The Mudaliar Commission (1952-53) was concerned with secondary education and stressed the need for practicals in science subjects. It recommended the introduction of scientific principles in normal teaching and the adoption of revised textbooks.

The Kothari Commission (1964-66) proposed a national education system with a focus on scientific and technical education. It emphasized awakening curiosity and developing skills such as independent study, critical thinking, and judgment, advocating for practical work and experimentation as essential to science education. It recommended the provision of specimens, models, and charts at the primary level and laboratory-cum-lecture rooms at higher primary and secondary schools to facilitate hands-on learning.

RMSA has prioritized the establishment of science laboratories in secondary schools. Since its inception in 2009, over one lakh science labs have been set up, significantly enhancing opportunities for practical and hands-on science learning. The scheme provides funding to states specifically for the creation and strengthening of science labs, ensuring that students have access to essential laboratory infrastructure. RMSA promotes practical, activity-based, and experiential learning in science. Teacher training under RMSA emphasizes practical-oriented teaching strategies, encouraging teachers to use real-life examples, demonstrations, and experiments to foster curiosity and understanding among students.

NCF 2005 advocates for activity-based, experiential, and collaborative learning in science, moving away from rote memorization to approaches that engage curiosity and creativity. It recommends that science education at the upper primary and secondary stages should include hands-on activities, experiments, and projects that are relevant to students' daily lives. It encourages the use of science laboratories, multimedia, virtual labs, and simulations to provide practical understanding and make abstract concepts tangible.

NEP 2020 calls for a shift toward exploratory, discovery-based, and inquiry-driven science education, promoting curiosity, critical thinking, and problem-solving skills among students. It emphasizes hands-on activities, experiments, and play-based learning to deepen understanding of scientific concepts. It mandates adequate infrastructure, including well-equipped science labs in all schools, to support practical learning and ensure equitable access to quality science education. It promotes the integration of science with other subjects and real-world applications, preparing students for contemporary challenges and careers. Stresses ongoing training and upskilling of science teachers to adopt innovative pedagogies and stay updated with scientific advancements. Advocates for regular updates to the science curriculum to include emerging fields and technologies, ensuring relevance and forward-looking education.

1.2 Nature of Science

Science is a novel and dynamic way of coming to know the world around us. Science is a systematic process of building and organizing knowledge by observing, testing, and reasoning. Science is not all about learning facts but, to a greater degree, learning how knowledge is built, tested, and continually refined.

Science has a certain method of inquiry and explanation of things. Contrary to the tradition, authority, or intuition-based belief system, science is guided by evidence from observation and experiment. Scientists ask questions, develop hypotheses, experiment, and interpret data in an attempt to make conclusions. This renders scientific knowledge non-static but dynamic because new evidence keeps arising.

The key characteristics that define the nature of science are:

• Empirical Evidence: Scientific information comes from observation and facts received through the senses or with instruments and equipment. The National Council of Educational Research and Training (NCERT) underscores that scientific information comes from verifiable facts and not from assumptions or beliefs.

• Tentativeness: Scientific theories and laws may be changed. With the discovery of new evidence, old theories can be modified or abandoned. This is not a flaw but a positive aspect, for science is capable of improvement over time. The World Health Organization (WHO) acknowledges this in its evolving guidelines, like in the case of the COVID-19 pandemic, where guidelines were updated based on new findings. Likewise, UNESCO reaffirms the dynamic nature of scientific knowledge and its development through continuous inquiry.

• Imagination: Science may require scientific methods, but it requires imagination as well. Scientists must be imaginative while designing experiments, interpreting data, and developing new hypotheses.

• Systematic: Science follows systematic methodologies, including hypothesis formulation, experimentation, and peer review. The National Science Foundation (NSF) and CSIR stress the importance of structured research methodologies to ensure validity and reliability.

• Subjectivity and Objectivity: Scientists try their best to be objective, but their background, experience, and perspective might influence their work. Scientific knowledge, therefore, is both an objective observation and a subjective interpretation.

• Social and Cultural Embeddedness: Science is not a detached endeavor. It is influenced by the culture and society where science is occurring. Economic imperatives, political goals, and ethical standards may influence the course and application of scientific investigation.

• Theory-Laden Observations: Observations by scientists are conceived in terms of dominant theories and paradigms. This means that what one observes and how one interprets what is observed can vary depending on the theoretical perspective.

1.3 Importance of science lab and its benefits

Science is not just a subject to be learned from textbooks; it is a dynamic field that thrives on experimentation, observation, and discovery. Science laboratories play a crucial role in transforming theoretical knowledge into practical understanding, making them an indispensable part of education. They provide students with hands-on experience, foster critical thinking, and nurture a scientific temperament.

Practical work is a major component of learning, particularly in science, technology, and vocational education. It consists of hands-on activities where students are actively involved with materials, experiments, and concrete demonstrations of theories. It is not an extra component of learning but an extremely useful methodology that renders learning more purposeful, effective, and fun. The benefits of experimentation and activities conducted in science laboratories are as follows:

- Enhanced Conceptual Comprehension: The greatest benefit of practical work is that it improves conceptual understanding. While the students perform experiments or prepare models, they see theories put into practice. This bridges the gap between conceptual knowledge and practical knowledge. For example, studying the process of photosynthesis becomes extremely simple when the students see plants growing in different conditions in a lab.
- Acquisition of Skills: Practical work enables students to acquire a broad variety of useful skills. These include:

• Observation skills: Students become able to observe minute changes and record exact details.

• Problem-solving skills: Hands-on activities tend to yield unforeseen outcomes, challenging the students to be creative and solve problems.

• Technical skills: Applying lab equipment, measuring instruments, and conducting experiments transfer valuable technical skills.

• Teamwork skills: All the practical exercises are in groups to promote teamwork and communication.

- Fostering Curiosity and Imagination: Practical work is all about developing curiosity, questioning spirit, and the ability to generate ideas among the students. In practical work, they are even allowed to design their experiments. This generates an element of curiosity and imagination, which are necessary skills in science and life as well. Practical work makes learning an active process of discovery rather than a passive one.
- Building Confidence: Executing experiments and practical exercises successfully provides students with a sense of pride. This increases the level of confidence in their ability. It also increases independent learning because students gain confidence in believing in their observation and reasoning capabilities instead of depending on teachers or textbooks.
- Fun in Learning: Laboratory activities introduce fun and variety to the class. Practical experiments are more likely to be interesting and entertaining to students compared to classroom lectures or even studying textbooks. Enjoyment can stimulate motivation and result in greater enthusiasm for the subject.
- Preparation for Real-Life Applications: Practical work exposes learners to how they can use what they have learned in real life. For example, learning chemical reactions in the laboratory can be applied in medicine, agriculture, and environmental science. Practical work prepares the learners appropriately for future careers where practical skills are essential.
- Developing Critical Thinking: Through performing work, students understand that scientific knowledge is based on evidence and testing and not on the acceptance of facts. They learn to question results, repeat experiments, and draw conclusions based on data. This helps to develop critical thinking, which is not only helpful in studies but also in making everyday decisions.

1.4 Significance of the Study

Science education is a pillar of modern education systems, promoting critical thinking, problem-solving, and innovation among students. Experimental, hands-on science learning in science laboratories is needed to close the gap between theory and practice. However, in the majority of secondary schools, especially in urban areas like Bhopal, the number and appropriate use of science laboratories are less than satisfactory. The current study tries to bridge this significant gap by investigating the condition of science laboratories in secondary schools of Bhopal, their usage, and the issues faced in operating them.

The study will assess the state and readiness of laboratory facilities, equipment, and safety features and give a clear picture of the infrastructure present. This information will be beneficial for policymakers and school authorities to make effective resource planning and ensure schools are equipped to deliver quality science education.

By examining the frequency and effectiveness with which labs are being used, the study will reveal discrepancies between facility usage and capacity. This will determine systemic issues like rigid schedules, insufficiently trained personnel, or curriculum incompatibility that hinder practical learning.

The research will pinpoint some of the main challenges encountered by students and teachers, including insufficient equipment, insufficient time, safety issues, and insufficient support staff. Addressing such issues can result in more effective and safer laboratory classes, improving the quality of learning.

Attitudes and perceptions of students and teachers towards laboratory-based learning will be investigated. Positive attitudes will confirm the value of practical work, whereas negative attitudes will identify areas for development, e.g., teacher training or student motivation strategies.

In order to gain a better perspective on the national and global situation of science laboratories in secondary education, the following table outlines major findings in relevant literature. The comparative overview outlines the urgent need to assess the situation in Bhopal.

Table 1: Summary of Literature on Science Laboratory Conditions.

Region	Author(s) & Year	Key Findings on Laboratory Availability & Utilization
Abroad	Geleta (2018), Ethiopia	Most schools lacked adequate lab equipment; poor management reduced utilization.
	Konyango (2011), Kenya	Labs were present but underutilized; poor utilization correlated with low performance.
	Oluwasegun et al. (2015), Nigeria	The availability of lab equipment significantly improved physics performance.
	Hodson (1990), UK	Practical work was often poorly implemented, reducing its educational effectiveness.
	Wahidah et al. (2021), Indonesia	Lab infrastructure, including prep/storage rooms, was vital for learning effectiveness.
India	Chakrapani & Puroshottama (1975)	50% of schools had no lab; private schools were better equipped than government ones.
	Rajput et al. (1978)	Over 90% of labs in MP lacked basic utilities like water, gas, or electricity.
	Pareek (2023)	Only 1 out of 21 surveyed schools had a functional science lab; poor scheduling too.
	Thakur (2015)	Chemistry labs were poorly equipped; teachers lacked support and training.
	Venkataraman (1976)	Equipment was insufficient; overcrowded classrooms and poor AV usage were prevalent.

This comparative literature reveals that while international studies highlight both the value and underutilization of science laboratories due to management or infrastructure issues, Indian studies show even more severe deficiencies, especially in government and rural schools.

Given this context, this study becomes highly significant, as it assesses the condition of science labs in Bhopal. The findings will inform local educational policy, improve resource allocation, and align with national educational reforms under NEP 2020, which emphasize experiential and inquiry-based learning through adequate lab infrastructure.

After reviewing the above literature, the following questions emerged which need research-based answers.

1.5 Research Questions

- What is the current state of availability of science laboratories in secondary schools in Bhopal district?
- How are science laboratories being utilized for teaching science in secondary schools?
- What are the challenges faced by schools in Bhopal in ensuring the effective utilization of science laboratories?
- What are the perceptions of students and teachers regarding the importance and role of science laboratories in secondary education?

Realizing the scenario, the researcher has worked upon the following problem.

1.6 Problem statement

"A Study of Availability and Utilization of Science Laboratories for Teaching-Learning Science in Secondary Schools of Bhopal"

1.7 Operational definitions

- ❖ Science Laboratory: A science laboratory is a specialized learning environment equipped with scientific tools, apparatus, and materials where students engage in experimental and investigative activities to explore scientific concepts. It provides a hands-on context for applying theoretical knowledge, encouraging critical thinking and inquiry-based learning.
- ❖ Availability of Laboratories: Availability refers to the presence and accessibility of dedicated science laboratory facilities, including infrastructure, apparatus, equipment, and materials, required for the conduct of practical science activities in schools. It includes whether the laboratory exists and is functionally ready for use by students and teachers.
- ❖ Utilization of Laboratories: Utilization indicates the frequency, manner, and effectiveness with which science laboratories are used for teaching-learning purposes. It involves the integration of laboratory activities into the curriculum, the nature of student participation, and the alignment with theoretical concepts taught in classrooms.
- ❖ Teaching-Learning Process: The teaching-learning process refers to the systematic interaction between teachers and learners, where knowledge is transmitted, constructed,

and applied. In the context of science education, this process includes both theoretical instruction and practical experimentation to facilitate deeper understanding and skill acquisition.

- ❖ Infrastructure: Infrastructure in the context of science laboratories refers to the physical and organizational structures, including buildings, lab rooms, furniture, lighting, ventilation, water supply, gas pipelines, electricity, storage areas, and safety arrangements, that support laboratory teaching and experimentation.
- ❖ Secondary School: A secondary school refers to an educational institution providing instruction typically to students in classes 9 and 10, catering to the age group of approximately 14–16 years. In this study, it specifically refers to central and state government schools within the Bhopal district.

1.8 Objectives of the Study

1. To determine the availability of science laboratories in secondary schools of Bhopal district.
2. To study the extent of utilization of science laboratories for teaching-learning science.
3. To identify the challenges faced by schools in utilizing laboratory resources for science teaching-learning.
4. To study the perceptions of students and teachers towards the importance and role of science laboratories in education.

1.9 Delimitations of the Study

- The study was confined to secondary schools in Bhopal, Madhya Pradesh.
- The sample consists of only class 10^{th} students.
- Only government and government-aided schools (both central and state-run) are included in the sample.
- The study was confined to Physics, Chemistry, and Biology laboratories only.