Parents do not permit them to stay after regular school hours, which severely limits their access.**
>
> *- ATL Teacher, Andhra Pradesh*

> **Girls usually don't come to this field. We took this as a challenge... girls were good at coding, boys at prototypes. We made sure both could do all tasks.**
>
> *- ATL Teacher, Karnataka*

School leadership's perspectives

Headmasters across the three states described ATLs as an important institutional innovation that had changed school culture, raised student aspirations, and created new avenues for hands-on learning. They reported that becoming a hub often conferred visibility and responsibility — hosting hub-and-spoke sessions, mentoring neighbouring schools, and showcasing student work at fairs. At the same time, headmasters pointed to recurring operational constraints (staffing, space, vendor performance, funding timelines) that limited scalability and sustained impact.

Most headmasters recounted that selection as a hub school followed district-level observation and endorsement (often by the District Science Officer). Hub status had allowed schools to run monthly hub-and-spoke sessions, host bootcamps, and provide training to neighbouring schools. One headmaster said the hub role had *"elevated our school's profile and contribution to the educational community"*.

Headmasters also noted that hub activity generated peer learning: they routinely *visited other schools to observe their work and provide training*, and they described mixed uptake at spoke schools — active where local interest existed, dormant where it did not.

Headmasters consistently reported that the ATLs had shifted teaching and learning towards project-based, interdisciplinary, and student-centred modes. Practical benefits were emphasized for STEM teaching, especially physics:

> **ATL has made teaching my Physics subject much easier... now we demonstrate circuits live.**
>
> *-Headmaster, Karnataka*

Several headmasters described observable student outcomes: improved confidence, curiosity, teamwork, higher class participation, and increased aspiration for engineering and technical careers. One principal noted that projects were reaching high levels of recognition and incubation:

> **In 2023, 38 projects were submitted; 2 were selected for start-up incubation; 12 went to national-level recognition in 2024.**
>
> *-Headmaster, Telangana*

Headmasters also valued the ATL for enabling students to work on community-relevant problems (rain detectors, irrigation systems, smart dustbins), which helped link school learning to local needs.

Headmasters appreciated UNICEF, Vigyan Ashram, Samagra Shiksha and other partners for technical guidance, trainings (including exposure visits to Vigyan Ashram's maker space facility at Pune), and connecting students to competitions. Several headmasters noted effective mentorship from Vigyan Ashram and engineering student rosters, and described the hub-and-spoke model as valuable for capacity spread.

However, some also urged a shift in training design towards deeper, practice-oriented in-school mentoring, and called for stronger government ownership and regular monitoring to complement partner support.

Operational & resourcing challenges
The following challenges emerged from the interactions with headmasters:

- **Vendor performance and procurement:** Several principals reported vendor unreliability: vendors delivered initial workshops but then reduced engagement once paid.

- **Staffing and role clarity:** Most schools lacked a dedicated, full-time ATL teacher. ATL responsibility was frequently an add-on for a subject teacher, creating workload tensions and uneven implementation. Headmasters repeatedly recommended appointment of a dedicated ATL in-charge.

- **Space and maintenance:** Many headmasters requested larger, consolidated ATL spaces and better maintenance arrangements (combining small rooms into one big lab, storage and security for equipment).

- **Timetabling conflicts:** School leaders observed pressure between syllabus completion and project time; students wanted more ATL periods but adjusting timetables proved difficult.

- **Sustainability of funds and monitoring:** While initial grants had created labs, headmasters emphasized that predictable maintenance funds, timely disbursements, and monitoring were needed to sustain activity.

Headmasters' accounts showed clear evidence that ATL could change teaching practice, raise student aspirations, and connect schools to broader innovation ecosystems. However, they were also forthright about the practical challenges, resourcing and staffing reforms needed to shift ATL from a vibrant but fragile initiative to a durable, system-level practice.

Experiences of other stakeholders
This section presents overall experiences of district and state level officials, and ecosystem actors such as UNICEF, Vigyan Ashram and NITI Aayog.

DSOs/DNOs[7] described their experience as *"engaging and transformative"*, with visible student growth in confidence, creativity, and technical skills.

A DSO from Andhra Pradesh expressed the pride many officers felt:

> **We've had some real successes. In the School Innovation Marathon 2024, out of the top 1000 projects, five came from Krishna district (2 of them from the Movva school). We also had the highest number of nominations across the district. At the international level, one of our teams got selected nationally and represented India in Dallas. Out of 2000 projects from 200 countries, they stood at the 4th place — that was a proud moment.**
>
> *– DSO, Andhra Pradesh*

[7] District Science Officers in Andhra Pradesh and Telangana, District nodal Officers in Karnataka

Across all states, DSOs/DNOs stressed that UNICEF and Vigyan Ashram's support had been highly relevant in jumpstarting ATL ecosystems. Key contributions included:

> **The trainings gave teachers the confidence to guide projects. We adopted a philosophy: 'Learn and let them learn'.**
>
> *- District Official, Andhra Pradesh*

- Training workshops (e.g., residential training, district-level workshops, online refreshers)
- Orientation handbooks and technical resources that boosted teacher confidence
- Exposure visits and bootcamps that created enthusiasm among students and teachers.

Across Andhra Pradesh, Telangana, and Karnataka, DSOs emphasized that ATLs have become catalysts of innovation and recognition for government schools. Students who once struggled with rote learning are now producing robotics projects, waste management machines, and agricultural prototypes that have reached state, national, and even international platforms.

Officials narrated how local leaders and education officials took note of student innovations, often funding or showcasing them. In Karnataka, a case in point was a student's ATL prototype shared online, which drew the Deputy Chief Minister's support for further development. For many DSOs, this signals not just a change in technical capacity but a broader cultural shift: *"Five years ago, such advanced, hands-on labs in schools were unimaginable. Today, ATLs have transformed the learning environment."* In their view, ATLs are now central to promoting holistic, 21st century skills — from design thinking and problem-solving to leadership and collaboration.

Barriers and implementation gaps

Despite strong starts, district officials were frank about systemic barriers:

- **Equipment fragility:** 3D printers, laptops, and Arduino kits frequently break down, with no clear repair budgets. Vendor dependency creates bottlenecks and vendors often do not respond on time or respond at all.
- **Teacher burden:** ATL duties are often "piled on" to physics/science teachers without compensation or adjustments in their schedule. As one Andhra DSO noted: *"ATL is treated as an extra period, not as part of the curriculum."*
- **Curriculum Disconnect:** Few links exist between ATL projects and textbooks, so many schools see it as "add-on" rather than integrated pedagogy.

- **Weak Monitoring:** Lack of reporting formats, inconsistent visits, and the absence of platforms like real-time dashboards meant that the education department, both at state and district levels, is not able to systematically track the functioning of ATLs.

In the three states, UNICEF and Vigyan Ashram supported the education department in developing a basic set of parameters for ATL monitoring. While this resulted initially in department reviews at the state level, the review process has not been consistent. The states of Andhra Pradesh and Telangana have, more recently, decided to integrate ATL monitoring with the overall school monitoring mechanisms using digital platforms. The state of Andhra Pradesh has set up the monitoring mechanism as part of its LEAP (Learning Enhancement Andhra Pradesh) digital platform. This platform enables the generation of data analytics, and it is hoped that this will strengthen the monitoring and review of ATLs more efficiently. Telangana has similarly developed a digital platform as part of its Telangana School Education App. Both these platforms enable self-reporting by ATL teachers, as well as reporting by department officers from the districts and state. In Karnataka, the department's monitoring of ATLs is yet to become systemic and regular.

The states of Andhra Pradesh and Telangana have, more recently, decided to integrate ATL monitoring with the overall school monitoring mechanisms using digital platforms. The state of Andhra Pradesh has set up the monitoring mechanism as part of its LEAP (Learning Enhancement Andhra Pradesh) digital platform.

These recent efforts are good examples of the mechanisms that the education department is envisaging to strengthen ATLs**.**

Administrative measures have also been undertaken to support district level officials to undertake ATL monitoring and review. In Andhra Pradesh, the state has allotted Rs. 50,000/- per year to each DSO to help meet mobility costs while visiting the ATLs. These measures are critical as the DSOs are full time teachers whose mobility costs need to be borne by the department if they are to play their additional role effectively.

District-level insights for future projects

DSOs/DNOs' reflections offer strategic insights:

- **Integration vs. Extracurricularity:** ATL must shift from "extra" activity to a core modality of teaching science, math, and even arts. For this, a strong linkage with the curriculum is needed.

- **Cascade Training Models:** Training only hub teachers creates bottlenecks. At least two teachers per school (across disciplines) should be trained. Ideally, all science and mathematics teachers, along with any other teacher who is interested in using the ATL as a learning space.

- **Student Mentorship:** Engineering students or young innovators (in Andhra Pradesh) can be brought in weekly — an idea echoed by both district officials and teachers in Karnataka.

The district officials viewed ATLs as more than just laboratories — they saw them as entry points into a new culture of learning. While gaps remain in

funding, staffing, and curriculum integration, the consistent message from district leaders is that the momentum must not be lost. As one DSO put it, *"ATL has changed the identity of our schools — students now dream differently."* With continued investment in teacher capacity, dedicated ATL coordinators, and stronger policy alignment, district officials believe the initiative can scale from isolated pockets of excellence to a system-wide driver of innovation and equity in public education.

3.2 Student skill development

As discussed under Chapter 2, responses were recorded from 437 students using a structured rubric to rate on problem understanding, ideation, iteration, and presentation skills. Students selected one problem statement through a draw of lots and then were given 45-60 minutes to solve the problem and present their solutions.

Responses from 335 students were also taken for Multiple Choice Questions.

Skills observed vis-vis administering problem statements

Problem statements were administered to 437 students across three states—Andhra Pradesh (n=166), Karnataka (n=122), and Telangana (n=149)—with a slightly female-skewed sample (232 females, 205 males). Within states, females constituted about 55% in Andhra Pradesh and Karnataka, while Telangana was near parity with a slight male majority.

Across the sample, average scores were above 3.5 on all indicators, indicating generally positive performance on a 1–5 scale. Problem


UNICEF

Understanding & Planning (PUP) emerged as the strongest area (mean 4.22), followed by Presentation & Reflection (PR) at 4.02. Implementation & Technical Skills (ITS) and Iteration & Problem Solving (IPS) trailed slightly at 3.94 and 3.87 respectively. The full range of scores (1–5) appeared on every indicator, signalling meaningful dispersion with both high and low performers present in the dataset.

Table 3.1: **Group-wise summary statistics: Cross-tabulation of gender and rubric indicators**

Variable	Observation	Mean	Std. Dev.	Min	Max
Female					
Problem Understanding & Planning	232	4.10	1.03	1	5
Implementation & Technical Skills	232	3.71	1.19	1	5
Iteration & Problem Solving	232	3.59	1.24	1	5
Presentation & Reflection	232	3.78	1.17	1	5
Male					
Problem Understanding & Planning	205	4.36	0.89	1	5
Implementation & Technical Skills	205	4.20	1.00	1	5
Iteration & Problem Solving	205	4.18	1.03	1	5
Presentation & Reflection	205	4.29	0.90	1	5

State-wise findings show the students in Karnataka were ahead consistently across all four areas, coupled with tighter dispersion (lower standard deviations), indicating both higher and more uniform performance. Karnataka's means ranged from 4.18 to 4.44 across the four indicators. Andhra Pradesh occupied a middle band (e.g., ITS 3.92; IPS 3.81), while Telangana's scores ranked third (e.g., ITS 3.77; IPS 3.63). The largest state gap appeared in IPS (Karnataka 4.23 vs Telangana 3.63), echoing the gender pattern.

In addition, the scores in Telangana show comparatively higher dispersion, pointing to uneven learning within the state. By contrast, Karnataka's lower standard deviations suggest more consistent learning among the students.

Gender-wise disaggregation shows that males scored higher than females on all four indicators, with modest differences in PUP (4.36 vs 4.10) and more pronounced gaps in other areas. The largest difference appeared in IPS (4.18 for males vs 3.59 for females), closely followed by PR (4.29 vs 3.78) and ITS (4.20 vs 3.71)[8].

Gender and rubric scores

To examine whether average performance differed by gender on each rubric domain, independent two-sample t-tests[9] with equal variances were conducted for all the rubric criteria. Findings from these tests are included in Annexure 2.

[8] It needs to be noted that interventions in three states did not begin at the same time. AP began first (end of 2021); Karnataka started in 2022; and Telangana in 2023.

[9] It compares the mean score of two independent groups (boys vs. girls) to see if the difference is bigger than we'd expect from random variation.


UNICEF

These results indicate that the skills related to PUP have a smaller gender gap, while those related to ITS, IPS and PR competencies show consistently larger male advantages in this dataset.

Across all four outcomes, males scored higher on average than females. The size of the gap varied by domain and was most pronounced for practice-oriented and reflective skills. For PUP, the female mean was 4.10 and the male mean was 4.36. This represents a modest gap, consistent with a small effect in practical terms. In contrast, ITS showed a larger separation: females averaged 3.71 versus 4.20 for males, a difference of –0.50 points, indicating a small-to-moderate, practically meaningful gap favouring males in technical execution.

The largest gender difference emerged for IPS. Females averaged 3.59 while males averaged 4.18; the mean difference being statistically significant. Presentation and Reflection also showed a clear difference, with females at 3.78 and males at 4.29; the mean difference of –0.51 points was significant.

These results indicate that the skills related to PUP have a smaller gender gap, while those related to ITS, IPS and PR competencies show consistently larger male advantages in this dataset.

States and rubric scores

To assess whether student scores varied significantly across the three states (Andhra Pradesh, Karnataka, and Telangana), one-way Analysis of Variance (ANOVA) tests for each rubric indicator were conducted. These tests were used to determine if the observed differences in group means were statistically significant. The detailed results from these ANOVAs are presented in Annexure 2 and their interpretation is given below for each criterion.

Problem Understanding & Planning by State

The ANOVA test for PUP showed a statistically significant difference between the three states. The mean student scores across states were as follows: Karnataka (4.44), Andhra Pradesh (4.17), and Telangana (4.09). These

results indicate that students in Karnataka scored significantly higher on PUP than those in Telangana, with Andhra Pradesh falling in between. While this is a modest difference, it is statistically reliable, and suggests that *students in Karnataka may have stronger problem understanding and planning skills compared to their peers in Telangana.*

Implementation & Technical Skills by State
The ANOVA for ITS revealed a statistically significant effect of state. Karnataka had the highest mean score (4.18), followed by Andhra Pradesh (3.92), and Telangana (3.77). These results suggest that students in Karnataka outperformed those in both Andhra Pradesh and Telangana on ITS tasks. The difference between Karnataka and Telangana was the largest.

Iteration & Problem Solving by State
The ANOVA for IPS showed the largest and most significant difference between states. The mean scores across states were: Karnataka (4.23), Andhra Pradesh (3.81), and Telangana (3.63). Students in Karnataka outperformed their peers in both Andhra Pradesh and Telangana on this skill, which involves testing, refining, and problem-solving. The differences between states were substantial, particularly between Karnataka and Telangana. These findings highlight Karnataka as the strongest performing state in terms of iteration and problem-solving.

Presentation & Reflection by State
The ANOVA for PR showed a statistically significant difference between the three states. Karnataka had the highest mean (4.24), followed by Andhra Pradesh (3.95), and Telangana (3.92). Although the differences were not as large as those seen in IPS, Karnataka again emerged as the state with the highest presentation and refection scores, followed closely by Andhra Pradesh and Telangana.

Summary
The results from statistical tests highlight meaningful state-based differences in all four rubric areas, with Karnataka consistently outperforming the other two states, particularly in IPS, followed by PUP and ITS. Students and other stakeholders from Karnataka seemed to echo this sentiment. A Headmaster in Karnataka shared how students are engaged with their ATL work:

The students get to know different skills. When they get involved with them, they learn different skills. They are getting engaged in it. Now, when we call them for their regular period, they are so engaged that... when they are engaged in ATL work, they do not come out from the room. They are not ready to come out. Even if you say, 'Hey, come for your class', they will say, 'Just a little more' and stay there. They stay right there.

– Headmaster, Karnataka

For me, ATL is all about interest. When we go there, we feel happy, like we're going to discover or invent something on our own. Just like how scientists made discoveries, we feel immense joy when we create even a small thing, a small model, and explain it. When I first came, I didn't even know how to use anything in the ATL lab. One time, sir gave me a model and explained it, and I thought, "Wow, this is so cool!" It was a great experience. That's why I love going to the ATL lab.

- Student, Karnataka

Overall, the result suggests significant gender and state-level differences, with female students performing lower and Karnataka students performing better on average.

Correlation between state, gender, and rubric indicators

The regression results show that on average, female students scored nearly half a point lower than males, and this difference is statistically significant. Among states, compared to Andhra Pradesh (the reference group), students in Karnataka scored significantly higher by about 0.31 points, while students in Telangana scored slightly lower by –0.14 points, though this was not statistically significant.

Overall, the result suggests significant gender and state-level differences, with female students performing lower and Karnataka students performing better on average.

Problem Understanding & Planning by State and Gender

The regression results indicate that that on average, female students scored about a quarter point lower than males, and this gap is statistically significant. Comparing states to Andhra Pradesh, students in Karnataka scored significantly higher by 0.27 points, while students in Telangana scored slightly lower by –0.10 points, but this difference is not statistically significant.

Overall, the findings suggest a measurable gender gap in problem understanding and planning that favours male students, along with a positive effect for Karnataka students relative to Andhra Pradesh, while Telangana shows no significant difference.

Implementation & Technical Skills by States

This regression shows that females score, on average, about half a point lower than males on technical skills, a gap that is both sizable and statistically significant. Relative to Andhra Pradesh (reference state), Karnataka students scored higher by 0.26 points, a modest but significant advantage, while Telangana students scored lower by –0.18 points, though this difference is not statistically significant.

Overall, the results highlight a notable gender disadvantage for female students in implementation and technical skills and a state-level advantage for Karnataka, whereas Telangana students do not differ significantly from those in Andhra Pradesh.

Iteration & Problem Solving by States

The regression results show that females scored, on average, more than half a point lower than males, a substantial and statistically significant disadvantage. Relative to Andhra Pradesh (reference state), Karnataka students scored higher by 0.41 points, showing a significant positive effect, while Telangana students scored lower by –0.22 points, but this was only marginally significant.

Overall, the results point to a clear gender gap disadvantaging females in integration and problem-solving, alongside a notable performance advantage for Karnataka students, while Telangana's performance does not significantly differ from Andhra Pradesh.

Presentation & Reflection by States

The regression results indicate that females scored, on average, about half a point lower than males, a statistically significant disadvantage. Compared with Andhra Pradesh, Karnataka students scored higher by 0.28 points, suggesting a modest but significant advantage, while Telangana students scored slightly lower by –0.07 points, though this was not statistically significant.

Overall, these results highlight a consistent gender gap disadvantaging female students and a positive performance effect for Karnataka, while Telangana shows no meaningful difference relative to Andhra Pradesh.

Summary of all four regression models

The regression analyses consistently show that gender and state are significant predictors of the four skills. Across all four skill domains, female students scored significantly lower than male students.

In terms of state-level differences, students in Karnataka consistently outperformed those in Andhra Pradesh (reference group) across all domains, with statistically significant advantages. By contrast, students in Telangana generally scored slightly lower than those in Andhra Pradesh, but these differences were not statistically significant in any domain.

Key Highlight

There is a gender gap with a clear disadvantage for female students across all skill domains, most pronounced in technical skills and problem-solving.

A state-level performance advantage for Karnataka students, while Telangana does not differ meaningfully from Andhra Pradesh.

Understanding reasons for low girls' scores

In order to have an in-depth understanding of low girls' scores across the states, the scores of respondents from girls' only schools (n=41) were analysed separately.[10] The following table presents mean scores of students from girls, only schools:

Table 3.2: **Summary statistics**

	Problem Understanding & Planning	Implementation & Technical Skills	Iteration & Problem Solving	Presentation & Reflection
Mean	4.41	3.93	3.72	4.10

[10] To understand why girls were getting low scores, we tried to analyse scores from girls, only schools separately. If girls score better in girls, only schools than co-ed schools, we could say that girls thrive better academically in girls-only schools. Though the analysis does not say this. There is only one area where advantage is shown.

- Problem Understanding & Planning: Girls' only mean 4.41 vs Co-ed mean 4.04; statistically significant uplift for girls in girls-only schools.
- Implementation & Technical Skills: 3.93 vs 3.67; positive trend, not significant.
- Iteration & Problem Solving: 3.72 vs 3.57; not significant.
- Presentation & Reflection: 4.1 vs 3.73; not significant at 0.05.
- Overall advantage for girls' only schools, but not statistically significant.

While girls' only schools show a clear, statistically significant advantage on PUP, there is no significant positive advantage on ITS, IPS, and PR. The advantage on PUP can be explained through the following possible scenarios:

- Since Karnataka is the highest-performing state on all four domains and 50% of the respondents from girls, only schools are from Karnataka, the mean scores for girls are likely to be higher.
- Girls-only environments can reduce stereotype threat, increase participation, and normalize leadership roles for girls. Other studies also support this hypothesis (Spencer, 1998). However, the data from girls, only schools is limited (n=41) and cannot be generalized.

The weightage of girls, only schools is low in the overall sample of girls. So, the overall score for girls is not impacted much. Responses from MCQs, FGDs and in-depth interviews can shed some light on the gender disparity in the scores.

Girls do not show interest due to personal reasons and because their parents won't allow them to attend sessions. This indicates a differential impact where girls are less engaged.

- ATL Teacher, Andhra Pradesh

If you look at the involvement, boys learn very fast and their involvement is high. Girls, however, need more. We have to push them a little forcefully. It's not like that for the boys; if you tell them to do this, they leave everything and come to ATL. Girls are not like that; they manage both (academics and ATL), so their presence in ATL is a bit low. Boys' presence is high. Girls are slightly lower, so this time I have selected more girls. We need to empower them; they hesitate. If they have to do something, they worry, "Sir, this might burn, or that might happen". So I insist, "No, you do it". I also taught them circuit connections and 3D card making during the previous training. When the first batch came one year ago, I finished the training first. At that time, I gave them work and taught them, and they were all doing it.

– ATL Teacher, Karnataka

However, a lot of positive responses on girls' participation have also been noted. Hence, this area needs more exploration to ascertain the root causes.

Design thinking skills


UNICEF

To understand if students acquired design thinking skills, students were presented with five statements and were asked to record their responses in a Likert scale with scores of 1-5. These statements represented five key elements of design thinking skills – Empathize, Define, Ideate, Prototype and Test. The statements presented before the students were:

- I took time to understand the thoughts, feelings, and challenges of those who are affected by a problem before trying to solve it.
- I could clearly explain what the core problem was before moving forward with solutions.
- I came up with different ideas to solve the problem, even if some ideas were unusual or were not practical.
- I built rough models, sketches, examples to test and improve my ideas before finalizing them.
- I actively sought feedback on my ideas and used it to make my solution better.

For Empathize, a majority students (89%) agreed or strongly agreed that they took time to understand others' challenges before solving problems, with a mean of 4.37. For Define, 85.4% reported being able to clearly explain the core problem, with a mean of 4.29, reflecting strong problem-definition skills. In Ideate, responses were more mixed: while 67.4% agreed or strongly agreed that they generated different ideas, 20% were neutral, and 12.4% disagreed. This stage had a lower mean of 3.93, suggesting relatively less confidence in idea generation compared to other stages. For Prototype, nearly 83% agreed or strongly agreed that they built sketches or models to test ideas, with a mean of 4.27. Finally, Test had the highest positive response, with 89.7% agreeing or strongly agreeing that they sought feedback and used it to improve their solutions, and a mean of 4.41.

Gender/State comparisons

Across states, Andhra Pradesh consistently demonstrated the strongest design thinking skills, particularly in Empathy (55% strongly agree), Defining problems (59%), Prototyping (63%), and Testing solutions (64%), showing students' confidence in applying these processes. Karnataka also performed well, especially in Ideation (50% strongly agree) and Defining Problems (50%), though with relatively higher neutrality, indicating mixed certainty among some students. In contrast, Telangana lagged in Ideation (31% strongly agree) and Prototyping (41%), with more neutral and disagreeing responses, suggesting lower confidence in generating creative ideas and building prototypes, even though overall agreement remained moderate.

Across states, gender differences in design thinking skills show mixed patterns. In Andhra Pradesh, both boys and girls reported similar levels across all five design thinking components, with no significant differences. In Karnataka, gender responses were also largely balanced, except in the Test stage where boys significantly outperformed girls. In contrast, Telangana showed consistent gaps across multiple components—particularly Empathize, Ideate, Prototype, and Test—with boys reporting higher levels of skills than girls, some reaching statistical significance. This indicates that while gender parity exists in Andhra Pradesh and mostly in Karnataka, girls in Telangana may require additional encouragement and opportunities to strengthen their design thinking skills.

At the state level, Karnataka recorded the highest mean score (4.37), closely followed by Andhra Pradesh (4.34), while Telangana reported the lowest (4.08), indicating comparatively weaker performance in design thinking skills. The standard deviations are moderate (0.60–0.66), suggesting a fairly consistent distribution of responses within each state.



Overall, while the design thinking skills are generally strong across states, students in Telangana lagged behind slightly, and the gender-wise analysis shows females displaying stronger and more consistent skills than males.



By gender, females (4.33) had a higher mean score compared to males (4.19), with females also showing less variation than males. This indicates that girls not only performed slightly better but also had more consistency in their design thinking skills, whereas boys' responses were more dispersed.

Overall, while the design thinking skills are generally strong across states, students in Telangana lagged behind slightly, and the gender-wise analysis shows females displaying stronger and more consistent skills than males.

Regression of design thinking scores on state and gender
The regression model examined the association of state and gender with students' overall Design Thinking score (N = 445). The analysis showed the following:

- **State:** Compared to Andhra Pradesh, students from Telangana scored significantly lower on design thinking, whereas no significant difference was observed between Andhra Pradesh and Karnataka

- **Gender:** Female students reported significantly higher scores than males, suggesting a female advantage.

Takeaway from high design thinking scores vs low rubric scores of girls
Observer-rated rubric scores across four domains show higher scores for boys overall while a self-reported design-thinking scale shows girls slightly higher and more consistent. These patterns can co-exist due to the following possible explanation:

- Measurement mode differs for the two tools: Self-reports are sensitive to identity-safe norms and social desirability, whereas rubrics capture what made it into prototypes/presentations given time, materials, observation.

- Likert scale emphasizes habits which are different from what the rubric is trying to measure.

- Gender gaps vary by state and girls' only schools lift girls' problem understanding and planning scores.

- Ceiling effects[11] on 1–5 scales further attenuate cross-measure links.

Other skills reported by students

The MCQs posed a number of questions which allowed students to self-report on diverse skills acquired through ATL sessions. These include problem-solving approach, application to real-life problems, creativity, technical skills, teamwork, etc.

- **Problem-solving approach:** When faced with a new problem, most students (60%) reported that they first try to understand the problem, while 23.3% immediately attempt solving it and 16.4% prefer to ask someone else for help.

- **Application to real-life problems:** Nearly two-thirds (64.5%) stated that they had worked on solving real-life problems, while about one-third (31%) had not, and 4.5% could not recall.

- **Creativity and new ideas:** 96.4% students felt they were encouraged to think creatively and come up with new ideas. Only a small minority were unsure (1.5%) or disagreed (2.1%).

- Students reported improvements across multiple skills. The most cited were technical skills (61.2%), creativity (56.7%), teamwork (55.2%), and problem-solving (54.6%). Confidence (47.2%) and communication (42.1%) were also reported to be enhanced. Fewer students highlighted improvements in patience (13.4%), team management (11.9%), and other skills such as self-discipline, respect for others, decision-making, innovation, planning, and motivation (each <1%).

- In terms of cumulative skills gained, almost half (49.3%) improved 1–3 skills, 38.8% gained 4–6 skills, while 10.2% reported 7+ skill improvements, and only 1.8% reported no skill improvement.

- **Comfort in sharing ideas:** A large majority (88.9%) reported being comfortable sharing ideas in class or group projects, reflecting improved self-expression.

- **Future preparedness:** 90.5% of students felt that school activities prepared them for their future career, while 9.6% were unsure or disagreed.

- **Testing and retrying Ideas:** An overwhelming 97.6% of students reported that they test and retry ideas if their first attempt fails, indicating skill related to iterative problem-solving.

- **Link with classroom learning:** 93.4% agreed that ATL activities **help them understand classroom topics better**, underscoring ATL's value in reinforcing academic concepts through practical application.

[11] Ceiling effect, here, refers to the limitation of using a 1-5 scale, which may not be able to

Relation between study scores and academic performance

The academic scores in Mathematics and Science in the most recent assessment of the students were also recorded for the study participants. The scores for each student were then compared with their scores in problem statements.

Statistical tests suggest weak linkage between academic scores and rubric scores across four domains – PUP, ITS, IPS and PR. Simple correlations between Maths/Science and Problem Understanding, Technical Skills, and Iteration were small and non-significant. PR shows the largest positive association.

These findings should be treated as indicative rather than conclusive. First, the design is cross-sectional and non-experimental, so we can detect association but cannot infer causation or direction (e.g., whether strong reflection enhances Science performance, or strong Science preparation improves reflection). Second, the constructs do not fully align: academic marks reflect syllabus coverage, test format, grading practices, and exam difficulty, while ATL domains emphasize design-thinking behaviours (empathize, ideate, iteration, prototyping, reflection). This misalignment naturally dampens correlations even when both measures are valid for their own purposes. Third, measurement properties further suppress signal: ATL scores are coarse (1–5) with ceiling effects (many 4–5s), while marks have been normalized on a 0–100 scale; such range restriction and scale mismatch push correlations toward zero. In addition, academic marks vary by teacher, paper, and school—biasing associations downward. Fourth, academic marks from all respondents were not collected due to absence on particular day of data collection, name mismatch, etc. Also, the timing between ATL scoring and examinations may not perfectly coincide, further weakening observable links.



PR show a modest, plausible connection to academic performance in Science, whereas scores in PUP, ITS, and IPS are not tightly reflected in recent academic marks. For stronger inference, future rounds should align assessments temporally, add standardized tests, model school/teacher clustering or fixed effects, and use longitudinal (pre/post) designs alongside artefact reviews of student work. That would reveal whether growth in ATL competencies translates into measurable changes in academic outcomes or whether ATL chiefly builds complementary capacities that conventional exams under-capture.

Reliability of scores

Reliability refers to the consistency of a measurement, indicating how stable and dependable the scores are across different conditions or items. In this study, the Cronbach's Alpha was calculated to determine the internal consistency of the ratings for the four areas (PUP, ITS, IPS, PR) of problem statements as well as five areas of Likert scale questions. Each of these areas reflects distinct competencies/skills being measured across gender and state, with scores assigned by the respondents.

The Cronbach's Alpha is a statistical measure that assesses the internal consistency of a set of items, assuming that these items are related to the same underlying construct (in this case- design thinking). A Cronbach's Alpha value closer to 1 indicates high reliability, while a value closer to 0 suggests poor internal consistency.

The Cronbach's Alpha for both problem statement dataset and five item Likert scale shows acceptable internal consistency.

3.3 Relevance and alignment

Academic alignment

Across all three states, ATL activities were widely perceived by students as beneficial for better understanding of classroom topics, with the strongest positive response in Karnataka (98.9%), followed by Andhra Pradesh (96%), and relatively lower in Telangana (86%). Responses of students from FGDs echo this sentiment:

> **In science[class], they show diagrams, but we don't have the materials to build them at home. Here [ATL], we get all the materials.**
>
> *- Student, Karnataka*

> **I am getting more knowledge about technical stuff and tools, which is very useful. "The activities help in practical learning for our science subjects.**
>
> *- Student, Telangana*

> **We have learnt a lot about physical science and how to build circuits. Our technical knowledge has improved greatly.**
>
> *- Student, Andhra Pradesh*

> **Our overall experience has been very positive. We like doing projects and working with components. It allows us to implement our innovative ideas. We believe these technical skills will be very useful for our engineering careers and in understanding physical science.**
>
> *- Student, Andhra Pradesh*

> **There is a lesson in our science textbook called 'Electric Current'. In it, we took six LEDs and connected them in a circuit. When we connected them in series, only three LEDs turned on. The question arose as to why the other three LEDs didn't turn on. It's because the potential difference is divided equally in a series connection. Sir explained this to us.**
>
> *– Student, Karnataka*

Other stakeholders such as ATL Teacher and Headmasters also felt that ATL sessions are relevant for the students.

Students are very happy with these opportunities. They have become more creative, engaged, and motivated. Many of them, especially from classes 7–9, eagerly wait for ATL periods. We also noticed improvements in their academic performance, confidence, and practical knowledge. Personally, I feel this is a wonderful platform that changed the mindset of both students and teachers.

- Headmaster, Andhra Pradesh

The ATL has proven to be highly relevant. It has made learning subjects like Physics much easier for students by improving their practical knowledge, directly supporting academic goals.

- ATL teacher, Andhra Pradesh

... in a regular school, we don't have that kind of environment or material. We hadn't seen a grinder machine or a welding machine. Seeing the circuits and sensors that the students make... we didn't even know what a sensor was. For example, when we go to a big hospital, the doors open automatically—we realize that's through a sensor. But when ATL came, we got to know what a sensor is, how it works, and everything. The children, even at a young age, get all this knowledge because these materials are present here. All the knowledge comes completely to the children. In addition, the children become more involved.

- Headmaster, Karnataka

Working on real-life problems

Across the three states, the responses from MCQs consistently show that the vast majority of students (96%) feel encouraged to work on real-life problems, and this perception is equally shared by both male and female students.

I can solve problems here with the knowledge I've gained. I even solved a real-life problem by making a fire-fighting robot.

– Student, Telangana

We can use this for real-life problems. For example, we can learn about circuit connections here, which we can use in real life. Coming here improves our communication. If an alarm clock breaks, we can fix it ourselves. If a circuit connection is wrong, we can figure it out ourselves.

- Student, Karnataka

ATL gave me real-life skills, like repairing my sister's remote car. That small success boosted my confidence. I realized learning here is practical and useful.

- Student, Andhra Pradesh

In Penamaluru, children tried to identify community problems. They went to the farmers and one of the things identified was that paddy gets destroyed during monsoon due to rain/flooding and poor storage. Children returned to the ATL, ideated, and designed a paddy dryer. This shows STEM Education must be expanded to include solving social/community problems—not just formulas, coding, or copying YouTube projects. ATL offers social, equity, gender, and disability orientations. It is inclusive by design.

- Representative, Vigyan Ashram

Future career readiness

Across all three states, most students acknowledged that the ATL activities contribute positively to career readiness. Students from Andhra Pradesh had the highest positive response (95.9%), followed by Karnataka (93.5%).

Here, we can do things practically. What we learn in theory, we understand better with practical. We remember what we do practically more than what we just read in theory, and it helps us in the future.

- Student, Karnataka

The interventions have helped students develop skills in electronics, critical thinking, and problem-solving. Students find ATL activities useful in their studies, and they are gaining exposure beyond the regular curriculum. I believe ATL will be very helpful for their future growth.

- ATL Teacher, Telangana

Many school students want to become engineers or scientists. Through this programme, students in Classes 6–8 were introduced to basic technologies they might face in the future. They may have read about them, but seeing and doing in the lab gave them hands-on experience.

- Faculty, Engineering College

The alignment is evident in how the programme empowers students with practical, future-ready skills that directly support the district's educational objectives of promoting STEM (Science, Technology, Engineering, and Mathematics) education and innovation.

– DSO, Andhra Pradesh



Case Studies

STORIES OF INNOVATIONS FROM THREE STATES

The following note presents stories from ATL schools across Telangana, Andhra Pradesh, and Karnataka where students have developed creative, practical solutions to everyday problems in their community.



1. Paddy Dryer

In the farming community of Penamaluru, Andhra Pradesh, frequent rains ruined harvested paddy, forcing farmers to bear heavy losses. Six students from a government high school (ZPHS, Penamaluru) took on this challenge. They met with farmers, understood how moisture and pests damaged grain, and decided to build a low-cost, efficient paddy dryer using locally available materials.

The students tested different heating mechanisms and airflow designs, learning physics through practice. More than the invention itself, the process changed the children-they saw how empathy and science could work together to solve community problems. The grain dryer helped farmers reduce crop loss and dry grains more efficiently, even during unpredictable weather. For the students, it proved that real change can start right from the classroom.

2. Smart Sprayer

In Korukonda (Andhra Pradesh), students (GHS, Korukonda) noticed that farmers carrying heavy pesticide sprayers developed shoulder pain and fatigue. They observed closely, spoke to local farmers, and designed a lightweight, ergonomic smart sprayer that required less effort while improving spray distribution.

They learned how concepts like pressure, force, and mechanics could be applied to create comfort and efficiency. After multiple iterations, their final model made spraying safer and more sustainable. The students realized that true innovation isn't just about machines-it's about making life easier for people. The project reinforced how design grows out of empathy and how listening to users can turn science lessons into life-changing inventions.



3. Smart-Hand Gloves



This story begins with a simple observation. Students (GGHS, Basapattana) met a community member who had paralysis and couldn't express basic needs without help. That moment sparked an idea-to build sensor-based hand gloves that could translate hand gestures into sound or text.

Using ATL resources like microcontrollers and sensors, they experimented tirelessly to make their concept work. Every trial taught them the importance of understanding user challenges-comfort, accuracy, and affordability. The Smart Gloves helped patients regain a basic human right – to ask for what they need. It showed how empathy and innovation, even with low-cost materials, can restore dignity and independence.

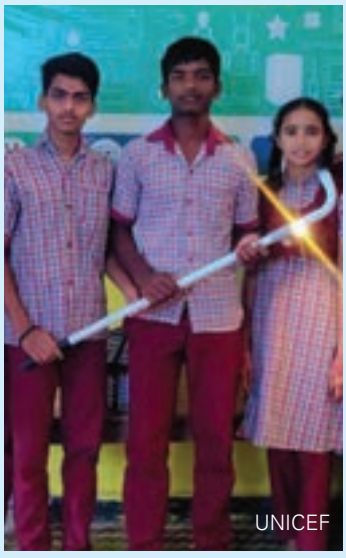


4. Hope Arm

At GPUC Kombettu in Karnataka, an "Idea Box" in the ATL lab encouraged students to share any thought they had, no matter how small. One such idea led to the creation of Hope Arm, an affordable prosthetic limb. It began when students noticed their classmate's grandmother, who had lost her arm due to diabetes, struggling to do everyday chores.

Motivated by empathy, the students visited hospitals and limb centres, spoke with amputees, and learned about the high cost of prosthetic devices. Guided by their teacher, they designed a low-cost prosthetic arm that restored basic functionality and hope. This project taught them that real solutions emerge from deep listening and shared problem-solving. They discovered that innovation has a human face and that design thinking starts not in a lab but in the heart.

5. The Farmers' Baton



When students (ZPHS Bhiknoor) learned that farmers often worked at night to save crops from animals and theft, they realized how unsafe those journeys were. Through brainstorming and user interviews, they designed the Farmers' Baton–a multi-purpose stick combining a flashlight, alarm system, and sturdy walking support.

The design process involved several failures–faulty switches, dim lights, broken handles–but each attempt brought new learning. The students saw how observation, persistence, and testing are integral to innovation. The Farmers' Baton designed by the students gives farmers a sense of safety during night-time field visits. It helps prevent harm to both people and animals, using a tool that was affordable, easy to carry and effective.


UNICEF

6. Peanut Peeler

In many households, peeling peanuts by hand is a tedious, time-consuming task. Two students from ZPHS in Karmanghat watched their families spend hours at this chore and decided to change it. They set out to create a simple mechanical peanut peeler that could save time and effort.

The journey was far from easy. The first prototypes failed repeatedly; the rubber tubes didn't align, and the shells wouldn't separate properly. Yet, instead of giving up, they refined their design through patience and teamwork. Eventually, they succeeded.

The peanut peeler designed by the students turned a slow, uncomfortable task into a quick, safe and mess-free process, all in a device that is affordable, easy to use, and kitchen-friendly.

In addition to these innovations, Annexure 8 includes a list of over 20 promising ideas which were worked on by students using a design thinking methodology across the three states through the support of UNICEF and Vigyan Ashram, often taking several months involving brainstorming, testing, re-testing, and refinement. Some of these were also shortlisted for national and state level competitions like 'Seed the Future Entrepreneurship' (Dassault Foundation) and ATL Marathon (Atal Innovation Mission). The ideas deserve further support.

3.4 Pedagogical change and teacher capacity

3.4.1 Impact on hub school teachers

> **ATL has helped me as a teacher by giving me opportunities to integrate practical experiments with my subject (Physics). This hands-on exposure has been beneficial in classroom teaching.**
>
> *- ATL Teacher, Andhra Pradesh*

Teachers across states (more than 50%), during qualitative interviews, described moving beyond textbook exposition to hands-on demonstrations, prototyping, and live experiments—for example, turning theoretical electricity lessons into practical sessions. Similarly, Headmasters and DSOs/DNOs consistently reported that this practical turn has spilled back into regular periods as teachers now integrate ATL tools into classroom teaching, use experiments to anchor theory, and plan lessons with a design-thinking lens. The result, in their words, is a "learn by touching and doing" culture that normalizes iteration, tolerates failure, and builds student confidence.

Yes, it has been very useful. For example, we have a chapter called Electricity: Magnetic Effect of Electric Current. We have done many experiments in series and parallel, and it is helpful to show the students in live rather than explaining this all just in a theoretical way.

- ATL teacher, Karnataka

It has been eight months since I started teaching in this class. The actual ATL work started for me about three months ago, in June, and I began with learning. Initially, I came from a non-ATL school. As soon as I arrived here, I started learning about each piece of equipment. I actually learned many things from the students first. Later, I began conducting experiments myself with the help of YouTube videos.

- ATL Teacher, Karnataka

Some teachers explained how they built confidence rapidly through ATL exposure. They learned alongside students, leveraged peer support and online resources (e.g., YouTube), and progressed from replicating kits to designing their own demonstrations and mini-projects. Several noted that ATL has made them more creative facilitators—guides who set problems, scaffold teamwork, and insist on testing and feedback, rather than sole content-deliverers. Headmasters also noted growth in accountability and planning skills among staff as ATL work requires scheduling, resource management, and showcase preparation.

ATL has improved their teaching methods. They now integrate ATL concepts into regular classes, which enhances student understanding. The approach has shifted towards more practical, experiment-based learning rather than only theory.

- Headmaster, Telangana

Teaching methods have surely changed 100%. Because we are living in an age of technology, they used to get only theory, as I told you earlier. Showing them things practically has a much bigger effect on them

- Headmaster, Karnataka

Some teachers credited UNICEF and Vigyan Ashram's inputs and the hub-and-spoke ecosystem for this shift: foundational trainings (including multi-day residentials), online sessions, mentorship visits, and teacher handbooks. Importantly, partners framed teacher upskilling itself as a design-thinking challenge—starting with empathy for teachers' pain points (language, unfamiliar tools, time) and iterating solutions (make-a-thons, step-wise modules, cross-subject examples). This approach helped teachers see ATL as relevant beyond Physics/Maths, with explicit cues to use it in other subjects.

They [UNICEF/Vigyan Ashram] have created a WhatsApp group. We have joined all the ATL Nodal Teachers and Headmasters to it. They are regularly updating. UNICEF is regularly providing all the necessary support, materials, handbooks, and addressing any doubts they have. And one more great thing that UNICEF has done is that they have collaborated with SSK to implement mapping the ATL activities to the textbook.

- DNO, Karnataka

Observed teacher competencies

As part of the study, the same problem statements were administered to ATL teachers across the three states. Averaging across the states, teachers scored on an average 4.55 in PUP, 4.45 in ITS, 4.35 in IPS and 4.45 in PR. While the average scores are high across four domains, the state difference mirror the findings from the student scores. Karnataka's consistently high teacher scores correspond with stronger, more uniform student rubric performance in the state while Telangana's variability in teacher scores (especially in ITS and IPS) aligns with wider dispersion and lower student scores in the state.

> **To overcome our internal skill gaps, we hired a dedicated STEM trainer specifically for ATL.**
>
> *- ATL Teacher, Andhra Pradesh*

Students in Karnataka scored higher across domains. The largest gap was noted in IPS, where students in Karnataka were notably stronger. This is the same domain where teacher scores showed sharpest separation (Karnataka 4.83 vs Telangana 3.71).

Teachers and headmasters, through their responses in IDIs, repeatedly emphasized that strong ATL functioning depends on system supports and not only individual teacher motivation. Three directly connect to the observed state wise gaps in ITS and IPS gap.

3.4.2 Outreach with spoke schools

UNICEF implemented a 'hub and spokes' model where each district has a central 'hub' ATL, serving as a training, learning, and demonstration center for at least five nearby 'spoke' ATLs. Over 4-5 years and with consistent support, these spokes were expected to develop into demonstration centres, thus expanding the intervention to cover all ATLs across each state. UNICEF's support for the hub and spokes model included teacher training, manual development, monitoring systems, and collaborations with higher education institutions, apart from bringing on board Vigyan Ashram as the technical agency.

To understand the impact of UNICEF's intervention in spoke schools, an online MCQ was administered with 126 ATL teachers of spoke schools across the three states (Andhra Pradesh- 51, Karnataka- 65, Telangana-10). The online MCQ captured school context (operational ATL months) and probed mentoring linkages with hubs (interaction frequency, modes, nature of support), teacher capacity and confidence (use of ATL equipment; participation in trainings), and integration into school routines (session frequency and duration; curriculum/textbook linkage).

The responses reveal that ATL is being used regularly across the spoke schools. About 71% schools run ATL sessions/classes weekly or more, with 75% teachers noting that each session lasts between 40–120 minutes. Around 82% of the respondents noted ATL activities are integrated with textbooks/curriculum.

While 69% felt confident using ATL equipment, 24% were "not sure," signalling a practical skills gap. About 38% respondents reported attending face-to-face trainings.

On engagement with hub schools, 60% respondents noted that they interacted with the hub at least 1–2 times last year, while 25% shared that they never did. Mentoring was described as "regular" by 24% and "sometimes" by 34%.

On impact on student skills, teachers overwhelmingly perceived gains. Total 90% saw significant or some improvement in students' problem-solving.

In terms of development of teacher's skill, the responses suggest positive impact. While 91% teachers felt that their own teaching skills improved (*to a great/some extent*), 22% teachers still perceive ATL as a "burden".



3.5 **Systemic enablers and barriers**

Enablers

Teacher and mentor support

Across all three states, teacher support in ATL projects was rated highly, with "always supportive" being the dominant response, especially in Andhra Pradesh (95.2%) and Karnataka (88.2%). Stakeholders also appreciated mentor support through students of engineering colleges.

I really like the ATL lab. We've made many kinds of models there. We would ask sir, "Sir, give us another model, we want to make it" and we would work in groups with friends to build it. If we made a mistake, we would correct it and show it to sir, and that made us happy. If there was a free period because a teacher was absent, we would ask sir if we could go to the ATL lab, and he would say, "Come on" and we'd go make models.

- Student, Karnataka

Our previous ATL teacher, [..] Sir, was exceptional. He was always polite and patient. He always motivated us to do projects and provided any instruments we needed very quickly.

- Student, Andhra Pradesh

When our project failed, we talked to the teacher, and they supported us. We learned that we can work like the teacher does. The teacher's support helped us a lot.

- Student, Telangana

Where mentor support is regular, children are very bright and active in projects. For example, in Kakinada, students built a flag-hoisting solution with technology. The district collector visited ATL and was impressed. In School Innovation Marathon, AP projects reached national level and received funding.

– State Nodal Officer, Andhra Pradesh

Interviews with a faculty member of an engineering college and mentor engineering students point to strong motivational effects on school students: enthusiasm, curiosity about lab equipment, regular attendance, and comfort created through the near-peer relationship (students addressing mentors as "*akka/anna*"). The mentoring relationship also appeared to enable more confident questioning and idea-generation, including gendered innovation aspirations. The linkage also created meaningful capability gains for mentors as one of the engineering students reported learning mechanical tools, coding exposure, and software such as Tinkercad, alongside teamwork, patience, and communication skills.

The interviews showed that HEI linkages supported ATLs not only as a lab space, but as a problem-solving platform grounded in local realities. Mentors described encouraging students to identify problems at home or in the community and then co-design solutions.

Their enthusiasm was the most striking part. They were curious about what's in the lab and why we (their "akkas and annas") were coming. The bond we built really helped mentorship. They would ask, "Sister, what are we going to learn? What is this component? What is this project?" They were punctual, often waiting in the lab with their books before we arrived, and if someone from our team missed a day, they noticed and said they missed us.

- Mentor, Engineering College, Andhra Pradesh

When we interacted with the school teachers, they expressed that students had become very active and were understanding regular curriculum topics better. They said, "There is a major impact on students when you guide them compared to our teaching, as the generation gap is less and communication is easier for you." Students also shared things with us openly that they hesitated to share with their teachers.

- Mentor, Engineering College, Andhra Pradesh

The programme's success is because of the mentors—they worked rigorously. It wasn't just about Saturday sessions; one or two days before, and every Sunday, they held Zoom meetings among themselves. They discussed plans and, in consultation with the trainer, prepared for sessions ahead. I can say our students and our college did reasonably well, which is likely why we were chosen to host the state felicitation programme here, where we felicitated 155 students from 31 colleges, along with the 31 Principals.

- Faculty, Engineering College, Andhra Pradesh

Gender inclusivity in participation

Across all three states, the majority of students felt that ATL participation was equally encouraged for both boys and girls. The state specific percentages for Andhra Pradesh, Karnataka and Telangana were 91.9%, 79.6% and 79.7% respectively.

Both boys and girls attend the ATL Lab equally. But most toppers and those who went to inspire awards (national) are mostly girls. The girls have also participated for state.

- ATL Teacher, Karnataka

ATL has supported our broader educational goals by encouraging innovation, problem-solving, and teamwork. Both boys and girls, including marginalized students, have benefited equally. Girls especially feel more confident and safer to participate in innovation activities. For example, we saw many girls come forward with design ideas during training sessions, which earlier they hesitated to do.

- Headmaster, Andhra Pradesh

ATL has definitely impacted students in a big way. Both boys and girls are equally encouraged, and girls are also showing great interest. Students are gaining confidence and learning to take charge of their own projects.

- ATL Teacher, Telangana

Peer diffusion

Across all three states, the vast majority of students regularly shared their ATL learnings with classmates (93.5%, 91.4% and 83.1% in Andhra Pradesh, Karnataka and Telangana respectively), reflecting a strong culture of peer-to-peer knowledge exchange.

Initially I was not confident, but ATL made me interested. Seeing my friends, work inspired me to try projects. Slowly, I discovered my passion for electronics and coding.

- Student, Andhra Pradesh

Seeing our friends succeed makes us feel that we can do it too. Our confidence has really grown. We feel brave enough to try things.

- Student, Karnataka

Barriers

For students

Across all three states, most students reported only one or two challenges in using the ATL, suggesting relatively manageable barriers. Students most often cited "lack of materials/components/equipment". Other recurring issues were "too many students/not enough space" and "limited teacher guidance". About 93.1% students across the states reported encountering at least a few (1–2) issues; 6.3% reported several (3–5).

Lack of materials, components, and equipment also emerged as a significant barrier. Across all three states, students overwhelmingly rated ATL material and equipment availability as poor or very poor.

The main challenge is with resources and maintenance. Sometimes the equipment, like the 3D printer or computers, do not work, and it takes time to repair.

- Headmaster, Karnataka

We need a separate ATL teacher who can be in the lab all the time and doesn't have other school work. Our current teacher is busy with other school work and can't always be available.

- Student, Telangana

There are also maintenance and infrastructure issues like network and power problems.

- Student, Andhra Pradesh

We need more and better-maintained tools. Sometimes the tools are insufficient or not available when we need them, which causes delays.

- Student, Andhra Pradesh

For ATL teachers

The key challenges for teachers included lack of dedicated staff, time, equipment, maintenance support and proper curriculum.

> **I am the sole in-charge of the ATL lab for the entire school. Managing the lab, its equipment, and coordinating activities for all students single-handedly is a considerable challenge.**
>
> *- ATL Teacher, Telangana*

> **Personally, first, I need more time, meaning more periods, to teach the children. For example, at the school level, we have allocated two periods per week. That is not enough for the children. Two periods a week, it is not possible to complete a model. So, we are arranging Saturday classes. We also need time. After this, we need further guidance, whether from our teachers, the Headmaster, or the Department.**
>
> *- ATL Teacher, Karnataka*

> **There is no maintenance fund. The budget allocated is only for equipment, instructors, and training, but not for maintenance. If there is a repair for electric appliances or equipment in the lab, the school has to use its own funds.**
>
> *– Headmaster, Telangana*

Key drivers of effective maker space implementation

The study shows that effective ATLs emerge where capacity, time, infrastructure and an ecosystem converge. Across the three states, the following drivers were found to enable strong implementation and visible student gains.

Skilled, capacitated teachers: Teachers in all states reiterated that training sessions organized by Vigyan Ashram and UNICEF were instrumental in developing their skills to manage ATLs. The weekly online sessions were noted as '*platforms for continuous learning and collaboration*'. Students also reported high levels of teacher support (85% students noted that teachers *always supported* them), which would be a key factor in sustaining engagement and confidence. In Telangana, 21% students noted *limited teacher guidance* as one of the challenges in using ATLs. This reflects in the overall scores of the students across the four domains - PUP, ITS, IPS and PR.

Curriculum linkage and attendance in labs: All three states showed high level of attendance in ATLs with over 60% students sharing that they attend ATLs at least 2-3 times a week. Teachers in all states also noted that linking ATL topics to regular syllabus helped in making ATL sessions more engaging. Around 93.4% students noted that ATL helps them understand classroom topics.

Participation in activities: Data from the study shows that in states where more students participated in more than one ATL related event, students from those states fared better in rubric scores. This is also true for the states where more students participated in different types of activities within the lab (eg. robotics, coding, 3D printing, etc) Teachers and officials, especially in the states of Andhra Pradesh and Karnataka.

4 Lessons Learned and Recommendations

4.1. Lessons learned

UNICEF's intervention across Andhra Pradesh, Telangana, and Karnataka for the past three years provides rich lessons for policy and practice. These lessons go beyond operational feedback, offering insights into how maker spaces can be sustained, scaled, and integrated into the wider education system.

Overall skill development of students

The findings from both quantitative and qualitative data show that ATLs had a positive impact on overall skill development of students.

Across the dataset, students show a broadly positive skills profile that blends strong design thinking mindsets with matching performance on assessed tasks. On the observer-rated rubric (1–5), averages were recorded above 3.5 in all four domains, with Problem Understanding and Planning the strongest, followed by Presentation and Reflection, then Implementation and Technical Skills followed by Iteration and Problem Solving. This pattern is echoed in self-reports: on a five-item design-thinking scale, students rate themselves especially high on empathizing with users, defining the core problem, prototyping early, and testing with feedback.

Evidence from MCQs reinforces that these dispositions translate into day-to-day habits. Most students shared that they approach any problem first by understanding the problem, follow with repeated testing in case of failure, and have also worked on real-life issues. Many students also credit ATL with improving technical ability, creativity, teamwork, problem-solving, confidence, and communication. Overwhelming majority of students saw ATLs as more engaging than regular classes, while noting that ATLs help them grasp classroom topics better, and would recommend it to peers. Similar sentiments were expressed by teachers, Headmasters and other stakeholders.

> **They now say that since they came to ATL, they are getting higher marks in Science. For some children, they don't understand concepts by rote learning. Therefore, if you show them through projects, they understand it. Once they understand, it becomes easy for them to write about it in their own language during the examination.**
>
> *- ATL Teacher, Karnataka*

Shift in pedagogy

Across states, teachers describe moving from established teaching methods to 'learning by doing' method, using live demonstrations, prototyping, normalizing iteration and error as part of the learning cycle. In addition, many teachers also reported that their overall teaching skills had improved due to time spent with student in ATLs.

> **Teachers (e.g., the Math teacher) who handle ATL have improved their teaching methods. They now integrate ATL concepts into regular classes, which enhances student understanding. The approach has shifted towards more practical, experiment-based learning rather than only theory.**
>
> *- Headmaster, Telangana*

> **In a normal classroom, the learning is mostly one-way—teachers explain, students listen, and then write exams. But in the ATL, learning is hands-on. Children learn by doing, experimenting, and even by making mistakes. Nobody scolds them if their project fails. Instead, they are encouraged to try again, which builds resilience. This environment is very different from the traditional system and helps develop creativity and critical thinking.**
>
> *- Headmaster, Karnataka*

Gender inclusion

Across the three states, most students perceived ATL participation as gender-equitable and teacher support was reported consistently strong by girls and boys alike. Girls also self-reported slightly stronger and more consistent design-thinking skills than boys (higher overall means with lower dispersion). Notably, in girls' only schools, girls performance rose towards their self-reported strengths. The qualitative accounts from teachers and students support girls in gaining confidence, taking on visible roles in showcases, and, in several schools, gaining recognition at district, state and national levels.

> **Both boys and girls, including marginalized students, have benefited equally. Girls especially feel more confident and safer to participate in innovation activities. For example, we saw many girls come forward with design ideas during training sessions, which earlier they hesitated to do.**
>
> *- Headmaster, Andhra Pradesh*

However, there were some participation and performance gaps that emerged from the study. On externally rated sores (problem statements), boys outscored girls across all four domains, with the largest gaps in IPS and ITS. Participation patterns can help explain some of this divergence – boys were more likely to attend ATLs daily, to engage in multiple activities, and to engage more with robotics, coding, and 3D design, while girls often reported single-activity involvement—especially in Andhra Pradesh and Telangana. Some of the access constraints reported during qualitative interviews and MCQ responses girls compound these differences: among girls, almost half reported that they were always allowed to stay after school for ATL, while others cited safety, transport, household duties, and academic pressure.

These findings highlight the need for specific focus on closing the gap across the two domains (ITS and IPS) while encouraging lead roles for girls in robotics, coding, etc. Further, there is a need to work on external social/ cultural factors that are impeding girls' participation in maker spaces.

Curriculum integration

Across states, students overwhelmingly reported that ATL helps them understand classroom topics better (93%). Their descriptions, along with teachers' and Headmasters' accounts, show that participation in ATLs raise attention in regular periods and make abstract ideas come to life. Some stakeholder accounts also pointed out specific efforts to link school curriculum with ATL activities.

> **When we correlated school curriculum with Innovation, that was very good experience. Till then, we were seeing ATL and school curriculum as separate. From 2023-24, we started planning to merge the two. The first step in this was allotting a period in the school time table as ATL period. Then we did some experiments with Hub and Spoke model. Thirdly, we focussed on integrating the curriculum. We also didn't know that we could integrate the ATL in so many areas. All this was done by our teachers.**
>
> *- State Official, Karnataka*

However, stakeholder voices pull in two directions in terms of actual curriculum integration. On one side, some argue for deeper curriculum linkage which, in turn, leads to better teacher and student engagement and overall improves better access to ATL for everyone. On the other side, some stakeholders shared that while integration is needed, ATLs should not become like regular syllabus/curriculum-based sessions (with grades/ attendance/evaluation) as these were meant to be *free spaces* with focus on innovation and flexibility.

> **In terms of making it a formal part of the curriculum, say, having it graded, or another way is to integrate it into the report card, grading structure, and evaluation process in schools, or having methods of testing, etc. There are two opinions. One is that ATL was meant to be a free space and not a subject with exams and grades. The idea of innovation flexibility gets defeated by that. For the longest time, we've hesitated to make those moves. It's still being discussed how it can become a more comprehensive part of the curriculum without making evaluation rigid.**
>
> *- Representative, NITI Aayog*

The responses suggest that while integration through teacher handbooks and weekly periods would be useful in improving participation, especially from girls, allowing students to 'tinker' and explore the lab without pressure of evaluation or assessments would be a practical way forward. UNICEF's efforts to develop a teacher handbook on ATLs for the teacher is a good step in this direction. The handbook provides sample lesson plans based on curricular topics and at the same time provides a primer on design thinking, which is to encourage the creative part and 'break' curricular boundaries. The handbook is also available on the AIM website.

Hub and spoke model

The hub and spoke model emerged as a way to balance the diversity of initial conditions/readiness in different schools. Some schools had kits but no trained teachers, some had unused equipment, others awaited supplies, hence, so clustering "strong" ATLs as hubs to mentor nearby spokes was the logical way to differentiate support and pace schools along different pathways. The idea of the hub and spokes also arose as it was not possible for any external agency to work directly with all the ATLs in a state. Hence, the emphasis was on building the in-house capacity of the state through the hubs and hope that the hubs would take over the task of reaching out to and supporting the spokes and other ATLs in their districts. In Andhra Pradesh, for instance, with the 31 hubs having to various extents developed as master trainers and resource schools, the education department has decided to expand the idea to develop a cadre of 130 master trainers to provide sustained capacity building to all 545 ATLs in the state.

The Headmasters and teachers valued hubs as visible anchors. The model has helped in accelerating peer learning through demos, visits, training sessions, etc.

> **When UNICEF has come out with an alternate of low-cost maker spaces, it is possible to scale to all schools. Within 2-3 lakhs, we can easily set up a small tinkering lab in school. If we train all science teachers in this integrated curriculum, like we did training of all Nalikali teachers[12], then there will be no need for outside mentor in the school. The teacher herself or himself becomes a mentor. The CBZ[13] teachers, Math and Science teachers, if need be Physical Education teachers – all need to be trained. Then we will make the ATLs as hubs and low-cost maker spaces as spokes, and we can strengthen both hub and spoke. We should not focus only on High School, we must start it from 6th standard – younger students can be engaged in small experiments like soil testing, etc. This way, we can build interest from young age. We must motivate parents also. Not all parents are educated, so we need to motivate them.**
>
> *- State Official, Karnataka*

[12] Nalikali programme is an activity-based teaching and learning system in the state of Karnataka. https://ssk.karnataka.gov.in/173/strengthening-the-nalikali-programme/en

[13] Chemistry, Biology and Zoology.

4.2. Recommendations

4.2.1 Stakeholder-wise recommendations

The recommendations emerging from the study have been grouped stakeholder-wise, showing stakeholder specific priorities and preferences.

From students

Many students recommended that the equipment in the lab need to be better and properly maintained, and more space needs to be provided to prevent overcrowding. Other key suggestions included continued dedicated ATL periods in a week and a dedicated staff/teacher for ATL.

> **Our lab needs bigger tables and a bigger screen. The room itself should be bigger. There's not enough space to make models. As more students like us come, they will also need space. So, the ATL lab should be bigger. Also, my younger sisters and everyone will be coming, right? They will be making models, and we will be making models. We need space to keep them. So, a slightly bigger room is needed.**
>
> *- Student, Karnataka*

> **Sometimes the lab is not clean, and we feel we cannot spend as much time as we want due to a lack of consistent support. We need a more proper and maintained environment.**
>
> *- Student, Andhra Pradesh*

> **We need a trained ATL teacher. Currently, the teacher is not always available to resolve our queries. The lab is not always maintained or clean.**
>
> *- Student, Andhra Pradesh*

From teachers and headmasters

Both teachers and headmasters converged on suggesting a system level strengthening of ATLs. Both agreed that ATL responsibility be distributed rather than parked with a single "ATL teacher". Work should be formally segmented across staff—computer, physics/chemistry/maths, and other subject teachers—with training that includes not only science but also non-STEM subject teachers so the ATL becomes part of everyday teaching, not just an add-on. Several Headmasters shared that ATL must be expanded beyond science to all subjects and that every school should have an ATL lab that is open and timetabled, so students get predictable access without overburdening one person.

Schools suggested a steady stream of human support around the lab. A recurring suggestion is to partner with local higher-education ecosystems—final-year BE, diploma, or ITI students—to visit weekly, co-mentor projects, and complete their practice requirements in schools. Teachers shared that students respond well to near-peer mentors and that this arrangement would both raise the technical standard of ATLs and reduce pressure on school staff.

> **Appoint a separate 'in charge' or a tutor (separate) for the ATL to ensure dedicated attention.**
>
> *- Headmaster, Telangana*

> **The school requires separate funds and technical staff dedicated to ATL, since ours is also a hub school and the workload is high.**
>
> *- ATL Teacher, Andhra Pradesh*

There is a need for active state support—clear policy, earmarked funds, and operational backing—to make these practices stick.

> **While the initial setup was supported, a key challenge has been funding. We faced delays in fund transfers, and while one tranche was completed, we did not receive a second expected fund transfer. This impacts our ability to maintain and upgrade equipment.**
>
> *- Headmaster, Andhra Pradesh*

If the hubs continue as an integral part of the larger strategy of strengthening ATLs, they would need funds and administrative support (e.g. permissions for the hub schools to undertake school visits for on-site support, funds for training at the district level, etc.) including HR support to do justice to their role.

> **All science teachers must be trained using the ATL equipment. They should understand that the future of science is about tinkering. In schools, this should be made compulsory. All practicals in Science should be done in correlation with ATL.**
>
> *- State Official, Karnataka*

From other stakeholders

Key suggestions from other stakeholders have been added below:

ATL lesson plans could be re-mapped to state-board chapters (with translations for non-English schools) so tinkering becomes a way to teach physics, chemistry, maths—and even languages—rather than as 'extra'. This would need a structured capacity pathway: an SOP for teacher development with basic/intermediate/advanced tiers; face-to-face trainings per teacher each year delivered in phases; and a district cadre of master trainers who seed peer-to-peer learning in schools and run monthly review cycles with state nodal teams and SCERT. Stakeholders also recommended training all science teachers on ATL equipment, expanding to other subjects so that in most schools, the teacher herself becomes the mentor.

Stakeholders stressed that maker spaces should be as routine as libraries—stocked not just with expensive kits but with a "scrap bank" (cardboard, sticks, glue guns, basic electronics) to keep projects moving. They suggested more ATL centres overall and a resilient hub-and-spoke network that reaches all ATL schools with ATLs in private schools also leveraged where they exist.

It was suggested that HEIs (consisting of engineering colleges, polytechnics and ITIs) should "adopt" clusters—supplying near-peer mentors, driving hub-and-spoke mentoring, and creating a bridge from school projects to incubation. This HEI–ATL connection has already shown

promise in Andhra Pradesh and could be replicated in other states. Parents and communities were identified as stakeholders who were not reached out to the fullest. Brief parent walkthroughs and hands-on PTM activities can demystify ATL, tap local vocational skills (plumbing, electrical, farming), and turn labs into community maker spaces.

> **We are empowering higher education institutions, giving them a mandate to nurture these hubs and spokes. What UNICEF and Vigyan Ashram are doing right now, we are trying to institutionalize in a more sustainable way by utilizing the existing infrastructure of India in terms of HEIs and ATLs—connecting them and making HEIs a bridge between ATLs.**
>
> *- Representative, NITI Aayog*

> **Bring parents during PTMs—show the ATL, let them do simple activities, and say, "Your children will learn this". Over time, ATL becomes a community effort. Parents often have skills—electricians, plumbers, carpenters, factory workers, farmers.**
>
> *- UNICEF Representative*

Finally, it was also suggested to form student ATL councils to manage stocks and projects, starting ATL from Grade 6 to build early interest, and issuing clear role orders so responsibility (and training *access) is distributed across staff—not confined to one teacher.*

> **Establish a student ATL council to manage materials/ stocks, and lead project development—just like food or mid-day-meal committees.**
>
> *- Representative, Vigyan Ashram*

4.2.2 Summary of key recommendations

Integration of ATL with the curriculum

ATL activities should be intentionally mapped to state-board chapters (with translation where needed) so teachers see tinkering as a way to teach core concepts, not an add-on. Schools should timetable a regular ATL period from Grade 6 onwards and involve all subjects—Maths, Science, Languages, and Social Science—so interdisciplinary projects become routine. At the same time, the ethos of ATL must not be diluted by syllabus-completion pressures. Assessment should therefore use fit-for-purpose approaches (e.g., process portfolios, project milestones aligned to design-thinking stages, showcases/ exhibitions) rather than routine subject examinations.

Building teacher capacity at scale

There is a need to adopt a clear training pathway with competency tiers (basic, intermediate, advanced) and ensure each ATL teacher receives 6–9 days of face-to-face training annually, delivered in phases. The principals should also be oriented during these sessions and be part of the training for at least one day. It is also recommended to train a group of at least three teachers per school, who can take responsibility for the functioning and integration of ATLs. Face-to-face training can be supplemented by online sessions once a fortnight, as done through the '*Nirmaan*' channel in Andhra Pradesh.

Staffing and distribution of roles

A dedicated ATL in-charge is needed. If this is not possible, then ATL responsibilities could be distributed across PCM (Physics, Chemistry, Maths), Computer Science, other subject teachers or HEI linked mentors to avoid



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overburdening a single person. Student ATL councils could be created to manage stocks and projects.

Reliable infrastructure and equipment

Maintenance of equipments is key for a functional ATL lab. It should be ensured that critical devices like 3D printers and laptops are functional, stable power/Wi-Fi is available, and cleanliness is maintained to create an inviting atmosphere in the lab.

ATLs have widely reported issues related to timely disbursement of annual maintenance grant of Rs. 2 lakhs from the AIM. This needs to be streamlined and the state education department should be given the responsibility of managing the finances. Further, the AIM grant is available for a period of five years. To sustain and upgrade the ATLs for the long term, the education department needs to budget adequate resources in its annual work plans.

Strengthening monitoring, safety, and operations

A simple dashboard can be developed that tracks lab uptime, usage, trainings, and student outputs, enabling timely fixes. Standardization of safety protocols, storage, and institutionalization of annual equipment audits could ease maintenance and make replacements proactive rather than crisis-driven. The Telangana and Andhra Pradesh monitoring mechanisms using digital platforms is a first and encouraging step to streamline monitoring of ATLs in real time. Monthly review meetings can be undertaken at state and district levels, and platforms such as ATL Consortium can be used to provide external feedback.

Equity and inclusion

Addressing barriers that limit girls' participation is essential. After-school engagement, permissions, transport, and safety are areas to be looked into more proactively by school administration. Promoting female student leaders and near-peer women mentors, so leadership and technical roles are normalized for girls across all ATLs, could be steps in a positive direction. In addition, gender-sensitive scheduling guidelines which promote safe timings for girls need to be instituted by schools. Female-led ATL clubs (e.g. girls' innovation circles) could be promoted to encourage more female participation. CSR and state funding can also be explored to set up maker spaces in more schools in a phased manner.

Linkages with engineering colleges and industry

The state of Andhra Pradesh pioneered linking school and higher education departments with engineering colleges as part of colleges' 'ATL Mentorship Programme'. This initiative received positive feedback from both schools as well as the engineering institutions. Moving forward, the following areas need attention:

- Expanding the duration of the internship from two to six months, as this helps the school and engineering college to develop a stronger linkage and mutually benefit from this arrangement.

- Expanding the ATL Mentorship Programme to cover all 300+ engineering colleges (in Andhra Pradesh) under the three Jawaharlal Nehru Technological University. The Vasireddy Venkatadri Institute of Technology (VVIT) developed a digital platform to help engineering students register as 'ATL Mentors'. This platform enables registration and monitoring of the internship, while also serving as a repository of modules and activities that the engineering students can use at the ATL. The platform is now ready for scale-up in the state. Simialr platforms could be envisaged in other states.

- Exploring the possibility of engineering colleges adopting one or more ATLs in its vicinity. The ATLs then function as an 'extension centre' of the institution, ensuring a continuous engagement between the college and the school.

- The state education department may consider developing a handbook for ATL Mentors along with a short online course which can help them keep their engagements at school focused.

- ATLs have the potential to develop as spaces for school level innovation and problem solving. To ensure that the schools do not function in isolation, linkages with local industries can contribute to the development of an 'innovation ecosystem' that begins with the school and extends as a pathway to the industry.

The following table presents stakeholder-wise key recommendations with a suggested timeframe for their implementation:

Table 4.1. **Stakeholder-wise key recommendations**

Recommendation	Responsible Actor	Timeframe
Reliable infrastructure and equipment Ensure that lab equipment is better maintained and larger spaces provided for ATL activities to prevent overcrowding.	School Heads, ATL Teachers, State Education Department	Short-term
Staffing Ensure that dedicated staff/teachers are assigned for ATL labs and regular ATL periods are provided every week within the timetable.	School Heads, Education Department	Short-term
Building teacher capacity Train all science teachers (tiered training pathway) on ATL equipment and ensure that ATL is integrated into all subjects, not just science. Further, integrate design thinking as part of teacher preparation efforts.	UNICEF, other agencies, State Education Department	Medium-term
Integration of ATL with curriculum Map ATL activities to state-board curriculum for better integration.	State Education Department, UNICEF and other agencies	Medium-term
Strengthening monitoring, safety, and operations Develop a dashboard for tracking ATL lab usage, monitor safety protocols, and ensure regular equipment maintenance and audits. Maintenance funds, timely disbursements and monitoring are needed to sustain ATL activities.	School Heads, State Education Department, NITI Aayog	Medium-term
Equity and inclusion Address barriers to girls' participation by promoting female leadership and ensuring safety, transport, and after-school access. CSR and state funding can also be explored to set up maker spaces in more schools in a phased manner.	School Heads, Teachers, UNICEF and other agencies	Long-term
Community involvement Introduce parents' engagement in ATLs through community activities/ events.	School Heads, Parents, Local Communities, UNICEF and other agencies	Long-term
Creating an innovation pathway: Linkages with engineering colleges and industry The Andhra Pradesh experience has shown that ATLs and higher education institutions such as engineering colleges can be brought together to strengthen the ATLs and offer, at the same time, a useful opportunity for the engineering students to develop their soft skills. If this can be extended and the engineering colleges can adopt the ATLs as their extension labs or centres, it will go a long way in sustaining the ATLs. Further, connecting the ATL, HEIs and local industry will ensure that an innovation pathway is created, which can also help in developing entrepreneurship and livelihood opportunities.	School education department, higher education institutions, local industry, UNICEF and other agencies	Medium to long term

Sustaining ATLs

UNICEF has been working closely with the state education departments in Karnataka and Telangana to ensure that the processes that have been put in place can be sustained even after UNICEF's withdrawal.

The hub and spokes approach to strengthen the ATLs was undertaken to demonstrate to the government that with sustained inputs and support from the school education department—through trainings (face-to-face and online modes), development of learning modules and resources for the teachers, curricular integration and departmental reviews—an important difference can be made in how children learn STEM and develop a range of critical skills using tools and frameworks such as the design thinking process.

The current study clearly shows the gains from this approach, both at the level of the child and teacher, even as it highlights the steps that need to be undertaken to institutionalize the ATLs within the school space. The following aspects have been focused upon in efforts to ensure sustainability of this initiative.

Access: The Union Government has decided to budget for an additional 50,000 ATLs across the country (already in Telangana, an additional 597 ATLs have been established in the summer of 2025 in PM Shri Schools). Unlike in Phase 1 when 10,000 ATLs were established through an online application process (which also resulted in a bypass of the school education departments), in the upcoming Phase 2, the Education Departments will be leading the expansion of the initiative. There is thus clear commitment from the Government to expand the establishment of maker spaces in schools.

Further, in Karnataka, UNICEF's advocacy has led to a state commitment to establish additional maker spaces (the 'Avishkar labs') in 123 secondary schools using its own resources. The budget has been allocated to the districts for the establishment of the maker spaces and the procurement process is complete. This is one result of UNICEF's advocacy with the school education department.

The Union Government's decision to expand the number of ATLs as well as state level decisions to use their own resources to expand access (the Avishkar example from Karnataka) are also a result of the encouraging experiences from Phase 1, contributing in important ways to sustainability. The 50,000 ATLs will also work on a 'hub and spokes' model, reaching out to 1,25,000 schools in their blocks/districts.

Capacity building: In Telangana, UNICEF has been engaging with Samagra Shiksha to convene a group of technical organizations that can provide capacity building support to the education department to strengthen the nearly 1000 ATLs in the state (before the recent addition of 597 ATLs, the state already had 384 ATLs). Resources are available in the department's budget for this. In Karnataka, UNICEF is engaging with the Government Tool Room and Training Centre (GTTC) to build its capacity as an in-house government technical resource centre that can carry forward the work of capacity building. This will contribute to a sustained way forward for strengthening the ATLs in the State.

Other aspects contributing to sustainability: UNICEF has, over the course of its engagement, brought into focus the need for regular departmental

reviews of the ATLs. In Telangana, a digital platform has been developed with UNICEF technical inputs. This platform will be used by teachers for self-reporting as well as reporting by department officers and, at a later stage, by civil society organizations working in this space. The gradual departmental reviews as well as aspects such as curriculum integration, allocation of resources within Samagra Shiksha plans for teacher training will also contribute to sustaining efforts.

Low-cost Makers Spaces

While the hub-and-spoke model has demonstrated great promise towards strengthening ATLs across the three states, the study also points to the need for complementary approaches that can expand "tinkering" more quickly and equitably. In this context, a low-cost maker spaces model could also be explored. Low-cost maker spaces need much less space as compared to an ATL. Further, they do not need to be provided with high end technologies and equipment which are common to ATLs. At the same time, low-cost maker spaces can provide ample opportunities for tinkering and learning design thinking.

Suggestions for establishing a low-cost maker spaces in a school

Grades: The low-cost maker space can cater to children from grades V to IX.

Cost: INR 1,50,000, with an estimated maintenance cost of INR 20000 per year. The education department can explore this provision for maintenance as part of the school's budget every year in the Samagra Shiksha budget.

Infrastructure: Ideally, 200-250 sq. ft, with two working tables (size 6 X 3 X 2.5 ft) and one almirah for storing equipment and working tools. A steady electrical as well as internet connection will be an advantage.

Teacher(s): At least one teacher needs to be assigned the responsibility of the maker space. Where science teachers are available (as in middle and secondary schools), one science teacher can be assigned this responsibility. Further, when classroom instruction is linked with maker space activities, all teachers can make plans for use of the maker space. This would be the ideal situation.

Tools: The low-cost maker space should have the basic or essential tools like:

- Mechanical tools including basic measuring instruments, cutting tools, screwdrivers and spanners, other fabrication tools
- Energy and environment tools (electrical and electronics)
- Basic agricultural tools
- Arts, craft and sewing tools
- Safety equipment.

Integration of maker space in the school: The school can assign two 'work experience' periods per week per class. The concerned teacher accompanies the children to the maker space during these periods. In the initial phase, students should be exposed to various equipment and their usage, including safety standards that need to be followed. Gradually, they can start working on projects/themes/ideas identified by them, with the support of the teacher.

There can also be a mapping of concepts in the core curriculum that can be taught using the maker space. This will serve as a reference point and guide for the teacher as he/she starts using the maker space.

Training of teachers: Teachers assigned the task of operating the low-cost maker space should undergo training, both online and offline. The offline training can also happen within the nearest hub ATL. The logistics and costs of such training would need to be borne by the school education department. Departmental circulars/instructions would help with respect to teacher training.

School selection: Schools which show interest and which can provide the basic facilities required for a low-cost maker space can be selected in the demonstration phase (20 schools each in Telangana and Karnataka). Schools like KGBVs and Girls Schools need to be focused upon given UNICEF's gender focus. Departmental circulars/instructions would help with respect to school selection.

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Annexures

Annexure 1: Data Tables

Table 1: **ATL Usages and Participation**

Variable		Observation	Frequency	Percentage	Mean	Std. Dev.	Min	Max
How did you come to know about the ATL?	Response	335			21.58	5.12	1	31
	Teacher/School		204	65.81				
	Self/Own Interest		77	24.84				
	Friends/Peers		12	3.87				
	Seniors/Alumni		9	2.9				
	Family		4	1.29				
	Events/ Bootcamps		4	1.29				
2 How often do you go to the ATL?		335			1.70	1.22	1	5
	2 to 3 times a week		212	63.28				
	Daily		78	23.28				
	Less than once a week		11	3.28				
	Never		1	0.3				
	Once a week		33	9.85				
Is ATL included in your timetable, or do you go voluntarily?		335			2.29	0.95	1	4
	Both		86	25.67				
	I go my own		97	28.96				
	It's part of the timetable		122	36.42				
	Not sure		30	8.96				
What activities do you participate in at the ATL (grouped)?		335			82.70	15.36	59	116
	Participated in Robotics (Y)		132	39.4				
	Participated Electrical Circuit (Y)		288	85.97				
	Participated 3D Design (Y)		134	40				
	Science Experiments (Y)		115	34.33				
	Participated in Art and Design projects (Y)		120	35.82				

Variable		Observation	Frequency	Percentage	Mean	Std. Dev.	Min	Max
	Participated in Coding/ Programming (Y)		106	31.64				
No. of activities participated	None		5	1.49				
	Once		56	16.72				
	Twice		95	28.36				
	Thrice		100	29.85				
	Four times		54	16.12				
	Five times		17	5.07				
	Six times and more		8	2.39				
Who usually guides you in the ATL?		335			18.81	10.36	1	45
	Teacher/School		204	65.81				
	Self/Own Interest		77	24.84				
	Friends/Peers		12	3.87				
	Seniors/Alumni		9	2.9				
	Family		4	1.29				
	Events/ Bootcamps		4	1.29				
How long does each ATL session typically last?		335			2.03	1.48	1	6
	45 minutes		163	48.66				
	1–2 hours		106	31.64				
	More than 2 hours		26	7.76				
	Half day/Whole day		2	0.6				
	It varies/Not sure		10	2.99				
	Mixed durations		28	8.36				
Have you attended any online sessions related to ATL?		335			1.56	0.50	1	2
	Yes		146	43.58				
	No		189	56.42				
Have you participated in any of the event (grouped category)?		225			3.37	1.87	1	7
	Science Fair/ Exhibition		70	31.11				
	ATL Marathons		7	3.11				
	Bootcamps		38	16.89				
	Make-a-thons		8	3.56				
	Online sessions		90	40				
	Inspire awards		5	2.22				
	Other competitions		7	3.11				

Table 2: **How did you come to know about the ATL (by State)?**

Values		Andhra Pradesh	Karnataka	Telangana	Total	Chi² (p-value)
Teacher/School	Frequency	65	68	92	225	0.000
	%	28.89	30.22	40.89	100	
Self/Own Interest	Frequency	50	13	15	78	
	%	64.1	16.67	19.23	100	
Friends/Peers	Frequency	6	1	5	12	
	%	50	8.33	41.67	100	
Seniors/Alumni	Frequency	1	7	1	9	
	%	11.11	77.78	11.11	100	
Family	Frequency	1	1	3	5	
	%	20	20	60	100	
Events/ Bootcamps	Frequency	0	2	1	3	
	%	0	66.67	33.33	100	
Other	Frequency	1	1	1	3	
	%	33.33	33.33	33.33	100	
Total	Frequency	124	93	118	335	
	%	37.01	27.76	35.22	100	

Table 3: **How did you come to know about the ATL (by Gender)?**

		Female	Male	Total	Chi² (p-value)
Teacher/School	Frequency	114	111	225	0.159
	%	50.67	49.33	100	
Self/Own Interest	Frequency	39	39	78	
	%	50	50	100	
Friends/Peers	Frequency	1	11	12	
	%	8.33	91.67	100	
Seniors/Alumni	Frequency	5	4	9	
	%	55.56	44.44	100	
Family	Frequency	3	2	5	
	%	60	40	100	
Events/Bootcamps	Frequency	2	1	3	
	%	66.67	33.33	100	
Other	Frequency	1	2	3	
	%	33.33	66.67	100	
Total	Frequency	165	170	335	
	%	49.25	50.75	100	

Table 4: **How often do you go to the ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
2 to 3 times a week	Freq.	44	39	83	0.003	36	18	54	0.001	37	38	75	0.527
	%	53.01	46.99	100		66.67	33.33	100		49.33	50.67	100	
Daily	Freq.	5	22	27		13	26	39		4	8	12	
	%	18.52	81.48	100		33.33	66.67	100		33.33	66.67	100	
Once a week	Freq.	9	5	14						9	10	19	
	%	64.29	35.71	100						47.37	52.63	100	
Less than once a week	Freq.									7	4	11	
	%									63.64	36.36	100	
Never	Freq.									1	0	1	
	%									100	0	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.36	100	

Table 5: **Is ATL included in your timetable or do you go voluntarily (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
Both	Freq.	12	12	24	0.592	14	24	38	0.013	8	16	24	0.339
	%	50	50	100		36.84	63.16	100		33.33	66.67	100	
I go on my own	Freq.	13	13	26		17	14	31		20	20	40	
	%	50	50	100		54.84	45.16	100		50	50	100	
It is part of the timetable	Freq.	30	33	63		18	6	24		19	16	35	
	%	47.62	52.38	100		75	25	100		54.29	45.71	100	
Not sure	Freq.	3	8	11						11	8	19	
	%	27.27	72.73	100						57.89	42.11	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	27.27	72.73	100		52.69	47.31	100		49.15	50.85	100	

Table 6: **What activities do you participate in at ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Activities		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
Robotics	Freq.	19	32	51	0.076	13	24	37	0.006	16	28	44	0.032
	%	37.25	62.75	100		35.14	64.86	100		36.36	63.64	100	
Electronic Circuit building	Freq.	46	62	108	0.015	44	42	86	0.302	47	47	94	0.716
	%	42.59	57.41	100		51.16	48.84	100		50	50	100	
3D Printing/ Design	Freq.	24	42	66	0.013	31	27	58	0.85	1	9	10	0.01
	%	36.36	63.64	100		53.45	46.55	100		10	90	100	
Science Experiment	Freq.	12	22	34	0.115	28	18	46	0.118	100	25	35	0.004
	%	35.29	64.71	100		60.87	39.13	100		28.57	71.43	100	

		Andhra Pradesh				Karnataka				Telangana			
Activities		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Art and design projects	Freq.	29	22	51	0.06	24	14	38	0.093	16	15	31	0.75
	%	56.86	43.14	100		63.16	36.84	100		51.61	48.39	100	
Coding/ Programming	Freq.	16	29	45	0.059	10	23	33	0.001	10	18	28	0.103
	%	35.56	64.44	100		30	69.7	100		35.71	64.29	100	

Table 7: **No. of ATL activities participated in (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Activities participated in (count)		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Once	Freq.	13	5	18	0.015	3	0	3	0.444	20	15	35	0.094
	%	72.22	27.78	100		100	0	100		57.14	42.86	100	
Twice	Freq.	22	14	36		7	7	14		25	20	45	
	%	61.11	38.89	100		50	50	100		55.56	44.44	100	
Thrice	Freq.	11	24	35		26	21	47		6	12	18	
	%	31.43	68.57	100		55.32	44.68	100		33.33	66.67	100	
Four times	Freq.	7	14	21		10	10	20		3	10	13	
	%	33.33	66.67	100		50	50	100		23.08	76.92	100	
Five times	Freq.	2	6	8		3	5	8		0	1	1	
	%	25	75	100		37.5	62.5	100		0	100	100	
Six times and more	Freq.	3	3	6		0	1	1		0	1	1	
	%	50	50	100		0	100	100		0	100	100	
None	Freq.									4	1	5	
	%									80	20	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 8: **Who usually guides in the ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Who guided?		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Teacher	Freq.	49	64	113	0.015	48	44	92	0.341	56	52	108	0.054
	%	45.36	56.64	100		52.17	47.83	100		51.85	48.15	100	
Senior student/ peer/friend	Freq.	9	15	24	0.311	15	14	29	0.9	16	12	28	0.333
	%	37.5	62.5	100		51.72	48.28	100		57.14	42.86	100	
Vigyan Ashram Team member	Freq.	33	37	70	0.925	20	17	37	0.83	20	23	43	0.664
	%	47.14	52.86	100		54.05	45.95	100		46.51	53.49	100	
External mentor/ Volunteer	Freq.	9	12	21	0.693	8	8	16	0.813	4	11	15	0.062
	%	42.86	57.14	100		50	50	100		24.67	73.33	100	
Not Mentioned- Not work independently	Freq.	58	66	124		46	44	90	0.095	58	60	118	NR
	%	46.77	53.23	100		51.11	48.89	100		49.15	50.85	100	

Table 9: How long does each ATL activity last (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Duration of each session		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
45 minutes	Freq.	16	30	46	0.209	30	22	52	0.1	35	30	65	0.345
	%	34.78	65.22	100		57.69	42.31	100		53.85	46.15	100	
1-2 Hours	Freq.	27	23	50		13	8	21		18	17	35	
	%	54	46	100		61.9	38.1	100		51.43	48.57	100	
More than 2 hours	Freq.	6	4	10		0	3	3		3	10	13	
	%	60	40	100		0	100	100		23.08	76.92	100	
Half day/ Whole day	Freq.	2	0	2									
	%	100		100									
It varies/ Not sure	Freq.	2	4	6		0	2	2		1	1	2	
	%	33.33	66.6	100		0	100	100		50	50	100	
Mixed duration	Freq.	5	5	10		6	9	15		1	2	3	
	%	50	50	100		40	60	100		33.33	66.67	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 10: Have attended any online session (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Attended any online session		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Yes	Freq.	16	16	32	0.671	19	24	43	0.128	33	38	71	0.475
	%	50	50	100		44.19	55.01	100		46.48	53.52	100	
No	Freq.	42	50	92		30	20	50		25	22	47	
	%	45.65	54.35	100		60	40	100		53.19	46.01	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 11: Participation in any event (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Event		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Participated in Science Fair/ Exhibition	Freq.	31	39	70	0.527	24	21	45	0.904	20	26	46	0.324
	%	44.29	55.71	100		53.33	46.67	100		43.48	56.52	1100	
Participated in ATL Marathons	Freq.	9	20	29	0.052	4	9	13	0.088	2	1	3	0.539
	%	31.03	68.97	100		30.77	69.23	100		66.67	33.33	100	
Participated in online session	Freq.	18	28	46	0.19	21	13	34	0.183	5	6	11	0.797
	%	39.13	60.87	100		61.76	38.24	100		45.45	54.55	100	
Participated in Inspire awards	Freq.						2	2	0.131		4	4	0.045
	%						100	100			100	100	
Participated in Other competition	Freq.	1	1	2	0.927		4	4	0.031		1	1	0.323
	%	50	50	100			100	100			100	100	

Table 12: **Summary statistics: Attitude and Perception**

Variable	Response	Observation	Frequency	Percentage	Mean	Std. Dev.	Min	Max
Are ATL sessions more engaging than regular classes?		335			1.96	0.21	1	2
	No		15	4.48				
	Yes		320	95.52				
Do you consider participation in ATL a burden?		335			0.28	0.64	0	3
	No		267	79.7				
	Yes		48	14.33				
	Sometimes		13	3.88				
	Conditional/ Context-based		7	2.09				
Are boys and girls equally encouraged to participate in ATL?		335			1.21	0.72	0	4
	No		12	3.58				
	Yes		282	84.18				
	Sometimes		5	1.49				
	Not Applicable		31	9.25				
	Gender-specific issues		5	1.49				
Do you share your ATL learnings with other classmates?		335			1.07	0.32	0	2
	No		7	2.09				
	Yes		299	89.25				
	Sometimes		29	8.66				
What challenges do you face in using the ATL?		335			1.056716	0.256195	0	2
Challenges grouped	None		2	0.6				
	Few (1–2)		312	93.13				
	Some (3–5)		21	6.27				
How would you rate the availability of materials and equipment in ATL?		335			4.17	0.71	1	5
	Excellent - everything is available		1	0.3				
	Good - most things are available		2	0.6				
	Average - some things are missing		48	14.33				
	Poor - many things are missing		171	51.04				
	Very poor - very limited resources		113	33.73				
To what extent do your teachers support you in your ATL projects?		335			3.72	0.73	0	4

Variable	Response	Observation	Frequency	Percentage	Mean	Std. Dev.	Min	Max
	Always		283	84.48				
	Not at all		1	0.3				
	Often		22	6.57				
	Rarely		10	2.99				
	Sometimes		19	5.67				

Table 13: **Are ATL sessions more engaging than regular class (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
ATL more engaging than regular classes		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
Yes	Freq.	56	66	122	0.128	48	42	90	0.495	50	58	108	0.041
	%	45.9	54.1	100		53.33	46.67	100		46.3	53.7	100	
No	Freq.	2	0	2		1	2	3		8	2	10	
	%	100		100		33.33	66.67	100		80	20	100	
Total	Freq.	58	66	123		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 14: **Do you consider participation in ATL a burden by State and Gender?**

		Andhra Pradesh				Karnataka				Telangana			
Perception of ATL as burden		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
No	Freq.	47	61	108	0.161	37	28	65	0.627	46	48	94	0.613
	%	43.52	56.48	100		56.92	43.08	100		48.94	51.06	100	
Yes	Freq.	8	4	12		9	12	21		9	6	15	
	%	66.67	33.33	100		42.86	57.14	100		60	40	100	
Sometimes	Freq.	3	1	4		2	2	4		2	3	5	
	%	75	25	100		50	50	100		40	60	100	
Conditional/ Context										1	3	4	
										25	75	100	
Total	Freq.	58	66	124		1	2	3		58	60	118	
	%	46.77	53.23	100		33.33	66.67	100		49.15	50.85	100	

Table 15: **Are boys and girls equally encouraged to participate in ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Boys and girls equally encouraged		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
No	Freq.	1	5	6	0.207	2	1	3	0.000	2	1	3	0.000
	%	16.67	83.33	100		66.67	33.33	100		66.67	33.33	100	
Yes	Freq.	56	58	114		31	43	74		39	55	94	
	%	49.12	50.88	100		41.89	58.11	100		41.49	58.51	100	
Sometimes	Freq.	1	3	4						1		1	
	%	25	75	100						100		100	

		Andhra Pradesh				Karnataka				Telangana			
Boys and girls equally encouraged		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Not Applicable	Freq.					16	0	16		15		15	
	%					100		100		100		100	
Gender specific issues										1	4	5	
										20	80	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 16: **Do you share ATL learnings with other classmates (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Share ATL learnings with classmates		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
No	Freq.	3	0	3	0.139	1	1	2	0.614	1	1	2	0.543
	%	100		100		50	50	100		50	50	100	
Yes	Freq.	52	64	116		46	39	85		46	52	98	
	%	44.83	55.17	100		54.12	45.88	100		46.94	53.06	100	
Sometimes	Freq.	3	2	5		2	4	6		11	7	18	
	%	60	40	100		33.33	66.67	100		61.11	38.89	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 17: **No. of Challenges faced in attending ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Challenges		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
One Challenge	Freq.	42	47	89	0.642	38	34	72	0.487	29	32	61	0.796
	%	47.19	52.81	100		52.78	47.22	100		47.54	52.46	100	
Two Challenges	Freq.	16	18	34		11	8	19		18	19	37	
	%	47.06	52.94	100		57.89	42.11	100		48.65	51.35	100	
Three Challenges	Freq.	0	1	1		0	1	1		10	7	17	
	%	0	100	100		0	100	100		58.82	41.18	100	
Four Challenges						0	1	1		0	1	1	
						0	100	100		0	100	100	
Total	Freq.	58	66	124		49	44	93		57	59	116	
	%	46.77	53.23	100		52.69	47.31	100		49.1	50.9	100	

Table 18: **Challenges grouped in using the ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Challenges		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Few (1–2)	Freq.	58	65	123	0.347	49	42	91	0.131	47	51	98	0.839
	%	47.15	52.85	100		53.85	46.15	100		47.96	52.04	100	
Some (3–5)	Freq.	0	1	1		0	2	2		10	8	18	
	%	0	100	100		0	100	100		55.56	44.44	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 19: **What challenges do you face in using the ATL (Select all that apply by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Challenges		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Lab Not Open/No access after school	Freq.	1	4	5	0.221	1	2	3	0.495	9	12	21	0.524
	%	20	80	100		33	67	100		42.86	57.14	100	
Lack of materials/ components/ equipment	Freq.	17	32	49	0.029	11	13	24	0.435	36	38	74	0.887
	%	34.69	65.31	100		45.83	54.17	100		48.65	51.35	100	
Limited teacher guidance/ Need specific teacher	Freq.		3	3	0.1	4	7	11	0.248	12	13	25	0.897
	%		100	100		36.36	63.64	100		48	52	100	
Too many students/ Not enough space	Freq.	12	10	22	0.421	4	3	7	0.806	15	10	25	0.222
	%	54.55	45.45	100		57.14	42.86	100		60	40		
Technical Issues (3D printer, power, wifi, RFID,etc.)	Freq.	2	5	7	0.32		3	3	0.063	3	3	6	0.996
	%	28.57	71.43	100			100	100		50	50	100	
Lack confidence/ Feel shy	Freq.	3	3	6	0.871	6	4	10	0.624	3		3	0.074
	%	50	50			60	40	100		100		100	

Table 20: **How do you rate availability of materials and equipments in ATL (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Challenges		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Excellent	Freq.								0.011	1	0	1	0.557
	%									100	0	100	
Good	Freq.									1	1	2	
	%									50	50	100	
Average - some things	Freq.	4	2	6	0.186	2	4	6		21	15	36	
	%	66.67	33.33	100		33.33	66.67	100		58.33	41.67	100	

		Andhra Pradesh				Karnataka				Telangana			
Challenges		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Poor - many things are not available	Freq.	27	41	68		14	24	38		29	36	65	
	%	39.71	60.29	100		36.84	63.16	100		44.62	55.38	100	
Very poor - very limited materials	Freq.	27	23	50		33	16	49		6	8	14	
	%	54	46	100		67.35	32.65	100		42.86	57.14	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 21: **To what extent teachers support you in ATL projects (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Challenges		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Not at all	Freq.										1	1	0.799
	%										100	100	
Rarely	Freq.									5	5	10	
	%									50	50	100	
Sometimes	Freq.									8	11	19	
	%									42.11	57.89	100	
Often	Freq.	1	5	6	0.13	4	7	11	0.248	3	2	5	
	%	16.67	83.33	100		36.36	63.64	100		60	40	100	
Always	Freq.	57	61	118		45	37	82		42	41	83	
	%	48.31	51.69	100		54.88	45.12	100		50.6	49.4	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 22: **Summary statistics: Safety and Access**

Variable		**Observation**	**Freq.**	**Percentage**	**Mean**	**Std. Dev.**	**Min**	**Max**
Have you or anyone else faced a minor injury or safety related issue while working in ATL?		335			0.22	0.42	0	1
	No		260	77.61				
	Yes		75	22.89				
If yes, what happened after the accident?		75			1.03	0.80	0	3
	No injury		16	21.33				
	Minor injury/ First aid		48	64				
	Minor injury/ No action		4	5.33				
	Other injury		7	9.33				
Is the respondent female?		335			0.50	0.50	0	1
	No		169	50.45				
	Yes		166	49.55				
Are you allowed to stay back after school to attend ATL sessions?		166			1.83	1.00	0	3

Variable		Observation	Freq.	Percentage	Mean	Std. Dev.	Min	Max
	No		29	17.47				
	Sometimes		13	7.83				
	Yes (always/ needed)		82	49.4				
	Not applicable		42	25.3				
Would you recommend ATL to other students or friends?		335			0.98	0.13	0	1
	No		6	1.79				
	Yes		329	98.21				

Table 23: **Have you or anyone else faced a minor injury or safety related issue while working in ATLs (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Faced minor injury/ Safety related issues		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
No	Freq.	45	49	94	0.664	40	27	67	0.03	54	45	99	0.007
	%	47.87	52.13	100		59.7	40.3	100		54.55	45.45	100	
Yes	Freq.	13	17	30		9	17	26		4	15	19	
	%	43.33	56.67	100		34.62	65.38	100		21.05	78.95	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 24: **Outcome after injury (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Outcome after injury		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Minor injury/No serious accident	Freq.	9	14	23	0.844	7	11	18	0.516	2	9	11	0.147
	%	39.13	60.87	100		38.89	61.11	100		18.18	81.82		
Other	Freq.					1	4	5			2	2	
	%					20	80	100			100	100	
Total	Freq.	9	14	23		8	15	23		2	11	13	
	%	39.13	60.87	100		34.78	65.22	100		15.38	84.62	100	

Table 25: **Are you allowed to stay back after school to attend ATL sessions (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Stay for ATL after school		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
No	Freq.	15		15	.0.12					14		14	0.004
	%	100		100						100		100	
Sometimes	Freq.	5	2	7						6		6	
	%	71.43	28.57	100						100		100	
Yes (Always stay)	Freq.	28	3	31		47		47		3	1	4	
	%	90.32	9.68	100		100		100		75	25	100	
Not Applicable	Freq.	7		7		2		2		33		33	
	%	100		100		100		100		100		100	
Total	Freq.	55	5	60		49		49		56	1	57	
	%	91.67	8.33	100		100		100		98.25	1.75	100	

Table 26: **Reasons for not staying back after school hours to attend ATL sessions (by State and Gender)?**

		Andhra Pradesh				Karnataka				Telangana			
Reason for not attending ATL after school		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Not Applicable	Freq.	22		22	0.194	7		7		32		32	
	%	100		100		100		100		100		100	
Safety concerns	Freq.	4	1	5		1		1		2		2	
	%	80	20	100		100		100		100		100	
Transport issue	Freq.	2		2		6		6		1		1	
	%	100		100		100		100		100		100	
Academic pressure	Freq.	3		3		13		13					
	%	100		100		100		100					
Household responsibilities	Freq.					1		1					
	%					100		100					
Extra classes	Freq.					1		1					
	%					100		100					
Lack of interest	Freq.					1		1					
	%					100		100					
No restriction	Freq.	7		7		7		7					
	%	100		100		100		100					
Not clear/Other	Freq.	2		2									
	%	100		100									
Total	Freq.	40	1	41		37		37		35		35	
	%	97.56	2.44	100		100		100		100		100	

Table 27: **Summary statistics: Skills and Problem Solving**

Variable		Observation	Frequency	Percentage	Mean	Std. Dev.	Min	Max
What do you do first when you face a new problem?		335			2.44	0.76	1	4
	Ask someone else for help		55	16.42				
	Immediately try solving it		78	23.28				
	Understand the problem		201	60				
	Wait for others to solve it		1	0.3				
Have you ever worked on something that tried to solve a real-life problem?		335			1.40	0.57	1	3
	Yes		216	64.48				
	No		104	31.04				
	Can't Remember		15	4.48				
Are you encouraged to think creatively and come up with new ideas?		335			1.06	0.31	1	3
	Yes		323	96.42				
	Can't Say		5	1.49				
	No		7	2.09				
What skills have you improved through your activities? (Select all that apply)		335			3.83	1.87	0	9
	Creativity improved (Y)		190	56.72				
	Problem Solving improved (Y)		183	54.63				
	Communication improved(Y)		141	42.09				
	Team work improved (Y)		185	55.22				
	Improvement in confidence (Y)		158	47.16				
	Improvement in patience (Y)		45	13.43				
	Team management improved (Y)		40	11.94				
	Tech skill improved (Y)		205	61.19				
	Self-discipline improved (Y)		1	0.3				
	Respect for others improved (Y)		1	0.3				
	Decision making		1	0.3				
	Innovation improved		1	0.3				
	Coding improved		2	0.6				
	Planning skill		2	0.6				
	Motivation improved		1	0.3				

Variable		Observation	Frequency	Percentage	Mean	Std. Dev.	Min	Max
Total skills improved	Nil skills		6	1.79				
	1–3 skills		165	49.25				
	4–6 skills		130	38.81				
	7+ skills		34	10.15				
Are you comfortable sharing your ideas in front of everyone during class or group projects?	Yes	335	298	88.86	0.89	0.31	0	1
Have your school activities helped you feel prepared for your future career?		335			1.01	0.31	0	2
	No		15	4.48				
	Not Sure		17	5.07				
	Yes		303	90.45				
Do you usually test and retry ideas if your first attempt doesn't work?	Yes	335	327	97.61	0.98	0.15	0	1
Do you think the activities in your school help you understand classroom topics better?	Yes	335	313	93.43	0.93	0.25	0	1

Table 28: What you do when faced with a new problem (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
When new problems arise		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
Ask someone else for help	Freq.	11	10	21	0.2	5	5	10	0.925	11	13	24	0.936
	%	52.38	47.62	100		50	50	100		45.83	54.17	100	
Immediately try solving it	Freq.	14	8	22		12	12	24		16	16	32	
	%	63.64	36.36	100		50	50	100		50	50	100	
Understand the problem	Freq.	33	47	80		32	27	59		31	31	62	
	%	41.25	58.75	100		54.24	45.76	100		50	50	100	
Wait for others	Freq.	0	1	1									
	%	0	100	100									
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 29: Ever worked on solving a real life problem (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Ever worked on solving a problem		Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)	Female	Male	Total	Chi² (p-value)
Yes	Freq.	39	55	94	0.08	29	29	58	0.547	22	42	64	0.001
	%	41.49	58.51	100		50	50	100		34.38	65.63	100	
No	Freq.	19	8	27		19	15	34		27	16	43	
	%	70.37	29.63	100		55.88	44.12	100		62.79	37.21	100	
Can't remember	Freq.		3	3		1		1		9	2	11	
	%		100	100		100		100		81.82	18.18	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 30: Are encouraged to work on real life problem (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Encouraged to work on real life problem		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Yes	Freq.	57	65	122	0.927	47	44	91	0.127	54	56	110	0.765
	%	46.72	53.28	100		51.65	48.35	100		49.09	50.91	100	
No	Freq.	1	1	2		2	0	2		1	2	3	
	%	50	50	100		100	0	100		33.33	66.67	100	
Can't remember	Freq.									3	2	5	
	%									60	40	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 31: What skills have you improved through your activities (by State and Gender)?

			Andhra Pradesh				Karnataka				Telangana			
Skill improved			**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Creativity improved	No	Freq.	27	13	40	0.001	28	22	50	0.49	26	29	55	0.703
		%	67.5	32.5	100		56	44	100		47.27	52.73	100	
	Yes	Freq.	31	53	84		21	22	43		32	31	63	
		%	36.9	63.1	100		48.84	51.16	100		50.79	49.21	100	
Problem Solving improved	No	Freq.	31	27	58	0.163	21	22	43	0.49	33	18	51	0.003
		%	53.45	46.55	100		48.84	51.16	100		64.71	35.29	100	
	Yes	Freq.	27	39	66		28	22	50		25	42	67	
		%	40.91	59.09	100		56	44	100		37.31	62.69	100	
Critical thinking improved (Yes responses)	No	Freq.	33	48	81	0.065	30	33	63	0.156	30	34	64	0.59
		%	40.74	59.26	100		47.62	52.38	100		46.88	53.13	100	
	Yes	Freq.	25	18	43		19	11	30		28	26	54	
		%	58.14	41.86	100		63.33	36.67	100		51.85	48.15	100	
Team work improved	No	Freq.	35	31	66	0.136	11	9	20	0.815	35	29	64	0.19
		%	53.03	46.97	100		55	45	100		54.69	45.31	100	
	Yes	Freq.	23	35	58		38	35	73		23	31	54	
		%	39.66	60.34	100		52.05	47.95	100		42.59	57.41	100	
Improvement in confidence	No	Freq.	34	41	75	0.691	5	8	13	0.268	49	40	89	0.025
		%	45.33	54.67	100		38.46	61.54	100		55.06	44.94	100	
	Yes	Freq.	24	25	49		44	36	80		9	20	29	
		%	48.98	51.02	100		55	45	100		31.03	68.97	100	
Communication improved	No	Freq.	40	40	80	0.332	12	19	31	0.056	44	39	83	0.197
		%	50	50	100		38.71	61.29	100		53.01	46.99	100	
	Yes	Freq.	18	26	44		37	25	62		14	21	35	
		%	40.91	59.09	100		59.68	40.32	100		40	60	100	
Patience improved	No	Freq.	50	53	103	0.382	39	38	77	0.388	55	55	110	0.495
		%	48.54	51.46	100		50.65	49.35	100		50	50	100	
	Yes	Freq.	8	13	21		10	6	16		3	5	8	
		%	38.1	61.9	100		62.5	37.5	100		37.5	62.5	100	

			Andhra Pradesh				Karnataka				Telangana			
Skill improved			**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Time management improved	No	Freq.	50	53	103	0.382	45	36	81	0.15	57	54	111	0.057
		%	48.54	51.46	100		55.56	44.44	100		51.35	48.65	100	
	Yes	Freq.	8	13	21		4	8	12		1	6	7	
		%	38.1	61.9	100		33.33	66.67	100		14.29	85.71	100	
Techonology skill improved	No	Freq.	21	22	43	0.737	20	10	30	0.062	35	22	57	0.01
		%	48.84	51.16	100		66.67	33.33	100		61.4	38.6	100	
	Yes	Freq.	37	44	81		29	34	63		23	38	61	
		%	45.68	54.32	100		46.03	53.97	100		37.7	62.3	100	
Self- discipline improved	No	Freq.	58	65	123	0.347	49	44	93		58	60	118	
		%	47.15	52.85	100		52.69	47.31	100		49.15	50.85	100	
	Yes	Freq.		1	1									
		%		100	100									
Respect for others	No	Freq.	58	65	123	0.347	49	44	93		58	60	118	
		%	47.15	52.85	100		52.69	47.31	100		49.15	50.85	100	
	Yes	Freq.		1										
		%		100										
Decision making improved	No	Freq.	58	66	124		48	44	92	0.341	58	60	118	
		%	46.77	53.23	100		52.17	47.83	100		49.15	50.85	100	
	Yes	Freq.					1		1					
		%					100		100					
Innovation improved	No	Freq.	57	66	123	0.284	49	44	93		58	60	118	
		%	46.34	53.66	100		52.69	47.31	100		49.15	50.85	100	
	Yes	Freq.			1									
		%			100									
Coding skills improved	No	Freq.	58	65	123	.0.347	49	43	92	0.289	58	60	118	
		%	47.15	52.85	100		53.26	46.74	100		49.15	50.85	100	
	Yes	Freq.		1	1			1	1					
		%		100	100			100	100					
Planning skill	No	Freq.	58	66	124		47	44	91	0.175	58	60	118	
		%	46.77	53.23	100		51.65	48.35	100		49.15	50.85	100	
	Yes	Freq.					2		2					
		%					100		100					
Self -motivation improved	No	Freq.	58	66	124		49	43	92	0.289	58	60	118	
		%	46.77	53.23	100		53.26	46.74	100		49.15	50.85	100	
	Yes	Freq.						1	1					
		%						100	100					

Table 32: Number of skills improved (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Total skills gained		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
1-3 skills	Freq.	35	36	71	0.352	8	17	25	0.006	36	33	69	0.083
	%	49.3	50.7	100		32	68	100		52.17	47.83	100	
4 -6 skills	Freq.	17	17	34		37	19	56		17	23	40	
	%	50	50	100		66.07	33.93	100		42.5	57.5	100	
7+ skills	Freq.	6	13	19		4	8	12		0	3	3	
	%	31.58	68.42	100		33.33	66.67	100			100	100	
Nil Skill										5	1	6	
										83.33	16.67	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 33: Comfortable sharing ideas in class and group projects (by State and Gender)?

		Andhra Pradesh				Karnataka				Telangana			
Total skills gained		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
No	Freq.	7	3	10	0.125		4	4	0.031	15	8	23	0.086
	%	70	30	100			100	100		65.22	34.78	100	
Yes	Freq.	51	63	114		49	40	89		43	52	95	
	%	44.74	55.26	100		55.06	44.94	100		45.26	54.74	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 34: School activities helped in future career readiness (by State and Gender)

		Andhra Pradesh				Karnataka				Telangana			
Career readiness		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Yes	Freq.	55	64	119	0.557	47	40	87	0.326	47	50	97	0.29
	%	46.22	53.78	100		54.02	45.98	100		48.45	51.55	100	
No	Freq.	2	2	4						4	7	11	
	%	50	50	100						36.36	63.64	100	
Not sure	Freq.	1		1		2	4	6		7	3	10	
	%	100		100		33.33	66.67	100		70	30	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 35: **Usually test and retry ideas if first attempts failss (by State and Gender)**

		Andhra Pradesh				Karnataka				Telangana			
Testing		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Yes	Freq.	3	1	4	0.25	49	44	93		56	58	114	0.972
	%	75	25	100		52.69	47.31	100		49.12	50.88		
No	Freq.	55	65	120						2	2	4	
	%	45.83	54.17	100						50	50	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 36: **ATL activities help to understand classroom topics better (by State and Gender)**

		Andhra Pradesh				Karnataka				Telangana			
Activities help to understand		**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**	**Female**	**Male**	**Total**	**Chi² (p-value)**
Yes	Freq.	56	63	119	0.757	49	43	92	0.289	51	51	102	0.642
	%	47.06	52.94	100		53.26	46.74	100		50	50	100	
No	Freq.	2	3	5			1	1		7	9	16	
	%	40	60	100			100	100		43.75	56.25	100	
Total	Freq.	58	66	124		49	44	93		58	60	118	
	%	46.77	53.23	100		52.69	47.31	100		49.15	50.85	100	

Table 37: **Summary Statistics: Design Thinking (Likert Scale)**

Variable		Observation	Freq	Percentage	Mean	Std. Dev.	Min	Max
Empathize: I took time to understand the thoughts, feelings, and challenges of those who are affected by a problem before trying to solve it.		445			4.37	0.79	1	5
	Strongly Disagree		5	1.12				
	Disagree		6	1.35				
	Cant Say/Neutral		38	8.54				
	Agree		168	37.75				
	Strongly Agree		228	51.24				
Define: I could clearly explain what the core problem was before moving forward with solutions.		445			4.29	0.81	2	5
	Strongly Disagree		1	0.22				
	Disagree		15	3.37				
	Can't Say/Neutral		49	11.01				
	Agree		167	37.53				
	Strongly Agree		213	47.87				
Ideate: I came up with different ideas to solve the problem, even if some ideas were unusual or were not practical.		445			3.93	1.10	1	5
	Strongly Disagree		11	2.47				
	Disagree		44	9.89				
	Can't Say/Neutral		90	20.22				
	Agree		122	27.42				
	Strongly Agree		178	40				

Variable		Observation	Freq	Percentage	Mean	Std. Dev.	Min	Max
Prototype: I built rough models, sketches, examples to test and improve my ideas before finalizing them.		445			4.27	0.96	1	5
	Strongly Disagree		7	1.57				
	Disagree		25	5.62				
	Can't Say/Neutral		44	9.89				
	Agree		132	29.66				
	Strongly Agree		237	53.26				
Test: I actively sought feedback on my ideas and used it to make my solution better.		445			4.41	0.82	1	5
	Strongly Disagree		5	1.12				
	Disagree		12	2.7				
	Can't Say/Neutral		29	6.52				
	Agree		147	33.03				
	Strongly Agree		252	56.63				

Table 38: **Overall levels of design thinking skills (%)**

Skill Item	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Empathize	1.12	1.35	8.54	37.75	51.24
Define	0.22	3.37	11.01	37.53	47.87
Ideate	2.47	9.89	20.22	27.42	40
Prototype	1.57	5.62	9.89	29.66	53.26
Test	1.12	2.7	6.52	33.03	56.63

Table 39: **State-wise distribution of design thinking skills (%)**

1. Empathize						
State	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi (p-value)**
Andhra Pradesh	1.82	0.61	3.64	38.79	55.15	
Karnataka	0	2.44	15.45	25.2	56.91	27.29 (P=0.001)
Telangana	1.27	1.27	8.28	46.5	42.68	
2. Define						
State	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	0.61	4.85	7.27	27.88	59.39	
Karnataka	0	2.44	14.63	32.52	50.41	31.59 (p=0.000)
Telangana	0	2.55	12.1	51.59	33.76	
3.Ideate						
State	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	2.42	9.7	21.82	24.85	41.21	
Karnataka	0	3.25	14.63	32.52	49.59	25.92 (p=0.001)
Telangana	4.46	15.29	22.93	26.11	31.21	
4.Prototype						
State	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	1.02	6.06	5.45	23.64	63.03	
Karnataka	0	3.25	12.2	29.27	55.28	21.56 (p=0.006)
Telangana	2.55	7.01	12.74	36.31	41.4	
5.Test						
State	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	0	3.64	4.85	27.27	64.24	
Karnataka	0	0.81	7.32	32.52	5.35	20.95 (p=0.007)
Telangana	3.18	3.18	7.64	39.49	46.5	

Table 40: **Gender differences in design thinking (DT) skills (by State)**

1. Emphatize							
State	**Gender**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	Female	2,3	0	1.15	40.23	56.32	4.62 (p=0.33)
	Male	1.28	1.28	6.41	37.18	53.85	
Karnataka	Female	0	3.03	18.18	19.7	59.09	2.73 (p=0.44)
	Male	0	1.75	12.28	31.58	54.39	
Telangana	Female	2.74	1.37	13.7	50.68	31.51	11.65 (p=0.02)
	Male	0	1.19	3.57	42.86	52.38	
2. Define							
State	**Gender**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	Female	1.28	5.13	3.85	23.08	66.67	6.07 (p=0.19)
	Male	0	4.6	10.34	32.18	52.87	
Karnataka	Female	0	3.51	14.04	28.07	54.39	1.51(p=0.68)
	Male	0	1.52	15.15	36.36	46.97	
Telangana	Female	0	1.19	10.71	45.24	42.86	7.44 (p=0.06)
	Male	0	4.11	13.7	58.9	23.29	
3. Ideate							
State	**Gender**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	Female	2.3	9.2	22.99	22.99	42.53	0.51 (p=0.97)
	Male	2.56	10.26	20.51	26.92	39.74	
Karnataka	Female		3.03	13.64	33.33	50	0.15 (p=0.98)
	Male		3.51	15.79	31.58	49.12	
Telangana	Female	8.22	20.55	21.92	24.66	24.66	8.84 (p=0.06)
	Male	1.19	10.71	23.81	27.38	36.9	
4. Prototype							
State	**Gender**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	Female	3.45	3.45	6.9	25.29	60.92	5.81 (p=0. 21)
	Male	0	8.97	3.85	21.79	65.38	
Karnataka	Female	0	4.55	13.64	27.27	54.55	1.18 (p=0.76)
	Male	0	1.75	10.53	31.58	56.14	
Telangana	Female	4.11	5.48	19.18	38.36	32.88	8.75 (p=0.07)
	Male	1.19	8.33	7.14	34.52	48.81	
5. Test							
State	**Gender**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Chi² (p-value)**
Andhra Pradesh	Female		3.45	5.75	27.59	63.22	0.36 (p=0.95)
	Male		3.85	3.85	26.92	65.38	
Karnataka	Female		1.52	13.64	21.82	53.03	9.62 (p=0.02)
	Male		0	0	33.33	66.67	
Telangana	Female	5.48	4.11	8.22	36.99	45.21	2.95 (p=0.56)
	Male	1.19	2.38	7.14	41.67	47.62	

Table 41: **Mean design thinking score (by State and Gender) (%)**

Composite index of all five skills			
Group	**Mean DT Score**	**Std. Dev.**	**N =445**
Andhra Pradesh	4.34	0.60	165
Karnataka	4.37	0.61	123
Telangana	4.08	0.66	157
Female	4.33	0.57	219
Male	4.19	0.69	226

Table 42: **Correlation matrix of design thinking skills (%)**

Variable	Empathize	Define	Ideate	Prototype	Test
Empathize	1.00				
Define	0.42*	1.00			
Ideate	0.34*	0.30*	1.00		
Prototype	0.38*	0.34*	0.43*	1.00	
Test	0.37*	0.34*	0.31*	0.48*	1.00

Note: * Indicate p<0.001, Observation 445

Table 43: **OLS Regression of design thinking score on state, class, and gender**

Predictor	Coef. (¤)	Std. Err.	t	p-value	95% CI
State (ref: Andhra Pradesh)					
Karnataka	0.018	0.075	0.24	0.813	-0.129, 0.165
Telangana	-0.265***	0.071	-3.71	0	-0.405, -0.125
Gender (ref: Male)					
Female	0.138**	0.059	2.33	0.02	0.022, 0.255
Constant	4.372***	0.221	19.76	0	3.937, 4.807
Model Fit					
R-squared	0.069				
Adj. R-squared	0.052				
F(8,436)	4.02***				

Table 44: **Summary statistics**

Variable (n=437)	Observation	Mean	Std. Dev.	Min	Max
State	437	1.96	0.85	1	3
Gender	437	1.47	0.50	1	2
Problem Understanding & Planning	437	4.22	0.97	1	5
Implementation & Technical Skills	437	3.94	1.13	1	5
Iteration & Problem Solving	437	3.87	1.18	1	5
Presentation & Reflection	437	4.02	1.08	1	5

Table 45: **Cross-tabulation of state and gender frequency and percentage**

State		Female	Male	Total
Andhra Pradesh	Frequency	92	74	166
	Row%	55.42	44.58	100
	Col %	39.66	36.1	37.99
Karnataka	Frequency	67	55	122
	Row%	54.92	45.08	100
	Col %	28.88	26.83	27.92
Telangana	Frequency	73	76	149
	Row%	48.99	51.01	100
	Col %	31.47	37.07	34.1
Total	Frequency	232	205	437
	Row %	53.09	46.91	100
	Col %	100	100	100

Table 46: **Cross-tabulation of gender and ruberic indicators**

	Female				
Variable	Observation	Mean	Std. Dev.	Min	Max
Problem Understanding & Planning	232	4.10	1.03	1	5
Implementation & Technical Skills	232	3.71	1.19	1	5
Iteration & Problem Solving	232	3.59	1.24	1	5
Presentation & Reflection	232	3.78	1.17	1	5
	Male				
Variable	Observation	Mean	Std. Dev.	Min	Max
Problem Understanding & Planning	205	4.36	0.89	1	5
Implementation & Technical Skills	205	4.20	1.00	1	5
Iteration & Problem Solving	205	4.18	1.03	1	5
Presentation & Reflection	205	4.29	0.90	1	5

Table 47: **T-test of Gender in rubric**

Variable	Female Mean (SD)	Male Mean (SD)	t-statistic	p-value
Problem Understanding & Planning	4.10 (1.03)	4.36 (0.89)	-2.83	0.0048
Implementation & Technical Skills	3.71 (1.19)	4.20 (1.00)	-4.68	<0.001
Iteration & Problem Solving	3.59 (1.24)	4.18 (1.03)	-5.43	<0.001
Presentation & Reflection	3.78 (1.17)	4.29 (0.90)	-5.14	<0.001

Table 48: **Summary statistics (by State)**

State		Problem Understanding & Planning	Implementation & Technical Skills	Iteration & Problem Solving	Presentation & Reflection
Andhra Pradesh	Mean	4.17	3.92	3.81	3.95
	SD	0.98	1.14	1.20	1.09
	Min	1	1	1	1
	Max	5	5	5	5
	N	166	166	166	166
Karnataka	Mean	4.44	4.18	4.23	4.24
	SD	0.85	0.94	0.92	0.95
	Min	1	1	1	1
	Max	5	5	5	5
	N	122	122	122	122
Telangana	Mean	4.09	3.77	3.63	3.92
	SD	1.02	1.23	1.29	1.15
	Min	1	1	1	1
	Max	5	5	5	5
	N	149	149	149	149
Total	Mean	4.22	3.94	3.87	4.02
	SD	0.97	1.13	1.18	1.08
	Min	1	1	1	1
	Max	5	5	5	5
	N	437	437	437	437

Table 49: **Pair-wise correlation between State, Gender and Rubric indictors**

	State	Gender	Problem Understanding & Planning	Implementation & Technical Skills	Iteration & Problem Solving	Presentation & Reflection
State	1					
Gender	0.05	1				
Problem Understanding & Planning	-0.03	0.13	1			
Implementation & Technical Skills	-0.05	0.22	0.76	1		
Iteration & Problem Solving	-0.06	0.25	0.74	0.84	1	
Presentation & Reflection	-0.01	0.23	0.71	0.79	0.81	1

Table 50: **One way ANOVA of design thinking (by State)**

Dimension	State	Mean	Std. Dev.	N	F (df=2,442)	p-value	Bartlett's Test (p)	Interpretation
Empathize	Andhra Pradesh (4.45) Karnataka (4.37) Telangana (4.28)	4.45, 4.37, 4.28	0.76, 0.83, 0.77	165, 123, 157	1.84	0.16	0.536	No significant differences across states. Variances are equal.
Define	Andhra Pradesh (4.41) Karnataka (4.31) Telangana (4.17)	4.41, 4.31, 4.17	0.87, 0.81, 0.73	165, 123, 157	3.6	0.028*	0.099	Significant differences: AP highest, Telangana lowest. Variances acceptable.
Ideate	Andhra Pradesh (3.93) Karnataka (4.28) Telangana (3.64)	3.93, 4.28, 3.64	1.11, 0.83, 1.20	165, 123, 157	12.24	0.000***	0	Strong differences: Karnataka significantly higher; Telangana lowest. Unequal variances (caution).
Prototype	Andhra Pradesh (4.40) Karnataka (4.37) Telangana (4.07)	4.40, 4.37, 4.07	0.97, 0.82, 1.03	165, 123, 157	5.62	0.004**	0.036	Significant differences: AP & Karnataka higher than Telangana. Some variance heterogeneity.
Test	Andhra Pradesh (4.52) Karnataka (4.50) Telangana (4.23)	4.52, 4.50, 4.23	0.75, 0.67, 0.95	165, 123, 157	6.29	0.002**	0	Significant differences: AP & Karnataka higher than Telangana. Variances unequal.

Table 51: **One way ANOVA of design thinking (by Gender)**

Dimension	Male Mean (SD)	Female Mean (SD)	F(df=1,443)	p-value	Bartlett's Test (p)	Interpretation
Empathize	4.31 (0.84)	4.42 (0.72)	2.38	0.124	0.02	No significant gender difference, though females score slightly higher. Unequal variances indicated.
Define	4.22 (0.80)	4.37 (0.82)	4.23	0.040*	0.778	Significant difference: females score higher than males. Variances equal.
Ideate	3.86 (1.16)	3.99 (1.04)	1.5	0.221	0.133	No significant gender difference; scores similar.
Prototype	4.20 (1.00)	4.35 (0.91)	2.48	0.116	0.159	No significant difference, though females again trend higher.
Test	4.34 (0.90)	4.49 (0.73)	3.65	0.057	0.002	Marginal difference ($p \approx 0.06$), with females scoring higher. Variances unequal.

Annexure 2: Findings from Statistical Tests

Gender and rubric scores

To examine whether average performance differed by gender on each rubric domain, independent two-sample t-tests[14] with equal variances were conducted for all the rubric criteria. For each criteria, group means, the mean difference with a 95% confidence interval, the t statistic with associated degrees of freedom[15], and the two-tailed p-value[16] are reported. Statistical significance was assessed at α=0.05, and where needed, the practical magnitude as small, moderate, or large based on the standardized gap has been interpreted. These tests complement the descriptive patterns by quantifying whether observed gender gaps are unlikely to be due to chance in this sample.

Across all four outcomes, males scored higher on average than females. The size of the gap varied by domain and was most pronounced for practice-oriented and reflective skills. For PUP, the female mean was 4.10 and the male mean was 4.36, yielding a statistically significant difference of −0.26 points (95% CI: −0.44, −0.08), t(435)=−2.83, p=0.0048). This represents a modest gap, consistent with a small effect in practical terms. In contrast, ITS showed a larger separation: females averaged 3.71 versus 4.20 for males, a difference of −0.50 points (95% CI: −0.71, −0.29), t(435)=−4.70, p<0.001), indicating a small-to-moderate, practically meaningful gap favouring males in technical execution.

The largest gender difference emerged for IPS. Females averaged 3.59 while males averaged 4.18; the mean difference of −0.58 points (95% CI: −0.80, −0.36) was statistically significant, t(435)=−5.28, p<0.001, and corresponds to a moderate practical gap in iterative problem-solving proficiency. PR also showed a clear difference, with females at 3.78 and males at 4.29; the mean difference of −0.50 points (95% CI: −0.70, −0.31) was significant, t(435)=−5.00, p<0.001.

[14] It compares the mean score of two independent groups (boys vs. girls) to see if the difference is bigger than expected from random variation.

[15] The t value standardizes the mean difference by its variability; df reflects information from sample sizes.

[16] The probability of seeing a difference this large (in either direction) if there were truly no group difference.

Reliability of scores

Cronbach's Alpha was calculated for the responses to each of the four areas. The formula used was:

$$\alpha = \frac{N}{N-1} \times \left(1 - \frac{\sum(\sigma^2_{\text{item}})}{\sigma^2_{\text{total}}}\right)$$

Where:

- N = number of items (areas being measured),
- σ^2_{item} = variance of each individual item,
- σ^2_{total} = variance of the total score (i.e., the sum of the scores from all items for each participant).

Annexure 3: Tools

Quantitative tools

The quantitative tools have been divided in two parts:

- MCQs/MAQs for students
- Assessment tool for students
- Assessment tool for teachers.

MCQs/MAQs for students

Student Questionnaire: Atal Tinkering Lab (ATL) Participation and Impact

Basic Information

Name of the Researcher

School ID:

Student ID:

Name: _____

Class: _____

Gender: ☐ Boy ☐ Girl ☐ Other ☐ Prefer not to say

Section A: ATL Usage and Participation

1. How did you come to know about the ATL?
   - ☐ Teacher asked me to join
   - ☐ I went on my own
   - ☐ It's part of the school timetable
   - ☐ Other (please specify): _____

2. When do you usually visit the ATL? (Select all that apply)
   - ☐ During school hours
   - ☐ After school hours
   - ☐ During holidays
   - ☐ Other (please specify): _____

3. How often do you go to the ATL?
   - ☐ Daily
   - ☐ 2–3 times a week
   - ☐ Once a week
   - ☐ Less than once a week
   - ☐ Never

4. Is ATL included in your timetable, or do you go voluntarily?
   - ☐ It's part of the timetable
   - ☐ I go on my own
   - ☐ Both
   - ☐ Not sure

5. What activities do you participate in at the ATL? (Select all that apply)
   - ☐ Robotics
   - ☐ Electronics/Circuit building
   - ☐ Coding/Programming
   - ☐ 3D Printing/Design
   - ☐ Science experiments
   - ☐ Art and design projects
   - ☐ Other (please specify): _____

6. Who usually guides you in the ATL? (Select all that apply)
   - ☐ Teacher
   - ☐ Senior student/Peer
   - ☐ External mentor/Volunteer
   - ☐ Vigyan Ashram team member
   - ☐ I work independently
   - ☐ Other (please specify): _____

7. How long does each ATL session typically last?
   - ☐ 45 minutes
   - ☐ 1–2 hours
   - ☐ More than 2 hours
   - ☐ It varies

8. Have you attended any online sessions related to ATL?
   - ☐ Yes
   - ☐ No

9. Have you participated in any of the following? (Select all that apply)
   - ☐ Bootcamps
   - ☐ Marathons
   - ☐ Make-a-thons
   - ☐ Online sessions
   - ☐ Science Fair/Exhibition
   - ☐ Other (please specify): _____

Section B: Learning and Engagement

10. Are ATL sessions more engaging than regular classes?
    - ☐ Yes
    - ☐ No

11. Do you consider participation in ATL a burden?
    - ☐ Yes
    - ☐ No
    - ☐ Sometimes
    - ☐ Other (please specify): _____

12. Are boys and girls equally encouraged to participate in ATL?
    - ☐ Yes
    - ☐ Sometimes
    - ☐ No
    - ☐ Not Applicable (for boys/girls only school)

13. Do you share your ATL learnings with other classmates?
    - ☐ Yes
    - ☐ Sometimes
    - ☐ No

Section C: Challenges and Access

14. What challenges do you face in using the ATL? (Select all that apply)
    - ☐ Lab is not open when I'm free
    - ☐ No access after school hours
    - ☐ Lack of materials/equipment
    - ☐ Limited teacher guidance
    - ☐ Too many students, not enough space
    - ☐ I feel shy or not confident
    - ☐ No major challenges
    - ☐ Other (please specify): _____

15. How would you rate the availability of materials and equipment in ATL?
    - ☐ Excellent – everything is available
    - ☐ Good – most things are available
    - ☐ Average – some things are missing
    - ☐ Poor – many things are missing
    - ☐ Very poor – very limited resources

16. To what extent do your teachers support you in your ATL projects?
    - ☐ Not at all
    - ☐ Rarely
    - ☐ Sometimes
    - ☐ Often
    - ☐ Always

17. Have you or anyone else faced a minor injury or safety related issue while working in ATL?
    - ☐ Yes
    - ☐ No
    - ☐ If yes, what happened after the accident?

Section C(a): Challenges and Access (Additional Questions for Girls Only)

18. Are you allowed to stay back after school to attend ATL sessions?
    - ☐ Yes, always
    - ☐ Yes, whenever needed
    - ☐ Sometimes
    - ☐ No
    - ☐ Not applicable (ATL runs only during school hours)

19. If you cannot attend ATL after school hours, what is the main reason? (Select the most relevant option)
    - ☐ Parents/Guardians don't allow
    - ☐ School doesn't allow
    - ☐ Safety concerns while returning home
    - ☐ Need to do household chores
    - ☐ School transport is not available
    - ☐ Not interested
    - ☐ Other (please specify): _____

Section D: Recommendations

20. Would you recommend ATL to other students or friends?
    - ☐ Yes
    - ☐ No

Section E: Design Thinking Skills

1. What do you do first when you face a new problem?
    - ☐ Understand the problem
    - ☐ Immediately try solving it
    - ☐ Ask someone else for help
    - ☐ Wait for others to solve it

2. Have you ever worked on something that tried to solve a real-life problem?
    - ☐ Yes
    - ☐ No
    - ☐ Can't remember

3. Are you encouraged to think creatively and come up with new ideas?
    - ☐ Yes
    - ☐ No
    - ☐ Can't say

4. What skills have you improved through your school activities? (Select all that apply)
    - ☐ Creativity
    - ☐ Problem-solving
    - ☐ Critical thinking
    - ☐ Communication

- ☐ Teamwork
- ☐ Time management
- ☐ Improvement in confidence
- ☐ Improvement in patience
- ☐ Technology skills
- ☐ None

5. Are you comfortable sharing your ideas in front of everyone during class or group projects?
   - ☐ Yes
   - ☐ No

6. Have your school activities helped you feel prepared for your future career?
   - ☐ Yes
   - ☐ No
   - ☐ Not sure

7. Do you usually test and retry ideas if your first attempt doesn't work?
   - ☐ Yes
   - ☐ No

8. Do you think the activities in your school help you understand classroom topics better?
   - ☐ Yes
   - ☐ No

Specific questions for assessing design thinking skills

Instructions

Ask the students to remember an instance when they worked on a practical assignment/science experiment/project. Based on the experience of working on that task, indicate how much they agree with each of the following statements.
(Scale: Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree)

(If the students cannot remember any assignment, ask them to respond to these as if they have asked to work on a science project)

1. **Empathize**
   I took time to understand the thoughts, feelings, and challenges of those who are affected by a problem before trying to solve it.

2. **Define**
   I could clearly explain what the core problem was before moving forward with solutions.

3. **Ideate**
   I came up with different ideas to solve the problem, even if some ideas were unusual or were not practical.

4. **Prototype**
   I built rough models, sketches, examples to test and improve my ideas before finalizing them.

5. **Test**
   I actively sought feedback on my ideas and used it to make my solution better.

Problem Statement tool for students

Objective

The primary objective of this tool is to systematically measure the impact of ATL on students' acquisition of 21st century skills—specifically, design thinking, creativity, computational thinking, and problem-solving—across Andhra Pradesh, Karnataka, and Telangana. The assessment seeks to generate robust, comparable data on student skill development, inform programme improvements, and provide evidence for policy and practice alignment with the National Education Policy (NEP), 2020 and UNICEF's experiential learning goals.

Methodology

Each student will individually undertake a common challenge-based task that simulates a mini design thinking cycle. The task is divided into three phases:

1. **Problem Understanding:** Students analyze the challenge, identify requirements and constraints, and sketch or plan their approach (5–10 minutes).

2. **Building:** Students use their knowledge from attending ATL sessions to create a solution, applying computational and technical skills, iterating as needed (90–120 minutes) per student.

3. **Presentation & Reflection:** Students present their solution, explain their process, and reflect on what worked, what didn't, and what they learned (5 minutes per student).

Universal Rubric

A standardized scoring rubric will be used to rate each student's performance across four key criteria:

- Problem Understanding & Planning
- Implementation & Technical Skills
- Iteration & Problem Solving
- Presentation & Reflection.

Each criterion will be rated on a 1–5 scale (Beginning to Advanced), with space for qualitative feedback to guide student growth.

Implementation

All participating schools will use the same task prompt and rubric to ensure consistency and comparability.

Researchers will orient students, administer the tool, and observe the process using a checklist to document engagement, collaboration, and problem-solving behaviours.

Each student will work independently to ensure individual skill measurement, while researchers provide minimal guidance to maintain authenticity of student responses.

Ask the students to choose any one problem statement from the list given below:

1. **Paper Circuit Greeting Card**
   Scenario: Riya wants to create a surprise birthday card for her best friend that lights up when opened. Can you suggest a method to build this card. Include all the steps in as much detail as possible.

2. **DIY Mechanical Grabber**
   Scenario: A clean-up drive is organized in school, but the students need a tool to pick up waste without using their hands.

   Suggest a way and step-by-step guide to make this tool.

3. **3D-Printed Keychain Design**
   Scenario: Maya wants to gift each of her classmates a personalized keychain with their initials. How should she proceed with this task?

4. **Traffic Light Circuit with Switches**
   Scenario: During road safety week, your team decides to create a working model of a traffic signal. How should they proceed with this task?

5. **Hydraulic Lift Model**
   Scenario: A toy company has asked students to design a lift for a miniature garage. How would you build a small hydraulic lift that can raise and lower a toy car safely?

   Suggest a way and step-by-step guide to make this tool.

6. **Tinkercad Simulation**
   Scenario: You want to make some project with a battery, switch and motor. But you do not have these electronic components in your lab. So, you decide to buy them. However, you are not sure if that project will work with these components or not. You are also not sure whether the circuit will work or not. How will you make sure the project will work without actual components?

7. **Solar-Powered Electric Fan**
   Scenario: It's a hot sunny day and the power is out. Kriti wants to cool down using a fan powered by the sun. Can you suggest steps to build a fan that works directly using sunlight?

8. **LED Torch**
   Scenario: You are going for a camp/trek in the jungle for which you need a torch. You do not have your own torch, there is no one that you can borrow the torch from, and all shops are also closed. What will you do?

9. **Simple Animation**
   Scenario: Pranav wants to make some animated short story about his friend using the computer.

   What will he do?

10. **Paper RC Wired Robot**
    Scenario: Kavya wants to gift her friend with a simple robot without an arduino and using basic available material including waste cardboard in the ATL.

    How will she build a robot?

11. **Redesigning an Auto Rickshaw**
    Scenario: Nikhil's grandmother finds it difficult to climb into a rickshaw. His team is redesigning the rickshaw to make it safer and easier for senior citizens.

    What features would you include to make the rickshaw more inclusive? Suggest steps to add those features.

Student Observation Rubric for ATL Labs

This rubric is designed to help observers assess students during ATL design challenges. It evaluates both the process and the outcome, with a focus on how students understand the problem, ideate, build, iterate, and reflect. Observers should use the scale from 1 to 5, where 1 = Beginning, 3 = Proficient, and 5 = Advanced. Decimal scores (e.g., 2.5) may be used with justification.

Notes for use:

- Observe each student over the full course of the task.
- Do not focus only on the final solution. Score based on process.
- Use the detailed descriptors to ensure consistency across researchers.
- Encourage students to explain their work at the end.
- Write qualitative comments, if possible, to support the scores.

Table 1: **Student Observation Rubric**

Indicator	Beginning (1)	Proficient (3)	Advanced (5)
Problem Understanding & Planning	Student appears confused about the problem or begins working without any planning. No sketching or steps are visible (and student is not able to explain verbally too). Questions asked (if any) show superficial understanding.	Student is able to describe the problem in basic terms and lays out a sequence of steps to solve it. A sketch or simple plan is made. Shows some initial organization.	Student articulates the problem clearly, often reframing it insightfully. Planning is thoughtful and complete, with multiple steps and visual representation. Shows evidence of analyzing constraints or context.
Implementation & Technical Skills	Struggles with tools, skips steps, or creates a non-functional model. Tools may be misused or unsafe. No logical connection between idea and output.	Follows basic steps to construct a functional prototype using tools correctly. May make some changes along the way. Shows some understanding of how design and implementation relate.	Demonstrates dexterity and confidence with tools. Carefully tries to build a model. Applies systematic thinking, problem decomposition, and good craftsmanship.
Iteration & Problem Solving	Gives up quickly when facing a problem or repeats the same method despite failure. No testing or modification observed.	Makes at least one change to improve the solution based on testing or reflection. Responds to some challenges with adjustments.	Frequently tests and refines the model. Identifies flaws early, modifies design multiple times, and responds creatively to unforeseen problems.
Presentation & Reflection	Is unable or unwilling to explain the design. Responds vaguely or with memorized phrases. Shows no insight into what worked or didn't.	Explains the main idea, how it works, and some reasoning behind choices. Can answer simple questions and acknowledge some learning.	Explains the design fluently and confidently. Reflects deeply on what worked, what didn't, and what could be done better. Offers suggestions for future improvements.

Table 2: **Assistive Checklist for Researcher for Each Indicator**

Indicator	Checklist
Problem Understanding & Planning	⚛ Did the student seek clarification to better understand the problem? (Y/N) ⚛ Did the student identify who is affected by the problem or what the needs are? (Y/N) ⚛ Did the student mention any important constraints or requirements for a good solution? (Y/N) ⚛ Did the student restate the problem in their own words? (Y/N)
Implementation & Technical Skills	⚛ Did the student lay out a clear sequence of steps to solve the problem? (Y/N) ⚛ Did the student explain why they would do each step in that order? (Y/N) ⚛ Did the student anticipate any challenges or obstacles and mention how they would address them? (Y/N) ⚛ Did the student's plan show an understanding of cause and effect (if-then thinking)? (Y/N)
Iteration & Problem Solving	⚛ Did the student suggest more than one possible solution or approach? (Y/N) ⚛ Did the student explain their reasoning for choosing one approach over others? (Y/N) ⚛ Did the student consider any alternative ideas or options? (Y/N) ⚛ Did the student anticipate any challenges or obstacles and mention how they would address them? (Y/N)
Presentation & Reflection	⚛ Did the student communicate their plan and logic clearly and confidently? (Y/N) ⚛ Did the student reflect on their approach (e.g., mention what might work well or what could be improved)? (Y/N) ⚛ Did the student connect their reasoning to prior knowledge or experience? (Y/N) ⚛ Did the student respond thoughtfully to follow-up questions or feedback? (Y/N)

Student Scoring Sheet (For Researchers)

School ID: _____

Student ID: _____

Date: _____

Observer Name: _____

Student Scoring Table

Criterion	Score (1–5)
1. Problem Understanding & Planning	
2. Implementation & Technical Skills	
3. Iteration & Problem Solving	
4. Presentation & Reflection	

Any Additional Comments: _____

Score Scale Reference

1 = Beginner

2 = Emerging

3 = Proficient

4 = Accomplished

5 = Advanced

Problem Statement Tool for Teachers

Same exercise for teachers as students.

Qualitative Tools

Research Question	Specific Questions
Teachers- IDI	
What has been the overall experience in engaging to strengthen maker spaces?	⚛ How long have you been with school and how long have you been associated with ATL? How did you get selected/appointed as the ATL teacher in your school? Was it out of your interest or were you asked to take up the role? Have you developed interest now? ⚛ Please share your overall experience engaging with VA/UNICEF on ATL activities. ⚛ What are the key challenges you face in executing your roles and responsibilities as an ATL teacher? ⚛ What support would you like from your school or from the department to be more meaningfully engaged in activities like the ATL?
How relevant are the initiatives undertaken by UNICEF in the area of maker spaces?	⚛ How closely do VA/UNICEF-supported ATLs align with the school's educational priorities? ⚛ Can you share how ATL sessions are organized- timings, frequency, what worked well and what were the challenges therein? ⚛ Has ATL helped the students and school? If yes, How? ⚛ Has the ATL differentially impacted girl and boy students, and marginalized students? How? ⚛ Has ATL differentially impacted girl students, boys, and marginalized students? How? ⚛ Do you think such engagement would benefit the local community at large? How?

Research Question	Specific Questions
In what ways have UNICEF-supported maker space interventions influenced student learning outcomes vis-a-vis design thinking, conceptual understanding, and applicable 21st century skills?	⚛ Have you noticed specific improvements in students' skills such as creativity, problem-solving, ideation, communication, team work, and practical technical abilities due to ATL activities? ⚛ Have you seen any changes in the life skills of students or yourself? ⚛ Can you give examples of successful student projects or notable outcomes linked to these interventions? ⚛ Do you think the labs are sufficiently equipped? Are there any suggestions for improvement? ⚛ How have trainings / online sessions helped shape your understanding better? What worked well in the trainings? What were some challenges? What would you like to see different?
How have teachers adapted their pedagogical approaches as a result of UNICEF's support?	⚛ Has ATL helped in teaching your subject? How? ⚛ Has ATL helped the students and school overall? If yes, How?
Principal/Head Teacher - IDI	
What has been the overall experience in engaging to strengthen maker spaces?	⚛ Can you share the process when you were selected as a hub school? (Prompt- how did you come to know about ATL) Was there clarity in your role as well as in the establishment and operation of ATLs in your school, as a school leader? ⚛ How did you identify vendors for your ATL class? Was there any challenge there? ⚛ Describe the school's experience with implementing ATL activities. ⚛ What were the key achievements and significant hurdles faced? ⚛ What are some challenges expressed by your teacher and students in participating in ATL activities? ⚛ As a hub school, have you reached out to other schools or your teachers/ other schools have reached out to you for trainings/exposure? What was your response and experience?
How relevant are the initiatives undertaken by UNICEF in the area of maker spaces?	⚛ How relevant do you find ATLs initiatives/activities in your school? ⚛ How do you find the collaboration with organizations like Vigyan Ashram and UNICEF in driving ATL activities/sessions? ⚛ Has ATL supported your school's broader educational goals? How? ⚛ Can you provide specific instances where these interventions clearly aligned with your school's priorities? ⚛ Has ATL helped the students and school? If yes, How? ⚛ Has ATL differentially impacted girl students, boys, and marginalized students? How? ⚛ Do you think such engagement would benefit local community at large? How? ⚛ Do you think ATL should be restricted to science teachers and students? Why? Why not? ⚛ What is the perception of ATLs among other teachers/staff? ⚛ What are your suggestions to improve the effectiveness of ATL in future?
How have teachers adapted their pedagogical approaches as a result of UNICEF's support?	⚛ Have you observed any notable changes in teaching methods and classroom engagement of the teachers who have engaged with ATL? If yes, what were these?

Research Question	Specific Questions
What resources were allocated by UNICEF (financial, human, time) to support maker spaces, and how effectively have these been managed to maximize impact?	⚛ Can you share the details on types of resources provided by UNICEF/ Vigyan Ashram? Were these adequate? ⚛ What support was provided by the state government for ATLs? Do you have specific suggestions to improve/strengthen state government ownership of the programme? ⚛ How effective were these resources (in terms of trainings, quality of trainings, etc.)? ⚛ What support is needed for sustaining ATL activities?
District Level Officials (DEO/DNO/DSOs) – IDI	
What has been the overall experience in engaging to strengthen maker spaces?	⚛ How long have you been associated with ATL? Do you have clarity on your roles and responsibilities with respect to ATLs as the nodal person/DSO? What is it? Please describe? ⚛ Please describe your experience with UNICEF's/Vigyan Ashram's initiative on ATLs in your district. ⚛ What support has been provided to you vis-a-vis monitoring ATL activities? ⚛ What is your overall role vis-a-vis ATL activities? ⚛ Please share successes and challenges at the district level faced during the implementation.
How relevant are the initiatives undertaken by UNICEF in the area of maker spaces?	⚛ How effectively does this initiative align with district-level educational objectives/activities? ⚛ Can you share any instance or example that demonstrates this relevance?
What resources were allocated by UNICEF (financial, human, time) to support maker spaces, and how effectively have these been managed to maximize impact?	⚛ Can you share the details on the types of resources provided by UNICEF/ VA? Were these adequate? ⚛ How effective were these resources (in terms of trainings, quality of trainings, learning materials, handbooks etc.)
What insights (in terms of challenges and gaps in implementation) have been gained from the implementation of maker spaces that can inform future projects?	⚛ Over the past year/s, what are your key observations on the activities initiated with support from UNICEF/Vigyan Ashram? ⚛ What kind of changes would you suggest if maker spaces had to be implemented across all schools of the state? ⚛ How better can the activities of ATLs be integrated with the set school curriculum? ⚛ What are your recommendations to improve overall efficiency? ⚛ Have there been any unintended consequences of adding ATL to school curriculum?
School Education Department Officials - IDI	
What has been the overall experience in engaging to strengthen maker spaces?	⚛ Please share your overall experience with the hub and spoke model of UNICEF/Vigyan Ashram around ATLs? ⚛ Is the hub and spoke model relevant or needed in the state for implementing ATL? ⚛ What are the key takeaways/learnings, if any, from this programme that have informed Samagra Shiksha's annual plans/proposals?

Research Question	Specific Questions
How relevant are the initiatives undertaken by UNICEF in the area of maker spaces?	❁ Do you think these initiatives are sustainable and scalable? ❁ How do you think the activities (training/orientation of teachers, workshops with students, make-a-thons, etc.) align with the state education department's long term objectives? ❁ Do you think ATL activities are relevant to students or are they an additional burden? Please explain.
What insights (in terms of challenges and gaps in implementation) have been gained from the implementation of maker spaces that can inform future projects?	❁ What are your recommendations to improve overall efficiency in implementing ATL activities? ❁ What are some things the department can ensure as a response to challenges that teachers, headmasters and DSOs have shared at the ground level? ❁ Do you think ATL should be there in all schools? What can be done for scaling? ❁ How can the activities of ATLs be integrated with the school curriculum?
Engineering Students - IDI	
What has been the overall experience in engaging to strengthen maker spaces?	❁ Please share your experience of engaging with the students in schools during your internships/visits to schools? ❁ What were the overall positives in your engagement? ❁ What were the challenges during your time spent in ATLs?
How relevant are the initiatives undertaken by UNICEF in the area of maker spaces?	❁ Do you think your interaction/time spent with the students in ATLs was helpful? What did you learn from this engagement? ❁ How did you help the students in their projects? Please share 1-2 key examples. ❁ How do you think the activities of ATLs are useful for the students in the long run.
AIM, New Delhi - IDI	
How relevant are the initiatives undertaken by UNICEF in the area of maker spaces?	❁ How do UNICEF-supported ATL activities align with AIM's national objectives? ❁ What are the best practices or gaps from UNICEF's approach you'd highlight? ❁ How does AIM plan to strengthen partnerships at the state and national levels? ❁ Are there any gaps or areas for improvement in UNICEF's approach? ❁ What are AIM's plans for strengthening partnerships at the state and national levels regarding ATLs?
What insights (challenges and gaps in implementation) have been gained from the implementation of maker spaces to inform future projects?	❁ Please share gaps or suggestions you would like to share to improve saturation of ATLs not only across the state but the country.
What is the potential for adapting and scaling UNICEF's model of support to other contexts or regions within India, identifying lessons learned and best practices?	❁ What are the elements of the hub and spoke or low-cost maker model that would be easy to replicate? ❁ Do you think the hub and spoke model is adaptable at a national level? If yes, how would you plan to adapt this? What would be the key barriers/ enablers?

Research Question	Specific Questions
Vigyan Ashram - IDI	
What has been the overall experience in engaging to strengthen maker spaces?	⚛ What technical or design support did you provide to schools under UNICEF's initiative? ⚛ Please share the rationale for designing the training programmes with teachers and also the different types of activities held with students (marathons, make-a-thons, bootcamps). ⚛ What innovations or local adaptations were most successful? ⚛ What challenges did you encounter (e.g., teacher preparedness, equipment availability, teacher/student readiness)?
How have teachers adapted their pedagogical approaches as a result of UNICEF's support? What are the stakeholder perspectives in this regard?	⚛ Did you observe changes in how teachers planned or facilitated ATL projects after the training sessions? What were these? ⚛ Were any teaching methods or resources particularly effective in your view? Why? ⚛ How were the topics/activities linked to the school curriculum?
What insights (challenges and gaps in implementation) have been gained from the implementation of maker spaces to inform future projects?	⚛ What were the key challenges, especially in designing and implementing the training programmes? ⚛ What recommendations would you make to improve project delivery and sustainability? ⚛ What lessons have been learnt in overall state-wide design and implementation and also, especially in the context of gender and inclusion? ⚛ What do you think the students learnt and benefited from ATLs? Are there any specific skills you want to highlight?
What is the potential for adapting and scaling UNICEF's model of support to other contexts or regions within India, identifying lessons learned and best practices?	⚛ What changes would be needed in the approach to scale this model across the country? ⚛ What support would be needed from respective governments to adapt and scale?
UNICEF Officials - KII	
Overall	⚛ Please share the overall rationale of the intervention and the initial implementation plan. Was any other model studied prior to implementation? ⚛ What was the overall Theory of Change?
What insights (challenges and gaps in implementation) have been gained from the implementation of maker spaces to inform future projects?	⚛ How did the project adapt to emerging challenges? ⚛ Have there been any unintended consequences?
What resources were allocated by UNICEF (financial, human, time) to support maker spaces, and how effectively have these been managed to maximize impact?	⚛ How was technical support structured and tracked across schools and states? How were the hub schools selected? ⚛ Were there notable differences in how technical support was managed across different states? ⚛ What types of technical assistance (mentoring, digital resources, workshops) were most cost-effective? ⚛ What key lessons were learned from managing partnerships with state education departments?

Research Question	Specific Questions
What is the potential for adapting and scaling UNICEF's model of support to other contexts or regions within India, identifying lessons learned and best practices?	❄ What are the future plans with respect to the hub and spoke model and low-cost maker in these three states? ❄ Is there any plan to adopt this model to other states?

Guiding questions for FGD with students

Note: These are just guiding questions. The researchers will be trained to prompt and ensure that students are able to share their learning around designing thinking.

1. How has been your overall experience of working on ATL projects/ working/visiting lab/making and learning new things?

   Prompts: Do you think this is useful or it adds value? What were the activities they have participated in (like make-a-thon, events, exhibition, etc.)? If you think it was not useful, or enjoyable, what went wrong? How could it be improved?

2. Describe one project you worked on in ATL. What was your goal and how did you/your group approach it practically?

   Prompts: What were the tools/technologies they used? Was it useful to the community at large?

3. What type of skills have you gained through ATL?

   Prompts: If the students don't respond, you can ask whether their communication, confidence, presentation skills have improved? Whether they are now able to look at problems in different way? If their understanding of scientific topics has improved?

4. If you could change one thing about your ATL experience, what would it be and why? Prompts: What would make your ATL experience more interesting/engaging?

5. Describe a time when your project failed or didn't work. What did you learn, and how did you fix or improve it?

   Prompt: Can you think of a scenario where you would use this learning in future?

6. What role the teacher has played in your ATL?

   Prompts: Does he/she attend every session? Is he/she available all the time to resolve your queries? How do you think their role could be improved?

7. Who helps you in your projects/experiments in ATL? Can you narrate one instance where they resolved any issues you were facing in any experiment?

   Prompts: What is the frequency in terms of help provided? Is this available all the time?

   What are your observations about participation in ATL, particularly regarding gender?

8. How is ATL class different from regular classes?

   Prompts: What is one good and one bad thing about ATL?

Closing Remarks

Thank you all for sharing your valuable insights and experiences today. Before we conclude, is there anything important we've missed or any final thoughts you'd like to share?

Your feedback has been incredibly helpful and will greatly contribute to improving our efforts.

Annexure 4: IRB Approval Certificate

INSTITUTIONAL REVIEW BOARD (IRB)

CENTRE FOR MEDIA STUDIES
34 B Research House, Community Centre,
Saket, New Delhi, India-110017

APPROVAL DOCUMENT

Reference ID: CMS-IRB/Ed/2025/010

Principal Investigator: S Raghavan

Project Title: Case Study of Maker Spaces in Andhra Pradesh, Telangana and Karnataka: Understanding Stakeholder Experiences

IRB Number: IRB00006230

The **CMS IRB #1 Behavioural** reviewed the above-mentioned research project protocol on **Case Study of Maker Spaces in Andhra Pradesh, Telangana and Karnataka: Understanding Stakeholder Experiences** in accordance with the compliance of the Title 45, Code of Federal Regulations, Part 46, sub-part A & B (common rule).

The CMS IRB discussed: (1) the appropriateness of the methodology to be used to secure informed consent; (2) the rights and welfare of the individual(s) involved and (3) the potential benefits of the projects. The CMS IRB has concluded that the principal investigator have taken sufficient safeguards to carry out the research study. There is no known physical, emotional, psychological, or economical risk. Therefore, the CMS IRB approves this proposal.

This approval certificate applicable only for the study to be conducted with the study participants in India.

Vasanti Rao PhD, Vice-Chairperson
(Director General, CMS)

01-09-2025
Date

The Principal Investigator, in signing this approved document, agrees to comply with the following (1) notify the CMS IRB Office about any additions or changes in procedure subsequent to this review; (2) to provide information on the progress of the research on an annual basis; (3) ensure data confidentiality and protection, and (4) report any instances of injuries to subjects and unanticipated problems involving risks to subject or others. Any consent form used in connection with this project must be retained by the Principal Investigator for three years after completion of the research.

S Raghavan, (PI)
(Director, New Concept Information Systems Private Limited)

Date

RESEARCH HOUSE, Saket Community Centre, New Delhi 110 017, INDIA
P: 91 11 2696 1601, 2696 4020 F: 91 11 2696 4282 E: info@cmsindia.org

Annexure 5: List of Meetings Attended

Date	Meeting
10.06.2025	Briefing Meeting
02.07.2025	Tool Finalization Workshop- Day 1
03.07.2025	Tool Finalization Workshop- Day 2
28.07.2025 – 01.08.2025	5 Day Orientation of Researchers and Pilot

Annexure 6: List of Persons Interviewed

Name	Organization
Sheshagiri Madhusudhan	Education Specialist, UNICEF
Kishore Gaikwad	Vigyan Ashram
Yogesh Kulkarni	Vigyan Ashram
Deepali Upadhyay	Programme Lead, Atal Innovation Mission, NITI Aayog
Shubham Gupta	Innovation Lead, Atal Innovation Mission, NITI Aayog
Prateek Deshmukh	Programme Lead, Atal Innovation Mission, NITI Aayog
State Project Directors	Samagra Shiksha (Andhra Pradesh, Telangana and Karnataka)
District Science Officers/District Nodal Officers	Samagra Shiksha (Andhra Pradesh, Telangana and Karnataka)
ATL Teachers	State Govt Schools (Andhra Pradesh, Telangana and Karnataka)
Headmasters	State Govt Schools (Andhra Pradesh, Telangana and Karnataka)

Annexure 7: Detailed Literature Review

Introduction

Over the last decade, the global educational landscape has witnessed a significant shift in how learning environments are conceptualized. Traditional chalk-and-talk methods are gradually giving way to experiential, learner-centric models, particularly in response to the demands of the 21st century — creativity, collaboration, critical thinking, and technological fluency. Among these transformative approaches, "maker spaces" have emerged as dynamic ecosystems for creativity and hands-on learning. These are physical or digital spaces designed to encourage students to build, invent, tinker, and explore using various tools and technologies. From Fab Labs in the United States and Europe to mobile innovation hubs in Africa and Southeast Asia, maker spaces have evolved to become avenues of inquiry, experimentation, and collaboration across education systems worldwide (Halverson & Sheridan, 2014; Sheridan et al., 2014).

The educational philosophy underpinning maker spaces draws heavily from constructionist learning theory, which posits that learners construct knowledge more effectively when they are actively engaged in making tangible objects (Papert & Harel, 1991). As such, maker spaces emphasize student agency, trial and error, interdisciplinary learning, and the application of knowledge to real-world problems. These environments are particularly aligned with STEM (Science, Technology, Engineering, and Mathematics) and STEAM (including Arts) education initiatives, and increasingly form part of national strategies for innovation and workforce development.

In the Indian context, the National Education Policy (NEP), 2020 promotes experiential learning, creative problem-solving, and integration of vocational skills from an early age (GoI, 2020). This policy vision found operational footing through the Atal Innovation Mission (AIM) and its flagship programme, the Atal Tinkering Labs (ATLs), launched in 2016 by NITI Aayog. ATLs are maker spaces embedded within government and private schools, primarily catering to students in grades 6–12. Equipped with tools like 3D printers, Arduino kits, computers, and mechanical components, ATLs aim to foster curiosity, innovation, and design thinking capabilities among adolescents (AIM, 2021). As of 2024, more than 10,000 ATLs are operational across India, reaching over 11 million students (AIM, 2024).

Despite the rapid scale-up of ATLs, questions remain about their effectiveness, inclusiveness, and sustainability. While anecdotal evidence and success stories abound — such as students designing air quality monitors or flood warning systems — systematic evaluations are limited. There is a lack of consolidated research on how ATLs influence student learning trajectories, impact teacher pedagogies, and interface with existing educational structures, particularly in under-resourced or rural settings.

This literature review synthesizes global and Indian scholarship on maker spaces, with a particular focus on their pedagogical foundations, learning

outcomes, institutional integration, and challenges in implementation. Through this lens, the review unpacks the broader global evidence on maker spaces, traces the evolution and impact of the ATLs in India, and highlights opportunities for improved alignment with educational goals. The review also sheds light on barriers and enablers to effective implementation, drawing insights from both global and Indian experiences.

Evolution and Global Trends in Maker Spaces

The maker movement, with its roots in the do-it-yourself (DIY) culture, gained prominence in the early 2000s, emphasizing creativity, innovation, and technology-enabled problem-solving. The emergence of digital fabrication tools and platforms like Arduino, Raspberry Pi, and 3D printing eased access to innovation, enabling students, hobbyists, and professionals to tinker and build prototypes. Central to this evolution was the development of maker spaces, Fab Labs (Fabrication Laboratories), and hackerspaces — physical spaces equipped with tools and resources to foster community-driven innovation (Gershenfeld, 2005; Dougherty, 2012).

Globally, maker spaces have been integrated into schools, libraries, universities, and community centres. In the United States, maker spaces became a core feature of STEM education, supported by initiatives like the White House Maker Education Initiative (2014), which aimed to empower every student to be an inventor and creator. Schools across the U.S. and Canada embedded maker spaces within libraries and classrooms, transforming passive learning environments into active, project-based spaces. In Finland and Estonia, education systems integrated maker pedagogy into curricula to promote transversal competencies such as creativity, collaboration, and technological literacy (Smith et al., 2020).

Research in these context points to the power of maker spaces in enhancing student agency and cognitive engagement. Halverson and Sheridan (2014) emphasize that maker activities facilitate the development of identity and agency among learners, particularly when they are allowed to pursue interest-driven projects. In Australia and Scandinavia, studies found that these environments foster inclusivity and help bridge the gap between formal and informal learning (Davies & Seitamaa-Hakkarainen, 2024).

Fab Labs, in particular, have had a major influence on the global maker ecosystem. Developed by MIT's Center for Bits and Atoms, Fab Labs provide access to digital fabrication tools, mentorship, and a networked community. Fab Labs serve as incubators of innovation and hands-on learning, especially in higher education settings. Their structure — combining peer learning, open-ended inquiry, and access to modern tools — offers a template that many school-based maker spaces have tried to emulate.

However, even globally, challenges persist. These include high cost of infrastructure, difficulty in assessment, and teacher apprehension towards new technologies and open-ended learning (Blikstein, 2018; Davies & Seitamaa-Hakkarainen, 2024). In addition, there is a challenge of

democratising maker spaces – how can such experiences be made available to children with the greatest disadvantages to make the movement an equalizing force, rather than another type of technology that widens the gap between private and public schools, affluent and low-income communities. Successful models prioritize teacher professional development, curricular alignment, community partnerships, and iterative, process-focused learning. Addressing these challenges requires reimagining teacher preparation, curriculum design, and policy alignment.

Maker Spaces in India

The establishment of maker spaces in India has largely been driven by policy thrusts on innovation, entrepreneurship, and STEM education, with AIM serving as the most prominent national-level programme. The AIM, under the aegis of NITI Aayog, established in 2014, has established more than 10,000 maker spaces called 'Atal Tinkering Labs' (ATL) in middle/ secondary schools across India. ATL is a key component of the mission's overall mandate, which is to: "*…create and promote a culture of innovation and entrepreneurship across the length and breadth of our country…develop new programmes and policies for fostering innovation in different sectors of the economy, provide platforms and collaboration opportunities for different stakeholders, and create an umbrella structure to oversee the innovation & entrepreneurship ecosystem of the country.*"

According to AIM, the Atal Tinkering Labs are 'state-of-the-art' maker spaces whose 'goal is to foster curiosity and innovation in young minds, between grades 6-12 across the country through 21st century tools and technologies such as the Internet of Things, 3D printing, rapid prototyping tools, robotics, miniaturized electronics, DIY kits and many more.' Further, "*The aim is to stimulate a problem-solving innovative mindset within the children of the ATL and nearby communities.*" The ATLs are established for Rs. 10,00,000, and this is followed by a Rs. 2,00,000 maintenance grant every year for five years. A total of Rs. 20,00,000 is thus spent on one ATL.

It is envisaged that ATLs will positively disrupt secondary school STEM pedagogy, and draw schools towards a pedagogy that is focused on developing design thinking abilities in teachers and children. The vision for ATLs, as articulated by AIM, is to 'Cultivate one million children in India as Neoteric Innovators.'

The idea of ATLs sits well with the intentions and aspirations of the NEP 2020, which emphasizes 'scientific temper and evidence-based thinking; creativity and innovativeness; sense of aesthetics and art; oral and written communication; health and nutrition; physical education, fitness, wellness, and sports; collaboration and teamwork; problem-solving and logical reasoning; vocational exposure and skills; digital literacy, coding, and computational thinking' among others (NEP 2020). Specifically, the element of 'design thinking' is a key dimension of the ATL.

The ATL initiative is closely aligned with national and international frameworks. The NEP 2020 recommends the promotion of hands-on, inquiry-based learning; the SDG 4 calls for inclusive and equitable quality education that fosters lifelong learning and technical skills. ATLs seek to actualize both, especially in under-resourced and government school settings.

UNICEF's initiatives in Andhra Pradesh, Telangana and Karnataka

In 2021, UNICEF's Hyderabad Field Office (HFO) began working to strengthen ATLs in Andhra Pradesh, extending its efforts to Karnataka in 2022 and Telangana in 2023 (UNICEF, 2025). Recognizing the significant role ATLs could play in middle and secondary school education to strengthen STEM education, UNICEF identified some critical systemic challenges. One of these was that ATLs were established through an online application process, with funds directly transferred to schools by the Atal Innovation Mission (AIM), bypassing the state education department (UNICEF, 2025). Consequently, many schools lacked the necessary support for oversight, monitoring, and implementation. Without guidance, school heads and teachers were often uncertain of how to integrate ATL activities, leaving many labs underutilized (UNICEF, 2025).

In collaboration with Vigyan Ashram, a "hub and spoke" model was established by UNICEF where each district has a central 'hub' ATL, acting as a training, learning, and demonstration centre for at least five nearby 'spoke' ATLs (UNICEF, 2025). Over the course of four to five years with consistent support, these spokes are expected to develop into demonstration centres, thus expanding the intervention to cover all ATLs across each state (UNICEF, 2025). UNICEF's support for the hub and spokes model includes teacher training, manual development, monitoring systems, and collaborations with HEIs. Additionally, UNICEF has established state-level training centres to support states in developing in-house capacities for training.

Engagement with teachers

Across the three states (Andhra Pradesh, Telangana and Karnataka), UNICEF has prioritized building teacher capacity and awareness around ATLs and the broader goals of STEM and design thinking. Teacher engagement has been facilitated through structured trainings, organized in partnership with Vigyan Ashram and the local education department officials. Teachers from ATL schools have also been invited to attend regular sessions at Vigyan Ashram's Training Centre. Till date, a total of 28 face-to-face trainings have been organized with hub school teachers (Vigyan Ashram, 2025).

The approach recognizes that many teachers might initially see ATL activities as an extra burden or are unsure about their relevance, especially when juxtaposed with exam-oriented curricula. In this context, there is a conscious effort to address these perceptions by highlighting the value of ATL which may not be limited to STEM (focus on also improved life skills) and encouraging broader ownership at the school level (UNICEF, 2025).

The hub school teacher training programme implemented across Andhra Pradesh, Telangana and Karnataka has been delivered at three levels—basic, intermediate and advanced—each spanning three days per training. At the basic level, the content covered an overview of ATL objectives and operations, materials and inventory management, orientation to the ATL curriculum and calendar, and foundational training in electronics, 2D and 3D design, safety guidelines, and introductory design thinking (Vigyan Ashram, 2025). The sessions were practical, with teachers engaged in hands-on DIY activities such as paper circuits, making robots using kits, and simple automation projects without Arduino, before progressing to basic programming for automation and design thinking demonstrations (Vigyan Ashram, 2025).

Intermediate training expanded on this foundation with medium-complexity DIY and robotics activities, projects using microcontrollers like Arduino, simulation using Tinkercad, robotics, curriculum linkage, and introductory programming with AI and ML tools. The advanced level focused on sophisticated DIY projects and simulations, deeper integration of design thinking for competitive projects, advanced robotics using platforms such as Raspberry Pi and ESP32, and higher-order programming skills including python and AI/ML projects. Across all levels, significant time was dedicated to management, equipment use, linking activities to the curriculum, with an increasing focus on project-based learning, complex problem-solving, and design thinking as teachers progressed (Vigyan Ashram, 2025).

UNICEF, in collaboration with Vigyan Ashram, has also developed a Handbook for Teachers. The handbook focuses on experiential learning through 'making' or fabricating, using one's hands and involving the head and the heart.

Engagement with students

Engagement with students include activities like bootcamps, make-a-thons and ATL marathons which are designed to foster a sense of ownership, curiosity, and joy in learning, moving away from rote approaches. Till date, 34 bootcamps and 10 make-a-thons have been organized across three states with participation of about 2000 students and teachers (Vigyan Ashram, 2025).

In Andhra Pradesh, engineering students have been strategically engaged with ATLs. Through the ATL Mentorship Programme (Phase 2), 135 engineering students from nine colleges were trained by Vigyan Ashram and subsequently assigned to 27 government schools. These students were tasked with conducting hands-on sessions over 12 consecutive Saturdays, with a focus on building basic prototypes using Arduino, 3D printing, circuit design, and IoT concepts (Vigyan Ashram, 2025).

In Andhra Pradesh and Telangana, some schools proactively call students and teachers from neighbouring schools for joint activities, illustrating the potential of the 'hub and spokes' model to extend benefits beyond a single institution (Vigyan Ashram, 2025).

Summer bootcamps for hub ATLs, typically conducted over three days during school vacations, provide students in grades 6–9 with immersive, hands-on experience in electronics, robotics, and advanced projects using Arduino and sensors (Vigyan Ashram, 2025). The bootcamps have been designed to foster engineering, creative, and soft skills such as teamwork, leadership, and divergent thinking. Each session focuses on specific activities like circuit building, block programming, and robotics, with students documenting their work and working alongside at least two teachers per school. Participation has been typically capped at around 20 students per bootcamp, with students and teachers from spoke schools also invited (Vigyan Ashram, 2025).

Make-a-thons offer a more intensive, four-day experience for groups of students and teachers from hub schools. These events were structured around design thinking methodology, with sessions on empathy, ideation, prototyping, and testing leading to the development of functional prototypes that address real-world problems. Each make-a-thon includes 20 students and 5 teachers (4 students and 1 teacher from each of five hub schools), supported by facilitators from Vigyan Ashram. Activities covered electronics, 3D design and printing, vinyl cutting, marketing and project presentation, culminating in group presentations and certificates (Vigyan Ashram, 2025). The make-a-thons aimed to build "champion" teachers and students who would lead project-based learning in their schools, promote model projects, and inspire further innovation. A total of four make-a-thons have been organized for hub ATLs from October 2023 to August 2024 (Vigyan Ashram, 2025).

Online sessions

In Andhra Pradesh, 84 online sessions were delivered via the *Diksha* channel[19], reaching 300 ATL teachers and 2.5 lakh students; 40 sessions on *Jnanadeepa* channel were conducted in Karnataka, reaching 250 teachers and 2 lakh students with each session averaging 800–1200 views; and 14 sessions were conducted in Telangana reaching out to over 100 teachers and 1 lakh students (Vigyan Ashram, 2025).

The topics covered spanned 3D printing, robotics, renewable energy, toy-making, electronics, programming, ATL operations, and best-out-of-waste innovations, among others. Teachers widely appreciated the focused, 45-minute format, engaging and practical demonstrations, and project-based content, which supported both their own and students' initial steps in ATL projects (Vigyan Ashram, 2025). The sessions were reported as highly relevant, sparking new ideas for classroom activities and exhibitions, and building confidence in simulation tools and digital applications. Teachers also valued the integration of curriculum topics, sustainability themes, and open-source resources (Vigyan Ashram, 2025).

[19] Diksha AP is the official YouTube channel of Andhra Pradesh DIKSHA (Digital Infrastructure for Knowledge Sharing), a wing of SAMO, Samagra Shiksha, Andhra Pradesh. https://www.youtube.com/@DIKSHA_ANDHRA_PRADESH

Some of the challenges included software compatibility issues in school, lack of materials, technical glitches, and pacing for first-time learners, all of which were addressed by providing step-by-step guides, pre-session materials lists, session recordings, and opportunities for peer-led sessions (Vigyan Ashram, 2025). Teachers also expressed desire for more time for interaction and post-session support, which was accommodated through Q&A, resource sharing, and inclusion of student project showcases. The overall experience confirmed that a blend of in-person and online formats, responsive support, and context-driven content are key to scaling effective ATL practices in diverse school settings (Vigyan Ashram, 2025).

Learnings from trainings

The face-to-face hub teacher training was experienced as highly engaging and hands-on, fostering both capacity building and peer learning. Trainers noted a visible shift in teachers' mindsets towards project-based, experiential learning, with many teachers eager to replicate activities and involve students in competitions (Vigyan Ashram, 2025). The in-person format broke down barriers, particularly for teachers less comfortable with technology, while collaborative group work facilitated immediate feedback and troubleshooting. Teachers were enthusiastic when engaged in practical model-building, and the hub-and-spoke structure enabled exchange of ideas and best practices (Vigyan Ashram, 2025).

Some of the challenges included: varying skill levels among teachers, low confidence with digital tools for some, limited time to cover theoretical and practical content in depth, infrastructure gaps such as unreliable internet or lack of hardware, etc. (Vigyan Ashram, 2025). Language barriers were mitigated by deploying local field officers. Pre-training assessments, modular content design, simplified documentation, vernacular resource materials, showcasing student work, daily reflection, and the train-the-trainer model have emerged as key lessons learnt from implementing the training programmes (Vigyan Ashram, 2025). Tailoring activities to local context, emphasizing local materials, and providing regular follow-up support, such as mentoring and online sessions, have proved essential for sustained impact.

Overall key learnings from the three states

Across Karnataka, Andhra Pradesh and Telangana, a few broad learnings stand out from implementing the hub and spokes model.

First, success hinges on effective communication and buy-in from school leadership—headmasters who understand and support ATL objectives make a significant difference in the overall uptake and sustainability of activities.

Second, there is recognition that the sustainability of ATLs depends on both technical (resource, maintenance, training) and motivational factors (ownership, relevance, reward structures). The challenge of teachers balancing regular duties with ATL responsibilities, often without extra incentives, remains a barrier.

Third, experiential learning through hands-on activities, project-based assessment, and peer-led learning has shown positive effects in student motivation and skills. However, there is a need for establishing a robust system for assessing student learning outcomes, monitoring project quality, and evaluating teacher performance post-training.

Assessment of ATLs

In 2023, NITI Aayog commissioned assessment of ATLs across the country. The assessment focused on infrastructure, student engagement, ATL events, school-based innovations, fund utilization, operational compliance, and the educational and career journeys of ATL students (Athena Infonomics, 2023). The assessment period covered the funding years from fiscal year 2016-17 (initiation of the first Atal Tinkering Lab) to fiscal year 2019-20.

Following were the key findings from the study:

- The establishment of ATLs was often driven by the desire for institutional branding, affiliation with AIM, and as a source of pride.
- 84% of respondents viewed ATLs as platforms that foster creativity and attract students to science and technology.
- Most schools set up their ATLs within six months, with rural and aspirational districts showing high compliance in procurement procedures.
- 90% of schools had their ATL in the main building and most dedicated a specific, well-equipped room for ATL activities, ensuring adequate space and resources like laptops and internet access, thus showing compliance with AIM guidelines.
- 98% of ATLs had an appointed in-charge, and 70% of schools had trained teachers for ATL-related activities. 69% percent of schools reported forming the required ATL Advisory Committee.
- Operationally, over half the schools integrated ATLs into their routines with fixed sessions at least twice a week and maintained separate attendance records. Monitoring and reporting practices were robust, with 74% of schools logging into the ATL dashboard, primarily influenced by clear AIM instructions.
- Student engagement was inclusive, with both male and female students participating (54% boys and 46% girls); rural schools displayed particular enthusiasm for innovation, leading to a consistent rise in student participation and innovation outputs over the years. On average, each school developed 10–16 innovations between 2016–17 and 2022–23, with a steady increase in the number of innovations, especially in rural and non-aspirational districts.

- The introduction of ATLs positively impacted the academic ecosystem, as 75% of schools observed improved student attitudes towards science and technology, and 69% reported more students pursuing science in higher education, while 58% noted enhanced 21st century skills among students.

- ATLs also contributed to leadership and professional growth for ATL in-charges and made it easier for teachers to engage students, exposing them to practical applications, with 40% of ATLs accessible to community schools.

- Financially, over 90% of ATLs effectively used their establishment funds, 78% efficiently utilized operation and maintenance grants, and 85% submitted utilization certificates, reflecting proactive fund management and compliance.

Need for a Case Study of Maker Spaces

While the comprehensive assessment of ATLs conducted in 2023 covers a wide range of indicators such as infrastructure, fund utilization, compliance, human resources, and basic levels of student participation and innovation output, several critical dimensions remain unexplored, necessitating a more focused, qualitative case study approach.

The assessment adopts a largely compliance and input-output perspective, focusing on whether ATLs were established as per guidelines, equipped with infrastructure, assigned in-charges, and whether funds were spent as per plan. While it reports positive trends in student participation, innovation output, and skill development, the assessment does not delve into the quality or depth of learning experiences, the actual processes of design thinking in practice, and the real transformations in classroom pedagogy. The nuances of how ATLs are integrated (or not) into the regular teaching-learning process, how teachers adapt their teaching to leverage ATL facilities, and how students perceive and internalize 21st century skills through tinkering remain largely unaddressed.

In addition, while the assessment reports increased student engagement, innovation outputs and community outreach, it does not delve into the lived experiences of students, teachers and administrators. There is minimal focus on the pedagogical shifts associated with design thinking, creativity or problem-based learning. The assessment acknowledges ATL's potential in enhancing 21st century skills, but does not explore how teachers understand and use design thinking frameworks, or how students progress through the stages of empathy, ideation, prototyping and testing.

UNICEF's interventions in the three states have focused on embedding a model of capacity-building, teacher training and peer learning through the "hub and spokes" model. Teacher training, content development, student engagement through innovative sessions/events, and mentorship from engineering students have been key strategies to support sustained change.

The Theory of Change behind this intervention also assumes that if there is a positive shift in the mindset and approach of the Education Department towards leveraging maker spaces such as ATLs and Low-Cost Maker spaces as a space for developing capacities for design thinking, supported through continuous systemic efforts at various levels (such as capacity building, allotting time required for ATL in the school routines and consistent review mechanisms), then teachers build capacities to use the ATL as a learning space and ensure that children develop a deeper understanding of concepts learned and become design thinkers (UNICEF, 2025).

Thus, it is important to examine how ATLs are being integrated into schools across Andhra Pradesh, Karnataka and Telangana. By capturing the lived experiences, perceptions and challenges of teachers, students, school leaders and administrators, the study will provide grounded evidence on what works, what does not, and why. It will also highlight contextual factors such as local adaptations, cultural attitudes and system-level supports or barriers that influence the success of maker space interventions.

This study is particularly timely in light of broader shifts in NEP, which now explicitly encourages experiential, project-based learning and innovation, as outlined in NEP 2020. It will not only document outcomes, but also help inform future models for scaling maker spaces, ensuring they are both impactful and inclusive.

Ultimately, this case study will serve as a vital tool for UNICEF, state governments and their partners to refine strategies, advocate for necessary policy changes, and promote more effective, equitable and sustainable integration of maker spaces within India's schools.

Annexure 8: Innovative Projects Undertaken by Students

The table below lists over 20 promising ideas which were worked on by students using a design thinking methodology across the three states through the support of UNICEF and Vigyan Ashram, often taking several months involving brainstorming, testing, re-testing and refinement. Some of these were also shortlisted for national and state level competitions like 'Seed the Future Entrepreneurship' (Dassault Foundation) and ATL Marathon (Atal Innovation Mission). The ideas deserve further support.

S. No.	State	Name of the project	Description	School name and location (district, mandal/Block)	Video overview
1	Andhra Pradesh	Scitech Innovators- Smart Iron Box Safety Solution	Smart Iron Box Safety Solution that combines advanced electronics and innovative design to ensure safety and efficiency during ironing.	ZPHS Penamaluru, Krishna	https://youtu.be/dkOthb-f6R9A?si=_G44gLOQWc-gdQilF
2	Andhra Pradesh	KUSSI- Lightweight and Eco-Friendly Seats	Lightweight and eco-friendly airplane seats using banana stem fibre, contributing to reduced fuel consumption and environmental sustainability in the aviation industry.	ZPHS Dharmavaram, Vijayanagaram	https://youtu.be/nQnsd-3Sa5qM?si=n7s6kIK8tmx-1rwaw
3	Andhra Pradesh	Dauntless Trailblazers- Silk Thread Blending Tool for Weavers	Autonomous, self-operative mechanical tool capable of blending the silk thread from old thread bundles. The system is designed to provide early warnings to prevent loss of life and property, and is equipped with a mechanism for safe explosive defusal.	APMS Dharmavaram, Sri Sathya Sai	https://drive.google.com/file/d/1D1kUFmhBfI-LAFVucPyshNZxj9EhQY-HUO/view?usp=sharing
4	Andhra Pradesh	Greengride Solutions- Paddy Harvesting Machine with Dryer	Integrating a heat dryer into the harvesting machine, this can revolutionize post-harvest processing by making it faster, safer, and more sustainable. It demonstrates how technology can empower farmers and reduce the challenges they face in their critical work.	ZPHS Govinda, Nandyal	https://youtu.be/2TRNaX-sSIPQ?si=h7Cmsq65NN-VqPPVk

S. No.	State	Name of the project	Description	School name and location (district, mandal/Block)	Video overview
5	Andhra Pradesh	Creative Innovators- Weed Remover	A prototype named "Weed Remover" which address pitfalls of using traditional methods in farming, wherein farmers bend and remove weeds with their hands, leading to spinal problems and back pain.	GHS Palasa, Srikakulam	https://drive.google.com/file/d/1BWnB0zgyMQM-hish9wfpl6ntYFSLcudTp/view?usp=sharing
6	Andhra Pradesh	Intellectual Innovators- Paddy Drier	A sensor-based automated paddy-drying and covering system that detects rain and adjusts the cover/dryer to keep crops safe and dry.	ZPHS Penamaluru, Krishna	https://youtu.be/6yBL_-py-W2E?si=H2yv4OeXC-JTaH9Ms
7	Andhra Pradesh	Ride-Safe Innovation- Bike riding safety device	A rider-safety device designed to address risky phone use and stunts while riding, helping reduce accidents on two-wheelers.	ZPHS Varadiah, Tirupathi	https://youtu.be/KW0Z-esIjbMM?si=EQ_NErL__zOla-ae
8	Andhra Pradesh	Urn Care	A 3D cone-shaped urine collection device with a moisture sensor that supports safer sanitation practices and reduces health risks from open urination.	ZPHS Dharmavaram, Vizianagaram	https://youtu.be/FJK4a-VzABhI?si=ZAkCwxey-Jk168Zqy
9	Andhra Pradesh	Agrito-Paddy collector	A paddy collection machine designed to make gathering and handling harvested paddy quicker and easier for farmers	GHS Kirlampudi, Kakinada	https://drive.google.com/file/d/1_ZULp-uulBuezB-cEZFvN0XChnd9E1KNj/view?usp=sharing
10	Andhra Pradesh	Smart Sprayer	A lightweight, reliable pesticide sprayer with improved battery performance that reduces physical strain and makes spraying safer and faster.	GHS Korukonda, East Godavari	https://drive.google.com/drive/folders/1CoqoFs-1R5JkP0fns6UB1z2b_EOo8adcc
11	Karnataka	Hope Arm	A prosthetic arm controlled through muscle-movement sensors, enabling users to move fingers and perform basic actions more independently.	GPUC Kombettu, Dakshina Kannada	https://youtu.be/BGIPVlVQZZQ?si=2Hqck-IVG0Wwl3Jy2

S. No.	State	Name of the project	Description	School name and location (district, mandal/Block)	Video overview
12	Karnataka	Smart Hand	A communication-assist glove where different finger-touch combinations trigger pre-set voice messages (e.g., "I need water") to support people with paralysis.	GGHS Basapattana, Koppala	https://youtu.be/_4Nz2M-LISaA?si=QoFVVp4C6N-VOZsfj
13	Karnataka	Volt IQ	A fault-detection device that identifies and communicates the location of power-line issues, reducing the need for risky manual checking by linemen.	GHS Shiragaon, Belagavi	https://drive.google.com/drive/folders/1hy6ZLB-wlSkKXbnephbuKYTZkZIi-iGDjy?usp=sharing
14	Karnataka	Steamforge	A cleaner alternative to traditional brick curing that reduces fossil-fuel burning and pollution by improving the curing method through controlled steam/heat.	GGHS Basapattana, Koppala	https://drive.google.com/drive/folders/1L-kBd6e-GI77RIB5nm8zliKowiRo_Za-d?usp=sharing
15	Karnataka	Smart Visitor Connect	An ESP32-CAM based visitor management system that enables faster parent–warden communication in residential schools by streamlining identification and connectivity.	MDRS Madanahalli, Kolar	
16	Telangana	Peanut Peeler	A peanut peeling machine that removes shells quickly without crushing, saving time and effort.	ZPHS Karmaghat, Ranga Reddy	https://drive.google.com/drive/folders/1U5tqAEX-RYqB7aKmdSULSNcpgL-tUBW28e?usp=drive_link
17	Telangana	Farmer Baton	A night-safety baton for farmers that provides light and protection cues during field visits, helping reduce risks like snake bites and animal encounters.	ZPHS Bhiknoor, Kamareddy	https://drive.google.com/drive/folders/1o-6MoII5zikRVY2fG2U9kyP-mdkU9pZGz7?usp=drive_link
18	Telangana	Smart Satchel for All	A smart school bag with load/weight alerts, GPS tracking, and a spill-safe lunch section that reduces strain and improves safety for students.	ZPHS Bhiknoor, Kamareddy	https://drive.google.com/drive/folders/1-7VSWHrPxf-h1oSXx-oWMqpFOJydZwjgb?usp=drive_link

S. No.	State	Name of the project	Description	School name and location (district, mandal/Block)	Video overview
19	Telangana	Revive	A portable kitchen-waste bin with separate compartments and a decomposition tray that converts wet waste into manure and helps reduce mosquito breeding.	ZPHS Gargul, Kamareddy	https://youtu.be/_1zkzth-VBsk?si=sYhVGb7Nr4DiS-BQ8
20	Telangana	Mruttika	A simple kitchen-waste composting model that converts wet waste into organic compost, supporting sustainable gardening and better waste management.	Telangana Model School Imampet, Suryapet	https://drive.google.com/drive/folders/1wVOsy-WAbSpmjDrENYHqmAT-sO7eC_iXHX?usp=drive_link
21	Telangana	Flush Tank	A sensor-based flushing system that fills the tank only when needed, reducing leakage-related wastage and promoting water conservation.	ZPHS Karmaghat, Ranga Reddy	https://drive.google.com/drive/folders/1sWsXFKon-fnaCnBHru4zIqBwJTeHo-3Tas?usp=drive_link
22	Telangana	Paddy Guard	An automated paddy protection and drying system that detects rain and moves paddy into a covered container, then spreads it back for drying using motors/ auger support.	ZPHS Karmaghat, Ranga Reddy	https://drive.google.com/drive/folders/1kUyGEXY-CYtw2lj5nvQMctOl-Ue-JvuzS_?usp=drive_link