Interpretation:

Several challenges hinder effective lab utilization. 46.7% of teachers identified time constraints as a major barrier, while 60% reported a shortage of lab assistants. This places a heavy burden on teachers to manage students, materials, and experiments alone—potentially compromising the safety and quality of instruction. Although 73.3% confirmed the presence of basic safety measures, 26.7% noted deficiencies, raising concerns about student safety. 73.3% of teachers do not get frequent training in lab teaching; lack of professional development limits their ability to integrate practical learning effectively and safely.

Students also reported challenges. 32.6% faced issues due to a lack of equipment, and 31.4% encountered broken or non-functional lab tools. While 90.7% felt the allocated lab time was insufficient, only 7% reported safety concerns, suggesting that most labs follow safety protocols but may lack proper maintenance. Time constraints are pointed out by both teachers and students, pointing towards a need to allocate longer, dedicated lab sessions.

**Objective 4:** To study the perceptions of students and teachers toward the importance and role of science laboratories in education.

Table 7.1: Teacher's perceptions towards the importance and role of science laboratories in education.

| **S. No.** | **Items** | **% Yes** | **% No** |
|---|---|---|---|
| 1 | Laboratory activities improve students' academic performance. | 100 | 0 |
| 2 | The primary aim of laboratory sessions is to reinforce theoretical concepts and develop experimental skills. | 100 | 0 |
| 3 | Laboratory sessions are mainly conducted to meet curriculum requirements. | 13.3 | 86.7 |

Table 7.2: Student's perceptions towards the importance and role of science laboratories in education.

| S. No. | Items | % Yes | % No |
|---|---|---|---|
| 1 | Laboratory experiments make science more interesting for students. | 82.5 | 17.5 |
| 2 | Laboratory activities improve academic performance. | 77.9 | 22.1 |
| 3 | Laboratory experiments help students understand real-life applications | 80.2 | 19.8 |
| 4 | Prefer lab sessions over only classroom teaching | 83.7 | 16.3 |
| 5 | The following skills have been developed through laboratory activities: | | |
| | Critical thinking | 37.2 | 62.8 |
| | Problem-solving | 52.3 | 47.7 |
| | Observation skills | 61.6 | 38.4 |
| | Collaboration | 26.7 | 73.3 |

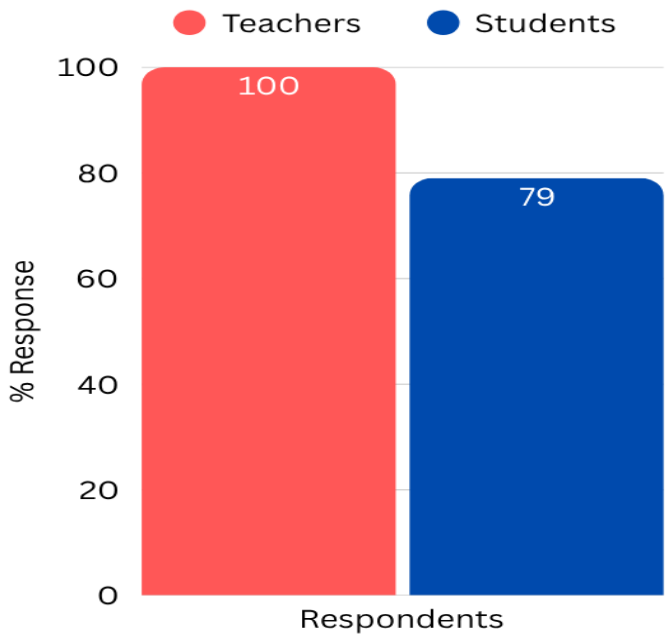


Figure 7: Laboratory activities improve academic performance.

Interpretation:

Both teachers and students highly value laboratory learning. All teachers (100%) agreed that labs improve academic performance and reinforce theoretical concepts, with only 13.3% viewing them as merely a curriculum requirement. Students also expressed strong support: 82.5% found labs more engaging than lectures, 77.9% believed they help in exams, and 80.2% recognized their real-life applications. Additionally, 83.7% preferred lab sessions over traditional classroom teaching.

However, skill development varied. While 61.6% improved observation skills and 52.3% enhanced problem-solving abilities, only 37.2% developed critical thinking, and 26.7% reported improved collaboration. This suggests that while labs are effective for certain skills, structured activities to promote higher-order thinking and teamwork are needed.

# Chapter 5:

# Results and Findings

### 5.1 Result:

The study investigated the availability, utilization, challenges, and perceptions of science laboratories in secondary schools of Bhopal through structured questionnaires administered to 15 teachers and 86 students.

- A robust 85% of students and 80% of teachers in central government schools confirmed the presence of science laboratories, reflecting strong infrastructure supported by national schemes like RMSA and NEP 2020. 100% of teachers and 82% of students reported sufficient tools and materials, indicating well-equipped facilities.
- In state government schools, only 60% of teachers and 66% of students acknowledged laboratories, underscoring infrastructural gaps. 40% of teachers and 43% of students cited insufficient tools, hindering effective experimentation.
- The disparity between central and state schools highlights systemic funding and prioritization issues. While central schools benefit from structured policies, state schools struggle with resource allocation, directly impacting practical learning opportunities.
- Laboratory usage was inconsistent. Only 53.3% of teachers conducted regular lab sessions, while 46.7% did not.
- Although 86.7% of schools allocated time slots for labs in timetables, 86.7% of teachers reported sessions lasting less than 60 minutes, insufficient for meaningful experimentation.
- Group demonstrations dominated (80% of teachers), with only 26.7% facilitating individual experiments. Student responses aligned: 93% worked in groups, 98.8% confirmed sessions were shorter than 60 minutes, and 84.9% agreed that lab work aligned with classroom theory. However, 15.1% disagreed, indicating gaps in integrating theory and practice.
- Key barriers included time constraints (46.7% of teachers), shortage of lab assistants (60% of teachers), and broken equipment (31.4% of students).
- While 73.3% of teachers confirmed basic safety measures, 26.7% noted deficiencies. Additionally, 73.3% of teachers lacked frequent training in laboratory pedagogy. Student perspectives reinforced these issues: 32.6% faced equipment shortages, and 90.7% deemed lab time insufficient.

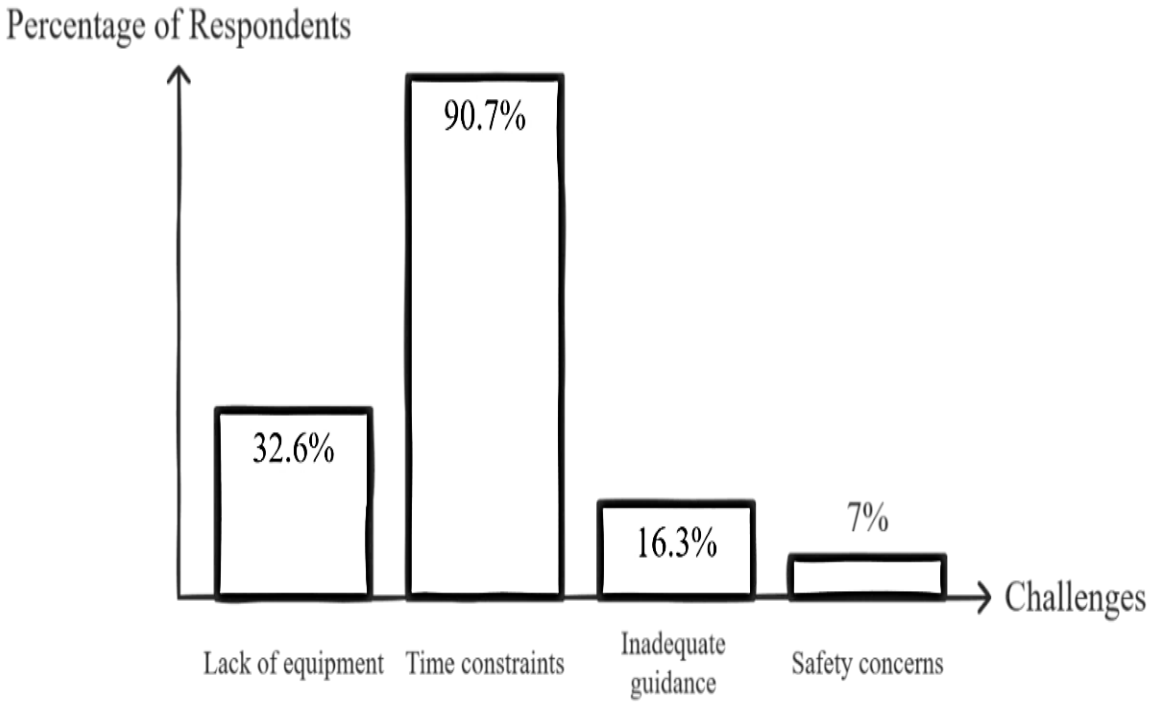


Figure 8: Challenges faced in laboratory usage (by Students)

- Both groups strongly endorsed laboratory-based learning. All teachers (100%) agreed labs improved academic performance and reinforced theoretical concepts. Similarly, 82.5% of students found labs engaging, 80.2% recognized real-life applications, and 83.7% preferred labs over classroom teaching. However, skill development varied: 61.6% honed observation skills, 52.3% improved problem-solving, but only 37.2% developed critical thinking, and 26.7% reported enhanced collaboration.

## 5.2 Conclusion

This study comprehensively assessed the availability, utilization, challenges, and perceptions of science laboratories in secondary schools of Bhopal. Significant disparities exist between central and state government schools. While central schools are well-equipped, state schools face infrastructural gaps and resource shortages. Laboratories are underutilized, with only 53.3% of teachers conducting regular sessions. Sessions are typically shorter than 60 minutes, and group demonstrations dominate over individual experiments, limiting hands-on learning. Key barriers include time constraints, inadequate equipment, staff shortages, and training gaps. Both teachers and students value labs for enhancing academic performance, engagement, and real-world relevance.

### 5.3 Discussion:

The findings suggest that to fully harness the educational benefits of science laboratories, systemic changes are needed.

First, school administrations and policymakers must prioritize laboratory time in the academic schedule, ensuring that practical sessions are not sidelined by theoretical lessons, especially for the secondary class ($9^{th}$ and $10^{th}$). Mandating lab hours (e.g., 60-minute sessions) and aligning assessments with practical skills (suggested by 45% of teachers) would reinforce their importance.

Second, investment in modern equipment and regular maintenance is crucial. This includes updating digital tools and simulation technologies that can enhance the quality of experiments and provide an interactive learning experience. Schools in rural areas require more investment in infrastructure, as many schools don't even have laboratories.

Third, professional development for teachers is essential. Regular training sessions and the hiring of dedicated laboratory assistants could help overcome the challenges of overcrowding and time management.

Moreover, a strategic review of the curriculum to integrate laboratory work more seamlessly with theoretical instruction could help in maximizing the impact of practical experiments. Engaging students in planning and executing experiments may also increase their motivation and ownership of their learning process.

### 5.4 Recommendations:

To bridge these gaps, policymakers and schools must:

1. Extend lab durations to ≥90 minutes for comprehensive experimentation.
2. Allocate funds for equipment maintenance and safety upgrades.
3. Train teachers in modern lab pedagogy and safety management.
4. Promote individual work to cultivate critical thinking and problem-solving.
5. Integrate labs into assessments to align with NEP 2020 goals.

By addressing these challenges, laboratories can transform into dynamic spaces for scientific inquiry, preparing students to meet global educational standards and fostering India's next generation of innovators.

### 5.5 Educational Implications

The findings of the study "A Study of Availability and Utilization of Science Laboratories for Teaching-Learning Science in Secondary Schools of Bhopal" hold significant implications for various stakeholders involved in science education. These implications not only highlight the steps that need to be taken but also shed light on how each group stands to benefit from improvements in laboratory-based learning.

**1. For Teachers**

Teachers are the facilitators of learning and play a pivotal role in translating textbook content into meaningful, real-world understanding through practical experiments. They are responsible for designing and conducting laboratory sessions that engage students actively and meaningfully.

Implications:

- Teachers should be empowered and trained to shift from passive demonstration methods to student-centered experimental learning, where students get to perform and explore scientific concepts themselves.
- Regular capacity-building workshops in lab safety, experiment planning, and integration of theory with practice will enhance their instructional skills.
- Teachers should be provided with sufficient preparation time, support staff, and access to updated teaching aids to conduct effective lab sessions.

Teachers who are well-equipped and confident in managing laboratory sessions will experience greater student engagement, improved academic outcomes, and personal and professional satisfaction. It will also ease their teaching load, as practical learning often leads to better retention and less repetition of concepts.

**2. For Students**

Students are at the center of the educational process. Their role is to explore, question, experiment, and construct knowledge through hands-on learning experiences in the laboratory.

Implications:

- Students must be given regular and equitable access to well-equipped laboratories that allow them to perform individual or group experiments.
- Practical sessions should be designed to foster essential 21st-century skills like critical thinking, problem-solving, observation, and collaboration.
- Adequate orientation on lab safety protocols and scientific handling of equipment should be provided to students.

Students engaged in active lab-based learning develop a deeper understanding of scientific principles, are better prepared for exams, and gain confidence in applying knowledge in real-life contexts. Such exposure also nurtures a scientific temperament and can inspire future careers in STEM fields.

**3. For Administrators** (School Leaders and Education Officers)

Administrators are responsible for creating an enabling environment where effective teaching and learning can take place. They manage resources, infrastructure, scheduling, and staff deployment to ensure smooth academic functioning.

Implications:

- Administrators should ensure that every secondary school has well-maintained, subject-specific science laboratories with appropriate infrastructure and materials.
- They must allocate a budget for lab upgrades, maintenance, and consumables, and prioritize the hiring of laboratory assistants or support staff to reduce the burden on teachers.
- Timetables should include dedicated, uninterrupted time slots for lab work to prevent practical sessions from being overshadowed by theoretical classes.