Ethical needs like the preservation of anonymity, informed consent, and data security were rigorously kept in place to ensure that the research process's integrity was preserved.

Each of these components is described with clarity and justification to establish the methodological integrity of the study. The aim is to ensure that the research findings are grounded in a robust and logical process, allowing for meaningful conclusions and practical recommendations that can contribute to improving science education in Bhopal's secondary schools.

3.2 Research Design

The study follows a mixed-method approach, using a survey method to gather data from a representative sample. This design was chosen because it is best suited for gathering detailed, factual information regarding existing conditions. In this case, it helped to assess the availability, condition, and utilization of science laboratories and to explore perceptions and challenges associated with their use in secondary schools of Bhopal.

A random sampling technique was used to select the schools to ensure representation from different types (central and state government) and locations (urban and rural).

3.3 Population and Sampling

The population for the study consisted of secondary schools in the Bhopal district, including both central government schools and state government secondary schools.

The study adopted a survey method in which primary data was collected from the 15 science teachers and 86 students of class 10^{th} belonging to the 08 government secondary schools located in the Bhopal districts of Madhya Pradesh state using questionnaires and an observation schedule.

The government of India's program for the Universalization of Secondary Education (USE), Rashtriya Madhyamik Shiksha Abhiyan (RMSA), has been in implementation since 2009-10 for the provision of secondary education of good quality that is accessible, available, and affordable to all children between the ages of 14 and 16 years. Consistent with this, the age group of 14-15 years was taken into consideration.

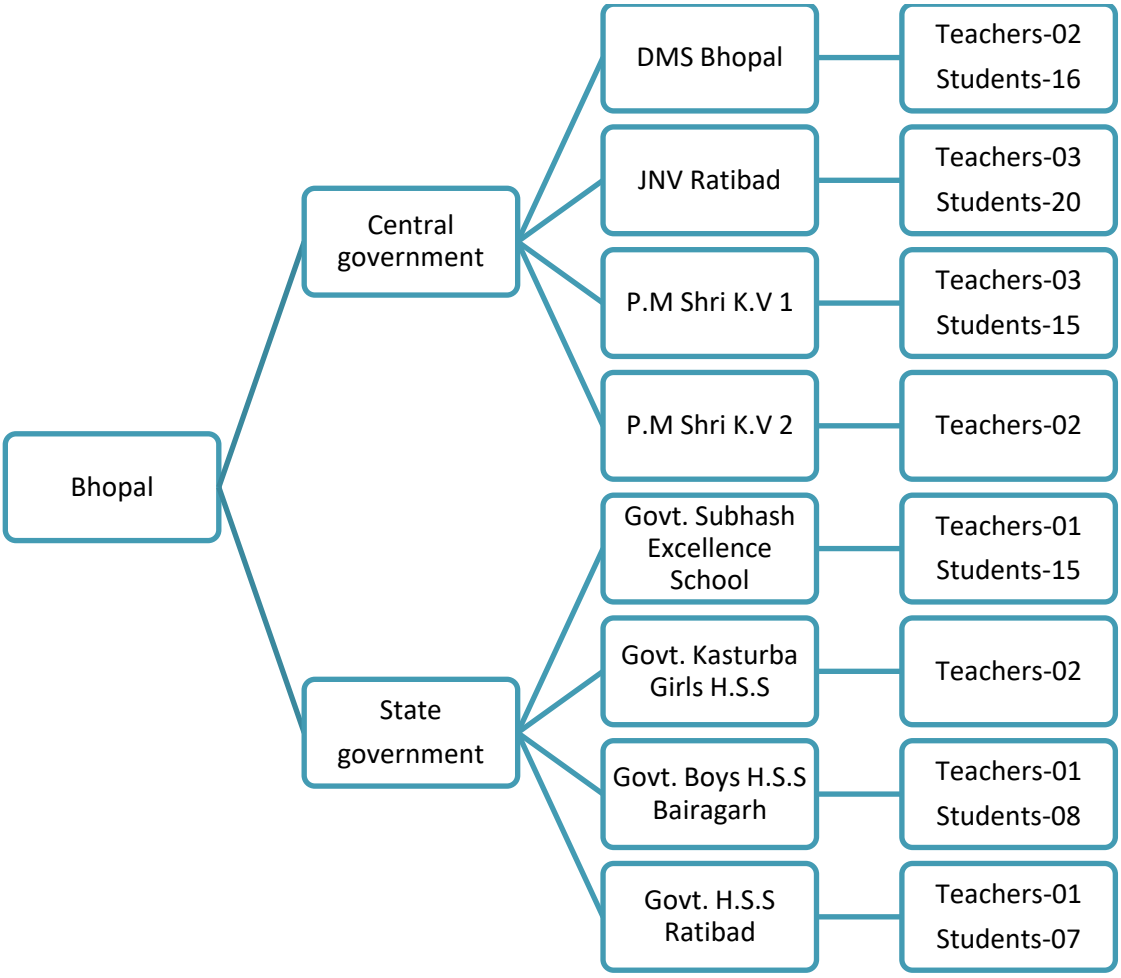

Figure 1: Population and Sampling.

Table 3: Schools Selected for Sampling.

S. No.	School Name	Category	Address
1	Demonstration Multipurpose School (DMS)	Central Government (Urban)	Regional Institute of Education, Shyamla Hills, Bhopal – 462002, Madhya Pradesh, India
2	Government Boys Higher Secondary School, Bairagarh	State Government (Rural)	Vivekanand Marg, Block A, Hemu Kalani, Bairagarh, Bhopal – 462030, Madhya Pradesh, India
3	Government H.S.S Ratibad	State Government (Rural)	Ratibad, Bhopal, Madhya Pradesh – 462044, India
4	Government Kasturba Girls Higher Secondary School, TT Nagar	State Government (Urban)	Near Mata Mandir, TT Nagar, Bhopal – 462003, Madhya Pradesh, India

5	Government Subhash Higher Secondary School for Excellence	State Government (Urban)	Shivaji Nagar, Bhopal – 462016, Madhya Pradesh, India
6	Jawahar Navodaya Vidyalaya (JNV) Ratibad	Central Government (Rural)	Village Ratibad, District Bhopal, Madhya Pradesh – 462044, India
7	PM Shri Kendriya Vidyalaya No. 1, Bhopal	Central Government (Urban)	Opp. Maida Mills, Hoshangabad Road, Bhopal – 462011, Madhya Pradesh, India
8	PM Shri Kendriya Vidyalaya No. 2, Bhopal	Central Government (Urban)	Bus Stop No.7, Shivaji Nagar, Bhopal, Madhya Pradesh 462016

3.4 Tools for Data Collection

The study employed three primary data collection tools: self-made **questionnaires** for teachers and students and an **observation checklist**, designed to holistically evaluate the availability, utilization, challenges, and perceptions related to science laboratories in secondary schools.

1. **Questionnaires for teachers**

   The questionnaire has 24 items, which were both closed and open-ended. The questions were related to general information about the teacher, availability of laboratory infrastructure and equipment, utilization patterns (frequency, methods, curriculum alignment), challenges faced (resource shortages, time constraints, safety concerns), perception of teachers about science laboratory, and open-ended suggestions for improvement.

2. **Questionnaires for students**

   The questionnaire contained 24 items, focused on laboratory access and availability, participation frequency, safety experiences, perception toward practical learning, skill development (e.g., observation, critical thinking), and open-ended suggestions for improvement.

3. **Observation Schedule**: A self-prepared checklist was used to observe laboratory infrastructure, equipment availability, maintenance, safety measures, and usage during visits to the sampled schools. A 17-item checklist was used to objectively assess laboratory conditions, including infrastructure adequacy (space, ventilation, seating), equipment availability and functionality, safety protocols (fire extinguishers, first-aid kits), and pedagogical practices (student engagement, teacher-student interaction). Observations were conducted during scheduled and unscheduled visits to minimize bias.

The questionnaires for teachers and students and the observation schedule are attached in Appendices A and B, respectively.

3.5 Data Collection Procedure

- Permission was obtained from the school principals before conducting the study.
- Questionnaires were administered personally to science teachers and students.
- Simultaneously, the laboratories were observed using the observation schedule.

Ethical Considerations:

- Informed consent was obtained from participants.
- Anonymity and confidentiality were strictly maintained.
- Data were used exclusively for research purposes.

3.6 Scoring procedures

The data collected through the teacher and student questionnaires, as well as the observation schedule, were primarily composed of close-ended items (Yes/No) along with a few open-ended questions. The scoring and analysis were carried out using the following procedure:

1. Close-ended Questions: the responses were tabulated using frequency counts. For each item, the number of respondents selecting “Yes” and “No” was counted separately. These frequencies were then converted into percentages for a clearer understanding.

2. Tabulation and Categorization: The frequency and percentage data for each item were organized objective-wise and presented in tables. Comparative analysis was performed between different types of schools and respondent categories to identify patterns, gaps, and consistencies in responses.

3. Open-ended Responses: The responses to open-ended questions were reviewed manually. Recurring themes, suggestions, and opinions were coded and categorized to support the quantitative data. These insights were included in the interpretation sections to add depth and context to the statistical findings.

Chapter 4:

Data Analysis And Interpretation

4.1 Introduction

Data analysis and interpretation are critical phases of the research process. Once data has been collected, it must be systematically organized, examined, and interpreted to derive meaningful conclusions. This chapter serves as the bridge between raw data and research findings. It transforms the responses gathered through questionnaires and observations into logical insights that directly address the research questions and objectives.

In the context of the present study, "A Study of Availability and Utilization of Science Laboratories for Teaching-Learning Science in Secondary Schools of Bhopal," this chapter aims to explore the actual status of science laboratories, their usage patterns, the challenges faced in their operation, and the perceptions of teachers and students toward laboratory-based science education.

The chapter is organized objectively and systematically based on the research objectives. Each section presents data in the form of tables, figures, and percentages, followed by detailed interpretation to identify patterns, discrepancies, and key insights.

The main areas of analysis include:

1. Availability of Science Laboratories in Secondary Schools.
2. Utilization of Laboratories for science teaching and learning.
3. Challenges faced by teachers and students in using laboratory resources.
4. Perceptions of teachers and students regarding the importance and effectiveness of laboratory work in science education.

This structured approach ensures that the findings are aligned with the aims of the study and provide a solid foundation for the conclusions and recommendations presented in the next chapter. The interpretation of data also offers insights into how national policies like NEP 2020 are being realized at the ground level, particularly in the Bhopal district.

4.2 Objective-wise analysis

It includes analyses of questions from both teacher (N=15) and student (N=86) questionnaires and is arranged accordingly with the objectives of the study.

Objective 1: To determine the availability of science laboratories in secondary schools of Bhopal district.

Table 4.1: Teacher's response to the availability of science laboratories in school.

S. No.	Items	Central government		State government	
		% Yes	% No	% Yes	% No
1	The school has a science laboratory for class 9^{th}–10^{th} students	80	20	60	40
2	Sufficient Tools and materials are available	100	0	60	40

Table 4.2: Student's response to the availability of science laboratories in school.

S. No.	Items	Central government		State government	
		% Yes	% No	% Yes	% No
1	The school has a science laboratory for class 9^{th} –10^{th} students	85	15	66	34
2	Sufficient Tools and materials are available	82	18	57	43

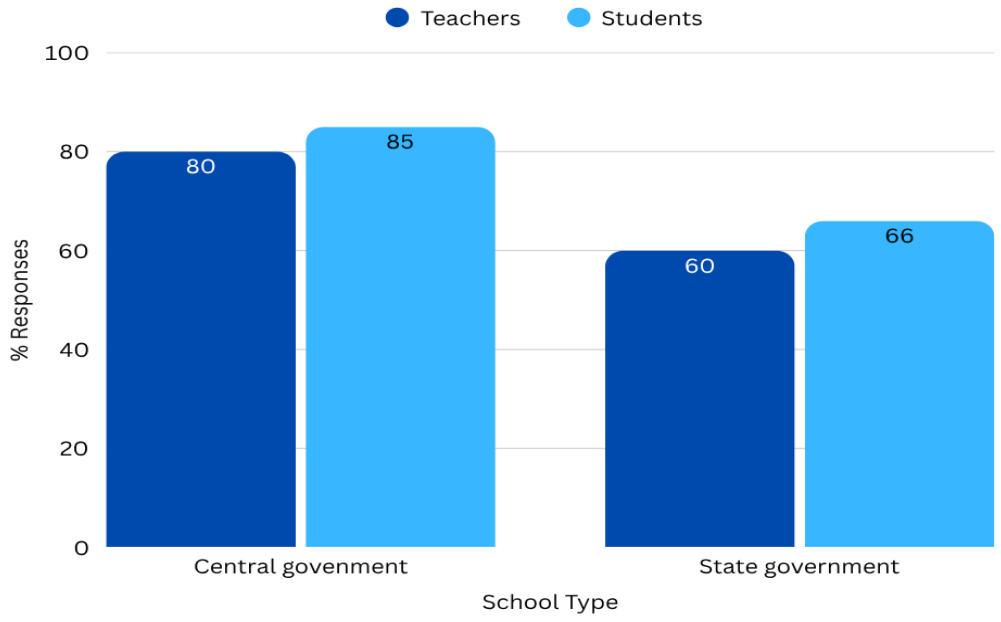

Figure 2: Availability of Science Laboratory in Secondary Schools of Bhopal District.

Interpretation:

A majority of teachers (80%) and students (85%) confirmed the presence of science laboratories in central government schools. This indicates robust infrastructure in centrally administered institutions, likely due to better funding and adherence to national educational frameworks like RMSA and NEP 2020. In state government schools, only 60% of teachers and 66% of students acknowledged the existence of laboratories, highlighting infrastructural gaps. The discrepancy between teacher and student responses could stem from varying access levels or awareness among students.

In central government schools, both teachers (100%) and students (82%) reported sufficient availability of laboratory tools and materials, reflecting well-equipped facilities that support practical learning. In state government, a notable 40% of teachers and 43% of students cited insufficient tools and materials, underscoring resource shortages. These findings were verified via observation, and all the science laboratories were separate and subject-specific for physics, chemistry, and biology. All the schools had enough space to accommodate the students with the availability of tables and stools (workstations); however, the labs of state government schools were not in good condition and not well-maintained. This inadequacy likely hampers effective experimentation and aligns with broader challenges in state-funded schools, such as limited budgets and delayed maintenance.

Objective 2: To study the extent of utilization of science laboratories for teaching-learning science.

Table 5.1: Teacher's response to the utilization of science laboratories for teaching-learning science.

S. No.	Items	% Yes	% No
1	Laboratory practical sessions are conducted regularly.	53.3	46.7
2	A typical laboratory session lasts more than 60 minutes.	13.3	86.7
3	There are dedicated time slots for lab sessions in the timetable.	86.7	13.3
4	Individual experiments are commonly conducted.	26.7	73.3

5	Group experiments or teacher demonstrations are conducted.	80	20
6	The laboratory is accessible outside regular science periods (e.g., during free periods or after school).	40	60
7	More than 20% of the science curriculum is covered through laboratory activities.	60	40
8	Students actively participate in laboratory activities.	86.7	13.3

Table 5.2: Student's response to the utilization of science laboratories for teaching-learning science.

S. No.	**Items**	**% Yes**	**% No**
1	laboratory experiments are performed in Physics	34.5	65.5
2	laboratory experiments are performed in Chemistry	64.3	35.7
3	laboratory experiments are performed in Biology	54.8	45.2
4	Regularly participates in laboratory activities	26.7	73.3
5	Laboratory sessions typically last more than 60 minutes.	1.2	98.8
6	Safety rules are strictly followed during laboratory sessions.	89.5	10.5
7	Experiments are usually performed individually.	7	93
8	Experimental activities are conducted in groups or pairs.	93.02	6.97
9	Practical work is aligned with the theory taught in class.	84.9	15.1

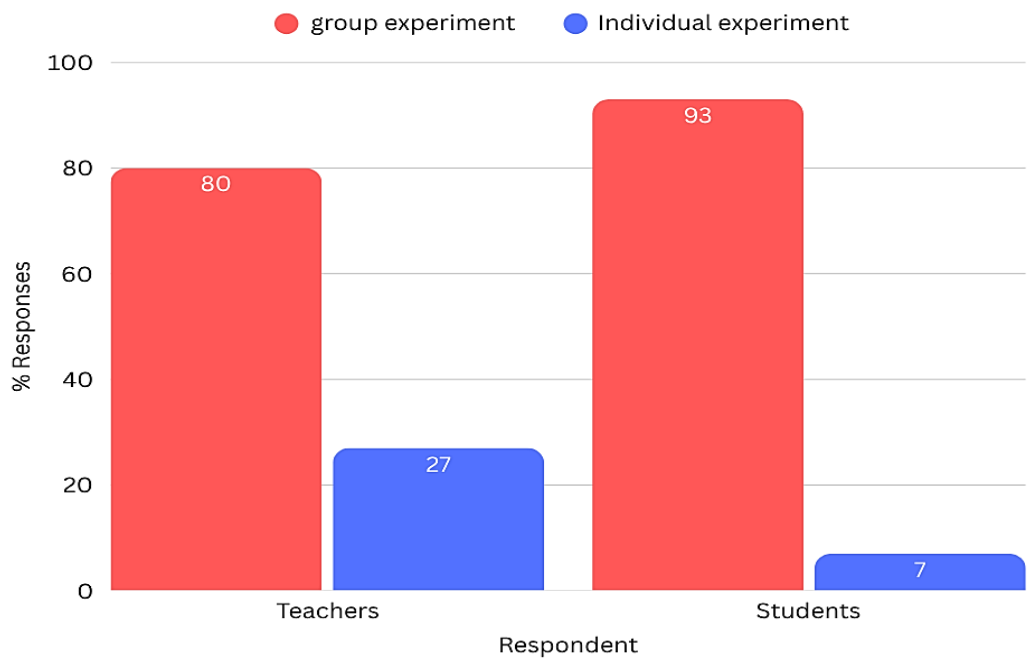

Figure 3: Methods of experimentation.

Interpretation:

Despite the availability of labs, their regular use remains inconsistent. Only 53.3% of teachers conduct lab sessions frequently, while 46.7% do not. 65.5% of students reported laboratory activities in physics are comparatively underrepresented, possibly due to equipment or space constraints. Although 86.7% of schools have dedicated time slots for labs in their timetables, just 13.3% of teachers reported sessions lasting more than 60 minutes; short duration may not be sufficient for setup, experimentation, analysis, and discussion, leading to rushed or incomplete learning experiences. 60% of teachers reported that lab access is largely confined to science periods. Limited flexibility restricts opportunities for project work, remedial sessions, or independent exploration, which are important for deeper engagement.

Furthermore, 80% of teachers rely on group demonstrations, while only 26.7% allow individual experiments. This suggests that students have limited opportunities for hands-on learning.

Student responses support these findings. A vast majority (93%) perform experiments in groups or pairs, with only 7% working individually. Nearly all students (98.8%) confirmed that lab sessions are shorter than 60 minutes, reinforcing the issue of insufficient time. While 84.9% agreed that lab work aligns with classroom theory, 15.1% disagreed, indicating a gap between theoretical and practical instruction.

It was observed that in labs of state government schools, essential science equipment (e.g., glassware, microscopes, physical equipment) was covered in dust, indicating that it was not utilized regularly and not cleaned at regular intervals of time. Storage rooms are available in all schools; laboratory rules and guidelines are displayed on walls along with posters related to science experiments.

Objective 3: To identify the challenges faced by schools in utilizing laboratory resources for science teaching-learning.

Table 6.1: Teacher's response to the challenges faced by schools in utilizing laboratory resources for science teaching-learning.

S. No.	Items	% Yes	% No
1	Inadequate laboratory equipment.	20	80
2	Laboratory assistants or support staff available	40	60
3	Time constraints	46.7	53.3
4	Laboratory resources are upgraded annually	86.7	13.3
5	Teachers receive frequent training	26.7	73.3
6	Basic safety measures (such as fire extinguishers and first aid kits) are available	73.3	26.7
7	Space is sufficient to accommodate the entire class.	86.7	13.3

Table 6.2: Student's response to the challenges faced by schools in utilizing laboratory resources for science teaching-learning.

S. No.	Items	% Yes	% No
1	lack of laboratory equipment.	32.6	67.4
2	Time constraints	90.7	9.3

3	Teachers do not always provide enough guidance	16.3	83.7
4	Safety concerns have been experienced while working in the laboratory.	7	93
5	Encountered broken or non-functional laboratory equipment.	31.4	68.6

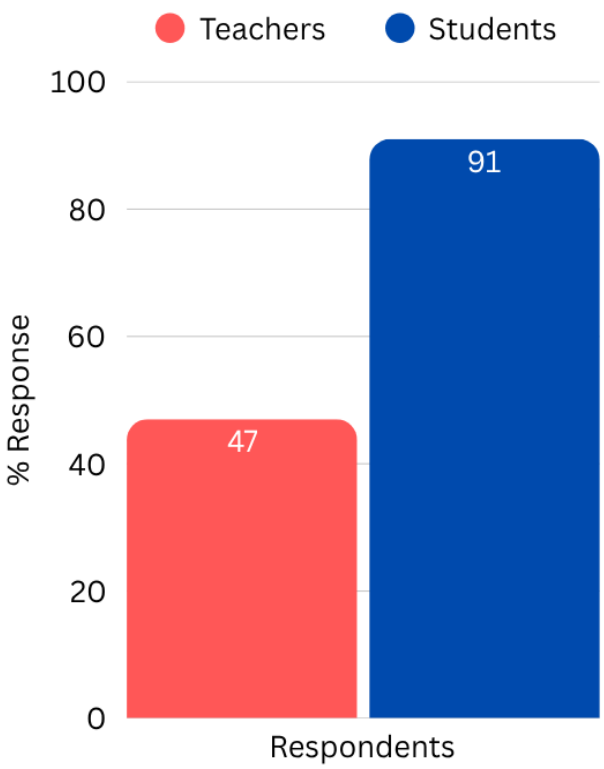

Figure 4: Time constraint

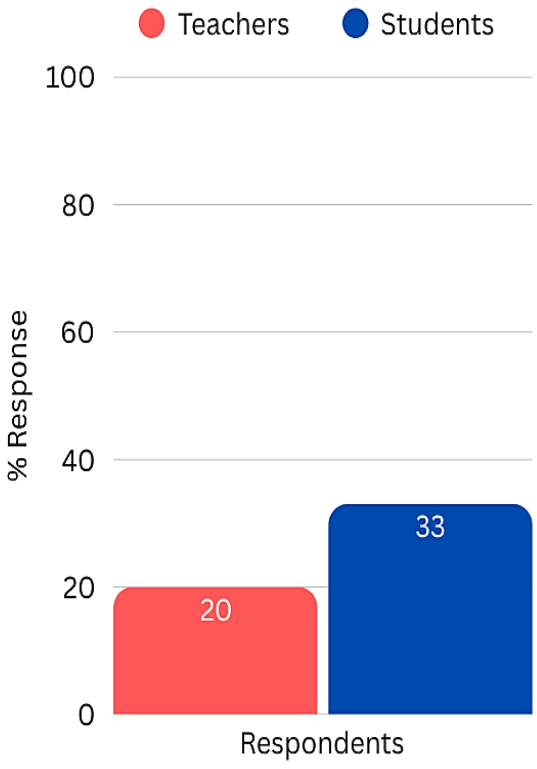

Figure 5: Inadequate equipment

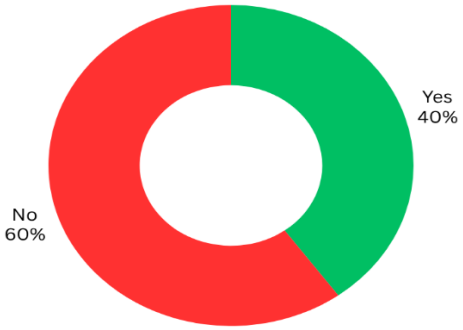

Figure 6: Availability of laboratory staff (Teachers)