

**A STUDY OF LINKAGE BETWEEN THEORY AND PRACTICAL
ASPECTS OF SCIENCE AT SECONDARY SCHOOLS OF MIZORAM**

**A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE
REQUIREMENTS FOR THE DEGREE OF DOCTOR OF
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**A STUDY OF LINKAGE BETWEEN THEORY AND
PRACTICAL ASPECTS OF SCIENCE AT SECONDARY
SCHOOLS OF MIZORAM**

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**In partial fulfilment of the requirement of the Degree of Doctor of
Philosophy in Education of Mizoram University, Aizawl.**

CERTIFICATE

This is to certify that Mr H.T. Malsawmtluanga, a Ph.D. Scholar in the Department of Education at Mizoram University, registration No. MZU/Ph.D./1809, of 18.08.2021 has written his thesis titled ‘A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools in Mizoram’ under my guidance and supervision. In preparing the thesis, he has fulfilled all the necessary requirements as per the Ph.D. regulations of the University. The thesis is the original works of the scholar and has not been submitted for any degree to any other University.

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DECLARATION
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I, **H.T. Malsawmtluanga**, hereby declare that the subject matter of this thesis is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to do the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the Mizoram University for the **Degree of Doctor of Philosophy in Education**.

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CHAPTER - I

INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Education has become essential for everyone's survival in contemporary society since it is a crucial key tool that allows people to learn and obtain information. Everyone desires quality education, but it must be encouraged in the right way from the beginning. A strong educational foundation offers enhanced perspectives on life and fosters a deeper understanding of the world. In present world, education serves as the keystone of intellectual and societal development. It is fundamentally logical, deeply embedded in human reasoning, and relies on the language structure to convey knowledge, ideas, and critical thinking skills. The importance of education is not only about the transfer of information; it shapes the way individuals perceive, analyse, and interact with the world around them. As society developed, education processes became modernized, reflecting the need for deeper understanding and application rather than rote memorization. As a result of this educational evolution, modern learning has become highly scientific in nature. The shift toward a more analytical and scientific approach to learning has paved the way for the increasing importance of STEM (Science, Technology, Engineering, and Mathematics) education in contemporary curricula (Bybee, 2013). Science education, in particular, plays a pivotal role in bridging various disciplines, encouraging interdisciplinary learning, and fostering a deeper understanding of the world.

Science is a systematic exploration of the natural and physical world, driven by observation, inquiry, and experimentation. It involves formulating hypotheses, rigorously testing them through experiments, evaluating evidence, and refining our understanding based on new findings, leading to the continual advancement of knowledge. This process extends beyond the confines of laboratories and is integral to the development of essential skills and mindsets, which are vital for individuals seeking to lead rational and fulfilling lives. Learning science enables one to gain valid knowledge about the world as well as acquire scientific values, capacities, and

dispositions, such as curiosity, creativity, evidence-based thinking, and sound decision-making that facilitate making informed and good decisions benefitting the individual and community (NCFSE, 2023). In a progressive and future-oriented society, science serves as a powerful force for liberation, enabling individuals to break free from the cycles of poverty, ignorance, and superstition. Developments in science and technology have revolutionized traditional sectors like agriculture and industry, while also giving rise to entirely new areas of employment. In today's rapidly evolving world, adaptability, innovation, and creativity have become the most essential skills for success. Thus, science is a dynamic, expanding body of knowledge, covering ever-new domains of experience. These different imperatives have to be kept in mind in shaping science education (NCF, 2005).

While science education has a reputation for just teaching facts by rote, it has increasingly focused on teaching concepts and resolving misconceptions that students may have about science concepts or other subjects in recent years. "The Structure of Scientific Revolutions" (Kuhn, 1962) had a significant influence on post-positivist science philosophy, stating that traditional natural science instruction tends to foster an inflexible mindset. Additionally, constructivist philosophy has had a considerable influence on science teaching since the 1980s. Constructivism in science education is based on a large body of study regarding student science thinking and learning, with a special focus on how teachers may help students transition to canonical scientific thinking. It emphasizes the learner's active role, the importance of present knowledge and understanding in mediating learning, and the value of instruction that gives learners the best possible direction. Recent research on scientific teaching and learning has become increasingly influential in science education practice. Thus, science education research employs a diverse set of approaches drawn from a variety of fields of science and engineering, including computer science, cognitive science, cognitive psychology, and anthropology. Consequently, scientific education research aims to describe or characterize what constitutes science learning and how it is accomplished.

Science education in institutions mostly refers to the teaching and learning of science for children, college students, and general public adults. As a subject in schools, science draws significantly from the disciplines of Biology, Chemistry, Physics, and Earth Sciences, as well as from Mathematics, Computational Sciences, and, where relevant, from Social Science and Vocational Education, to provide an interdisciplinary understanding and appreciation of the role of science in everyday life (NCFSE, 2023). The three most common fields studied within this category are biology, chemistry, and physics. The National Curriculum Framework (2005) outlines key objectives for secondary-level science education, emphasizing an integrated approach to learning science as a unified discipline rather than isolated facts. At this stage, students engage in more advanced hands-on activities, using tools to design and develop technological models that build upon their upper primary foundation. The curriculum encourages concern much towards environmental and health-related issues through practical analysis and problem-solving activities. A core component involves systematic experimentation, where students test and verify theoretical principles while developing essential scientific skills. Besides, the framework stresses the importance of locally relevant projects that apply science and technology to real-world contexts, adopting meaningful connections between classroom learning and community needs. By incorporating these elements, NCF 2005 highlights the critical role of practical scientific work at the secondary level, aiming to cultivate both conceptual understanding and applied competencies among learners

Scientific practical refers to the practical application of scientific theories and principles in a controlled environment. These activities involve the manipulation of materials, instruments, and variables to test hypotheses, gather empirical evidence, and draw conclusions. Practical serve multiple purposes in scientific education, such as providing a platform for students to engage in inquiry-based learning, develop problem-solving skills, and foster scientific reasoning abilities. Hands-on experiments with measurements should be a key part of high school science classes to help students test and understand scientific concepts. While most educators agree that learning through activities is the best way to teach

science, and textbooks now include some practical work, this approach hasn't really made its way into most actual classrooms." Activities still tend to be regarded as a way to verify the ideas/principles given in the text, rather than as a means for open-ended investigations. (Position Paper of National Focus Group on teaching of science, 2006)

In the context of education, science practical offer a hands-on approach to learning that complements theoretical instruction. By actively engaging with materials and equipment, students can bridge the gap between abstract concepts and real-world applications. Hofstein and Lunetta (2004), state that science practical provide a unique opportunity for students to experience science as a dynamic process, promoting an active learning environment that fosters curiosity and creativity. Further, practical learning makes learning more enjoyable, is believed to help pupils recall things more easily, and is frequently utilized to create interest and excitement among students. Thus, practical activities can assist in the development of a wide range of transferable abilities. In other words, such abilities can increase the value of students' education and help them succeed in their chosen careers. Practical exercises are supposed to benefit students because they assist them in developing their conceptual grasp of science allowing them to envision and make sense of complex scientific principles and ideas. Practical activity then becomes the foundation of deep learning results marking practical work as an essential part of science education.

Science education involves expanding students' knowledge of the natural world while deepening their grasp of the concepts, theories, and models that scientists use to explain and predict its phenomena. Effective science teaching inherently includes providing learners with experiences or opportunities to observe and explore these concepts first hand. Hands-on activities like investigations, laboratory work, and fieldwork are the major tasks within practical. Students' practical laboratory abilities might benefit from such exercises, as can their understanding of key scientific concepts and occurrences. Thus, practical assignments have two main goals: to interest students in the subject and to help

them better understand the concepts covered in scientific classes. Additionally, practical group work can aid students learn in a variety of ways. However, this significant overarching premise i.e. the ability to connect the tangible and abstract world is often neglected in practice. The National Curriculum Framework for School Education (NCFSE) 2023 recommends that secondary schools need proper science labs with good equipment so students can do experiments safely and comfortably. Schools should have spacious, well-equipped labs for science activities. When labs are small but classes are big, teachers can either divide students into groups or schedule experiments on different days. While schools need to save money on science supplies, they should avoid buying poor quality equipment (like weak magnets or plastic-lens microscopes) that would not work properly for real experiments.

1.1.1 Theory and practical aspects of science

The relationship between scientific theory and practical application is essential for the advancement of knowledge and its real-world application. Theories offer frameworks for understanding natural phenomena, while practical applications serve to validate and refine these theories through empirical evidence. This mutual relationship ensures that theoretical insights are grounded in reality and that practical endeavours are informed by sound reasoning. For example, the integration of practical experiences into traditional learning frameworks reflects a pedagogical progress that values contextualized learning alongside theoretical knowledge (Fantinelli et.al., 2024). Moreover, the balance between theory and practice is essential across various fields, as it enables the application of theoretical knowledge to solve real-world problems effectively.

In the context of scientific progress, changes are crucial. Theories not only lead the direction of practical investigations but are also continually tested and refined through applied research. This process fosters a deeper understanding of complex phenomena and drives innovation. By exploring this complicated relationship, we can appreciate how theory and practice complement and reinforce each other in the pursuit of scientific advancement. Theories are comprehensive

explanations that encompass a wide range of observations, experimental data, and logical reasoning and serve as the foundation upon which scientific knowledge is built. They provide a conceptual framework that allows scientists to organize and make sense of the natural world. According to Chalmers (2013), scientific theories are formulated based on a combination of empirical evidence, logical reasoning, and predictive power, enabling scientists to develop a coherent understanding of complex phenomena. Practical applications, on the other hand, involve the implementation and testing of scientific theories in real-world contexts. Practical work allows scientists to gather empirical evidence, validate or refute theoretical predictions, and refine existing theories. Through practical experiments and observations, scientists can assess the applicability and accuracy of theoretical models and propose modifications or new hypotheses. As noted by Hesse (1974), practical investigations serve as a crucial test of the validity and reliability of scientific theories.

Theories provide the conceptual framework for designing practical experiments, while practical experiments generate data that can support or challenge existing theories. This cyclical process of theory formulation and empirical testing leads to the refinement and evolution of scientific knowledge. As described by Popper (1959), the testing of theories through practical experiments allows for the falsification or confirmation of hypotheses, leading to a more accurate understanding of the natural world. Moreover, the relationship between theory and practical application is symbiotic, with each informing and influencing the other. Theoretical frameworks guide the design and interpretation of practical experiments, providing scientists with a roadmap for investigation. Conversely, practical findings can inspire the development of new theoretical models or modifications to existing ones. This reciprocal relationship between theory and practice fosters a dynamic feedback loop that drives scientific progress.

The relationship between theory and practice is evident across various scientific disciplines. In physics, for example, theoretical models such as Newton's laws of motion and Einstein's theory of relativity provide the foundation for

practical applications in engineering, technology, and space exploration. Experimental verification of these theories through practical experiments, such as the famous Michelson-Morley experiment supporting Einstein's theory of special relativity, solidifies their validity and broadens their practical implications. In biology, theoretical frameworks such as Darwin's theory of evolution and Mendelian genetics form the basis for practical applications in agriculture, medicine, and conservation. Practical experiments and observations, such as the breeding experiments conducted by Gregor Mendel, provide empirical evidence that supports and refines these theories, contributing to advancements in the understanding of genetic inheritance and the mechanisms of evolution.

1.1.2 History of Science Education at Secondary Level Schooling in India

The history of science education at the secondary level in India reflects a multifaceted journey shaped by socio-political dynamics, cultural shifts, and educational reforms. As the nation transitioned from colonial rule to independence, the education system underwent significant transformations aimed at fostering scientific literacy among the youth. Initially, science education was heavily influenced by Western curricula, which often overlooked indigenous knowledge and local contexts. However, as India sought to establish its own educational identity post-independence, there was a conscious effort to integrate traditional scientific practices alongside contemporary methods (Sharma, 2018). This evolution not only aimed to cultivate critical thinking and analytical skills among students but also aspired to prepare a workforce capable of contributing to national development (Kumar & Gupta, 2020). Understanding this historical trajectory provides valuable insights into the current frameworks of science education and underscores the on-going challenges and opportunities within the domain.

The significance of science education in secondary schooling in India cannot be overstated, as it shapes students' understanding of the natural world and fosters critical thinking skills fundamental for personal and societal development. In a nation aiming for technological advancement, science education not only equips students with essential knowledge but also encourages innovative thinking

and problem-solving capabilities essential for various career paths, particularly in STEM fields (Mukherjee, 2016). Moreover, it plays a pivotal role in achieving broader educational goals, as empirical studies indicate that universal access to quality education, particularly in science, positively influences economic and social outcomes (Buchmann et al., 2003). However, the historical context in India reveals disparities in educational access, where socio-economic factors and institutional frameworks impacted the effectiveness of science education (Takasaki, 2015). Addressing these challenges is crucial for enhancing the quality and significance of science education in preparing the next generation for future challenges.

The historical development of science education in India reveals a complex relationship of socio-political influences and educational reforms. During the early 20th century, India's educational landscape was shaped significantly by colonial policies, which often prioritized Western knowledge over indigenous learning methodologies. This period witnessed minimal access to structured schooling, leaving a large portion of the populace without formal education, a trend evident across the BRIC nations, including India, as highlighted in studies focusing on educational inputs and outputs during this era (Musacchio et al., 2014). However, post-independence reforms began to emphasize science as a critical component of national development, aligned with global educational trends. Efforts were made to decentralize education and widen access, yet disparities persisted due to entrenched socio-economic inequalities (Musacchio et al., 2014). Thus, the evolution of science education in India has been marked by a struggle between colonial legacies and the aspiration for an inclusive, modern educational framework.

The evolution of science curricula in India from pre-independence to post-independence reflects broader socio-political transformations and educational reforms shaped by the aspirations of a newly independent nation. Prior to 1947, the curriculum largely emphasized a Eurocentric scientific framework, often neglecting indigenous knowledge systems and local contexts. This period saw education utilized as a tool for fostering colonial ideologies, which aimed to create a distinct national identity based on divisive ethnic and religious narratives, as evidenced in

the practices of both Indian and Pakistani governments rewriting educational content to serve their political agendas (Lall, 2007). Following independence, there was a concerted effort to reform the science curriculum to promote critical thinking and local relevance, aligning with global advancements while addressing social aspirations (Chakraborty, 2019). As a result, contemporary education frameworks emphasize not only scientific literacy but also an integrated approach that reflects India's diverse socio-cultural landscape (Singh et al., 2021).

1.1.3 Key Policies and Reforms in Science Education

With the growth of science education in India, significant policies and reforms have sought to enhance both accessibility and quality in the curriculum. These reforms have aimed to align educational practices with modern scientific standards and societal needs. For instance, post-independence efforts concentrated on creating a integrated educational framework that could move away from the colonial legacy, establishing a more equitable system of science education. Critical to these advancements has been the emphasis on fostering inquiry-based learning and enhancing practical skills among students. However, challenges persist, particularly with bureaucratic inertia and insufficient support for teachers, which hinder the effective implementation of these innovative policies. In this context, the analysis of educational reforms reveals that achieving substantial progress requires not only strong political will but also community engagement in educational practices (Little et al., 2010). Ultimately, these reforms must evolve to meet the demands of the 21st century, ensuring that science education keeps pace with global developments and local needs (Buckler et al., 2018).

The evolution of science education in India has been highly influenced by national policies and educational reforms aimed at enhancing pedagogical methodologies. The introduction of various educational frameworks has prompted a shift towards more student-centered approaches, incorporating inquiry-based learning and practical experimentation in science curricula. These reforms are often reflective of a broader international trend to address disparities in educational access and quality, similar to initiatives observed in countries implementing charter

school models, which show a positive impact on student achievement among disadvantaged groups. Additionally, the focus on interdisciplinary methodologies underscores the necessity of integrating diverse perspectives to foster social justice, particularly in addressing educational inequities faced by marginalized communities. Thus, the interplay between national policies and science teaching methodologies plays a critical role in shaping both academic outcomes and social equity in the educational landscape of India. The evolution of science education in India has also been shaped by several key milestones. The Secondary Education Commission (1952) recommended making general science a compulsory subject in high schools and upper secondary levels. In 1961, the Indian Parliamentary and Scientific Committee, led by Sri Lal Bahadur Shastri, emphasized improving school-level science education. That same year, the National Council of Educational Research and Training (NCERT) was established, creating a dedicated division for science education.

The Indian Education Commission (1964–1966) further suggested integrating science into general education, improving teaching methods, and connecting science with agriculture and technology. The National Policy on Education (1986) stressed restructuring science education to develop problem-solving skills and relate scientific concepts to real-life applications in health, industry, and agriculture. The Scheme for Improvement of Science Education in Schools (1988), introduced by the Ministry of Human Resource Development, emphasized hands-on learning which state that science teaching should go beyond theory, incorporating students' real-world experiences and practical experiments. The policy recommended well-equipped laboratories and science libraries in all secondary schools. However, Pareek (2019) found that many schools lacked proper labs, and teachers struggled with large class sizes and insufficient equipment, hindering effective science instruction. A study by the Azim Premji Foundation found that "many schools lack basic facilities such as laboratories, libraries, and computers" (Azim Premji Foundation, 2018). This lack of infrastructure hinders the ability of schools to provide hands-on learning experiences, which are essential for science education. The curriculum and assessment methods used in secondary level

science education in India are also in need of reform. The current curriculum is often criticized for being overly broad and shallow, with too much emphasis on rote memorization (Kumar, 2018). Additionally, the assessment methods used, such as board exams, can be high-stakes and stressful for students, which can discourage critical thinking and creativity. Despite these challenges, there are opportunities for improvement. One of the significant challenges facing secondary level science education in India is the lack of qualified teachers. According to a report given by the National University of Educational Planning and Administration (NUEPA), "the shortage of science and mathematics teachers is a major concern in Indian schools" (NUEPA, 2019). This shortage is particularly critical in rural areas, where schools often struggle to attract and retain qualified teachers.

The National Education Policy (NEP) 2020, aims to transform India's education system, including science education, by promoting experiential learning, critical thinking, and interdisciplinary approaches (Ministry of Human Resource Development, 2020). The policy also emphasizes the importance of teacher training and development, which is critical for improving the quality of science education. National Education Policy (2020) also outlines a new curricular structure of 5+3+3+4, with the latter four phases representing secondary education. The Secondary Stage will consist of four years of multidisciplinary education that expands upon the subject-focused approach of the Middle Stage. This phase emphasizes deeper learning, enhanced critical thinking skills, and greater consideration of students' future goals through increased subject flexibility and choice. For example, students may choose to leave formal schooling after Grade 10 and later return to complete Grades 11 to 12, either through vocational programs or specialized courses at different institutions.

1.1.4 Secondary Level Science Education in Mizoram

The foundation of formal education in Mizoram was laid by Christian missionaries, who introduced the Roman script with phonetic spelling in 1894. Their educational efforts began in 1901 with the establishment of schools in villages like Khawrihnim, Phulpui, and Chhingchhip. The initiative expanded

rapidly, with three additional schools opening in 1903 and seven more the following year. A significant milestone came in 1909 when the region's first middle schools were established in Aizawl and Serkawn. The educational landscape transformed further in 1944 with the creation of Mizoram's first high school in Aizawl, funded through community contributions. This development marked a turning point in the educational advancement of what is now known as Mizoram (Directorate of School Education, 2024).

In Mizoram, the school education system follows a structured stage-wise approach to ensure a smooth academic progression for students. The elementary stage comprises Classes I to VIII, laying the foundational groundwork in core subjects. Upon entering the secondary stage, which includes only Classes IX and X, students prepare for their first major external examination—the Class X board exam. However, before appearing for this board exam, Class IX students undergo internal summative assessments conducted by their respective schools, and only those who pass proceed to Class X. The next phase, known as the higher secondary stage (Classes XI and XII), allows students to specialize in streams such as Science, Commerce, or Arts, culminating in the crucial Class XII board examination. The board exams are held only at the end of Class X and XII, with no external examinations in other grades. Additionally, Science subjects follow a distinct evaluation pattern, incorporating practical examinations alongside theory. Both Class IX and X have separate practical syllabi, requiring students to perform experiments and laboratory works, ensuring a balanced assessment of theoretical knowledge and hands-on application.

According to the Scheme of Examination for HSLC examination, (2019) published by MBSE; The evaluation for science subjects in class IX and class X includes both internal and external assessment. Internal assessment shall be based on the record of the candidate during his/her continuous assessment in the school and shall carry a maximum of 20 marks. Schools are expected to maintain regular records of student's achievement and progress. These records are subject to scrutiny by the Board when it deems fit. The external board examination for class IX was

conducted by the Mizoram Board of School Education every year during the month of February and March. Science theory carry 70 marks including objective type, very short answer type, short answer type I & II and long answer type questions. Science practical carry 10 marks which shall be given by the external examiner at the time of practical examination. The guideline for practical examination highlighted that practical marks shall be given from practical exercise, viva voce and practical records (Mizoram Board of School Education, 2019).

According to the National Achievement Survey (2015) conducted by NCERT, Class X students in Mizoram performed significantly below the national average in science. Furthermore, a 2017 study by NEDFi, in collaboration with IIT Guwahati and the Homi Bhabha Centre for Science Education, analyzed science education in Northeast India. The report revealed that Mizoram, along with Nagaland and Meghalaya, scored below the regional benchmark (North Eastern Development Finance Corporation Ltd. 2017).

According to the study conducted by Darchhingpuii (1988), on science achievement, attitude toward science, and problem-solving ability among secondary school students in Aizawl, reflected that there was a shortage of science teachers and that schools lacked laboratory space, teaching aids, equipment, and even books for proper science instruction. Zohmingliani (2011), in her doctoral thesis, observes that the state lacked a distinct policy for science education, as well as a proper monitoring structure, particularly to assess practical science work. From high school to college, the uneven distribution of theory and practical work was highly undesirable. Science education had a relatively low enrollment rate, especially from the Higher Secondary School Leaving Certificate (HSSLC) level onwards. The state needs to modernize its science education system, starting with human resources and expanding to include stronger facilities.

These research observations highlight how science, as a discipline, was subjected to disregard. Although, efforts taken by state and central government policies have resulted in numerous advances that are now readily apparent, science

education in Mizoram still appears to be lagging compared to national standards. To date, the general picture of science education remains unpromising. However, the Mizoram government has made a concerted effort to promote science education. For this reason, a distinct science promotion arm has been established under the Directorate of Education.

The organization of school education in Mizoram was restructured in accordance with the expectations outlined in the National Policy on Education (NPE) 1986/1992 (Education Reforms Commission, 2010). The framework has been reorganized as follows: Primary (I–V), Upper Primary (VI–VIII), Secondary (IX–X), and Higher Secondary (XI–XII). The Education Reforms Commission (2010) also recommended that the State Council of Educational Research and Training (SCERT) and the Mizoram Board of School Education (MBSE) be re-examined in light of scientific advancements to ensure that the process of science is prioritized over the outcome of science. Furthermore, every school should be required to have a scientific laboratory and mathematics kits appropriate for the conceptual needs of different stages of schooling. This may necessitate reorienting the state's current courseware.

1.1.5 Perception in Science Education

Science education is influenced by several factors that shape both theoretical understanding and practical application. These factors include students' perception of science, their attitudes toward learning, teaching methods, availability of resources, curriculum design, and societal influences (Osborne et al., 2021). Among these, perception plays a crucial role, as it determines how students interpret and engage with scientific knowledge. Teachers' perceptions of science and their teaching approach also impact how effectively they deliver scientific concepts in the classroom (Kind et al., 2007). Misconceptions, prior knowledge, and personal beliefs often influence learning experiences, making it essential to assess and address these perceptions systematically.

Perception is a complex cognitive process that involves the selection, organization, and interpretation of sensory information to construct our understanding and representation of the world around us (Goldstein, 2020). It includes all the processes by which humans take in, interpret, and use sensory inputs, including touch, taste, smell, sound, and sight. Through perception, we assign meaning to our experiences, creating a subjective understanding that directs our behavior and interactions with the external world. Perception is not solely determined by internal cognitive processes but is also influenced by external factors and individual differences. Cultural and social factors shape our perception of the world (Nisbett, 2003). Cultural norms, values, and experiences influence how we interpret sensory stimuli. For instance, different cultures may have distinct interpretations of facial expressions or perceive time and space differently. Perception involves both physical senses, such as sight, hearing, and touch, and cognitive processes such as attention, memory, and categorization. It is a complex and dynamic process influenced by both internal states and external contexts. Perceptual concepts are concepts formed through sensory experiences. Young children can begin differentiating objects based on their color, shape, texture, and perhaps even taste and smell. More complex concepts, such as recognizing that birds have feathers or that dogs have legs and bark, are also perceptual concepts. These are formed through careful observation and sensory engagement. Children almost automatically develop these concepts through their experiences. Language plays a crucial role in developing and expressing these concepts by assigning names to objects and experiences.

In contrast, practical concepts are formed not only by perception but also through their embedded practical use (National Curriculum Framework for School Education [NCFSE], 2023). To form practical concepts, children need some understanding of social life. To comprehend a practical concept, one must grasp the function and usage of an object in a social context (Dearden, 1968). Through engagement and exposure to practical life exercises, children develop practical concepts.

One of the most critical elements of perception is attention—the ability to selectively focus on certain aspects of the environment while ignoring others. This process is crucial for efficient information processing and is influenced by both bottom-up (stimulus-driven) and top-down (cognitive) factors (Pashler, 1998). For example, when searching for a specific object in a cluttered scene, selective attention helps us quickly find the target by focusing on distinguishing features (Treisman & Gelade, 1980). Attention is also influenced by internal states such as arousal and motivation (Grossberg & Raizada, 2000).

Memory, the ability to encode, store, and retrieve information over time, plays a critical role in perception. It allows us to recognize familiar objects and events and to make predictions about future occurrences (Marr, 1982). Memory is influenced by various factors, including attention, emotions, and context (Tulving & Thomson, 1973). For example, seeing an object in a specific context can prime our memory for the object, making it easier to recognize later, even in a different setting (Biederman & Cooper, 1991).

Categorization is another essential aspect of perception. It involves grouping similar objects or events based on shared features, enabling us to process the vast array of stimuli in our environment more efficiently (Rosch & Mervis, 1975). Categorization is influenced by sensory features and higher-level cognitive processes such as knowledge and expectations (Barsalou, 1983). For example, people may categorize different dog breeds based on size, shape, and fur color, but also based on prior experience and cultural norms.

One challenge in perception is dealing with ambiguity and uncertainty in the environment. This is particularly relevant when encountering novel or unexpected stimuli, where prior knowledge and expectations may not apply (Kowler et al., 1995). In such cases, the brain relies on probabilistic inference to interpret stimuli, using contextual cues and prior experiences to generate the most plausible interpretation (Friston, 2005).

Perception and sensation are closely interconnected processes. Sensation forms the foundation of perception, beginning with our sensory organs detecting environmental stimuli like light, sound, and pressure. These organs - including eyes, ears, skin, tongue and nose - transform physical energy into neural signals the brain can process. For example, the eye's retina converts light into electrical impulses sent to the brain. Perception builds upon this sensory input through three key functions: selecting important information from our surroundings, identifying what it represents, and interpreting its meaning. A crucial aspect is attention, which acts as a filter by focusing on relevant stimuli while ignoring unimportant background information. Perception in science education is particularly significant because it affects both students' and teachers' engagement with scientific content. Students enter classrooms with preconceived notions that may either align with or contradict scientific principles (Vosniadou, 2019). For instance, students may believe that objects of different weights fall at different speeds, a common misconception that conflicts with Newtonian physics. Similarly, teachers' perceptions of science and pedagogy influence their instructional methods, which can either foster or hinder scientific curiosity. When teachers hold strong, research-based perceptions about science, they are more likely to encourage inquiry-based learning and hands-on experimentation, leading to better student understanding. However, if teachers themselves possess misconceptions or lack confidence in their subject knowledge, their teaching effectiveness can be compromised (Fraser, 2020).

Construction and standardization of a perception scale:

Given the importance of perception in science teaching and learning, the construction and standardization of perception scales are essential for assessing and improving science education. A perception scale is a structured tool used to measure attitudes, beliefs, and misconceptions about science (Likert, 1932). Standardizing such scales ensures that they provide reliable and valid data, allowing educators to make informed decisions about teaching strategies and curriculum development (Moore & Foy, 2021). These scales can help identify gaps in teachers' understanding of science, assess their confidence in teaching, and determine how

their perceptions influence student learning outcomes. For science teachers, a well-constructed perception scale serves multiple purposes. First, it helps in identifying areas where they may need professional development or subject reinforcement (Osborne et al., 2021). Second, it allows researchers to study trends in science education and implement changes that enhance teaching effectiveness. Developing a standardized perception scale involves defining clear constructs, designing unbiased survey questions, and validating the instrument through statistical analysis and pilot testing (Kind et al., 2007). By using perception scales regularly, educators can track changes over time and adapt teaching strategies to improve science education outcomes.

In brief, science education is shaped by various factors, with perception playing a central role in both student learning and teacher effectiveness. Addressing misconceptions and fostering positive perceptions of science requires evidence-based teaching methods and reliable assessment tools. The construction and standardization of perception scales provide a valuable framework for evaluating and enhancing science education, ultimately benefiting both teachers and students.

1.2 RATIONALE OF THE STUDY

The importance of science practical in learning science cannot be overstated. As highlighted by high school curriculum (2009), science practical are expected to engages students in the development of their abilities, capabilities, creating awareness of scientific knowledge, and may provide an understanding of scientific topics (MBSE, 2009). Hands-on learning may facilitate and enhance the aptitude and understanding level of students in science subjects. It is generally accepted that practical is at the heart of science education. Without actual practice, learning science is akin to learning literature without reading books (Position Paper on National Focus Group on Teaching of Science, 2006). The education system today is more inclined towards examination-oriented learning, and even the practical examination is conducted not in line with the objectives set forth in the practical syllabus and sometimes may not serve the main purpose or objectives (NCFSE, 2023).

NCFSE (2023) also highlights that the major challenge in science education is the weak connections between the school curriculum and what students observe and experience outside school. Students enter the classroom with pre-existing conceptions about how the world works, actively seeking to understand their observations. Frequently, these personal understandings contradict established scientific principles taught in school - everyday intuition and academic theories often diverge. A classic example is how our everyday perception strongly suggests a flat Earth, making the scientific concept of a spherical planet difficult to grasp. This cognitive conflict presents a significant challenge in science education, as students struggle to reconcile their direct experiences with abstract scientific concepts. If teachers do not use appropriate methods to explain, students may believe the wrong ideas. To fix this, teachers should use hands-on activities, real-life examples, and discussions to help students understand and change their thinking.

As per the objectives of science practical laid down by the High School curriculum (2009) at the secondary level, the practical activities try to engage the students in exploratory and hands-on activities that lead to the development of basic cognitive and psychomotor skills through language, observation, recording, differentiation, classification, inference, drawing, illustrations, design and fabrication, estimation, and measurement (MBSE, 2009). Practical examination as conducted by MBSE may or may not be in compliance with the prescribed syllabus, and this makes the present study extremely relevant to be taken up as a research topic.

It is a well-known fact that theoretical knowledge alone cannot suffice for quality science education without practical knowledge. Secondary school science curricula in Mizoram are currently divided into two categories: theory and practical. There is a separate syllabus for theory and practical, and there are clear demarcations of marks for theory and practice. In many instances, science practical at the secondary level are sometimes not taken seriously, and students are typically found to obtain good marks in the practical examinations of science subjects (Position Paper on National Focus Group on Teaching of Science, 2006). Students

hardly complete the prescribed practical activities even when theory aspects are thoroughly covered. This type of trend, which occurs across the state, casts doubt on the practice of science practical in schools and even puts the linkages between theory and practicality in question.

At the secondary level, the three different areas of science, viz. Biology, Physics, and Chemistry are clubbed into one whole single subject, i.e., Science Subject. Since secondary school serves as the foundation for science education due to the introduction of all major concepts and theories, science education at this level cannot be ignored. At present, the criteria of recruitment rules for science teachers at the secondary level include all graduates in science subjects such as biology, chemistry, physics, biotechnology, and environmental science. Consequently, many science teachers face challenges while teaching topics that are not within their areas of expertise. This issue may arise from teachers lacking knowledge of the subjects they are required to teach, which could impede the learning process and its outcome (Position Paper on National Focus Group on Teaching of Science, 2006). Some common issues may need to be addressed in science practical classrooms, like lack of proper science equipment, lack of physical space for laboratories, lack of motivation in science by students, and so on (NCFSE, 2023). Thus, another common challenge for learning science is the lack of infrastructure. Learning Science especially requires access to apparatus, equipment, and laboratories. Unfortunately, this remains a neglected need. Low-cost, easily available materials are also not used since teachers cannot often develop such local, low-cost teaching-learning materials (Position Paper on National Focus Group on Teaching of Science, 2006). At the secondary stage, access to a laboratory is non-negotiable—students must be able to assemble and manipulate apparatus, use materials, and design simple experiments to truly develop important competencies related to science (NCFSE, 2023).

The Position Paper on National Focus Group on Teaching of Science (2006) mentioned that “The oft-repeated recommendation of integrating experimental work and theory teaching has not been realized because of a perceived lack of

facilities and trained teachers in most of the schools. The degeneration of rigor in practical examinations has also lent weight to the argument to first remove them from the ambit of evaluation and then to trivialize or totally remove them from teaching practice itself. Often practical difficulties are cited as an excuse for this lack of commitment and awareness that experiment is fundamental to doing and learning science. Even well-endowed schools have tended to give only cosmetic importance to laboratory work in the prevailing scheme of things.” The position paper further suggested an approach to deal with the problem: encourage practical components of the curriculum through non-formal channels and introduce some designed experiment-based questions in the theoretical paper itself.

Practical lessons can become confusing if they are not properly linked with the theoretical knowledge of students and if students are unclear about the aims and objectives of doing practical in science. Science teachers may also face issues in administrative functioning like timetabling, procurement of equipment for science laboratories, and the provision of adequate room for science laboratories for the successful execution of practical activities. The Position Paper by the National Focus Group on Teaching of Science (2006) emphasizes that fostering both creativity and scientific competence should be fundamental goals of science education. However, India's current science education system primarily focuses on developing technical proficiency while neglecting the cultivation of innovative thinking. This imbalance becomes apparent when we observe that although many Indian students excel in standardized examinations, only a small percentage emerge as exceptional researchers or pioneering scientists. Furthermore, most science students in India demonstrate limited capabilities in both creative application and fundamental scientific understanding.

Apart from these, the Position Paper on National Focus Group on Teaching of Science (2006) also highlighted the existence of a huge gap in science education, particularly between rural and urban students as well as gender differences. The existing inequalities in science education stem primarily from inadequate infrastructure, insufficient support systems, limited access to information and

resources in rural areas, and a persistent urban-centric allocation of educational resources. Particularly, both science textbooks and educators often perpetuate gender stereotypes, mirroring broader societal biases. This situation demands deliberate, systematic efforts to eliminate gender prejudice from educational materials and teaching methodologies. These concerns underscore the necessity to examine science teachers' perspectives, instructional approaches, and student outcomes in secondary-level science education (NCFSE, 2023).

While practical work is universally recognized as essential to effective science instruction, research has predominantly focused on conceptual definitions and classifications of laboratory work. There remains a significant gap in detailed studies exploring the integration of theoretical knowledge with practical application, particularly in the context of secondary science education in Mizoram. This lack of comprehensive research highlights an important area for further academic investigation. The teachers' perception is also believed to be a great factor affecting the students' comprehension level of science subjects. The goal of this study is to find out the issues related to science practical, the challenges faced by science teachers in relation to science laboratory status, and the teaching and learning of science. It also examines the perception of science teachers towards science practical, as they are believed to enhance students' understanding of science. The study will also try to examine the correlation between the achievement of students in theory and practical science subjects in order to understand the impact of theory on practical aspects or vice versa. Keeping in view the issues and problems stated above, "A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram" is selected to be taken up for study.

The investigator aims to address the following questions after examining the challenges associated with science education at the secondary school level:

1. Is there a proper linkage between theoretical content and prescribed practical of secondary school science subjects in Mizoram?
2. Do schools allot adequate time for conducting science practical in their timetable?

3. Does the school follow the norms and regulations prescribed by regulating body for conducting practical?
4. What type of relationship exists between student's performance in science theory and practical?
5. What are the educational qualifications of secondary school science teachers?
6. What are the major challenges faced by science teachers in Mizoram?
7. What is the perception of secondary school science teachers toward science practical in Mizoram?
8. Is there any difference in perception of secondary school science teachers towards science practical with reference to gender, school management and locale?

1.3 STATEMENT OF THE PROBLEM

The title of the present study is “A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram”

1.4 OPERATIONAL DEFINITION OF THE TERMS USED

Linkage:	For the present study, linkage means connectedness and or interconnectedness of theory and practicum of science subject under Mizoram Board of School Education
Science:	Science is a systematic study of the natural and physical world through observation, experimentation, and evidence-based revision of knowledge. In the present study, science refers to one of the subject of Secondary schools comprising of physics, chemistry and biology.
Theory:	Theory in the present study refers to the theoretical content given in the secondary science textbook prescribed by the Mizoram Board of School Education.
Practical:	For the present study, practical refers to the experimental activities of science for secondary schools laid down by the

prescribed syllabus under Mizoram Board of School Education.

Secondary school: In the present study, secondary school means the schools which runs standard 9th and 10th level under Mizoram Board of School Education.

1.5 OBJECTIVES OF THE STUDY

1. To investigate the linkages between theoretical contents and prescribed practical of secondary school science subject in Mizoram
2. To analyse class period allotted for science practical in the weekly time table of the schools.
3. To study the implementation of prescribed science practical by secondary schools in Mizoram
4. To study the relationship between the achievement of students in theory and practical.
5. To analyse the profile of teachers teaching science subject in secondary schools of Mizoram.
6. To study the challenges faced by science teachers in Mizoram.
7. To construct and standardise teachers' perception scale towards science practical
8. To find out the perception of secondary school science teachers toward science practical in Mizoram.
9. To compare the perception of secondary school science teachers towards science practical in relation to gender.
10. To compare the perception of secondary school science teachers towards science practical based on type of school management.
11. To compare the perception of secondary school science teachers towards science practical with reference to locale

1.6 HYPOTHESES OF THE STUDY

The following are the research hypotheses laid down by the investigator for the proposed study:

- 1) There is a significant difference in the perception of science practical between male and female science teachers
- 2) There is a significant difference in the perception of science practical between government and private school science teachers.
- 3) There is a significant difference in the perception of science practical between rural and urban science teachers.

The above research hypotheses are converted into null form for testing purpose as follows:

- H_0 1 : There is no significant difference in the perception of science practical between male and female science teachers
- H_0 2 : There is no significant difference in the perception of science practical between government and private school science teachers.
- H_0 3 : There is no significant difference in the perception of science practical between rural and urban science teachers.

CHAPTER-II

REVIEW OF RELATED LITERATURE

This chapter reviewed existing studies to understand past research in the same field. By looking at previous work, it highlighted areas that have already been studied, helping the current research build on existing knowledge. Examining related studies provides a strong foundation for the research, offering useful ideas and guiding the choice of methods, data sources, and analysis techniques. This review also helps the researcher develop clear and logical hypotheses based on the study's purpose. To gather information, various academic sources are used, such as books, dissertations, manuals, research journals, articles, and theses, which offer valuable insights for the study. The literature review is categorized into three main sections: Studies conducted in India, Mizoram and studies done abroad.

2.1. STUDIES CONDUCTED ABROAD:

Okebukola and Ogunniyi (1984) studied the effects of cooperative, competitive, and individualistic science laboratory interaction patterns on students' achievement and acquisition of the practical skills. The study involved 1025 junior secondary school students and 12 science teachers. The results indicated that cooperative learning environments led to higher achievement scores, while competitive settings were more effective in developing practical skills. Additionally, mixed-ability cooperative groups outperformed mixed-ability competitive groups in academic achievement but not in practical skills. The findings supported the differential effects of interaction patterns on cognitive and psychomotor learning tasks.

Gooding et al. (1989) explored the significance of experimentation in natural sciences in their study, "The Uses of Experiment: Studies in the Natural Sciences." They argued that while experiments were widely regarded as a defining feature of natural science and essential for understanding the world, little research had been conducted on how scientists actually designed and utilized experiments. Their study addressed this gap by presenting 14 case studies of important and well-known experiments. The investigators examined various aspects of experimentation,

including the tools used, the process of scientific argumentation through experiments, the challenges faced, and the ways in which scientists verified their experimental accuracy. Additionally, they investigated whether differences existed between experiments in physical sciences and technology. Scholars from fields such as history, sociology, and philosophy of science contributed discussions on topics such as the interaction between experiments, instruments, and theory; the reliability of scientific experiments; the credibility of experimental findings; and the broader contexts that influenced experimental practices. By analyzing experiments ranging from Galilean mechanics to nuclear missile testing, the study highlighted the strategic and persuasive elements involved in scientific experimentation.

Koulaidis and Tsatsaroni (1996) presented a paper titled "A Pedagogical Analysis of Science Textbooks: How Can We Proceed?" discussing frameworks for analyzing science textbooks from a pedagogical perspective. The paper distinguishes between two types of studies: (a) those focusing on elements like content, vocabulary, illustrations, and teaching methods, and (b) those addressing the principles organizing the content and presentation form. The investigators explore two key issues: the relationship between scientific knowledge and school knowledge, emphasizing that the latter is not just a simplified version of the former but a complex social process; and the pedagogic relationship, particularly how the text (book) shapes the roles of content, teacher, and student. The study argues that contemporary views on knowledge suggest a reconceptualization of teaching, where the pupil's competence is seen as a function of the textbook. The investigators discuss three approaches to textbook analysis—socio-cognitive, sociolinguistic, and socio-epistemic—and examine the merits of the socio-epistemic approach, using examples from Greek science textbooks.

Gott and Duggan (1996) explored the role of practical work in understanding scientific evidence. The study suggested that the objectives of practical work, including the development of experimental skills, should be linked to an understanding of scientific evidence. The investigators highlighted the significance of understanding evidence in scientific literacy and employment in science and

engineering fields. A framework for a knowledge base related to evidence was proposed, and teaching methods were evaluated. The investigator concluded that while various instructional methods could be employed, practical work remained crucial for teaching evidence, provided that practical activities were carefully selected with clear objectives.

Donnelly (1998) explored secondary science teachers' perceptions of the role of laboratory work in their teaching. Based on interviews with teachers in England, the study focused on how they structured their lessons using theory and practical work. The research analyzed how teachers' perspectives influenced lesson planning, classroom management, and relationships with students. The study concluded with an analysis of the senses in which science teachers' work can be said to be 'structured' by its engagement with the laboratory, drawing on the work of the sociologist Anthony Giddens on the relationship between structure and agency.

Berry et al. (1999) investigated the effectiveness of laboratory work in secondary science education. Despite the significant time allocated to laboratory activities, they found that students exhibited minimal learning gains. Their study suggested that this issue stemmed from students' limited application of scientific processes during laboratory work. The investigators explored strategies teachers could employ to enhance students' use of scientific processes, thereby improving their overall learning experience.

Abd-El-Khalick and Lederman (2000) critically reviewed attempts to improve prospective and practicing science teachers' conceptions of nature of science (NOS). The reviewed studies fell into two approaches: implicit and explicit. The implicit approach involved science process-skills instruction and inquiry-based activities, whereas the explicit approach directly addressed aspects of NOS using historical and philosophical perspectives. Findings indicated that the explicit approach was relatively more effective in enhancing NOS understanding. The ineffectiveness of the implicit approach was attributed to assumptions that NOS understanding develops passively through scientific activities. Despite the explicit

approach's relative success, further efforts were necessary to foster a comprehensive understanding of NOS. The study emphasized that explicitness and reflectiveness should be prioritized in future NOS instruction.

Van Driel et al. (2001) investigated how teachers' practical knowledge—a blend of experience, formal training, and personal beliefs—shapes their response to science education reforms. They critiqued past reforms for neglecting teachers' pre-existing perspectives, leading to ineffective implementation. Their study emphasized action-oriented professional development, advocating for long-term strategies like peer coaching, collaborative research, and case-based learning. A key recommendation was assessing teachers' practical knowledge before reforms and tracking its evolution to tailor support effectively.

Pell and Jarvis (2003) designed a validated scale ($\alpha = 0.96$) to evaluate primary teachers' attitudes toward science teaching in 16 English schools. Baseline data revealed that teachers lacked confidence in teaching science compared to English, especially in physical processes, guided inquiry, and curriculum-aligned lesson planning. The study found declining attitudes among administrators to the pressures of the National Curriculum, suggesting targeted training could bolster teacher confidence and outcomes.

Nsabayezu et al. (2003) studied the impact of science kits on chemistry education in lower secondary schools. Results showed high student engagement (92.5%), better conceptual understanding (96.2%), and improved exam performance (80.2%). However, challenges included exam-centric teaching (91.3%), large class sizes (88.8%), and kit shortages (72.8%). Solutions proposed were teacher training in kit use (92.5%), guaranteed kit availability (100%), and safety protocols (74.0%), underscoring the need for hands-on, student-centered science instruction.

Kang and Wallace (2004) explored the relationship between secondary science teachers' epistemological beliefs, teaching goals, and laboratory practices. They examined how teachers' beliefs about knowledge influenced their instructional

decisions regarding lab activities. The study investigated several key research questions, including teachers' epistemological perspectives on laboratory activities, their motivations for incorporating lab work, and the connection between their epistemological beliefs and teaching actions. Their findings suggested that while naïve epistemological beliefs were directly reflected in teaching practices, sophisticated epistemological beliefs did not always align with instructional methods. This misalignment was attributed to the need for teachers to negotiate between their epistemological beliefs, classroom contexts, and instructional objectives. The study concluded that different combinations of epistemological beliefs and instructional goals shaped teachers' diverse approaches to laboratory activities.

Millar (2004) conducted research on the role of practical work in science teaching and learning. The study provided a critical review of changes in the role of practical work in England's science curriculum over four decades. The curriculum emphasized an approach to practical enquiry that suggested school students could act as 'real' scientists. The study critically examined this perspective by tracing developments in practical work and reviewing empirical studies on its implementation in secondary schools. The study also offered suggestions on the current status and future directions of practical work in science education.

Bradley (2005) explored issues related to the theoretical foundations, rationale, and implementation of practical work in junior secondary science programs. The researcher conducted a multi-stage field study using both qualitative and quantitative methods. Science practical were defined in the study, and a new Science Practical Theoretical Model was introduced. This model facilitated the classification and purpose definition of eight types of science practical. The study targeted Australian science teachers and students, providing a theoretical foundation for developing the Science Practical Inventory (SPI) to assess students' perceptions of practical work in science learning. The study's results had implications for science curricula and included recommendations for further research, with findings applicable to Australian science teachers and students.

Braund and Driver (2005) investigated students' perceptions of practical science in primary and secondary schools, focusing on progression and continuity in learning. The study highlighted the difficulties students faced during the transition from primary to secondary education, particularly in science. Findings revealed that a significant proportion of both primary and secondary students believed practical work positively contributed to their general learning in science.

Pekmez et al. (2005) examined science teachers' understanding of the nature and purpose of practical work within the context of the National Curriculum for Science in England. They focused on investigative work in science classrooms, which had been a mandatory part of the curriculum since 1989. Through interviews with science teachers about their classroom practices, the study revealed that little emphasis was placed on procedural understanding, particularly in relation to data quality. The investigators argued that this lack of attention limited students' ability to engage in meaningful investigative work.

Mohan and Slater (2006) explored the connection between theory and practice in a high school science register from a functional linguistic perspective. Utilizing extensive classroom data, they examined how language facilitated the link between theory and practice in science education. The study tracked the instructional progression from introducing scientific concepts and terminology to problem-solving activities requiring the application of these terms. The research highlighted the value of a functional perspective in understanding science learning as a social practice, improving analysis of language's role in science education, and emphasizing the significance of the theory-practice contrast in student learning. Additionally, the study emphasized the potential for deeper comprehension of scientific discourse development and the linguistic connections between students' practical experiences and theoretical understanding of science.

Chen (2006) developed and field-tested an instrument to assess views on the nature of science (NOS) and attitudes toward teaching science. The instrument, the Views on Science and Education Questionnaire, comprised 15 questions, each with

multiple items representing different philosophical perspectives, which participants ranked on a five-point scale. The items were empirically based, validated by experts, and administered to 302 college students. The study detected mixed and conflicting conceptions of NOS. The instrument demonstrated a test-retest correlation coefficient of 0.82, confirming its validity and reliability. It provided a practical tool for science educators to compare views on NOS with other educational outcomes.

Aladejana and Aderibigbe (2007) examined students' assessments of their science laboratory environment and its impact on academic performance. The study used an ex-post facto design with a sample of 328 randomly selected senior secondary school chemistry students in Nigeria. Analysis of the data showed that students were able to assess five critical aspects of their lab setting: peer collaboration, experimental flexibility, subject integration, clarity of guidelines, and physical resources. Among these factors, students rated teamwork and peer support most positively, whereas their satisfaction with available equipment and facilities scored the lowest. The study also found positive correlations between these components and students' academic performance, highlighting the importance of improving laboratory conditions to enhance science learning outcomes.

Childs and McNicholl (2007) investigated the relationship between subject content knowledge and pedagogical practice through the analysis of classroom discourse. The research revealed that secondary science teachers faced substantial difficulties when instructing topics outside their expertise, particularly in delivering clear and accurate scientific explanations - a core competency of effective science teaching. This finding carries important implications for teacher training programs. The study specifically investigated how a teacher's content knowledge influences their instructional methods, analyzing one educator's approach to explaining concepts both within and outside their specialization. While the single-subject design limits broader application, the case study provides valuable insights for future research examining how teachers' professional knowledge shapes classroom practice.

Kind et al. (2007) developed measures to assess pupils' attitudes toward science. The research examined distinct dimensions of students' attitudes toward science, including: (1) classroom science learning, (2) hands-on laboratory work, (3) scientific applications beyond school, (4) perceived value of science, (5) self-perception of scientific ability, and (6) interest in future science engagement. To improve upon prior attitude research limitations, the study operationalized each dimension as a clearly defined, single-faceted construct. After preliminary testing, the researchers administered identical attitude surveys to adolescents (ages 11-14) across five English secondary schools, with a one-month test-retest interval to assess response consistency. A total of 932 students completed the first questionnaire, and 668 completed the second. Factor analysis confirmed the unidimensionality of attitude constructs, with high internal reliability (Cronbach's $\alpha > 0.7$). The step-by-step approach allowed for the future inclusion of additional constructs in attitude assessment.

Abrahams and Millar (2008) examined the effectiveness of practical work as a teaching and learning method in school science. The study analyzed 25 science lessons in English secondary schools using observational field notes and interviews with teachers and students. The findings indicated that practical work effectively engaged students with physical tasks but was not successful in encouraging them to use intended scientific concepts for guiding their actions and reflect on collected data. Teachers primarily focused on developing students' substantive scientific knowledge rather than understanding scientific inquiry processes. The study highlighted the need for explicit strategies to help students connect observations with scientific concepts and suggested improvements in designing practical activities to enhance cognitive engagement.

Chang et al. (2009) explored the perceptions of secondary earth science teachers regarding the Goals of Earth Science Education (GESE) in Taiwan. The GESE were intended to articulate the philosophical and educational objectives guiding educators while providing a vision for earth science education. The study aimed to examine teachers' perceptions of GESE at the secondary school level (Grades 7–12)

in Taiwan. A national survey was conducted in May 2004, involving 1,000 earth science teachers, with a response rate of 70.2%. The findings indicated that the most important GESE, according to teachers' preferences and actual classroom practice, was ensuring that students acquired basic earth science concepts. However, a significant gap was identified between teachers' preferred and actual GESE regarding the preparation of students for entrance examinations. Additionally, variations in teachers' preferred and actual GESE were influenced by factors such as teachers' age, school size, and their educational background.

Feyzioğlu (2009) explored the relationship between science process skills, laboratory use, and chemistry achievement among university students. The study employed a questionnaire to assess students' perceptions of their scientific process skills, an attitude scale to evaluate laboratory use, and a science achievement test to measure academic performance. The sample comprised 180 students enrolled in a general chemistry course. The findings indicated significant positive correlations between students' science process skills, their efficient use of laboratory resources, and their course achievement.

Huang and Fraser (2009) conducted research on science teachers' perceptions of the school environment, with a particular focus on gender differences. They investigated how school environments influenced teacher and student performance by analyzing a large sample of secondary school science teachers in Taiwan. The study revealed distinguished gender-based variations in how teachers perceived their workplace climate. Specifically, women educators reported stronger feelings of: (1) collaborative relationships with colleagues, (2) fair gender treatment, and (3) professional engagement. Conversely, their male counterparts indicated experiencing: (1) less job-related stress and (2) more positive interactions with students. These gender disparities remained significant even when controlling for demographic and institutional factors. Based on these findings, the researchers proposed actionable strategies to enhance working conditions for all teaching staff while identifying potential avenues for further investigation.

Abrahams and Saglam (2010) examined science teachers' views on practical work in secondary schools in England and Wales. The study investigated changes in teachers' perceptions of the importance of practical work over time. A national survey was conducted using a stratified sample of 912 teachers, with 393 responses received (42.5% response rate). The coefficient of concordance and significance levels were calculated, along with z-scores. The findings suggested significant changes in teachers' views at Key Stages 4 and 5 (ages 15-18) but minimal changes at Key Stage 3 (ages 11-14). Across subject specializations, gender, and teaching experience, views remained consistent. Changes in assessment criteria, particularly the introduction of Science Investigation (Sc1) at Key Stage 4, appeared to influence teachers' perceptions of practical work's value.

Nivalainen et al.(2010) explored the challenges faced by pre-service and in-service physics teachers in planning and conducting practical work in physics. Using the principles of grounded theory, the study framed several factors that posed significant challenges to successful laboratory work and lesson preparation. Detailed analysis of tutoring discussions between instructors and participants in a school laboratory course revealed that the primary obstacles included limitations in laboratory facilities, insufficient physics knowledge, difficulties in understanding instructional approaches, and general organizational challenges in conducting practical work. Based on these findings, the study recommended strategies for preparing pre-service and in-service teachers for the effective integration of practical work in school physics education.

Banu (2011) investigated the role of practical work in teaching and learning physics at the secondary level in Bangladesh. The study revealed that teachers predominantly used transmissive pedagogy to explain physics concepts and theories. Teachers and students in non-government schools faced more challenges compared to their counterparts in government schools. Factors such as low teacher-student ratios and the absence of laboratory assistants contributed to teachers' heavy workloads. The study suggested the need for adequate equipment in both government and non-government schools, the appointment of qualified teachers

with practical training, the creation of laboratory assistant positions, and the establishment of smaller classroom sizes to facilitate effective practical work in physics.

Kim and Tan (2011) investigated the challenges encountered by elementary pre-service teachers in conducting inquiry-based practical work. Their research focused on the teachers' decision-making processes and the internal conflicts between their abilities and personal beliefs about teaching science. Drawing on narratives from 38 third-year university students enrolled in a science methods course in Korea, the study revealed several factors hindering practical work, such as limited time, insufficient resources, curriculum pressures, and underlying pedagogical assumptions. The investigator highlighted the need to understand how teachers internally negotiate the significance of science education and practical work within both classroom and societal contexts.

Millar (2012) examined the relationship between theory and experiment in science education, emphasizing that practical work distinguished school science from other subjects. The study noted that science classes in the UK traditionally occurred in laboratories and involved practical investigations and demonstrations. It was observed that students aged 11–13 typically spent more than half of their science lesson time engaged in practical activities, while students aged 16–18 dedicated approximately one-third of their lesson time to such work.

Toplis (2012) conducted an interpretive study on students' perspectives regarding the role of practical work in secondary school science lessons. The research involved 29 students aged 13 to 16 from the three secondary schools in England. Data were collected by observing lessons and in-depth interviews. The findings indicated that students viewed practical work as essential for maintaining interest, fostering participation and autonomy, serving as an alternative to traditional pedagogical methods, and enhancing learning through memorization and recall. The study concluded that while practical work provided opportunities for student

engagement, its effectiveness as a learning tool required further research and evaluation.

Abrahams et al. (2013) reviewed the assessment of practical work in school science, focusing on the summative evaluation of practical skills. The study noted a lack of clarity in defining and assessing these skills. It highlighted significant variations among countries in using 'Direct Assessment of Practical Skills' (DAPS) and 'Indirect Assessment of Practical Skills' (IAPS), with each approach having advantages and disadvantages. The findings suggested that an overreliance on IAPS diminished the likelihood of effective teaching and learning of practical work in science.

Kabungaidze et al. (2013) examined how job satisfaction and certain demographic factors influence teachers' intentions to leave the profession. Using a stratified sampling method, self-administered questionnaires were distributed to 300 teachers, and the responses were analyzed through statistical techniques including independent samples t-tests, correlation analysis, chi-square tests, and one-way ANOVA. The results showed that low job satisfaction significantly contributes to decisions to resign from teaching, and that variables such as age, length of service, and area of specialization can predict turnover intentions. The study also stressed the need for school authorities to create strategies that address the needs of teachers with lower satisfaction and commitment levels. Such proactive measures, the authors argue, would reflect administrators' readiness to respond to teacher concerns and help reduce absenteeism and attrition rates.

Oginni et al. (2013) conducted a study on the correlation between school factors and students' achievement in Chemistry. Research evidence indicated that an enabling environment facilitated enjoyable learning in Chemistry. However, in practice, this was not always the case, leading to a decline in students' achievement in the subject. This research investigated how school-related factors influence Chemistry achievement among senior secondary students. Using an ex-post facto

survey design, the study examined Chemistry students and teachers across 57 local government and development areas in Lagos State. Researchers developed and validated specialized instruments to collect relevant data for analysis. The three research questions were formulated and addressed. Pearson Product Moment Correlation and Multiple Regression Statistics were employed for data analysis. The findings demonstrated that as school conditions improved, students' performance in Chemistry also improved. Recommendations were provided based on these findings.

Hofstein et al. (2013) conducted a study on learning in chemistry laboratories. They examined the central role laboratory activities played in chemistry education, emphasizing their importance in helping students understand the natural world. Their research highlighted the numerous benefits associated with laboratory-based learning, as evidenced by a broad array of literature. They provided a theoretical discussion that justified laboratory learning and assessed its educational potential. This theoretical framework was followed by a practical examination of different laboratory approaches, teachers' behavior in laboratory settings, student assessment methods, and various organizational and educational factors influencing laboratory learning.

Chumo (2014) investigated the effects of practical investigation on scientific creativity among secondary school Biology students in Kericho District, Kenya. The evolving needs of the 21st century require graduates to cultivate creativity for personal, societal, and economic growth. Although science curricula emphasize practical work as a catalyst for creativity, rigidly structured Biology experiments in Kenyan secondary schools often limit students' opportunities for independent inquiry. This study evaluated the effectiveness of the Practical Investigation approach in fostering scientific creativity among Form Three Biology students in Kericho District. Using a Solomon-four Non-equivalent Control Group design, the study purposively sampled 180 students from four county secondary schools. Two schools served as experimental groups (exposed to the Practical Investigation method), while two maintained conventional teaching as controls. Validated

instruments—the Biology Creativity Test (BCT) for pre-testing (8 open-ended items) and the Scientific Creativity Test in Biology (SCTB) for post-testing (15 items on nutrition, transport, and ecology)—measured outcomes. Four null hypotheses were tested via t-tests and ANOVA. The Practical Investigation approach significantly outperformed traditional methods in developing students' scientific creativity ($p < 0.05$). The study advocates for integrating open-ended laboratory investigations to nurture creativity in science education.

Ramnarain (2014) examined teachers' perceptions of inquiry-based learning across different school contexts in South Africa, including urban, suburban, township, and rural high schools. The study found that teachers generally held positive views on inquiry-based learning, citing its benefits for developing experimental skills and making science more engaging. However, notable differences emerged between school contexts. Teachers in suburban and urban schools favoured inquiry-based learning for conceptual understanding, whereas those in township and rural schools preferred a didactic approach due to resource constraints, large class sizes, and limited exposure to inquiry-based methods. The study emphasized the impact of contextual factors on science curriculum implementation and suggested that limited resources and class sizes influenced teaching approaches in underprivileged schools.

Akani (2015) investigated the role of laboratory teaching in students' academic achievement in chemistry in secondary schools in Ebonyi State, Nigeria. A sample of 240 students was selected using a simple random sampling technique from ten secondary schools in three education zones. The study utilized a questionnaire to collect data, revealing that laboratory teaching fostered scientific attitudes, problem-solving skills, and interest in chemistry. The study recommended that chemistry be taught in laboratories, that governments build and equip science laboratories, and that more qualified chemistry teachers be employed.

Denessen et al. (2015) investigated the relationship between primary school teachers' and students' attitudes toward science and technology. The longitudinal

study, involving 91 teachers and 1,822 students from Dutch primary schools, examined the effects of teachers' attitudes on students' perceptions of science and technology. Results indicated that students developed less positive attitudes toward science and technology as they progressed through primary school, with girls displaying less enthusiasm than boys. Female teachers exhibited less positive attitudes toward teaching science and technology compared to male teachers. Additionally, female students were more influenced by their teachers' attitudes and demonstrated less enthusiasm when their female teachers showed less interest in science education. The study discussed implications for teacher education and recruitment.

Khanyane et al. (2016) investigated perceived gender differences in science performance among secondary school students in Lesotho. Their study examined beliefs about gender disparities in science achievement and explored potential factors contributing to these differences. Using the Educational Effectiveness Research model, they conducted focus group discussions with students and teachers and administered a questionnaire to school principals. The findings revealed mixed perceptions regarding which gender performed better in science, although school principals generally believed that boys outperformed girls. The study identified a variety of factors influencing gender differences in science performance, including self-efficacy, gendered attitudes, perseverance, home environment, language proficiency, socio-economic challenges, and learning strategies. These factors were perceived to have a more negative impact on girls' achievement compared to boys.

Okafor (2016) studied the influence of laboratory practical work on the academic performance of secondary school students in physics in Idemili South Local Government Area. A descriptive survey design was employed, utilizing a questionnaire with 13 structured research questions. The study revealed that physics laboratories in the area's secondary schools were inadequate and poorly equipped. It recommended that the government provide well-equipped science laboratories, regularly train physics teachers, and encourage frequent practical sessions to enhance students' understanding and performance.

Ambusaidi and Al-Farei (2017) explored Omani science teachers' attitudes toward teaching science, particularly in relation to gender and teaching experience. They designed a 30-item questionnaire assessing attitudes in three domains: classroom preparation, hands-on science management, and developmental appropriateness. The study, which surveyed 139 randomly selected teachers, found that overall attitudes toward teaching science were positive. Additionally, it revealed significant gender differences, with female teachers exhibiting more positive attitudes than male teachers. Teachers with longer experience also demonstrated more favorable attitudes toward science instruction. The study proposed several recommendations to enhance teachers' attitudes, particularly among male educators. These included professional development programs, peer observation opportunities, and incentives such as financial and social rewards.

Wei and Li (2017) explored science teachers' perceptions of experimentation to restructure school practical work. Although many studies had addressed definitions, typologies, and purposes of practical work, few had sought input from practicing teachers. This study involved qualitative interviews with 87 secondary school science teachers, who were asked to compare student experiments with scientific experiments. Eight dimensions of experimentation emerged from qualitative data analysis, and their distributions between the two experiment types were analyzed. An ideal model for restructuring practical work in secondary schools was proposed, highlighting issues affecting effective implementation.

Kasiyola et al. (2017) examined the challenges faced by natural science teachers in conducting practical work in three selected primary schools in the Zambezi region of Namibia. The study found that many primary schools struggled to engage students in practical work, leading to minimal or no implementation of such activities. Interviews with natural science teachers uncovered significant obstacles hindering effective practical science instruction. Key challenges identified included: (1) insufficient laboratory equipment and dedicated science facilities, (2) failure to allocate specific timetable slots for hands-on experiments, and (3) inadequate professional development opportunities to keep pace with educational

reforms. These systemic constraints collectively compromise the quality of practical science education. The study suggested that addressing these challenges would enhance the effectiveness of practical work, improve learner performance, and yield better academic results in natural science.

Roy (2017) investigated teachers' perceptions of the role of practical work in teaching Integrated Science at junior secondary schools in Pemba District, Zambia. The study aimed to determine teachers' perceptions of practical work, the extent of student engagement in practical activities, and challenges associated with teaching practical work. A qualitative approach with a descriptive research design was employed. Thirty-two teachers participated in the study, selected through purposeful sampling. Data were analysed thematically. Although teachers expressed positive views on practical work, their perceptions were not fully reflected in classroom practice. Challenges identified included large class sizes, work overload, lack of teaching aids, and inadequate administrative support. Recommendations included improving the assessment of practical work, increasing professional development opportunities, and ensuring the availability of adequate teaching resources.

Adofo (2017) examined teachers' perceptions of inquiry-based learning in science education. The study found that both teachers and student teachers held similar views and strongly supported the use of inquiry in science instruction. Inquiry-based teaching was perceived as an effective strategy for engaging students, fostering interest, and promoting positive attitudes toward science. It was also seen as beneficial in enhancing students' understanding of scientific concepts, improving memory retention, and encouraging active participation in science lessons. However, despite these benefits, the study identified several challenges hindering the implementation of inquiry-based teaching. These included time constraints due to curriculum demands, large class sizes, and teachers' personal judgments. Additionally, inadequate resources and equipment were noted as significant barriers to effective inquiry-based learning in science classrooms.

Kaindume (2018) investigated factors limiting Grade 7 Natural Science teachers from engaging learners in practical work in the Ogongo circuit of the Omusati Region. Using a qualitative case study approach, the study involved semi-structured interviews and observations with two Natural Science teachers and six Grade 7 learners. Thematic analysis revealed key challenges, including a lack of pedagogical knowledge, insufficient time, inadequate laboratory materials, and limited training on effective teaching strategies. The study recommended increased training opportunities for teachers and knowledge-sharing initiatives to enhance the teaching and learning of Natural Science. The findings also informed stakeholders on measures to improve science education at the Grade 7 level and address existing challenges in the field.

Maponya (2018) explored the perceptions of Grade 11 Physical Sciences teachers regarding practical work. Data were collected through interviews, classroom observations, and an examination of teachers' portfolios. The study focused on four Grade 11 teachers from Mankweng Circuit in Limpopo province. Observations revealed that teachers primarily conducted structured demonstrations rather than inquiry-based practical work. Additionally, practical activities were often carried out solely for assessment purposes. Although teachers acknowledged the value of practical work in science education, resource constraints and time limitations hindered effective implementation. The study also found that teachers lacked practical work lesson plans in their portfolios, apart from those required for reporting purposes. Moreover, inadequate apparatus, large class sizes, a lack of scheduled time for practical work, and pressure to complete the curriculum were cited as major barriers. The study recommended that subject specialists provide support to enhance teachers' ability to conduct inquiry-based practical work.

Idah and Eya (2018) examined the challenges faced by Chemistry teachers in teaching practical chemistry in secondary schools within Enugu East Local Government Area of Enugu State. Their study emphasized that comprehending chemistry without practical experiments was nearly impossible. The research followed four research questions and one null hypothesis. The study population

included all 53 chemistry teachers from 26 private and 10 government-owned secondary schools in the area. Using a simple random sampling technique, 36 teachers were selected from the total population. A structured questionnaire served as the data collection instrument. The collected data were analyzed using mean and standard deviation to address the research questions, while a t-test was used to test the hypothesis. The findings revealed that certain teacher-related factors hindered the teaching of practical chemistry, including unwillingness to conduct practical sessions and a lack of manipulative skills. Student-related factors included the perception of chemistry as a difficult subject and discouragement due to poor performance in external examinations. Based on these findings, recommendations were provided.

Bal-Taştan et al. (2018) studied the impact of teachers' efficacy and motivation on students' academic achievement in science education among secondary and high school students. In the 21st century, rapid advancements in science and technology underscored the need for strong science education at all levels. This research investigated how teacher self-efficacy and motivation affect students' academic performance in science education in Iran and Russia. It employed the Motivation for Academic Performance Scale ($\alpha = 0.89$), the Teacher Self-Efficacy Scale ($\alpha = 0.91$), along with a science achievement test. Two hypotheses were examined through statistical methods, and t-tests were used to compare demographic variations in students' academic outcomes. The findings indicated that gender differences were not significant, but nationality differences significantly impacted students' academic achievement in science. Furthermore, teacher self-efficacy and motivation significantly influenced students' academic performance. The study provided implications and recommendations for students, teachers, school administrators, parents, policymakers, and educational counselors.

El-Emadi et al. (2019) analysed differences in teaching styles between male and female science teachers in Qatari schools and their potential impact on student achievement. Their research focused on Qatar's gender-segregated schools, where female students consistently outperformed male students in international science

assessments such as PISA and TIMMS. However, despite this academic advantage, female students reported lower levels of interest in science careers compared to their male counterparts. The study investigated whether differences in teaching styles contributed to this trend. Through classroom observations and semi-structured interviews, they found that female teachers were more effective in delivering theoretical lessons, whereas male teachers demonstrated superior performance in laboratory-based instruction.

Musa and Muhammed (2019) examined the correlation between students' performance in theoretical and empirical aspects of biology in senior secondary schools in Kwara State, Nigeria. The study used a correlational research design to compare recorded scores in both aspects of biology. The sample consisted of 90 students randomly selected from urban and rural schools. The results showed that students performed better in theoretical aspects than in practical ones. Additionally, gender and location influenced students' achievement, with female students outperforming their male counterparts. The study recommended increased emphasis on practical experiments and resource improvisation, particularly in rural schools with limited laboratory facilities.

Jalal (2019) studied the difficulties science teachers encounter in implementing practical work, focusing on the availability and functionality of laboratory facilities and science materials in basic schools. Conducted in Kurdistan Region Government (KRG) schools, the study surveyed 250 science teachers using a structured questionnaire. Data analysis using SPSS version 20 revealed that most schools lacked adequate laboratory equipment, and more than half of the teachers struggled with limited access to laboratory aids and materials, lack of science training courses, and various governmental and practical barriers. Nevertheless, teachers demonstrated a strong willingness to incorporate practical work into their lessons. The findings also showed variations in teachers' perspectives based on years of experience and emphasized the urgent need to improve laboratory infrastructure and provide targeted training.

Winarto et al. (2019) conducted a study on teachers' perceptions of Science Practices Learning (SPL). The study aimed to develop survey instruments for assessing teachers' perceptions of SPL and to describe their views on science learning practices. A descriptive survey method was employed, involving 74 elementary, junior high, and high school science teachers in Central Java. The research instrument was a science learning practice perception questionnaire, which underwent expert validation and empirical testing. Data analysis indicated that science teachers across different educational levels exhibited similar perceptions of SPL. Elementary, middle, and high school science teachers demonstrated moderate levels of understanding in various SPL dimensions, with elementary school teachers scoring slightly lower in some areas. Overall, science teachers' perceptions of SPL were categorized as moderate.

Bae et al. (2020) examined the role of teachers in implementing science education reforms in the United States. The study employed latent profile analysis to examine how cognitive elements, such as pedagogical content knowledge, and motivational traits, including instructional goal orientations, self-efficacy beliefs, and commitment to educational reform, shaped distinct profiles of middle school science teachers. Factors influencing profile membership—such as the teacher's level of education and the school's percentage of students receiving free or reduced-price lunch (%FRL)—were also assessed. Additionally, the analysis considered teacher outcomes (science instructional practices) and student outcomes (achievement, engagement, and self-efficacy). Five teacher profiles emerged: severely discouraged yet reform-oriented, discouraged but reform-oriented, conventional, confident with a mastery focus, and confident with multiple goal orientations. The results showed significant associations between these profiles and three key aspects of science instruction: communication, discourse, and reasoning. Moreover, the profiles were strongly linked to student performance and motivation in science. The study emphasized the need for differentiated approaches to teacher professional learning and support for science instruction.

Ferreira and Morais (2020) investigated the different pedagogic practices of practical work in science education in Portuguese high schools. Four teaching practices were analyzed based on the complexity of scientific knowledge and cognitive skills, as well as their structural and interactional characteristics. Findings suggested that the social context of schools, along with teachers' academic qualifications and professional development, influenced science teachers' practical work approaches. Schools with lower national assessment levels and students from underprivileged backgrounds exhibited lower complexity in scientific knowledge and cognitive skills, favoring horizontal discourse and implicit evaluation criteria.

Nghipandulwa et al. (2020) investigated Biology teachers' perceptions of the importance of practical work in selected secondary schools in the Oshana Education Region (OER). The findings revealed that 69.9% of the teachers did not have dedicated Biology laboratories and instead conducted practical in shared laboratories or classrooms. Among the nine observed teachers, two did not incorporate practical work, opting for theoretical instruction, which disadvantaged students in assessments requiring practical skills. Furthermore, 66.6% of the teachers claimed to conduct practical, but in reality, minimal practical work took place. Observations indicated that four out of six teachers relied solely on demonstrations. The study also found that essential materials for conducting practical were unavailable in Biology classrooms and laboratories, with no practical manuals provided for teachers or students. Consequently, teachers resorted to using self-prepared handouts. The study recommended that the Ministry of Education and Biology Advisory Teachers address laboratory space shortages and resource deficiencies to facilitate practical work. It also suggested that teachers borrow materials from nearby schools when resources were insufficient.

Yeşiloğlu and Köseoğlu (2020) examined epistemological problems underlying pre-service chemistry teachers' aims in using practical work in school science. The study involved 22 pre-service chemistry teachers and employed qualitative data collection tools, including reflective writings, practical work plans, open-ended questions, and follow-up interviews. The findings categorized participants' aims

into six themes: providing learning through discovery, verifying scientific theory, making scientific theories concrete, developing students' scientific process skills, fostering an understanding of the nature of science, and enhancing curiosity and motivation toward science. The study discussed epistemological problems associated with these aims and recommended explicit integration of epistemology into science teaching approaches and practical work methodologies.

The findings categorized participants' objectives into six key themes: facilitating learning through discovery, validating scientific theories, making abstract theories tangible, developing students' scientific process skills, promoting an understanding of the nature of science, and stimulating curiosity and motivation toward the subject. The study also examined the epistemological issues linked to these goals and recommended the deliberate incorporation of epistemology into science teaching strategies and practical work practices.

Salvan and Hambre (2020) investigated the impact of teachers' demographic profiles on students' performance using the K-12 Earth and Space module. The study examined the effect of teachers' demographics on students' academic achievement in Earth and Space 9. A total of 214 students and 16 teachers from two high schools participated. Results indicated that most teachers were female, aged 27-32, had 22-26 years of teaching experience, but had only taught Earth and Space for 1-4 years. Findings showed an improvement in post-test scores for one school, while the other exhibited minimal progress. A significant difference in pre-test and post-test scores was observed at $\alpha=0.05$, but no significant relationship was found between students' performance and teachers' demographic profiles.

Shana and Enas (2020) examined the impact of science practical work on high school students' academic achievement. This quasi-experimental study examined the impact of practical work on students' academic achievement in science. The participants comprised tenth-grade students in Chemistry and Biology, as well as eleventh-grade Chemistry students, who were assigned to either control or experimental groups. While the control groups received instruction through conventional teaching methods, the experimental groups engaged in intensive

practical activities. Both pre-tests and post-tests were conducted for all groups. A comparison of mean scores revealed a significant improvement in the performance of students exposed to practical work compared to those in the control groups. Based on these findings, the study recommended increasing opportunities for practical lessons in secondary schools and highlighted the importance of equipping laboratories adequately to support the effective execution of practical activities.

Arnejo et al. (2021) examined students' perceptions of science laboratory functionality in Zamboanga del Sur National High School. The study aimed to assess whether students perceived functional science laboratories as beneficial or not. Findings showed that while students acknowledged the value of well-equipped laboratories, they experienced difficulties conducting experiments in physics, biology, and chemistry. STEM students rarely engaged in laboratory experiments but recognized the advantages of functional labs, particularly for those intending to pursue medical courses in college. The study concluded that the absence of laboratory facilities made it difficult for STEM students to effectively learn specialized subjects.

Wei et al. (2021) conducted a case study on how a beginning science teacher navigated practical work in a physics classroom through the lens of professional identity. Data were collected over ten months through semi-structured interviews, classroom observations, brief interviews, lesson plans, and other artifacts. Using a constant comparative analysis method, the study applied a three-dimensional framework of professional identity (personal, social, and situational). The findings identified four key themes influencing the teacher's engagement with practical work: personal characteristics, sense of agency, contextual constraints, and ongoing interpretation of experiences. These insights provided recommendations for supporting new teachers in integrating practical work into their teaching.

Setiawan (2021) conducted a study titled "The Analysis of Science Textbooks: Science-Chemistry Teachers' Book and Students' Book of Junior High School" to analyze the content and formality in junior high school science textbooks for

chemistry. Using qualitative content analysis, the study focused on three formality values: terminology and notation, nominalizations, and passive voice. Both teacher and student books had high values in terminology, notation, and nominalizations, while the passive voice usage was low. The analysis revealed weak power relationships and involvement, as shown by a preference for interrogative and declarative sentences over imperatives and the use of plural personal pronouns more than singular ones. Overall, the textbooks demonstrated a high degree of formality in the content related to acids and bases.

Wei et al. (2021) investigated the representation of scientific methods in practical work within science textbooks. Using an analytical framework based on Brandon's matrix, the study examined the diversity of scientific methods in biology, chemistry, and physics textbooks for junior high school students in China. The findings revealed discrepancies in the distribution of scientific methods across different subjects, with non-manipulative parameter measurement (NPM) being the predominant method. The study suggested that future research could explore changes in the practical work nature and compare the representation of scientific methods in textbooks from different regions and countries.

Chen et al. (2022) developed and validated an instrument to measure upper-secondary school science teachers' perceived practical knowledge regarding practical work. Their study was based on five components in the conceptual framework of pedagogical content knowledge (PCK) related to practical work. A questionnaire was developed and administered to 636 Chinese upper-secondary school science teachers. The results of factor analysis and correlation analysis shows strong evidence for the instrument's construct validity. The high Cronbach's alpha coefficient indicated good internal consistency reliability. Ultimately, an instrument with six factors and 25 items was established, offering a valuable tool for science teacher educators and researchers.

Navarro et al. (2022) conducted a descriptive study analysing the personality traits associated with gender, attitudes, and self-efficacy in teaching science and

mathematics among pre-service primary teachers. The study employed convenience sampling to select a sample of 92 pre-service primary teachers in Chile, who were assessed using a set of instruments designed to measure relevant variables. These instruments showed satisfactory validity and reliability. The results revealed that a considerable proportion of the participants displayed low self-efficacy and negative attitudes toward teaching science and mathematics, along with personality traits indicative of strong gender stereotypes. Additionally, the combination of measured variables led to the identification of distinct profiles among the pre-service teachers. The study highlighted the importance of these findings for promoting more inclusive and equitable school environments, aiming to increase student engagement in science and mathematics, especially among girls

Li et al. (2022) investigated Chinese rural science teachers' self-perceptions of their teaching competencies. They sought to measure teaching competency and identify rural-urban differences by developing a standardized assessment instrument. Using factor analysis, they validated a 21-item questionnaire encompassing four competency dimensions. Their findings indicated significant rural-urban disparities in teaching implementation and learning evaluation, as well as differences in teacher distribution. The study aimed to contribute to the development of a competency framework for rural science teachers and inform policies to enhance professional development in rural education.

Teig and Nilsen (2022) analysed instructional quality in primary and secondary science education. The study examined Norwegian data from TIMSS 2015 for Grades 5 and 9, using multi-level latent class analysis to identify instructional quality profiles. The profiles focused on instructional clarity, teacher support, engaging teaching, social and emotional support, and subject domain support. Findings indicated that instructional quality varied across grades. Student characteristics such as socioeconomic status and language spoken at home influenced profile memberships, while teacher self-efficacy in science teaching affected classroom-level instructional quality. Different instructional quality profiles were significantly related to student motivation and, to some extent,

achievement in science. The study highlighted the need for personalized professional development programs to enhance instructional quality in science education.

Twahirwa et al. (2022) examined teachers' perceptions of inquiry-based learning in science education in selected secondary schools in Kirehe District, Rwanda. The study adopted a quantitative approach and employed a descriptive research design. Data were collected through a closed-ended questionnaire administered to 82 secondary school science teachers. The findings indicated that the choice of teaching and learning approaches significantly influenced students' understanding of science. Inquiry-based learning was found to be effective in fostering practical skills and higher-order thinking. However, a lack of continuous professional development hindered teachers' ability to implement this approach effectively. The study concluded that inquiry-based learning could enhance students' understanding of science concepts. It was recommended that school administrators familiarize themselves with the 5-E model of inquiry-based learning and collaborate with teachers to facilitate the adoption of innovative teaching strategies.

Yalçinkaya-Önder et al. (2022) conducted a study titled "Investigation of Science Textbooks in terms of Science Process Skills" to examine the extent to which science process skills are represented in the texts and activities of 3rd to 8th-grade science textbooks according to the science curriculum. Using a document analysis method, the researchers analyzed course contents and activities in science textbooks through descriptive analysis. The study revealed that a total of 899 science process skills were identified across 42 units in the textbooks. The 6th-grade science textbook had the highest representation of these skills (n=215), while the 3rd-grade science textbook had the least (n=112). It was found that science process skills were most frequently used in the 6th (%23.9) and 7th (%18.8) grade textbooks, with a noticeable increase in skills from the 3rd to the 4th grade at the primary education level. However, a similar increase was not observed in secondary school textbooks. The study also noted that "observing" was the most commonly used science process skill, while "using data" and "modelling" were the least utilized.

2.2 STUDIES CONDUCTED IN INDIA:

Desouza et al. (2004) investigated science teaching self-efficacy and outcome expectancy beliefs among elementary and middle school teachers in urban India. Teachers completed the Science Teaching Efficacy Belief Instrument (STEBI-A), and responses were analyzed using Rasch analysis and parametric tests. The study found that while the instrument functioned well for both groups, teachers interpreted some items differently. Middle school teachers, those without science degrees, and those lacking a formal science curriculum exhibited high correlations between self-efficacy and outcome expectancy beliefs. Factors such as weekly instructional minutes, educational qualifications, and curriculum availability significantly influenced self-efficacy. The study concluded that teaching experience alone was insufficient to enhance outcome expectancy beliefs and emphasized implications for teacher education and policy development.

Chunawala and Natarajan (2011) analyzed policies related to science education and diversity in India, a country with significant geographical and socio-political diversity. The study, funded by the European Commission FP7 program, examined how diversity was addressed in science curricula. The research found that diversity either posed challenges in curriculum implementation or was incorporated to promote cultural preservation and national integration. In India, government initiatives such as scholarships, ICT integration, and science events promoted science education. However, diversity-related issues were rarely addressed. The study highlighted trends in science education policies and the need for more inclusive approaches.

Nargund-Joshi et al. (2011) explored Indian secondary teachers' orientations and practices for teaching science in the context of educational reform. In 2005, India introduced the National Curriculum Framework to promote a constructivist learning approach across subjects. Previous research in other countries, such as the United States, indicated that successful curriculum reform required early consideration of teachers' orientations toward teaching and learning. The study examined two Indian secondary science teachers' orientations and how they aligned with their

instructional practices. Data were collected through semi-structured interviews, classroom observations, and artifacts. The findings revealed that while teachers' orientations aligned with the reform goals, their classroom practices did not reflect these orientations due to external constraints. The study emphasized the need for professional development that aligns orientations, practices, and reform goals while addressing cultural barriers.

Agarkar (2016) investigated the role of open educational resources (OER) in supporting school science education in India. Despite shifts in science teaching methods, most Indian schools continued traditional instruction aimed at examination preparation. To address this, a project was undertaken to develop OER for students, teachers, and parents. The student resources included games, hands-on activities, self-assessment tests, and enrichment material. Teacher resources provided guidance on teaching aids, classroom management, and action research, while parental resources focused on everyday science, hygiene, and child development. Workshops involving educators, social workers, and parents developed these resources, which were tested in approximately 200 schools. The results indicated that the OER effectively enhanced student-teacher and student-parent interactions.

Chavan (2017) examined secondary school students' interest in science, selecting a sample of 1,454 students from 29 secondary schools in Pune using random and purposive cum incidental sampling methods. Data were collected using Dubey and Dubey's Science Interest Test (SIT). Findings indicated that students exhibited above-average interest in science, with girls showing slightly more interest than boys, though the difference was not statistically significant. Similarly, students from middle socioeconomic status groups demonstrated higher interest than those from lower socioeconomic backgrounds, but the difference remained insignificant. Students from private-aided schools showed more interest in science compared to those from municipal corporation schools, but the difference was not significant.

Malathi and Rohini (2017) investigated the challenges faced by physical science teachers in conducting practical work in higher secondary schools in the Aranthangi Educational District. The study utilized a structured questionnaire to identify difficulties encountered by physical science teachers. Data analysis indicated that the primary challenges included inadequate time, unavailability of resources, large class sizes, and the pressure of frequent assessments and examinations. The study suggested that addressing these issues would enhance the effectiveness of practical work and subsequently improve students' performance in physical science at the higher secondary level.

Sharma (2018) conducted a study titled "Content Analysis of 6th Grade NCERT Science Textbook to Study the Scope of Developing Desirable Values in Students" to evaluate the presence of explicit and implicit values within the textbook. The analysis revealed that the NCERT Science textbook incorporates numerous values across various topics, offering opportunities for character education and moral development. However, the study emphasizes the role of teachers in recognizing these values and employing innovative teaching strategies to effectively impart them to students.

Koul (2019) examined diversity in Indian science classrooms and the need for teachers to address students' diverse socio-cultural backgrounds. The study highlighted factors such as language development, contextual understanding, and social skills in fostering scientific literacy. Two research projects were conducted, involving three-day professional development workshops in Mumbai and Gwalior, where Indian science teachers engaged in inquiry-based teaching methods inspired by Australia's "Science by Doing" program. The workshops encouraged collaboration and problem-solving among teachers. While participants found the training valuable, they expressed a need for activities aligned with commonly used textbooks and strategies for managing large classes with limited resources.

Singh (2019) conducted a study titled "An Analysis of the Activity of Science Textbook with Reference to Science Process Skills" to evaluate the nature and effectiveness of activities in NCERT's 9th-grade science textbooks. The study

aimed to analyze how science process skills were incorporated into these activities. Using purposive sampling, the research found that the activities largely included basic science process skills in an operant form, with clear step-by-step explanations. However, some activities were supplemented with non-operant forms, though none were entirely non-operant. The study also found that while the activities were well-structured, the figures and charts in the textbooks were often unclear and blurred.

Kuchy and Chakraborty (2021) investigated the impact of Teacher's qualification and experience on their job satisfaction. By random sampling technique, a representative sample of 324 teachers was selected from the high schools of Kulgam district, J and k, India. With the help of the Job satisfaction Scale, constructed and standardised by Meera Dixit (1993), data were collected from the selected respondents. The collected data were subjected to descriptive (Mean, S.D, Percentage and frequency) differential a (t-test, ANOVA, DMRT) and Regression analysis for statistical treatment. The study's findings indicated that: (i) most teachers demonstrated an average level of job satisfaction, both in the overall sample and across sub-samples; (ii) academic qualifications significantly affected teachers' overall job satisfaction and most of its dimensions, except for satisfaction with authorities and rapport with students; and (iii) teaching experience also had a significant impact on overall job satisfaction and several of its dimensions, with the exception of rapport with students and relationships with co-workers.

Ragukumar (2021) assessed the status of higher secondary school science laboratory activities in Thoothukudi, Southern India. A survey was conducted using primary and secondary data from teachers, laboratory technicians, and students. Findings indicated that 80% of teachers reported a lack of trained laboratory technicians in some schools, while 77.8% cited an overall shortage of skilled technicians. In schools without dedicated staff, junior science teachers often performed laboratory technician duties. Additionally, 40% of teachers indicated that neither teachers nor technicians received regular training on laboratory

procedures, and 17.8% expressed low job satisfaction. The study concluded that the lack of proper laboratory facilities adversely impacted the quality of science education.

Chaudhuri and Agnihotri (2022) conducted a study titled "Nurturing the Scientific Temper and Vision of Ancient Indian Physicists through NCERT Science Textbooks: An Analysis" to examine the integration of ancient Indian scientific knowledge in the NCERT Science textbooks. The study aimed to analyze how the spirit of scientific inquiry, as envisioned by Jawaharlal Nehru, is reflected in the works of ancient Indian physicists and to identify gaps in the current textbooks. The analysis revealed that content related to ancient Indian physics was primarily concentrated in the Class VIII science textbook, specifically in the chapter "Stars and Solar System." The study suggests further incorporation of original investigations and discoveries by ancient Indian physicists. The Indian government's decision to include such knowledge in future revisions of NCERT textbooks aligns with the broader goals of the New Education Policy (2020) and the United Nations' SDG4.

Remya and Chetan (2022) assessed the current status of science education in secondary schools in Palghar district, Maharashtra. A survey method was employed to collect data from secondary school students. The study analyzed teaching methods and the overall state of science education in schools using measures of central tendency and standard deviation as statistical techniques. The study revealed that lecture method is followed in most of the classes for teaching science even in this technological era.

Sharma (2022) conducted a descriptive analysis titled "Descriptive Analysis of Visual Representations of NCERT Science Textbooks" to examine the visual content in NCERT Science textbooks for classes IX and X. The study analyzed 507 visual images and found that most were conventional and iconic, with minimal use of advanced techniques like augmented reality to depict scientific concepts. The images were well-indexed and captioned, but static pictures were preferred over

dynamic ones. The analysis also revealed that the class X textbook had fewer visual representations compared to the class IX textbook. The study suggests that as concepts become more complex in class X, the use of visual representations should be increased to enhance understanding.

Nandy and Pramanik (2024) compared the secondary school science curricula in India and Singapore. Through qualitative data analysis and a comparative approach, the study highlighted significant contrasts between the two educational systems. India's curriculum has historically focused on rote memorization, whereas Singapore's system has promoted creativity and critical thinking. In an effort to overcome these shortcomings, India implemented the National Education Policy (NEP) 2020 as a reform measure. The study provided insights into the strengths and weaknesses of both curricula, highlighting the significance of curriculum reform in fostering scientific literacy. The originality of the research lay in its comparative perspective, as no previous studies had conducted a similar analysis.

2.3. STUDIES CONDUCTED IN MIZORAM:

Darchhingpuii (1988) examined science achievement, attitudes towards science, and problem-solving abilities among secondary school students in Aizawl. The findings indicated that male students outperformed female students in science achievement. However, no significant difference was observed between students from government and deficit schools in terms of science achievement.

Zohmingliani (2011) critically examined the status of science education in Mizoram and concluded that despite government efforts, science education progressed steadily but still required significant development. The study revealed the absence of a defined policy for science education until the last academic session it covered. Additionally, no effective monitoring system for practical science work was in place, and science education enrolment at the HSSLC level was notably low. The high student-to-teacher ratio at the high school level contrasted with the nearly balanced teacher-student ratio at the college level, reflecting the high cost of

science education in the state. Furthermore, the uneven distribution of theoretical and practical work from high school to college was deemed undesirable.

NAS (2015), conducted by NCERT for Class X students, reported that the average performance of students in Mizoram was significantly lower than the national average in science. No significant performance difference was observed between rural and urban students or between boys and girls in the state. The study indicated a need for a 64.8% improvement in science achievement, with no students scoring 75% or higher in the subject.

Lalmuanzuali et al. (2019) examined science achievement and attitudes toward science among higher secondary school students in Aizawl. A sample of 300 students (150 males and 150 females) was randomly selected for the study. Data on attitude toward science were collected using the 'Science Attitude Scale,' while science achievement was measured using the 'Achievement Test in Science (ATS-GR).' Findings revealed no significant gender difference in attitudes towards science, but boys exhibited significantly higher science achievement than girls. No significant correlation was found between attitude towards science and science achievement.

Lalramnghinglova et al. (2019) examined the integration of environmental studies across elementary, secondary, and senior secondary schools in Mizoram, India, based on in-depth interactions with key stakeholders. The study revealed a shortage of qualified teachers to handle the subject at all levels, with many displaying significant knowledge gaps and misconceptions on critical environmental issues such as acid rain, ozone layer depletion, and the greenhouse effect. Survey results showed that innovative teaching methods were rarely employed, with lectures being the predominant approach, while field visits, practical activities, study tours, and demonstrations were absent in many schools. The analysis also noted that the course content lacked progression, with frequent repetition of topics. At the college level, greater emphasis on environmental education and enhancement of course content was deemed necessary. The investigators recommended both pre-service

and in-service training for teachers to incorporate emerging environmental issues into curricula. Such training should enable teachers to source and utilize relevant teaching materials effectively. Several suggestions and recommendations were proposed based on this critical analysis.

Lalrinmawia and Fanai, (2020) examined the science achievement levels of higher secondary students, comparing performance by gender and school type (government, deficit, private). Previous reports (NCERT, 2015; NEDFi, 2016-17) highlighted poor science performance in the region, prompting this investigation. Using a standardized test with 298 students, the findings revealed alarmingly low achievement (95.64% below average), no gender difference, and higher scores in deficit schools compared to government and private institutions. The study recommends collaborative learning, activity-based methods, and lab experiments to enhance science education. These insights call for pedagogical reforms to improve student engagement and performance in science.

Cherthangpuii and Fanai (2022) conducted a study titled "Analysis of Science Textbook for Class IX Prescribed by Mizoram Board of School Education" to evaluate the Class IX science textbook prescribed by the Mizoram Board of School Education. The study analyzed both the physical aspects of the textbook and its content, focusing on the figures, activities, and assessments to determine whether the textbook effectively supports the objectives of the curriculum as outlined in the NCF 2005. The findings revealed that the input of in-text question, solved numerical and exercise were too vast to be completed within the time period of single session. The content provided in the chapter figures, activities, and assessment are very relevant to daily life and may promote learners-centered as well as useful in promoting scientific creativity and seems to be appropriate in promoting inventiveness among them.

Kaur (2023) investigated the competence of high school science teachers in teaching science process skills. The study emphasized that science was more of a process than a product and that process skills were essential for scientific inquiry

and critical thinking. However, integrating these skills into classroom instruction remained challenging. The study evaluated the effectiveness of high school science teachers in delivering science process skills across five districts in Mizoram. A total of 32 teachers took part in the research. To measure their knowledge and instructional practices concerning both Basic and Integrated Science Process Skills, a specifically designed assessment instrument was employed. Contextual factors influencing teachers' instructional approaches were also examined. The study identified fundamental needs and suggested areas for improvement in teaching science process skills.

Vanlalruati and Fanai (2023) conducted a study titled "Content Analysis of XII Grade Mizoram Board of School Education Biology Textbook" to evaluate the content of the XII-grade biology textbook. The study highlights the importance of textbooks as essential resources in education and emphasizes their potential to foster a value system among students. The findings indicate that the textbook contains both explicit and implicit moral values within most topics, which can contribute to students' overall growth and development. The study underscores the need for teachers to recognize these values and incorporate them into the teaching process to enhance character and moral development in students.

OVERVIEW OF THE REVIEWED LITERATURE

A total of 93 studies, spanning four decades (1984 to 2024), were reviewed to analyse various aspects of science education. The literature was categorized into four main themes: science education, curriculum, science textbook and pedagogy (30 studies), which explored teaching methodologies, curriculum design, and instructional strategies; science practical (25 studies), which examined the role, effectiveness, and challenges of hands-on experiments in science learning; perceptions of science teachers and students (20 studies), which investigated attitudes, confidence levels, and engagement in science education; and challenges faced by science teachers (18 studies), which highlighted issues such as resource constraints, pedagogical difficulties, and systemic barriers in delivering effective science instruction.

Thirty (30) studies focusing on science education, curriculum, science textbook and science pedagogy explored broader aspects of science education, including curriculum design, teaching methodologies, and pedagogical approaches. Key findings included the effectiveness of cooperative learning in enhancing academic achievement (Okebukola and Ogunniyi, 1984) and the strategic role of experimentation in shaping scientific understanding (Gooding, Pinch, and Schaffer, 1989). Studies also emphasized the importance of explicit approaches in improving teachers' understanding of the Nature of Science (Abd-El-Khalick and Lederman, 2000) and the need for long-term professional development to implement science education reforms (Van Driel et al., 2001). Research in India highlighted gaps between reform goals and classroom practices (Nargund-Joshi et al., 2011) and the potential of Open Educational Resources (OER) to enhance science education (Agarkar, 2016). Comparative studies, such as Nandy and Pramanik (2024), advocated for curriculum reforms to foster creativity and critical thinking.

Numerous researches from the reviewed literature concentrated on the relationship between science theory and practical aspects. Mohan and Slater (2006) investigated how language in science textbooks connects theory and practice. Their research made clear how crucial linguistic ties are to helping students comprehend scientific discourse. In their analysis of how scientific techniques are portrayed in science textbooks, Wei, Jiang, and Gai (2021) discovered differences in the way practical work is presented in various areas. They proposed that a lack of diversity in scientific methodologies in textbooks can make it more difficult for students to relate theory to real-world applications. An instrument to gauge teachers' practical knowledge was created by Chen Bo et al. (2022), highlighting the need of alignment between theory and practice to promote a deeper comprehension and application of scientific concepts.

Studies concerning science practical, focused on the role, effectiveness, and challenges of practical work in science education. Researchers found that while practical work engages students, it often fails to connect observations with

scientific concepts (Abrahams and Millar, 2008). Studies like Chumo (2014) demonstrated the benefits of inquiry-based approaches in fostering scientific creativity, while others highlighted resource constraints in underprivileged schools (Ramnarain, 2014). Akani (2015) emphasized the importance of laboratory teaching in developing problem-solving skills, and Wei and Li (2017) proposed models to restructure practical work based on teachers' perceptions. Shana and Abulibdeh (2020) provided evidence that intensive practical work improves academic achievement, while Wei, Jiang, and Gai (2021) identified discrepancies in the representation of scientific methods in textbooks.

Studies related to perceptions or views of science teachers and students, examined attitudes and beliefs toward science education. Studies revealed that many teachers lack confidence in teaching science (Pell and Jarvis, 2003), while students' enthusiasm for science tends to decline over time, particularly among girls (Denessen et al., 2015). Research also highlighted gender differences in teaching styles, with female teachers excelling in theoretical instruction and male teachers in laboratory-based teaching (El-Emadi et al., 2019). Navarro et al. (2022) identified gender stereotypes and low self-efficacy among pre-service teachers, underscoring the need for targeted training to improve confidence and effectiveness.

Problems of Science Teachers related studies explored the challenges faced by teachers in delivering effective science instruction. Common issues included inadequate resources, time constraints, and difficulties in teaching outside their subject specialism (Childs and McNicholl, 2007). Studies in various regions, such as Bangladesh (Banu, 2011) and South Africa (Maponya, 2018), highlighted resource shortages and large class sizes as barriers to practical work. Pre-service teachers also faced challenges, including insufficient materials and lack of guidance (Kim and Tan, 2011). Regional studies, such as Jalal (2019) in Kurdistan and Nghipandulwa et al. (2020) in Namibia, emphasized the need for better infrastructure and training to support science education.

Research conducted in India and Mizoram provided insights into unique regional challenges. Studies in India revealed issues such as low teacher self-efficacy (Desouza et al., 2004), lack of inclusive curricula (Chunawala and Natarajan, 2011), and inadequate laboratory facilities (Ragukumar, 2021). In Mizoram, research highlighted gender disparities in science achievement (Darchhingpuii, 1988) and the need for policy reforms to improve enrolment and teacher training (Zohmingliani, 2011), (Lalramnghinglova et.al. 2019) (Kaur, 2023) identified gaps in teachers' competency in teaching science process skills, calling for enhanced professional development.

The findings from reviewed literatures emphasize the vital role of science practical in education while also highlighting key obstacles such as limited resources, disconnects between theoretical knowledge and practical application, and challenges faced by educators. To address these issues, several recommendations have been suggested, including improving laboratory infrastructure through increased investment in science education facilities, enhancing teacher training programs to better equip educators for conducting practical lessons, and ensuring a stronger alignment between theoretical content and hands-on experiments to reinforce conceptual understanding. Additionally, providing sufficient administrative support can help manage teachers' workload, allowing them to focus more on delivering effective instruction. Refining pedagogical approaches to encourage student engagement and promote inquiry-based learning is also essential. These reviews emphasizes the need for comprehensive reforms to strengthen the implementation of science practical, ensuring a more effective and enriching learning experience that bridges the gap between theory and practice.

CHAPTER III METHODOLOGY

Methodology is crucial in all types of research, as it establishes the guidelines researchers must follow throughout their study. It provide a detailed account of the steps undertaken by the researcher, including research design, the selection of the study population and sample, the methods and tools used for data collection, the process of administering and gathering data, data organization, and the statistical techniques applied for analysis. Consequently, this chapter on methodology and procedure addresses these essential aspects.

3.1 Method of the study

The present study adopted a descriptive survey method as it involves fact-finding inquiry into the current state of science education, particularly focusing the linkages between the theoretical content and practical aspects at the secondary level in Mizoram. The study also explored the challenges faced by science teachers. As an approach, the present study employs both quantitative and qualitative analysis techniques.

3.2 Population of the study

The population of the study consisted of all secondary school science teachers in Mizoram as shown in table no 3.1

Table 3.1 : Status of secondary schools in Mizoram

District	School management type				Total
	Government / Aided School	Deficit	Samagra	Private	
Aizawl	78	5	13	101	197
Champhai	34	0	5	18	57
Hnahthial	16	0	2	5	23
Khawzawl	12	0	2	14	28
Kolasib	22	1	13	10	46

Lawngtlai	22	0	11	30	63
Lunglei	40	1	19	34	94
Mamit	30	0	12	12	54
Saiha	18	1	9	13	41
Saitual	28	0	7	15	50
Serchhip	27	1	6	13	47
Total	327	9	99	265	700

Source: *Statistics of School Education 2022-2023*

3.3 Sample of the study

For the present study, 100 out of 700 secondary Schools were proportionately selected using stratified cluster sampling technique as follows:

Table 3.2 : Sample of the study

District	Type of School Management				Total No. of schools	Total No. of science teachers
	Govt School	Deficit school	Samagra funded School	Private School		
Aizawl	7	3	2	18	30	32
Lunglei	6	2	2	2	12	12
Siaha	3	0	1	1	5	5
Champhai	5	1	2	2	10	10
Kolasib	3	0	2	2	7	7
Serchhip	4	1	0	1	6	6
Lawngtlai	3	1	2	0	6	6
Mamit	3	0	2	1	6	6
Saitual	4	0	1	2	7	7
Khawzawl	3	0	1	2	6	6
Hnahthial	4	0	0	1	5	5
Total	53	8	15	32	100	102

3.4 Tools used for data collection

The following tools are used in the present study.

1. To study perception of teachers, the investigator developed and standardized Teacher's Perception Scale towards Science Practical which is attached in Appendix-2
2. Questionnaire on Teacher's Profile and Challenges to study various issues including profile of science teachers and teacher's challenges which is attached in Appendix-3
3. Checklist for implementation of science practical which is attached in Appendix-4
4. Questions / Points For Focus Group Discussion (FGD) which is attached in Appendix-5

3.5 Mode of data collection

The investigator personally visited 100 schools and took permission from the concerned authorities to collect data. After getting approval, perception scale, checklist for implementation of science practical and questionnaires for collecting challenges faced by science teachers were distributed with thorough instructions beforehand. A focus group discussion among secondary school science teachers was also conducted to discuss the matters concerning science practical and challenges faced by science teachers.

3.6 Data analysis

Considering the nature of the study, the characteristics of the data, and the research objectives, the investigator employed the following methods for data analysis:

- Qualitative data analysis: In order to study the linkage between theory and practical aspects of science, Classes IX and X science text book and science practical manual of MBSE were examined.
- Descriptive statistical measures: Measures such as central tendency, percentages, Stanine grades, and percentiles were utilized

- Test of significance for mean difference: ANOVA and t-test were applied to determine the significance of differences in mean scores among various groups categorized by gender, type of school management and locale.
- Coefficient of correlation: The pearson product moment correlation method was used to examine the relationship between theory and practical marks of Class X students over the past five years.

CHAPTER –IV

ANALYSIS AND INTERPRETATION

The present chapter highlights the analysis and interpretation of data for the present study. For the present study data were collected using opinionnaire, interviews, focus group discussion and teacher's perception scale. The responses from participants were tabulated and meaningfully interpreted using descriptive and inferential statistics. Objective wise analysis and interpretation was presented in the present chapter.

4.1. Objective No 1: To investigate the linkages between theoretical contents and prescribed practicals of secondary school science subject in Mizoram

In science education, practical work is crucial for linking theoretical knowledge with real world application. For secondary school students, the practical provides hands-on learning experiences that enhance understanding of scientific concepts by directly applying theoretical lessons. This alignment between practical activities and the theoretical lesson is vital, as it reinforces classroom teachings and promotes experiential learning.

4.1.1: Class-IX Science

The prescribed class IX secondary science textbook of Mizoram Board of School Education published by Arya Publishing Company written by R.R. Mishra, A.P. Shreelatha, Neetu Sing, Yash Pal and Joginder Singh was currently in use. It consists of fifteen chapters which were divided into various sections, with five chapters dedicated to physics, four chapters focusing on chemistry, and another six chapters on biology. The practical manual currently used by Class IX students in Mizoram, titled "*New Experimental Skills in Science - IX*" is based on the latest syllabus prescribed by Mizoram Board of School Education published by Geeta Publishing House, Pragati Complex, Idgah Chowk, Delhi-110006. The practical manual contains 15 experiments, each introduced with a general overview, followed by the aim of the experiment, a list of materials required, the underlying

principles, the procedure for setting up and conducting the experiment, observations in tabular form, the results, and precautions to be observed during the process.

Analysis of linkages between theoretical contents and prescribed practical

The table below outlines the textbook chapters along with their corresponding experiments. The linkage analysis was conducted according to the chapter structure specified in the recommended science textbook.

Table 4.1.1 : Chapters in class IX science textbook and their corresponding experiments.

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
Chapter 1 Motion	Exp. 8: To determine the velocity of a pulse propagated through a stretched string/ slinky.	Speed and velocity	Aligned
Chapter 2 Force and Laws of Motion	Nil		NA
Chapter 3 Gravitation and Floatation	Exp. 5: To determine the density of a solid (denser than water) by using spring balance and a measuring cylinder.	Density	Aligned
	Exp. 6(a): To establish the relation between the loss in weight of a solid when fully immersed in tap water with the weight of water displaced by it by taking at least two different solids.	Archimedes principles	Aligned
	Exp. 6(b): To establish the relation between the loss in weight of a solid when fully immersed in strongly salty water with the weight of water displaced by it by taking at least two different solids.		

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
Chapter 4 Work and Energy	Nil		NA
Chapter 5 Sound	Exp. 4: To verify the laws of reflection of Sound.	Reflection of sound	Aligned
	Exp. 8: To determine the velocity of a pulse propagated through a stretched string/ slinky.	Wave propagation	Aligned
Chapter 6 Matter in Our Surroundings	Exp. 12: To determine the melting point of a ice and the boiling point of water.	States of matter	Aligned
Chapter 7 Is Matter Around Us Pure	Exp. 1.1: To prepare a true solution of (a) Water and Sodium Chloride (Common Salt), (b) Sugar, (c) Alum.	Types of mixture	Aligned
	Exp. 1.2: To prepare a suspension solution of (a) Soil, (b) Fine Sand, (c) Chalk Powder.		
	Exp. 1.3: To prepare a colloidal solution of (a) Starch in Water, b) Egg Albumin in Water, (c) differentiation of the colloidal solution from true solution and suspension solution		
	Exp. 2: To differentiate between a mixture (containing two components) and pure compound by using iron filings and sulphur powder.	Types of mixture	Aligned
	Exp. 11: To separate the components of a mixture of Sand, Common Salt and Ammonium Chloride (or camphor) by sublimation.	Types of mixture	Aligned
Chapter 8 Atoms and Molecules	Nil		NA

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
Chapter 9 Structure of Atom	Nil		NA
Chapter 10 The fundamental Unit of Life Compounds	Exp. 9(a) To prepare stained temporary mount of onion peel and to record observations and draw labelled diagram. Exp. 9(b) To prepare a stained temporary mount of human cheek cells.	Structure and function of cell	Aligned
Chapter 11 Tissues	Exp. 10(a) To identify parenchyma and sclerenchyma tissues in plants from prepared slides and to draw their labelled diagrams. Exp. 10(b) To identify striped muscle fibers in animals and nerve cell (Neuron) from prepared slides and to draw their labelled diagrams.	Plant and animal cell	Aligned
Chapter 12 Diversity in living organisms	Exp. 14: To study the characteristics of (i) Spirogyra or Agaricus (ii) Moss or Fern (iii) Pinus (iv) An Angiospermic plant- Mustard and Onion; Draw and give two identifying features of group they belong to. Exp. 15 :To observe and draw the given specimens - Earthworm, Cockroach, Bony fish and Bird. For each specimen record (a) one specific feature of its phylum (b) one adaptive feature with reference to its habitat.	Classificatio n of living organisms Classificatio n of living organisms	Aligned Aligned

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
Chapter 13 Why do we fall ill	Nil		NA
Chapter 14 Natural Resources	Nil		NA
Chapter 15 Improvement in Food Resources	Exp. 13(a) To test the presence of starch in a given sample of food. Exp. 13(b) To test the presence of adulterants in a given sample of food material turmeric or starch in a given sample of food.	Nutrients and food composition	Aligned

The analysis of theory and practical content in the class IX science textbook, vide table No. 4.1.1 showed the integration of experimental activities with theoretical content in various chapters in the science textbook. Among the 15 chapters examined, six chapters were found to lack practical support entirely, with two chapters each from physics (Force and Laws of Motion, Work and Energy) and chemistry (Atoms and Molecules, Structure of Atoms), along with two chapters from biology (Why Do We Fall Ill and Natural Resources). Further examination of experiment-chapter alignment showed that experiment 8 (determining pulse velocity in a stretched string/slinky) had alignment to both chapter 1 (Motion) and chapter 5 (Sound). Remarkably, 13 experiments maintained linkage with the textbook's theoretical framework. However, two experiments namely experiment No. 3 (Studying the chemical reaction of various compounds) and experiment No. 7 (To measure the temperature of hot water as it cools and plot a temperature-time graph) had no linkages with any chapters in the textbook.

The linkages between theoretical content and practical for class IX science were further analysed as follows:

Chapter 1: Motion

The chapter covered the concept of motion along straight lines, clearly differentiating between distance and displacement. It presented various numerical problems dealing with speed, average speed, and acceleration. Students were taught to derive and apply motion equations through graphical methods while solving related numerical problems. The content included discussions on both uniform and non-uniform motion patterns, concluding with uniform circular motion. These concepts provided students with fundamental knowledge applicable to real-world situations such as analyzing vehicle movements and understanding planetary orbits.

Related experiments:

Exp. 8 To determine the velocity of a pulse propagated through a stretched string/ slinky.

This experiment is related to sound waves, specifically transverse waves and longitudinal waves. It also touched on concepts of sound, where the nature of sound waves is discussed in detail. Additionally, it was connected with the idea of velocity, which is a fundamental concept for understanding how quickly a pulse or wave travels through a medium. The experiment was based on the concept of velocity and the principles governing the speed of moving objects. However, while the concept of velocity was present, the specific context of measuring the velocity of a pulse through a slinky or string were not explicitly covered in the textbook. The focus on the pulse propagation aspect did not directly align with the textbook content.

Chapter 2: Force and Laws of Motion

This chapter examined different types of forces, beginning with balanced and unbalanced forces before detailing Newton's three laws of motion. Practical demonstrations showed these principles in action, using examples like seatbelt mechanisms to illustrate inertia and rocket launches to demonstrate action-reaction pairs. Students practiced solving

numerical problems involving force calculations and momentum. Real-world applications were emphasized, particularly how these laws explained phenomena such as braking systems and frictional forces in daily life.

Related experiments: No prescribed practical for the chapter

Chapter 3: Gravitation and Floatation

The chapter introduced gravitational concepts including free fall and acceleration due to gravity, while distinguishing between mass and weight. Archimedes' principle was explained in detail, with practical examples of buoyancy and relative density problems. Students explored applications ranging from ship design to hydrometer functionality. Numerical exercises reinforced understanding of thrust and pressure concepts, connecting theoretical knowledge to engineering principles.

Related experiments:

- Exp. 5 To determine the density of a solid (denser than water) by using spring balance and a measuring cylinder.*
- Exp. 6(a) To establish the relation between the loss in weight of a solid when fully immersed in tap water with the weight of water displaced by it by taking at least two different solids.*
- Exp. 6(b) To establish the relation between the loss in weight of a solid when fully immersed in strongly salty water with the weight of water displaced by it by taking at least two different solids.*

Experiment 5, which focused on determining the density of a solid denser than water, demonstrated a clear alignment between the theoretical concepts presented in the textbook and the practical application of these principles in the laboratory. This experiment is grounded in the concept of gravitation and floatation, which discussed key concepts such as density, buoyancy, and the principles that govern the behavior of objects in fluids. Within this chapter, students learned

about relative density, which compared the density of a substance to that of water. The understanding of how density influences whether an object sinks or floats is essential to grasp the broader implications of buoyancy in various contexts.

The experiments 6(a) and 6(b) are rooted in the concepts presented in same chapter - gravitation and floatation, with a specific emphasis on Archimedes' principle. This principle is essential for understanding the different behaviors of objects when submerged in various fluids. The experiments demonstrated the relationship between the loss of weight of a solid when immersed in a fluid and the weight of the displaced fluid, thereby providing practical evidence for Archimedes' principle. Both the theoretical content and practical activities highlighted the connection between buoyancy and fluid displacement, equipping students with the theoretical knowledge needed to comprehend the objectives of the experiments. By immersing solids in both tap water and salty water, students could be able to see how differences in fluid density influence buoyancy and weight loss, further deepening their understanding of the concepts covered in the textbook.

Chapter 4: Work and Energy

Definitions and calculations of work and energy formed the core of this chapter. It differentiated between kinetic and potential energy through numerous numerical problems. The principle of energy conservation was demonstrated using examples like pendulum motion and power generation systems. Students learned about energy transformations between different forms and performed calculations related to power output, gaining insight into machine efficiency metrics.

Related experiments: No prescribed practical for the chapter

Chapter 5: Sound

Starting with sound production and propagation, the chapter explored wave characteristics including frequency and wavelength through numerical problems. It examined sound reflection phenomena and medical applications of ultrasonic waves. Detailed study of human ear anatomy connected physical principles to biological systems, while discussions on noise pollution highlighted environmental impacts on hearing health.

Related experiments:

Exp. 4 : To verify the laws of reflection of Sound.

Experiment no 4 aimed to demonstrate how sound waves behave when they encounter a surface, specifically how they reflect off that surface according to established physical laws i.e Laws of Reflection. This experiment aligned closely with the concepts of laws of reflection of sound, which enhanced students' understanding of sound as a wave phenomenon. The connection to textual parts stressed the importance of experiential learning in comprehending key physical concepts, allowing students to observe and validate the principles of sound reflection in a hands-on manner.

Chapter 6: Matter in Our Surroundings

This chapter analyzed the physical nature of matter and its various states. Phase transitions were explained in terms of temperature and pressure effects. Practical examples like the cooling effect of evaporation helped students understand molecular behavior. The content bridged observable macroscopic phenomena with underlying particle-level explanations.

Related experiments:

Exp. 12 : To determine the melting point of a ice and the boiling point of water.

Experiment 12 involved understanding the melting point (the temperature at which ice transitions from solid to liquid) and the boiling

point (the temperature at which water transitions from liquid to vapor). The experiment also explored the change of state of matter, such as the transition from solid to liquid (melting) and from liquid to vapour (boiling). The experiment was directly aligned with the specific topic on states of matter and the conditions under which substances change from one state to another. The textbook provided a theoretical explanation of how matter changes its state with temperature, highlighting key concepts such as melting and boiling points. Meanwhile, the experiment also reinforced those ideas by allowing students to observe these changes in real-time.

Chapter 7: Is Matter Around Us Pure?

This chapter provided a comprehensive examination of the nature of matter, beginning with clear distinctions between pure substances (elements and compounds) and various types of mixtures. Students explored homogeneous and heterogeneous mixtures, including colloidal solutions and suspensions. The text detailed multiple separation techniques such as chromatography, distillation, crystallization, and fractional distillation, explaining their principles and applications. Practical examples included the industrial separation of air components (like oxygen and nitrogen) and municipal water purification processes. The chapter also contrasted physical changes (like melting or dissolving) with chemical changes (such as rusting or burning), using everyday examples to demonstrate these concepts. Environmental applications showed how these chemical principles are used in pollution control and resource management.

Related experiments:

- Exp. 1.1: To prepare a true solution of (a) Water and Sodium Chloride (Common Salt), (b) Sugar, (c) Alum.*
- Exp. 1.2: To prepare a suspension solution of (a) Soil, (b) Fine Sand, (c) Chalk Powder.*

- Exp. 1.3: To prepare a colloidal solution of (a) Starch in Water, b) Egg Albumin in water, (c) differentiation of the colloidal solution from true solution and suspension solution on the basis of Transparency, Filtration and Stability.*
- Exp. 2 :To differentiate between a mixture (containing two components) and pure compound by using Iron Filings and Sulphur Powder.*
- Exp. 11 To separate the components of a mixture of sand, common Salt and ammonium chloride (or camphor) by sublimation.*

Experiment 1.1(a), (b), and (c) focused on preparing true solutions using water and sodium chloride (common salt), sugar, and alum, respectively. These experiments helped students to explore key theoretical concepts like solutions, which involved a solute and a solvent, and the characteristics of a true solution. Additionally, the experiments emphasized the understanding of a homogeneous mixture. The theoretical foundation for these experiments is based on the topics such as types of mixtures, including true solutions and their properties. The experiments served as a practical application of the theoretical knowledge, illustrating how solutions were formed and what makes them homogeneous. This alignment between the practical exercises and the theoretical content ensures that students could directly relate their hands-on experiences to the concepts they had studied in class.

Experiment 1.2(a), (b), and (c) involved preparing suspension solutions using soil, fine sand, and chalk powder. These experiments focused on the concept of suspensions, which are heterogeneous mixtures where the solute particles did not dissolve but remain suspended in the solvent. Like the previous set of experiments, these were aligned with the textbook content on different types of mixtures, including suspensions, which contrast with true solutions by being non-homogeneous and having larger particles that are visible and tend to settle over time. By

performing these experiments, students might observed the properties of suspensions first hand, such as the fact that the particles could be separated by filtration and did not pass through filter paper. This practical work reinforced the theoretical understanding of suspensions and their distinction from solutions, ensuring strong alignment between the practical and theoretical components of the curriculum.

Experiments 1.3(a) and (b) implicated preparation of colloidal solutions of starch and egg albumin in water. These experiments were intended to help students to explore the properties of colloids, which are mixtures in which fine particles are dispersed throughout a liquid or gas but do not settle out over time.

Experiment 1.3(c) driven a step further by allowing students to differentiate between colloidal solutions, true solutions, and suspension solutions based on key characteristics:

Transparency: Colloidal solutions appear cloudy due to particle scattering, while true solutions are clear, and suspensions may also be cloudy but have larger particles.

Filtration: Colloidal solutions cannot be separated by simple filtration, unlike suspensions, which can be filtered to remove larger particles.

Stability: Colloidal solutions remain stable, with dispersed particles not settling, while suspensions will settle over time.

These experiments were closely aligned with the theoretical concepts focusing on the different types of mixtures and their properties. By engaging in these practical activities, students not only reinforce their understanding of colloids but also gain valuable insights into how to distinguish between various types of mixtures based on observable characteristics. This alignment enhanced their overall comprehension of the topic and its real-world applications.

Experiment no. 2 is more or less same in the principles with experiment no 1. However, the differences existed that experiment 1 focused on preparation while experiment No. 2 focused on separation of mixtures, containing two or more components. These experiments intended to inculcate the in-depth knowledge on types of solution to the students.

Experiment no 11 demonstrated the process of separating mixtures into their individual components. Sublimation was used to separate substances like ammonium chloride or camphor that transition directly from solid to gas without passing through the liquid phase. Filtration was applied to remove sand from the mixture, and boiling/evaporation helps to separate common salt by evaporating the water after dissolving the salt. The experiment still aligned directly with the different methods of separating mixtures and the purity of substances available in chapter 7.

Chapter 8: Atoms and Molecules

Beginning with Dalton's ground breaking atomic theory, this chapter established the foundation of modern chemistry. It systematically presented atomic symbols for various elements and explained molecular classification (from monatomic to polyatomic molecules). Students learned the systematic approach to writing chemical formulas, including rules for using valency and constructing compound names from formulas. The revolutionary mole concept was introduced as a bridge between the atomic and macroscopic worlds, with practical exercises demonstrating its use in laboratory calculations. The chapter emphasized stoichiometric relationships and their importance in chemical reactions, providing students with essential tools for quantitative chemistry.

Related experiments: No prescribed practical for the chapter

Chapter 9: Structure of the Atom

Delving deeper into atomic architecture, this chapter explored electron configurations and their arrangement in different shells. It explained critical concepts like valence electrons and their role in chemical bonding. The discussion of atomic number and mass number provided understanding of elemental identity and nuclear composition. The chapter thoroughly examined isotopes (like carbon-12 and carbon-14) and their diverse applications in radiocarbon dating and medical diagnostics. The concept of isobars was introduced to highlight elements with similar mass but different properties, demonstrating the complexity of atomic structure.

Related experiment: No prescribed practical for the chapter

Chapter 10: The Fundamental Unit of Life

This comprehensive study of cellular biology contrasted prokaryotic and eukaryotic cell structures in detail. Each organelle's structure and function were examined, from energy-producing mitochondria to genetic material-containing nuclei. The chapter explained membrane phenomena like osmosis and active transport using plant and animal cell examples. Historical context was provided through the evolution of microscopy techniques, from early light microscopes to modern electron microscopes, showing how technological advances have expanded our understanding of cellular biology.

Related experiments:

Exp. 9(a) To prepare stained temporary mount of onion peel and to record observations and draw labeled diagram.

Exp. 9(b) To prepare a stained temporary mount of human cheek cells.

Both experiments 9(a) and (b) focused on the preparation of temporary mounts to observe epidermal cells, specifically from onion peel and human cheek. Key cellular structures such as the cell wall, nucleus, vacuole, and cytoplasm in onion cells, as well as the cell membrane,

nucleus, and cytoplasm in human cheek cells, were observed under a microscope. These experiments aligned directly with the basic structure and function of cells available in the textbook. The chapter explained the differences between plant and animal cells, which are clearly demonstrated through these experiments. The hands-on process of mounting and staining the cells allows students to observe the theoretical concepts of cell structure in real-time, reinforcing the textbook material on the nucleus, cytoplasm, cell wall, and other cellular components

Chapter 11: Tissues

The chapter presented an organized study of plant and animal tissues, classifying them based on structure and function. Plant tissues included detailed examinations of meristematic and permanent tissues like xylem and phloem. Animal tissues were categorized into epithelial, connective, muscular, and nervous types, with each type's specialized functions explained. Modern medical applications like stem cell therapy and tissue engineering were introduced to show the practical importance of tissue studies in regenerative medicine.

Related experiments:

Exp. 10(a) To identify parenchyma and sclerenchyma tissues in plants from prepared slides and to draw their labeled diagrams.

Exp. 10(b) To identify striped muscle fibers in animals and nerve cell (Neuron) from prepared slides and to draw their labeled diagrams.

Experiment 10(a) involved studying parenchyma and sclerenchyma, which are fundamental plant tissues. Parenchyma cells were involved in storage, photosynthesis, and other metabolic activities, while sclerenchyma provides structural support. Experiment 10(b) focused on striped muscle fibers (skeletal muscles) in animals, which were responsible for voluntary movements and nerve cells (neurons), the basic units of the nervous system responsible for transmitting signals.

These experiments are strongly aligned with *Chapter 11: Tissues*, which provides detailed information on both plant tissues (like parenchyma and sclerenchyma) and animal tissues (like muscle fibers and nervous tissues). The theoretical content in the textbook about the structure, function, and classification of tissues were directly demonstrated through the observation of prepared slides, allowing students to visualize the textbook descriptions of both plant and animal tissues.

Chapter 12: Diversity in Living Organisms

This chapter systematically organized life's diversity through hierarchical classification systems. It explained binomial nomenclature rules and their importance in scientific communication. Detailed comparisons between Kingdoms Plantae and Animalia highlighted evolutionary adaptations to different environments. The content emphasized biodiversity's ecological significance and the need for conservation, providing examples of species interdependence in ecosystems.

Related experiments:

Exp. 14 :To study the characteristics of (i) Spirogyra or Agaricus (ii) Moss or Fern (iii) Pinus (iv) An Angiospermic plant- Mustard and Onion; Draw and give two identifying features of group they belong to.

Exp. 15 :To observe and draw the given specimens - Earthworm, Cockroach, Bony fish and Bird. For each specimen record (a) one specific feature of its phylum (b) one adaptive feature with reference to its habitat.

Experiment 14 involved the classification of organisms, specifically focusing on the Kingdom Plantae and its subgroups, such as algae, fungi, bryophytes, pteridophytes, gymnosperms, and angiosperms. The identification of these plants helped students to understand the diversity and the defining characteristics of each group. This experiment was

directly aligned with Chapter 12: Diversity in Living Organisms, where the classification of living organisms, including plants, were discussed in detail. The chapter covered the Kingdom Plantae, explaining the features of algae (*Spirogyra*), fungi (*Agaricus*), bryophytes (Moss), pteridophytes (Fern), gymnosperms (*Pinus*), and angiosperms (Mustard and Onion). The theoretical concepts related to the classification and characteristics of these groups were clearly presented in the textbook, making this experiment well-aligned with the content.

Experiment 15 stressed the identification of characteristic features specific to the phylum of each organism and their adaptive traits that help them survive in their respective habitats. By examining different organisms from various animal phyla, students learned how these creatures have evolved structural and functional adaptations to thrive in their environments. This experiment was closely aligned with *Chapter 12: Diversity in Living Organisms*, which covers the classification and characteristics of various animal phyla, including Annelida, Arthropoda and Chordata. The textbook provided theoretical background on the classification of animals, explaining the distinguishing features of each phylum, as well as the specific adaptive traits that allow these organisms to survive in different environments.

Chapter 13: Why Do We Fall Ill?

The chapter established clear distinctions between health and disease states, classifying illnesses as acute or chronic. It examined various disease causes, from pathogens to lifestyle factors. Transmission mechanisms were explored in detail, including direct contact, vectors, and environmental factors. Treatment principles covered both traditional and modern approaches, while discussing challenges like antibiotic resistance and emerging diseases in public health contexts.

Related experiments: No prescribed practical for the chapter

Chapter 14: Natural Resources

This environmental science chapter analyzed different pollution types affecting air, water, and soil. It explained essential biogeochemical cycles (water, carbon, nitrogen, oxygen) that maintain ecological balance. The ozone layer's formation, function, and depletion were discussed, along with international efforts to address environmental challenges. The chapter connected scientific understanding to sustainable practices and conservation strategies.

Related experiment: No prescribed practical for the chapter

Chapter 15: Improvement in Food Resources

Focusing on agricultural science, this chapter detailed crop improvement methods including hybridization and genetic modification. It explained sustainable farming practices like crop rotation and organic farming (using vermicompost). Animal husbandry sections covered modern techniques in cattle breeding, poultry farming, aquaculture, and apiculture. Case studies demonstrated how scientific innovations address global food security challenges while maintaining ecological balance.

Related experiments:

Exp. 13(a) To test the presence of starch in a given sample of food.

Exp. 13(b) To test the presence of adulterants in a given sample of food material turmeric or starch in a given sample of food.

These experiments involved the analysis of foodstuffs to determine the presence of key nutrients (like starch) and detect potential adulterants that might degrade food quality. Exp. 13(a) focused on starch as a nutrient, while Exp. 13(b) dealt with identifying harmful adulterants in food samples. Both experiments were broadly related to *Chapter 15: Improvement of Food Resources*, which addresses food production, nutrients, and ways to enhance food quality. Exp. 13(a) is well-aligned with the chapter's content on nutrients and food composition, providing a practical approach to understanding food analysis. However, Exp. 13(b), which focused on adulterants, had no direct theoretical

counterpart in the current textbook. The textbook did not cover the topic of food adulteration, resulting in a misalignment between the theory and this specific practical activity.

A thorough analysis of the prescribed Class IX science experiment list, two additional experiments were identified beyond those previously listed. Interestingly, these two did not directly correspond to any particular chapter in the Class IX curriculum. Instead, they demonstrate stronger conceptual alignment with topics on the Class X Science textbook. The experiments were:

1. *Exp. 3(a) To study the chemical reaction of Iron (nail) with Copper Sulphate solution in water.*

Exp. 3(b) To study the reaction (when Magnesium is burnt in the air) burning of Magnesium in air.

Exp. 3(c) To study the chemical reaction of Zinc with Dilute Sulphuric acid.

Exp. 3(d) To study the reaction when Lead Nitrate is heated and identify the chemical reaction involved.

Exp. 3(e) To study the reaction between Sodium Sulphate and Barium Chloride in the form of their solutions in water.

Experiment 3(a) involved studying the chemical reaction of an iron nail with copper sulfate solution in water, which is classified as a redox reaction. In this experiment, iron (Fe) displaces copper (Cu) from copper sulfate (CuSO_4), resulting in the formation of iron sulfate (FeSO_4) and copper metal. This reaction illustrated the principles of oxidation and reduction, where iron was oxidized (loses electrons) and copper was reduced (gains electrons).

Experiment 3(b) focused on the burning of magnesium in air. This experiment exemplified a combination reaction, where magnesium (Mg) reacts with oxygen (O_2) to form magnesium oxide (MgO). The bright light emitted during the combustion of magnesium highlights the exothermic nature of this reaction, producing a single product from two reactants.

Experiment 3(c) examined the chemical reaction of zinc with dilute

sulfuric acid (H_2SO_4). This reaction represented both a redox reaction and a displacement reaction. In this case, zinc (Zn) displaces hydrogen ions from sulfuric acid, generating hydrogen gas (H_2) and zinc sulfate (ZnSO_4). This demonstrates the transfer of electrons and the displacement of one element by another in a compound.

Experiment 3(d) investigated the reaction when lead nitrate was heated. This experiment identified the chemical processes involved, including sublimation and decomposition reactions. When lead nitrate ($\text{Pb}(\text{NO}_3)_2$) was heated, it decomposed into lead oxide (PbO), nitrogen dioxide (NO_2), and oxygen gas (O_2). The release of gas during the heating process highlights the characteristics of decomposition reactions and sublimation.

Experiment 3(e) studied the reaction between sodium sulfate (Na_2SO_4) and barium chloride (BaCl_2) when their solutions were mixed, resulting in a double displacement reaction. In this reaction, barium sulfate (BaSO_4) precipitated out of the solution as a solid, while sodium chloride (NaCl) remains dissolved. This illustrates the principles of ionic reactions and precipitation.

It is important to note that these experiments were not included in the Class IX textbook; Moreover, they are part of the Class X curriculum.

2. *Exp. 7: To measure the temperature of hot water as it cools and plot a temperature-time graph.*

Experiment 7 involved the principles of heat transfer, including conduction, convection, and radiation. As the hot water cools, heat was lost to the surroundings through these methods, and this process was governed by Newton's Law of Cooling, which states that the rate of cooling of an object is proportional to the temperature difference between the object and its surroundings (Winterton, R. H. S., 1999).

While this experiment explored important concepts related to heat transfer and Newton's Law of Cooling, these specific theoretical parts are not covered in the Class IX textbook. As a result, this experiment was not

aligned with the content of the textbook. Although it provides valuable practical insight into heat transfer mechanisms, the absence of this topic from the textbook limits the direct connection between the practical and theoretical components.

4.1.2: Class-X Science

The prescribed secondary science textbook of Mizoram Board of School Education, Mizoram, published by Arya Publishing Company written by R.R. Mishra, Neetu Sing, Yash Pal and Joginder Singh is presently used for class X in Mizoram. This textbook is organized into sixteen chapters, encompassing five chapters on physics, five on chemistry, and six on biology. The current science practical guide book used for class X is the “New Experimental Skills in Science - X” containing 15 experiments which is prescribed by Mizoram Board of School Education published by Geeta Publishing House, Pragati Complex, Idgah Chowk, Delhi–110006.

Analysis of linkages between theory and practical

The list of textbook chapters and their associated experiments were provided in the table below. The linkage analysis was done based on the chapterisation given in the prescribed science textbook as follows:

Table 4.1.2 : Chapters in class X science textbook and their corresponding experiments.

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
Chapter 1 Light-Reflection and Refraction	Exp.no 1 (A): To determine the focal length of a concave mirror by obtaining the image of a distant object.	Spherical mirror	Aligned
	Exp.no 1 (B): To determine the focal length of a convex mirror by obtaining the image of a distant object	Spherical mirror	

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
	Exp.no 2: To trace the path of light through a rectangular glass slab and measure the angle of incidence and the angle of emergence.	Refraction of light	Aligned
Chapter 2 The Human Eye and the Colourful World	Nil		NA
Chapter 3 Electricity	Exp.no 6: To study the dependence of current (I) on the potential difference (V) across a resistor and to determine its resistance. Also plot a graph between V and I.	Ohm's Law	Aligned
	Exp.no 11: To determine the equivalent resistance of two resistors connected in series.	Resistance of a system of resistors	Aligned
	Exp.no 12: To determine the equivalent resistance of two resistors connected in parallel.	Resistance of a system of resistors	Aligned
Chapter 4 Magnetic Effects of Electric Current	Nil		NA
Chapter 5 Sources of Energy	Nil		NA
Chapter 6 Periodic Classification of Elements	Nil		NA
Chapter 7 Chemical Reactions and Equations	Nil		NA
Chapter 8 Metals and Non-metals	Exp.no 4: To observe the action of Zn, Fe, Cu and Al metals.	Chemical properties of metals	Aligned

Chapter No and name	Related experiments	Name of Sub-topic	Alignment of Theory & Practical
Chapter 9 Acids, Bases and Salts	Exp.no.7(A): To study the properties of an acid (dilute HCl).	The pH scale	Aligned
	Exp.no.7(B): To study the properties of a base.	The pH scale	
	Exp.no.8: To study the following properties of acetic acid CH_3COOH	Properties of Acids	Aligned
	Exp.no.13: To find the pH of the given samples using pH paper	The pH scale	Aligned
Chapter 10 Carbon and Its Compounds	Nil		NA
Chapter 11 Life Processes	Exp.no 9: To show experimentally that carbon dioxide is given out during respiration.	Respiration	Aligned
	Exp.no 14: To show experimentally that light is necessary for photosynthesis.	Photosynthesis	Aligned
Chapter 12 Control and Coordination	Nil		NA
Chapter 13 How do Organisms Reproduce?	Exp.no 10: To study (a) Binary Fission in Amoeba (b) Budding in Yeast with the help of a prepared slide.	Reproduction	Aligned
Chapter 14 Heredity and Evolution	Nil		NA
Chapter 15 Our Environment	Nil		NA
Chapter 16 Management of Natural Resources	Nil		NA

The data depicted vide table no. 4.1.1 showed that nine chapters i.e. more than half of the chapters (i.e 10 out of 16 chapters) lacked practical support or experimental activities. From physics section, three chapters were without prescribed practical. viz.- Chapter 2: The Human Eye and the Colourful World, Chapter 4: Magnetic Effects of Electric Current and Chapter 5: Sources of Energy. From chemistry section, three chapters namely - Chapter 6: Periodic Classification of Elements, Chapter 7: Chemical Reactions and Equations and Chapter 10: Carbon and Its Compounds were without practical. The biology section has six chapters, out of which four chapters have no prescribed practical. The four chapters without practical were- Chapter 12: Control and Coordination, Chapter 14: Heredity and Evolution, Chapter 15: Our Environment and Chapter 16: Management of Natural Resources. The data shown in table No. 4.1.1 also revealed that 13 experiments out of 15 have proper linkage with the theoretical content of the science textbook with three experiments viz. experiment No. 3 (To prepare SO₂ gas), experiment No. 5 (To prepare the temporary mount of a leaf peel to show its stomata) and experiment No. 15 (To determine the percentage of water absorbed by raisins) had no linkages with any chapters in the textbook.

The linkages between theoretical content and practical for class X science were further analysed as follows:

Chapter 1: Light-Reflection and Refraction

This chapter explored the principles of light, including how it converges and diverges, as well as the formation of images using mirrors and lenses. It also discussed key applications of spherical mirrors and lenses in daily life, such as in telescopes and eyeglasses. Additionally, the chapter explained fundamental concepts like refraction and reflection, detailing how light bends when passing through different media and how surfaces reflect light waves.

Related experiments:

Exp.no 1 (A) : To determine the focal length of a concave mirror by obtaining the image of a distant object.

Exp.no 1 (B) : To determine the focal length of a convex mirror by

obtaining the image of a distant object

Exp.no 2 : To trace the path of light through a rectangular glass slab and measure the angle of incidence and the angle of emergence.

The main objectives of Exp. no. 1(a) and 1(b) is to determine the focal lengths of concave and convex mirrors by capturing the image of a distant object on a screen, such as a white sheet of paper. By conducting these experiments, students will gain practical insights into the concepts they've studied in class, such as the types of mirrors, their unique properties, and related principles of reflection and refraction. The hands-on experience of measuring focal lengths not only reinforces their theoretical understanding but also helps in visualizing abstract ideas, making them more concrete and easier to grasp. These practical exercises serve as a crucial bridge between theory and application, enhancing students' comprehension of the behaviour of concave and convex mirrors. Through these experiments, students can see the real-world application of the concepts they've learned, solidifying their knowledge and fostering a deeper understanding of the subject matter.

The focus of experiment no 2 is to trace the path of light through a rectangular glass slab and measuring the angle of incidence and the angle of emergence. Using the glass slab, students will observe how a light ray bends as it transitions from one medium to another. Students will be able to explore the relationship between the angle of incidence, the refracted ray, and the angle of emergence, governed by the Laws of Refraction, also known as Snell's Law. This hands-on experiment is a practical application of the theoretical concepts covered in the classroom. It enables students to visualize and better understand how light behaves when it passes through different mediums. By directly measuring the angles involved, students can see how the abstract principles of light refraction apply in a real-world context, making these concepts more accessible and easier to grasp.

Chapter 2: The Human Eye and the Colourful World

The chapter examined the structure and function of the human eye, including its ability to adjust focus, known as the power of accommodation. It also covered vision defects and corrective measures. Furthermore, it delved into optical phenomena such as the refraction of light through a prism, dispersion into a spectrum of colours, and the scattering of light, which explains why the sky appears blue.

Related experiments:

Exp.no 2 : To trace the path of light through a rectangular glass slab and measure the angle of incidence and the angle of emergence.

The focus of experiment no 2 is to trace the path of light through a rectangular glass slab and measuring the angle of incidence and the angle of emergence. Using the glass slab, students will observe how a light ray bends as it transitions from one medium to another. Students will be able to explore the relationship between the angle of incidence, the refracted ray, and the angle of emergence, governed by the Laws of Refraction, also known as Snell's Law. This hands-on experiment is a practical application of the theoretical concepts covered in the classroom. It enables students to visualize and better understand how light behaves when it passes through different mediums. By directly measuring the angles involved, students can see how the abstract principles of light refraction apply in a real-world context, making these concepts more accessible and easier to grasp.

Chapter 3: Electricity

Focusing on electricity, this chapter introduced essential concepts like electric current, charge, and Ohm's Law, which relates voltage, current, and resistance. It also explained electrical power and resistance, along with practical calculations involving these quantities. Real-world

applications, such as household wiring and circuit design, were discussed to illustrate these principles.

Related experiments:

Exp.no 6 :To study the dependence of current(I) on the potential difference(V) across a resistor and to determine its resistance. Also plot a graph between V and I.

Exp.no 11 :To determine the equivalent resistance of two resistors connected in series.

Exp.no 12 :To determine the equivalent resistance of two resistors connected in parallel.

Experiment No. 6 focused on exploring the relationship between current (I) and potential difference (V) across a resistor. The main objective of this experiment is to verify Ohm's Law, which states that the potential difference (V) across the ends of a conductor is directly proportional to the current (I) flowing through it. By conducting this experiment, students will gain a deeper understanding of Ohm's Law and related concepts, such as the calculation of resistance. They will also develop practical skills in taking accurate readings using an ammeter and voltmeter. In addition to verifying Ohm's Law, students will plot a graph between V and I, which should result in a straight line if the conductor obeys Ohm's Law. This graphical representation reinforces the linear relationship between voltage and current, making the abstract principles more concrete. This experiment is well-aligned with the theoretical content of the textbook, providing students with a hands-on opportunity to apply what they've learned in class. It not only solidifies their understanding of key electrical concepts but also enhances their ability to work with electrical measuring instruments.

Experiments No. 11 and 12 focused on determining the equivalent resistance of two resistors when connected in series and parallel, respectively. These experiments provide students with practical experience in understanding circuit diagrams, setting up and operating

circuits, and accurately taking readings using an ammeter and voltmeter. These experiments correspond to the content in the textbook, where students learn about the resistance of a system of resistors and the laws governing the combination of resistances in series and parallel circuits. By performing these experiments, students can reinforce their theoretical knowledge with hands-on practice, helping them to better understand how resistors behave in different circuit configurations. These experiments are clearly aligned with the textbook's theoretical content, offering students a valuable opportunity to apply and deepen their understanding of electrical circuits and resistance.

Chapter 4: Magnetic Effects of Electric Current

This section studied magnetic fields and how electric currents produce them, including the force exerted on current-carrying conductors in magnetic fields. It explained the working principles of electric motors and generators, along with the differences between alternating current (AC) and direct current (DC). The chapter also touched on electromagnetic induction and the distribution of domestic electricity.

Related experiment: No prescribed practical for the chapter

Chapter 5: Sources of Energy

The chapter categorized energy sources into conventional (like thermal power and hydroelectricity) and non-conventional (such as solar, wind, and tidal energy). It also examined the environmental impacts of energy exploitation, including pollution from fossil fuels and the benefits of renewable alternatives like biogas and nuclear energy.

Related experiment: No prescribed practical for the chapter

Chapter 6: Periodic classification of elements

This section traced the historical development of the periodic table, from early classification attempts to Mendeleev's periodic law and the modern periodic table. It highlighted trends in atomic properties, such as

electronegativity and atomic radius, and explained the long-form arrangement based on atomic numbers.

Related experiment: No prescribed practical for the chapter

Chapter 7: Chemical reactions and equations

Covering various types of chemical reactions, this chapter included combination, decomposition, displacement, and redox reactions. It also explained precipitation and neutralization reactions, along with real-life examples like rusting (oxidation) and acid-base reactions. The effects of oxidation in daily processes, such as food spoilage, were also discussed.

Related experiments: No prescribed practical for the chapter

Chapter 8: Metals and Non metals

The chapter differentiated between metals and non-metals, detailing their chemical properties and reactions, including ionic bonding. It also explored metallurgy, the extraction of metals from ores, and the significance of alloys in enhancing material properties for industrial use.

Related experiment:

Exp.no 4: To observe the action of Zn, Fe, Cu and Al metals.

In Experiment No. 4, students will observe how zinc (Zn), iron (Fe), copper (Cu), and aluminium (Al) react when placed in solutions of ZnSO_4 , FeSO_4 , CuSO_4 , and $\text{Al}_2(\text{SO}_4)_3$. The aim of the experiment is to arrange these metals in decreasing order of reactivity based on the observed results. By conducting this experiment, students can practically explore the reactivity of different metals and see the displacement reactions in action. This hands-on experience reinforces the theoretical concepts covered in the textbook, making the principles of metal reactivity and chemical reactions more tangible and easier to understand. The experiment effectively supports and extends the textbook content, helping students to deepen their grasp of these important chemical concepts.

Chapter 9: Acids, bases and salts

This section defined acids and bases, explaining their chemical properties and reactions, including neutralization. It introduced the pH scale and its importance in agriculture, medicine, and daily life. The chapter also discussed the formation of salts, their sources (like common salt), and the concept of water of crystallization.

Related experiments:

Exp.no.7(A) : To study the properties of an acid (dilute HCl).

Exp.no.7(B) : To study the properties of a base.

*Exp.no.8 :To study the following properties of acetic acid
CH₃COOH*

Exp.no.13 : To find the pH of the given samples using pH paper

Experiments No. 7(A) and 7(B), along with Experiment No. 8, are designed to explore the properties of acids and bases, focusing on physical properties such as odour, solubility, and the effect on litmus paper. These experiments also involve observing the reactions of dilute HCl with sodium carbonate, dilute NaOH with HCl, and CH₃COOH with sodium bicarbonate. Through these activities, students can witness first hand the characteristic reactions of acids and bases. Experiment No. 13 further complemented experiment no 7 and 8 by focusing on determining the pH of various samples or solutions using pH paper or a universal indicator. Students will observe the colour changes, measure the pH values, and determine the nature of the samples— whether they are acids, bases, or salts. All these experiments are drawn from the theoretical concept of the topic “Acids, Bases and Salts”. By conducting these experiments, students could better understand the properties of acids, bases, and salts, as well as the concept of pH, enhancing their comprehension of the subject matter. These hands-on activities serve as practical applications of the concepts covered in the classroom, making the abstract ideas more tangible and easier to comprehend.

Chapter 10: Carbon and its compounds

The chapter covered a series of concepts on carbon and its related compounds. The sub-topics include bonding in carbon compounds, allotropy, formation of covalent bond by carbon atom, hydrocarbons, functional groups, IUPAC system of nomenclature of organic compounds, nomenclature of alkenes, types of structural isomerism, chemical properties of carbon compounds, ethanol and ethanoic acids and soaps and detergents.

Related experiment: No prescribed practical for the chapter

Chapter 11: Life processes

The chapter detailed essential biological processes such as photosynthesis in plants, nutrition in unicellular and multicellular organisms, and human digestion. It also explained respiration, circulatory systems, and excretory mechanisms, emphasizing how living organisms maintain life.

Related experiments:

Exp.no 9 :To show experimentally that carbon dioxide is given out during respiration.

Exp.no 14 :To show experimentally that light is necessary for photosynthesis.

Experiment No 9 aimed to show that carbon dioxide (CO_2) is released during respiration. It involves studying the process of respiration, specifically how air is inhaled and how CO_2 is exhaled, which can be demonstrated by the way it turns lime water milky. This visual change provides evidence that CO_2 is present in the exhaled air, providing students with a clearer understanding of the concept of respiration. It effectively illustrates the theoretical concepts discussed in class, making the process of respiration more tangible and easier to grasp. However, one critique of this experiment is that while it generally confirms the release of CO_2 by the turning of lime water milky, the consistency of this result might vary, leading to occasional uncertainty in the demonstration.

Despite this, the experiment remains a valuable and relevant exercise for reinforcing the textbook content.

The experiment No 14 intended to show experimentally that light is essential for photosynthesis. It involves demonstrating how plants use light to manufacture their own food (glucose) through the biochemical process of photosynthesis. In this experiment, students will observe how plants require light to perform photosynthesis, which involves using carbon dioxide and water to produce glucose and oxygen, with the help of chlorophyll. The experiment typically involves comparing the results of photosynthesis in plants exposed to light with those kept in darkness, highlighting the critical role of light in this process. By aligning closely with the textbook content, this experiment reinforces students' understanding of how plants synthesize their food and the importance of light in this fundamental biological process. Therefore the experiment effectively supports and illustrates the theoretical concepts from the textbook, providing a practical demonstration of the role of light in photosynthesis and deepening students' comprehension of this essential life process.

Chapter 12: Control and coordination

This section explored the nervous system in animals, including the human brain's functions, and compared it with plant coordination through hormones and tropic movements. It highlighted how organisms respond to stimuli for survival.

Related experiment: No prescribed practical for the chapter

Chapter 13: How do organisms reproduce?

The chapter discussed both asexual and sexual reproduction, covering reproductive health topics like family planning, women's health, and sexually transmitted infections (STIs), including HIV/AIDS. It emphasized the biological and social aspects of reproduction.

Related experiment:

Exp.no 10 : To study (a) Binary Fission in Amoeba (b) Budding in Yeast with the help of a prepared slide.

These experiments focused on observing two types of asexual reproduction: binary fission in amoeba and budding in yeast, using prepared slides. By studying these processes, students will gain insights into how different organisms reproduce without the involvement of gametes.

(a) Binary Fission in Amoeba: Students will observe how an amoeba divides into two identical daughter cells through a process where the nucleus and cytoplasm split, resulting in two separate organisms. This observation helps illustrate the concept of simple cell division in unicellular organisms.

(b) Budding in Yeast: Students will examine how yeast cells reproduce by forming new individuals from outgrowths or "buds" that eventually separate from the parent cell. This demonstrates a more complex form of asexual reproduction in unicellular fungi.

By directly observing these experimental processes, students can connect theoretical concepts with practical examples, deepening their understanding of the topic. In addition to reinforcing textbook content, this experiment helps students develop skills in microscopic observation and analysis. It provides a hands-on opportunity to see how asexual reproduction occurs in different organisms, bridging the gap between theoretical knowledge and real-world applications.

Chapter 14: Heredity and Evolution

Exploring genetic inheritance, this chapter explained evolutionary theories, the origin of life, and evidence supporting evolution, such as fossils and homologous structures. It also discussed methods for tracing evolutionary relationships among species.

Related experiment: No prescribed practical for the chapter

Chapter 15: Our environment

Focusing on ecosystems, this chapter addressed environmental challenges like pollution, ozone depletion, and waste management. It highlighted sustainable solutions, including reducing fossil fuel consumption and adopting eco-friendly practices.

Related experiment: No prescribed practical for the chapter

Chapter 16: Management of Natural resources

The final chapter stressed the importance of conserving natural resources like water, coal, and petroleum. It discussed global fossil fuel reserves, sustainable usage, and policies for equitable resource distribution to ensure long-term availability.

Related experiment: No prescribed practical for the chapter

Additionally, upon reviewing the list of experiments to be performed for Class X students, it was found that there are three more experiments apart from those already mentioned above. These three additional experiments had no linkages with any specific chapter in the Class X Science textbook but were more closely related to topics covered in the Class IX Science textbook. These experiments are-

1. *Exp.no 3: To prepare SO₂ gas.*

In Experiment No. 3, the aim is to prepare sulphur dioxide (SO₂) gas, observe its properties, and draw conclusions regarding its colour, solubility in water, effect on litmus paper, and its reaction with acidified potassium dichromate solution. This experiment provides a hands-on opportunity for students to learn how to handle laboratory equipment and set up apparatus correctly. Moreover, the experiment reinforces knowledge about the solubility of compounds, a topic already introduced in Class IX. However, the specific chemical reaction for preparing SO₂ using concentrated H₂SO₄ is not explicitly covered in the textbook. This could be seen as a gap, but still presents an excellent opportunity for students to explore and understand the process beyond the textbook, fostering curiosity and independent learning.

2. *Exp.no 5: To prepare the temporary mount of a leaf peel to show its stomata.*

Experiment No. 5 involves preparing a temporary mount of a leaf peel to observe the stomata. The primary focus of this experiment is to examine the epidermis of the leaf, specifically the stomata, which play a crucial role in the process of transpiration and gas exchange. This experiment is valuable for teaching students how to prepare a temporary mount and observe it under a microscope. It also provides a practical opportunity to learn the proper techniques for using and handling a microscope, enhancing their skills in microscopic observation. While the theoretical concepts related to stomata and leaf structures were covered in earlier classes, this experiment provides a hands-on approach that reinforces those earlier lessons. However, it does not align as closely with the current Class X textbook content, as the topic has already been introduced in previous years. Nonetheless, it remains a useful exercise for strengthening students' practical skills and deepening their understanding of plant biology.

3. *Exp.no 15 : To determine the percentage of water absorbed by raisins.*

This experiment focuses on determining the percentage of water absorbed by raisins. The underlying principle involves understanding the movement of water through processes like osmosis and endosmosis, and the effects of different types of solutions—such as hypotonic and hypertonic solutions—on the absorption process. In this experiment, students will immerse raisins in water and measure the change in their mass to determine how much water they absorb. This practical activity illustrates key concepts related to osmosis, including how water moves across cell membranes and the impact of different solution concentrations. While this is a valuable experiment for exploring osmotic principles, it's worth noting that the theoretical aspects related to osmosis and solution types were covered in class IX. As a result, these concepts may not be explicitly detailed in the current textbook but build on prior knowledge. The experiment thus provides a hands-on approach to understanding water absorption and osmotic processes, reinforcing previously learned concepts and offering practical experience with these important biological principles.

4.2. Objective No. 2: To analyse class period allotted for science practical in the weekly time table of the schools.

To analyse class periods allotted for science practical in the school weekly time table, the investigator collected school time tables from 100 high schools. The inclusion of practical class in the weekly time table is given in the following table no. 4.2.

Table No 4.2: Inclusion of practical period in the weekly time table.

		Inclusion of practical period in weekly time table	
		Yes	No
Overall (N=100)		19 (19%)	81 (81%)
Type of School Management	Government (n=45)	5 (11.11%)	40 (88.89%)
	Deficit (n=8)	3 (37.5%)	5 (62.5%)
	Samagra (n=15)	2 (13.3%)	13 (86.7%)
	Private (n=32)	9 (28.1%)	23 (71.9%)
Locality	Urban (n=68)	14 (20.59%)	54 (78.41%)
	Rural (n=32)	5 (15.6%)	27 (84.4%)

As depicted in table no. 4.2.1, out of 100 schools surveyed, only 19 schools incorporated practical periods in their weekly time table. On the other hand, 81 failed to include practical periods in their weekly time table. Among government schools, only 5 schools (11.11%) included science practical in their weekly time table, while the remaining 40 out of 45 schools (88.89%) did not include practical classes in the time table. Three deficit schools i.e. 37.5% out of 8 included science practical classes into their weekly time tables, while 5 deficit schools (62.5%) did not include in their time table. Out of 15 samagra schools surveyed, only two i.e. 13.2% included science practical classes, whereas 13 schools (71.9%) did not

include practical classes in their weekly timetable. Among private schools, only 9 schools (28.1%) included practical period and 23 schools (84.4%) failed to include practical period in their weekly time table.

Among the urban schools, only 14 (20.59%) out of 68 schools included science practical period in their weekly timetable, whereas the majority i.e. 78.41% schools did not practical classes in their weekly time table. Only 5 schools i.e. 15.6% out of 32 schools in rural area included science practical period in the school weekly time table. Majority of the rural schools i.e. 84.4% failed to include practical period in their weekly time table.

4.3. Objective No 3 : To study the implementation of prescribed science practical by secondary schools in Mizoram

To study the implementation of prescribed science practical in Class IX and Class X. A survey was conducted among 102 science teachers. The details are presented in table No. 4.3.1.

Table No 4.3.1 : List of Class IX science practical in physics portion and its implementation in the school

N=102

Sl. No.	Name of Experiment (Class IX)	No. of science teachers conducting practical	No. of science teachers not conducting practical
1	Laws of reflection of Sound.	9 (8.8%)	93 (91.2%)
2	Determination of density of Solid by using spring balance and a measuring cylinder.	6 (5.9%)	96 (94.1%)
3	Relation between the loss in weight of a solid when fully immersed in water with the weight of water displaced by it	9 (8.8%)	93 (91.2%)
4	Measuring the temperature of hot water as it cools and plot a temperature-time graph	16 (15.7%)	86 (84.3%)
5	Determining velocity of a pulse propagated through a stretched string/slinky	5 (4.9%)	97 (95.1%)

As shown in Table 4.3.1, out of 102 science teachers surveyed, only 9 i.e. 8.8% teachers conducted physics experiment 'Laws of reflection of sound' while majority of the teachers i.e. 91.2% failed to conduct the experiment. The experiment on 'Determination of density of Solid by using spring balance and a measuring cylinder' was conducted by only 6 (5.9%) science teachers (5.9%), and the majority, 96 (94.1%), science teachers did not conduct the experiment. With regard to the experiment on 'Determination of relation between the loss in weight of a solid when fully immersed in water with the weight of water displaced by it' was conducted by 9 (8.8 %), science teachers while 93 (91.2%) science teachers

failed to conduct the experiment. Out of 102 science teachers, 16 teachers i.e 15.7% conducted the experiment on ‘Measuring the temperature of hot water as it cools and plot a temperature-time’, while the remaining 86 (84.3%) did not conduct the experiment. The experiment ‘Determining the velocity of a pulse propagated through a stretched string/slinky’ was conducted only by 4.9 % of science teachers while 95.1 % failed to conduct the experiment.

Table No 4.3.2 : List of Class IX science practical in chemistry portion and its implementation in the school

N=102

Sl. No.	Name of Experiment (Class IX)	No. of science teachers conducting practical	No. of science teachers not conducting practical
1.	Preparation of different types of solution	25 (24.5%)	77 (75.5%)
2.	Differentiation between mixture & pure compound	24 (23.4%)	78 (76.6%)
3	Carrying out chemical reactions on given compounds	6 (5.9%)	96 (94.1%)
4	Separation of components of a mixture of Sand, Common Salt and Ammonium Chloride (or camphor) by sublimation.	10 (9.8%)	92 (90.2%)
5	Determination of melting point of a ice and the boiling point of water	10 (9.8%)	92 (90.2%)

As depicted in table No. 4.3.2, the experiment on ‘Preparation of different types of solution’ was conducted by 25 science teachers i.e. 24.5%, while the majority, 77 i.e. 75.5%, did not conducted the experiment. With regard to the experiment on ‘Differentiation between mixture & pure compound’, 24 (23.4%) science teachers conducted the experiment, whereas 76.6% failed to conduct the experiment. The experiment on ‘Carrying out chemical reactions on given compounds’ was conducted only by 6 (5.9%) science teachers out of 102 teachers, while the remaining 96 (94.1%) science teachers did not conducted the experiment.

The experiment on ‘Separation of components of a mixture of Sand, Common Salt and Ammonium Chloride (or camphor) by sublimation’ was carried out by 10 (9.8%) science teachers (9.8%) whereas 92 (94.1%) science teachers failed to conduct the experiment. In the same way, only 10 (9.8%) teachers out of 102 conducted the experiment on ‘Determination of melting point of ice and the boiling point of water’, while the majority 92 (90.2%) teachers failed to conduct the experiment.

Table No 4.3.3: List of Class IX science practical in biology portion and its implementation in the school

N=102

Sl. No.	Name of Experiment (Class IX)	No. of science teachers conducting practical	No. of science teachers not conducting practical
1	Preparation of stained temporary mount of onion peel & human cheek cells	9 (8.8%)	93 (91.2%)
2	Identification of parenchyma and sclerenchyma tissues in plants and identification of striped muscle fibres in animals and nerve cell (Neuron) from prepared slides	6 (5.9%)	96 (94.1%)
3	To test the presence of starch in a given sample of food	15 (14.7%)	87 (85.3%)
4	Studying the characteristics of (i) Spirogyra (ii) Moss or Fern (iii) Pinus (iv) An Angiospermic plant-Mustard and Onion;	6 (5.9%)	96 (94.1%)
5	Observation and drawing of the given specimens	11 (10.8%)	91 (89.2%)

Data vide table No 4.3.3 showed the list of experiments under biology section and its implementation rate. The experiment on ‘Preparation of stained temporary mount of onion peel & human cheek cells’ was carried out only by 9 (8.8%) science teachers, while the majority 93 (91.2%) did not conducted the experiment. Only 6 (5.9%) out of 102 science teachers conducted the experiment on ‘Identification of parenchyma and sclerenchyma tissues in plants and

identification of striped muscle fibres in animals and nerve cell (Neuron) from prepared slides’, whereas 96 (94.1%) science teachers failed to conduct the experiment. The experiment “To test the presence of starch in a given sample of food’ was conducted by 15 (14.7%) teachers, while 87 (85.3%) did not conducted the experiment. The experiment on ‘Studying the characteristics of spirogyra, moss or fern, pinus and angiospermic plant (mustard or onion’ was conducted only 5.9% of science teachers, while 94.1% did not conducted the experiment. With regard to the experiment on ‘Observation and drawing of the given specimens’, 11 teachers out of 102 (10.8%) conducted the experiment, while 91 science teachers (89.2%) failed to conduct the experiment.

Table No 4.3.4: List of Class X science practical in physics and its implementation rate in the school

N=102

Sl. No.	Name of Practical (Class X)	No of science teachers performing experiment	No of science teachers not able to perform experiment
1	Determination of focal length of concave mirror	26 (25.5%)	76 (74.5%)
2	Determination of focal length of convex mirror	23 (22.5%)	79 (77.5%)
3	Tracing the path of a ray of light through a rectangular glass slab and measure the angle of incidence and angle of emergence	87 (85.3%)	15 (14.7%)
4	Resistance of two resistors connected in series	5 (4.9%)	97 (95.1%)
5	Resistance of two resistors connected in parallel	6 (5.88%)	96 (94.1%)

Table 4.3.4 highlighted data on the implementation of Class X science practical in physics, showing the number of science teachers who conducted each experiment and those who did not. The experiment on ‘Determination of the focal length of a concave mirror’ was conducted by 26 i.e. 25.5% science teachers while,

76 i.e. 74.5% science teachers did not conducted the experiment. A similar trend was observed in the experiment on ‘Determination of the focal length of a convex mirror’, with just 23 teachers (22.5%) conducted the experiment and 79 (77.5%) failed to conduct the experiment. With regard to the experiment on ‘Tracing the path of a ray of light through a rectangular glass slab and measuring the angles of incidence and emergence’ was conducted by 87 science teachers (85.3%) and only 15 (14.7%) science teachers failed to conduct the experiment. On the other hand, the experiment on ‘The resistance of two resistors connected in series’ was carried out only by 5 (4.9%) science teachers, while 97 (95.1%) did not conducted the experiment. Similarly, the experiment on ‘Resistance of two resistors connected in parallel’ was conducted by 6 (5.88%) science teachers while 96 (94.1%) science teachers failed to conduct the experiment.

Table No 4.3.5: List of Class X science practical in chemistry and its implementation rate in the school

N=102

Sl. No.	Name of Practical (Class X)	No of science teachers performing experiment	No of science teachers not able to perform experiment
1	Experiment on pH test	102 (100%)	0 (0%)
2	Studying the properties of acids and bases	78 (76.5%)	24 (23.5%)
3	Preparation of Sulphur dioxide (SO ₂) gas and observation of its properties	9 (8.82%)	93 (91.2%)
4	Observation of action of Zn, Fe, Cu and Al metals	10 (9.8%)	92 (90.2%)
5	Studying the properties of acetic acid	49 (48 %)	53 (52%)

As shown in table No. 3.4.5, the experiment on ‘pH test’ was conducted by all 102 (100%) science teachers surveyed. The experiment on ‘Studying the properties of acids and bases’ was carried out by 78 science teachers (76.5%), while 24 (23.5%) did not conducted the experiment. The experiment on ‘Preparation of sulphur dioxide (SO₂) gas and observation of its properties’ was conducted by only 9 science teachers (8.82%), with 93 (91.2%) failed to conduct the experiment. Similarly, the experiment on ‘Observation of action of Zn, Fe, Cu, and Al metals’, was conducted by only 10 teachers (9.8%), while 92 (90.2%) did not conducted the experiment. With regards to the experiment on ‘Studying the properties of acetic acid’, the experiment was conducted by 49 i.e. 48% science teachers, while a nearly equal number, 53 science teachers i.e. 52% failed to conduct the experiment.

Table No 4.3.6: List of Class X science practical in biology and its implementation rate in the school

N=102

Sl. No.	Name of Practical (Class X)	No of science teachers performing experiment	No of science teachers not able to perform experiment
1	Preparation of a temporary mount of a leaf peel to show stomata	40 (39.2%)	62 (60.8%)
2	Photosynthesis experiment	18 (17.6%)	84 (82.4%)
3	Experiment on respiration	35 (34.3%)	67 (65.7%)
4	Studying binary fission in Amoeba & Yeast with the help of prepared slide.	35 (34.3%)	67 (65.7%)
5	Determination of the percentage of water absorbed by raisins.	20 (19.6%)	82 (80.4%)

As depicted in table No. 4.3.6, the experiment on ‘Preparation of a temporary mount of a leaf peel to show stomata’ was conducted by 40 science teachers i.e 39.2%, while 62 (60.8%) failed to conduct the experiment. The

photosynthesis experiment was carried out by only 18 (17.6%) science teachers and majority 84 (82.4%) science teachers failed to conduct the experiment. The experiment on respiration, was conducted by 35 (34.3%) science teachers, while 67 (65.7%) did not conducted the experiment. The same pattern was observed in the experiment on 'Studying binary fission in Amoeba & Yeast with the help of prepared slide, where 35 science teachers i.e. 34.3% conducted the experiment, while 67 (65.7%) failed to conduct the experiment. The experiment on 'Determination of the percentage of water absorbed by raisins' was conducted by 20 (19.6%) science teachers while 82 (80.4%) science teachers did not conducted the experiment.

4.4. Objective No. 4: To study the relationship between the achievement of students in theory and practical.

The correlation between achievement of secondary school students in science theory and science practical was analysed by using Pearson product moment correlation. Comparison of last five year result of HSLC under Mizoram Board of School Education was done and shown in table no. 4.4

Table 4.4: Analysis of five years HSLC result of MBSE in science subject

Year	N	Average Theory marks	Average Practical marks	Co- efficient of correlation between Theory & Practical
2019	17989	28.06 (40.08%)	7.61 (76.1%)	0.54
2020	18594	25.21 (36.01%))	7.77 (77.7%)	0.53
2021	18738	31.06 (44.37%)	7.96 (79.6%)	0.58
2022	18357	29.54 (42.2%)	7.87 (78.7%)	0.56
2023	18708	26.99 (38.55%)	8.12 (81.2%)	0.52
Total	92386	28.17 (40.24%)	7.86 (78.6%)	0.54

**Values in the bracket indicate percentage of average mark from the total mark i.e 70 for theory and 10 for practical*

From table No. 4.4, it was shown that the average marks in science theory in the year 2019 was 28.06 i.e.40.08% while the mean in the practical was 7.61 i.e. 76.1%. In 2020, the average mark in theory was 25.21 (36.01%) while the average mark in practical was 7.77 (77.7%). The average mark in theory and practical in 2021 was 31.06 (44.37%) and 7.96 (79.6%) respectively. Again, in the year 2022, the average mark in theory and practical was 29.54 (42.2%) and 7.87 (79.6%) respectively. Moreover, the average marks in science theory in the year 2023 was

26.99 i.e. 38.55% of the total theory marks while the mean in the practical was 8.12 i.e. 81.2% of the total practical mark

Over the past five years, a moderately positive correlation was observed between practical and theory marks. The coefficient of correlation between theory and practical marks in HSLC science subject in 2019 was 0.54, 0.53 in 2020, 0.58 in 2021, 0.56 in 2022, and 0.51 in 2023. The correlation coefficients indicated that students who performed well in theory also performed well in practical examinations.

Fig No 1: Five years average marks of theory

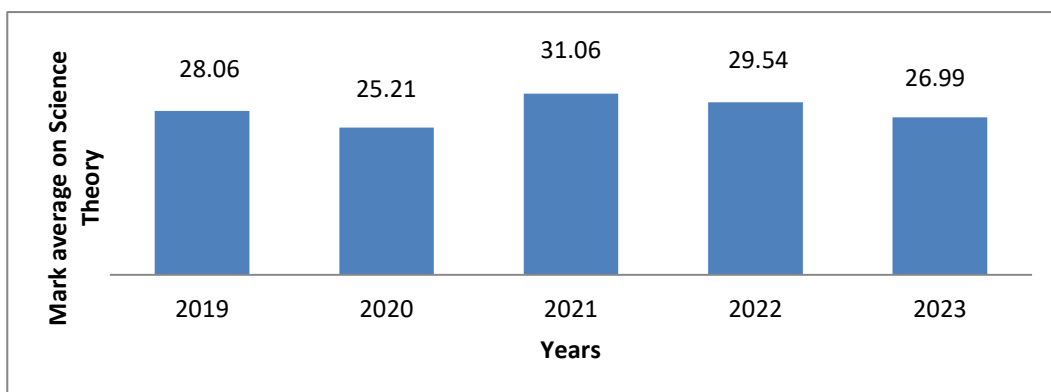
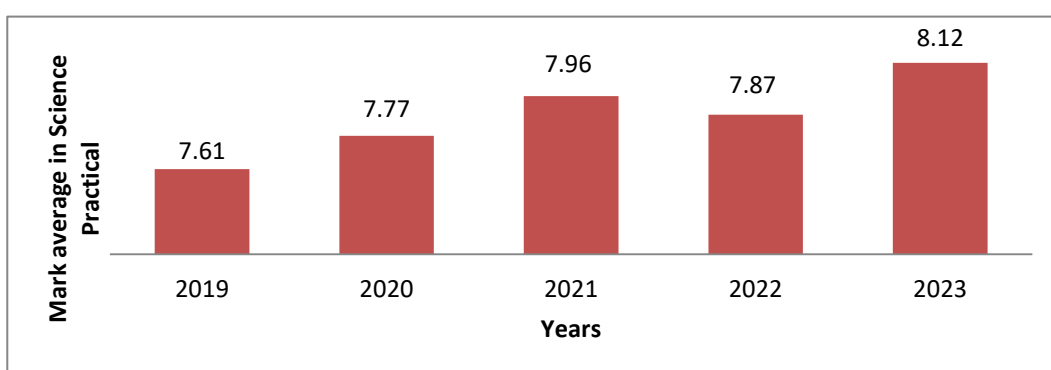


Fig No. 2: Five years average marks of practical



4.5. Objective No 5: To analyse the profile of science teachers teaching science subject in secondary schools of Mizoram.

In order to analyse the profile of science teachers, different attributes of teachers like educational and professional qualifications, nature of appointment, and teaching experience of science teachers across different types of school management—government school, deficit school, samagra school, and private schools were tabulated as follows

Table 4.5: Profile of science teachers

		Type of School Management				Total (N=102)
		Government School (n=47)	Deficit School (n=8)	Samagra School (n=15)	Private School (n=32)	
Educational Qualification	M.Sc.	18 (38.3%)	7 (87.5%)	9 (60%)	13 (40.6%)	47 (46.1%)
	B.Sc.	29 (61.7%)	1 (12.5%)	6 (40%)	15 (46.9%)	51 (50.0%)
	B.E	0 (0.0%)	0 (0.0%)	0 (0.0%)	3 (9.4%)	3 (2.9%)
	Others	0 (0.0%)	0 (0.0%)	0 (0.0%)	1 (3.1%)	1 (1.0%)
Professional Qualification	M.Ed.	1 (2.1%)	0 (0.0%)	1 (6.7%)	0 (0.0%)	2 (2.0%)
	B.Ed.	46 (97.9%)	7 (87.5%)	14 (93.3%)	11 (34.4%)	78 (76.5%)
	D.El.Ed.	0 (0.0%)	1 (12.5%)	0 (0.0%)	1 (3.1%)	2 (2.0%)
	None	0 (0.0%)	0 (0.0%)	0 (0.0%)	20 (62.5%)	20 (19.6%)
Nature of appointment	Regular	45 (95.7%)	8 (100%)	0 (0.0%)	0 (0.0%)	53 (52%)
	Contract	2 (4.3%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	2 (2%)
	CSS	0 (0.0%)	0 (0.0%)	15 (100%)	0 (0.0%)	15 (14.7%)
	Private	0 (0.0%)	0 (0.0%)	0 (0.0%)	32 (100%)	32 (31.4%)
Teaching experience	10 years and below	19 (40.4%)	4 (50%)	12 (80%)	28 (87.5%)	63 (61.8%)
	11 to 20 years	18 (38.3%)	3 (37.5%)	3 (20%)	4 (12.5%)	28 (27.5%)
	21 years and above	10 (21.3%)	1 (12.5%)	0 (0.0%)	0 (0.0%)	11 (10.8%)

As depicted in table no. 4.5, the educational qualification, professional qualification, employment status and teaching experience of science teachers across different type of schools was shown. Out of 102 teachers, 47 i.e. 46.1% possessed M.Sc. degree, 51 (50%) with B.Sc., 3 (2.9) with B.E. and 1 (1%) with B.A. degree. Among government schools, 38.3% science teachers possessed M.Sc degree and 61.17% with B.Sc. degree. There were no science teacher with educational background from the field of engineering and arts in government schools. Out of 8 science teacher from deficit schools, 7 (87.5%) teachers were with M.Sc. degree and only 1 (12.5%) teacher possessed B.Sc. degree. Out of 15 teachers from samagra schools, 60 % teachers have M.Sc. degree while the remaining 40% have B.Sc. degree. Out of 32 science teachers surveyed from private schools, 13 i.e. 40.6% of science teachers hold M.Sc. degree, 15 i.e. 46.9% with B.Sc. degree. 3 (9.4%) teachers of private school hold bachelor degree in Engineering and only 1 (3.1%) teacher having degree in Bachelor of Arts.

With regards to the professional qualification of science teachers, only 2 out of 102 teachers have M.Ed. degree and another 2 teachers have D.El.Ed. degree. Majority of science teachers 76.5% were B.Ed. degree holders while 20 (19.6%) teachers have no professional degree. 46 science teachers i.e. 97.9% from government schools have B.Ed. degree, 1 teacher having M.Ed. degree. Deficit schools have 7 science teachers (87.5%) with B.Ed. degree, 1 teacher having D.El.Ed. degree. Out of 15 science teachers from samagra schools, 14 teachers (93.3%) have B.Ed. degree and 1 teacher having M.Ed. degree. Among private schools, only 34.4% (11 science teachers out of 32) have B.Ed. degree, and only 1 teacher had D.El.Ed. Majority of the science teachers from private school comprising of 20 teachers (62.5%) do not have professional degree.

Table N0. 4.5 also shows the nature of appointment of science teachers from different schools. Majority of science teachers i.e 52% hold regular positions, 2 teachers with contract appointment, 15 (14.7%) teachers with CSS appointment and 32 (31.4%) with purely private appointment. Among government schools, 45 (95.7%) science teachers had regular appointment and the remaining 2 (4.3%) had

contractual appointment. All 8 teachers from deficit school were employed in regular mode. Similarly all 15 teachers from samagra schools were employed in co-terminus under centrally sponsored scheme. There are 32 teachers from private schools where all of them are employed privately.

Regarding the teaching experience, the majority of science teachers (61.8%) have 10 years or less of experience, while 27.5% have 11 to 20 years, and only 10.8% (11 teachers) had more than 21 years of experience. Among the 47 government school teachers surveyed, 40.4% (19 teachers) had less than 10 years of experience, 38.3% (18 teachers) have 11–20 years, and 21.3% (10 teachers) had over 21 years. In deficit schools, out of 8 teachers, 4 (50%) teachers had less than 10 years of experience, 37.5% (3 teachers) had 11–20 years of experience, and only one teacher (12.5%) with more than 21 years of experience. Among samagra school teachers, 80% (12 out of 15) had 10 years or less of experience, while the remaining 20% (3 teachers) have 11–20 years of experience. 28 out of 32 private school teachers have under 10 years of experience, and the remaining 12.5% (4 teachers) having 11–20 years of experience.

4.6. Objective No. 6: To study the challenges faced by science teachers in Mizoram.

Table No. 4.6: Challenges faced by science teachers

Challenges	Yes/ No	Govt. School (n=47)	Deficit School (n=8)	Samagra School (n=15)	Private School (n=32)	TOTAL (N=102)
Heavy theoretical content	Yes	8 (17%)	1 (12.5%)	3 (20%)	3 (9.4%)	15 (14.7%)
	No	39 (83%)	7 (87.5%)	12 (80%)	29 (90.6%)	87 (85.3%)
Challenges related to laboratory	Yes	18 (38.3%)	3 (37.5%)	11 (73.3%)	20 (62.5%)	52 (51%)
	No	29 (61.7%)	5 (62.5%)	4 (26.7%)	12 (37.5%)	50 (49%)
Challenges related to practical equipment	Yes	35 (74.5%)	3 (37.5%)	15 (100%)	25 (78.1%)	78 (76.5)
	No	12 (25.5%)	5 (62.5%)	0 (0%)	7 (21.9%)	24 (23.5%)
Challenges related to practical examination	Yes	7 (14.9%)	1 (12.5%)	3 (20%)	8 (25%)	19 (18.6%)
	No	40 (85.1%)	7 (87.5%)	12 (80%)	24 (75%)	83 (81.4%)
Challenges related to subject expertise	Yes	3 (6.4%)	0 (0%)	0 (0%)	8 (25%)	11 (10.8%)
	No	44 (93.6%)	8 (100%)	15 (100%)	24 (75%)	91 (89.2%)
Challenges related to finance	Yes	34 (72.3%)	4 (50%)	13 (86.7%)	15 (46.9%)	66 (64.7%)
	No	13 (27.7%)	4 (50%)	2 (13.3%)	17 (53.1%)	36 (35.3%)

The above table no. 4.6 shows various challenges faced by science teachers in different types of school management i.e. government, deficit, samagra, and

private schools. Issues related to issues related to theoretical content, problems related to science laboratory, problems related to availability of practical equipment, issues on practical examinations, subject expertise and financial problems.

As depicted in table No 4.6, out of 102 science teachers surveyed, only 15 (14.7%) science teachers across all school types reported issues regarding the theoretical content, while the remaining 87 (85.3%) faced no issue. Among different type of school management, 8 i.e. 17% science teachers from government schools faced issues relating to theoretical content while 39 (83%) teachers did not face issue. Only 1 teacher from deficit schools reported issues relating to the theoretical content and the remaining 7 teachers reported no issue. Out of 15 science teachers from samagra schools, only 3 (20%) reported issues related to theoretical content while majority of the teachers i.e. 80% reported having no issue. Out of 32 private school teachers, only 3 (9.4%) encountered difficulties in delivering theoretical material, whereas the other 29 had no problems.

Regarding the issues related to availability of science laboratory, out of 102 science teachers, 52 science teachers reported the availability of science laboratory was and 50 teachers reported the absence of science laboratory. Among teachers from different school management, 61.7% of science teachers from government schools, 62.5% from deficit schools, 26.7% from samagra schools and 37.5% teachers from private schools reported the availability science laboratory. On the other hand, the lack of a science laboratory was reported by 38.3% of government school teachers, 37.5% of deficit school teachers, 73.3% of samagra school teachers, and 62.5% of private school teachers.

Though science laboratory was reported available in schools by 52 teachers, 76.5% of science teachers reported the lack of adequate practical equipment while 23.5% out of 102 science teachers reported having adequate practical equipment. Only 12 (25.5%) out of 47 science teachers from government schools have adequate practical equipment while 35 i.e. 74.5% teachers reported insufficient practical equipment. Among Deficit schools, out of 8 teachers, 5 (62.5%) faced no issues and 3 i.e. 37.5% teachers faced problems regarding availability of practical equipment. 15 out of 15 teachers from samagra schools reported having no practical

equipment. Majority of teachers from private schools i.e. 76% reported issues related to practical equipment while only 24 schools faced no issues.

Table No. 4.6 also revealed that out of 102 teachers, 19 i.e. 18.6% reported issues related to practical examinations. Majority of the teachers i.e. 81.4% do not have issue relating to practical examinations. Among teachers from different school management, the issues related to practical examinations was reported by 14.9% of government school teachers, 12.5% of deficit school teachers, 20% of samagra school teachers, and 25% of private school teachers. On the other hand, 85.1% of science teachers from government schools, 87.5% from deficit schools, 80% from samagra schools and 75% teachers from private schools did not have issue related to practical examinations.

Only 10 teachers i.e. 10.8% reported issues related to subject expertise while majority of the teachers i.e. 89.2% reported no issue. Among different school types, 6.4% of government school teachers (3 out of 47) reported issues related to subject expertise while 93.6% of government school teachers do not have any issue. No teacher from deficit schools reported issues relating to subject expertise. At the same time, all 15 (100%) teachers from samagra schools reported no issues relating to subject expertise. Out of 32 private school teachers, 8 (25%) teachers encountered issues related to subject expertise while 24 (75%) teachers faced no problem.

As shown in Table 4.6, financial constraints was seen as an issue by 64.7% of science teachers, only 35.3% disregarded financial constraint as an issue. 72.3% of government school teachers, 50% from deficit schools, 86.7% from samagra schools, and 46.9% from private schools reported issues relating to financial constraint. On the other hand, 27.7% of government school teachers, 50% of deficit school teachers, 13.3% of samagra school teachers, and 53.1% of private school teachers reported that financial constraint is not an issue.

4.7. Objective No. 7: To construct and standardise teachers' perception scale towards science practical.

The researcher is interested in finding out the perception of science teachers towards science practical and no available scale is available in Mizoram to study the perception of science teachers towards science practical. Hence, the investigator decided to construct and standardised teachers' perception scale towards science practical.

Selection of items

In order to formulate the statements needed for measuring science teacher's perception, the investigator reviewed various perception scales, literature and books on the subject. After studying related scales, books, and literature, a preliminary draft comprising 43 statements was drafted. This thorough process aimed to incorporate a comprehensive range of statements that could accurately capture the genuine perception exhibited by secondary school science teachers. These items were prepared keeping in view different dimensions on perception related to understanding science practical, practical skills, execution of science practical, content of science practical at secondary level, and examination related issues in science practical at secondary level.

Content Validity:

Validity refers to the extent to which an instrument accurately measures what it is designed to measure and performs as intended. For the draft statements, content validity was evaluated by a panel of fifteen experts, including professionals with expertise in education and science education. These experts were responsible for both revising the draft statements and assessing their content validity. Based on the experts' feedback, revisions were made to the initial draft of the perception scale. Some statements were removed, new ones were added, and others were modified according to their recommendations. This process resulted in a preliminary draft of the perception scale containing 35 statements.

Try Out of the Scale:

The perception scale, comprising 35 items, was then prepared for try out. It was administered to 20 randomly selected secondary school science teachers. The purpose of the try out was to find out feasibility of the tool and to check if there are words that are difficult to comprehend. This try out was given to teachers mainly to find out the suitability of the items for the teachers. After modifying some words and making slight modification in grammar, the preliminary draft of the scale was ready for item discrimination.

Item Discrimination:

For item discrimination, the scale was administered to 100 science teachers. Scoring was done following Likert's five point scale. After scoring, all scores were arranged in ascending order, and the top 27% and bottom 27% of scores were identified for item analysis and discrimination purposes.

The mean and standard deviation for both groups were calculated and t test between the two groups were calculated for each statement. Statements with calculated t value 1.98 and above were retained with 95% confidence level. At the same time, statements with t-value below 1.98 were discarded. After this process, two statements were removed, resulting in a final perception scale with 33 statements for the final scale. The mean, standard deviation, and t-values (discrimination values) for the top and bottom groups for each statement are presented in Table No. 4.7.1 below.

Table No. 4.7.1 : Mean, standard deviation and t-value of high and low groups on different items of perception scale

Item No	High Group		Low Group		t-value	Level of Significance
	Mean	SD	Mean	SD		
1	4.22	0.64	3.82	0.67	2.25	*
2	3.33	1.11	2.32	0.72	3.97	**
3	4.07	0.78	3.50	0.75	2.76	**
4	4.33	0.48	3.39	0.88	4.90	**
5	4.41	0.50	3.61	0.92	3.98	**
6	4.70	0.47	3.93	0.81	4.30	**
7	4.59	0.50	3.75	0.75	4.85	**
8	4.41	0.50	3.61	0.67	4.53	**
9	4.93	0.27	4.11	0.88	4.65	**
10	4.70	0.47	3.86	0.45	6.81	**
11	4.85	0.36	4.07	0.72	5.05	**
12	4.70	0.61	4.21	0.50	3.23	**
13	4.59	0.57	3.82	0.61	4.78	**
14	4.78	0.42	3.93	0.47	7.01	**
15	4.89	0.32	4.04	0.33	9.62	**
16	4.63	0.49	3.79	0.69	5.19	**
17	4.26	0.98	3.18	0.98	4.04	**
18	4.74	0.53	3.89	0.88	4.32	**
19	4.89	0.32	4.04	0.51	7.38	**

Item No	High Group		Low Group		t-value	Level of Significance
	Mean	SD	Mean	SD		
20	4.78	0.42	4.00	0.27	8.03	**
21	4.67	0.48	4.04	0.33	5.62	**
22	4.67	0.48	3.86	0.45	6.40	**
23	4.81	0.40	4.04	0.74	4.80	**
24	4.81	0.40	4.00	0.61	5.83	**
25	4.63	0.49	4.11	0.42	4.12	**
26	4.74	0.45	3.93	0.38	7.21	**
27	4.74	0.45	3.86	0.65	5.82	**
28	3.26	1.32	2.89	0.92	1.19	N.S
29	4.37	0.88	3.96	0.96	1.62	N.S
30	4.89	0.32	4.11	0.74	5.05	**
31	3.22	1.28	2.18	0.86	3.51	**
32	3.15	1.26	1.93	0.81	4.22	**
33	3.22	1.31	1.93	0.54	4.74	**
34	4.70	0.47	3.89	0.42	6.75	**
35	4.78	0.42	3.86	0.45	7.75	**

*NS = not significant, * significant at 0.5 level, ** significant at 0.1 level*

Establishment of Reliability of the Scale:

Reliability of a tool is considered one of the most important qualities of a good measuring instrument. To determine the reliability of the newly constructed perception scale, the researcher used the 'test-retest' method. This involved administering the scale to science teachers twice, with a two-weeks interval between the tests. For the first test, the investigator administered the scale to 105 science teachers. After two weeks, the same scale was again administered to the same teachers. However, due to certain issues, only 101 teachers responded to the second test. Thus, a total of 101 secondary-level science teachers completed both tests. Their scores were carefully recorded and analysed statistically.

To evaluate the reliability of the perception scale, the reliability coefficient was calculated using the "Pearson product moment correlation" method, comparing the scores from the two tests. The reliability coefficient was found to be 0.82, indicating that the scale is sufficiently reliable. The test-retest scores of all 101 science teachers are presented in Table No. 4.7.2 below:

Table No 4.7.2 : Test-retest scores for determining the reliability of the perception scale

Sl.No	Score on first test	Score on second test	Sl.No	Score on first test	Score on second test
1	131	131	52	136	132
2	131	117	53	145	145
3	126	124	54	124	117
4	124	135	55	165	163
5	135	129	56	139	149
6	133	128	57	110	113
7	126	133	58	149	141
8	136	142	59	149	149

Sl.No	Score on first test	Score on second test	Sl.No	Score on first test	Score on second test
9	131	140	60	126	134
10	125	120	61	132	118
11	131	126	62	113	141
12	120	120	63	141	148
13	114	107	64	127	122
14	115	123	65	134	144
15	146	137	66	128	150
16	137	125	67	140	139
17	124	133	68	141	141
18	129	130	69	122	124
19	119	132	70	123	123
20	130	130	71	140	140
21	157	156	72	135	135
22	140	134	73	132	132
23	124	126	74	129	129
24	132	141	75	146	146
25	132	132	76	125	125
26	139	141	77	133	133
27	149	148	78	110	110
28	135	130	79	139	139
29	126	128	80	129	129
30	140	136	81	158	158
31	150	145	82	126	126
32	121	125	83	121	121
33	129	127	84	128	128
34	121	134	85	130	130

Sl.No	Score on first test	Score on second test	Sl.No	Score on first test	Score on second test
35	152	141	86	136	136
36	127	124	87	130	130
37	145	138	88	150	150
38	164	147	89	134	134
39	135	120	90	142	142
40	136	141	91	136	136
41	131	133	92	123	123
42	130	124	93	132	132
43	144	145	94	143	143
44	126	132	95	145	145
45	99	103	96	126	126
46	140	148	97	124	124
47	124	124	98	131	131
48	140	136	99	153	153
49	150	149	100	134	134
50	125	128	101	148	148
51	122	125			

To further establish the reliability of the perception scale, the researcher used 'Cronbach's alpha' and "Split-Half" method to establish internal consistency. The Cronbach's alpha for the science teacher's perception towards science practical was 0.902 which is considered highly acceptable (Taber K.S, 2018). For Split-Half method the responses from 101 science teachers were divided into two equal halves based on item numbers. Items with odd numbers were grouped together, and those with even numbers were grouped separately. The correlation coefficient between the two halves was calculated using the "Pearson product moment method," resulting in a coefficient of 0.88, indicating strong reliability.

The split-half scores of all 101 science teachers are presented in Table No. 4.7.3 as follows:

Table No. 4.7.3: Split scores for determining the internal validity of the perception scale

Sl.No	Score on 1st half	Score on 2nd Half	Sl.No	Score on 1st half	Score on 2nd Half
1	68	63	52	67	69
2	65	66	53	76	69
3	65	61	54	63	61
4	63	61	55	85	80
5	70	65	56	68	71
6	69	64	57	57	53
7	65	61	58	75	74
8	70	66	59	77	72
9	68	63	60	63	63
10	64	61	61	66	66
11	69	62	62	62	51
12	63	57	63	72	69
13	55	59	64	65	62
14	58	57	65	70	64
15	73	73	66	66	62
16	70	67	67	71	69
17	62	62	68	67	74
18	68	61	69	62	60
19	61	58	70	63	60
20	68	62	71	72	68
21	81	76	72	68	67
22	72	68	73	70	62
23	64	60	74	67	62
24	67	65	75	75	71
25	68	64	76	65	60

Sl.No	Score on 1st half	Score on 2nd Half	Sl.No	Score on 1st half	Score on 2nd Half
26	71	68	77	67	66
27	76	73	78	56	54
28	70	65	79	72	67
29	66	60	80	68	61
30	72	68	81	82	76
31	78	72	82	65	61
32	62	59	83	61	60
33	65	64	84	64	64
34	62	59	85	67	63
35	78	74	86	70	66
36	65	62	87	67	63
37	74	71	88	79	71
38	85	79	89	69	65
39	72	63	90	72	70
40	70	66	91	72	64
41	66	65	92	63	60
42	64	66	93	68	64
43	77	67	94	72	71
44	65	61	95	76	69
45	54	45	96	65	61
46	73	67	97	63	61
47	64	60	98	68	63
48	70	70	99	77	76
49	75	75	100	70	64
50	64	61	101	76	72
51	61	61			

Scoring Procedure:

The constructed scale is a five point scale and each statement has five possible responses viz. Strongly Agree, Agree, Undecided, Disagree, and Strongly Disagree and each statement was assigned values of 5, 4, 3, 2, and 1, respectively. With 33 statements in the scale, the maximum possible score is (33×5) 165, while the minimum score is (33×1) 33. The scoring procedure is detailed in Table 4.7.4 below.

Table No. 4.7.4 : Scoring procedure

Responses	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
Score	5	4	3	2	1

Norms and Interpretation of perception scale:

To establish norms for the current perception scale, the researcher administered the newly developed scale to 169 secondary school science teachers from various districts of Mizoram. The responses were scored according to the predefined procedure. For interpreting the scale, the researcher adopted stanine norms. To establish the norms for interpreting the scale, the investigator converted the raw score into z-score and then converts the standard score into stanine scale. The first three stanine grade 1, 2, and 3 indicates low perception towards science practical, the 4th, 5th and 6th stanine indicates average perception towards science practical and stanine grade 7, 8 and 9 indicates high perception towards science practical. The norms for interpretation of the score on teacher's perception towards science practical scale based on stanine is provided in the following table No. 4.7.5

Table No. 4.7.5: Norms for interpretation of perception based on stanine

Sl.No	Score range	Stanine Grade	Level based on stanine
1	86 & above	9	High Perception
2	80 to 85	8	
3	75 to 79	7	
4	69 to 74	6	Average Perception
5	64 to 68	5	
6	59 to 63	4	
7	53 to 58	3	Low Perception
8	48 to 52	2	
9	47 & below	1	

4.8. Objective No. 8: To find out the perception of secondary school science teachers toward science practical in Mizoram.

Table No. 4.8: Perception of secondary school science teachers toward science practical

Sl.No	Perception level	No of science teachers	Percentage
1	High Perception	20	19.6%
2	Average Perception	52	51%
3	Low Perception	30	29.4%

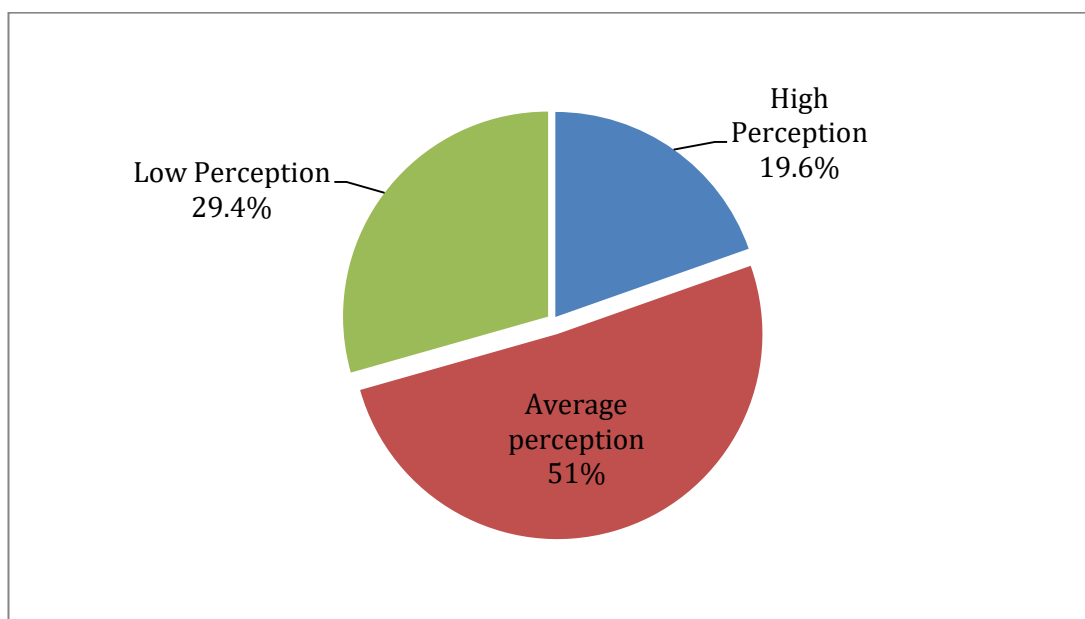


Fig. 3: Pie Chart showing perception of secondary school science teachers toward science practical.

The data vide table 4.8 shows the perception of secondary school science teachers in Mizoram towards science practical. The responses were categorized into three levels: High, Average and Low Perception. The data revealed that only 20 teachers i.e. 19.6% have a high perception, 52 (51%) teachers with average perception and 29.4% of teachers (30 out of 102) have low perception.

4.9. Objective No. 9: To compare the perception of secondary school science teachers towards science practical in relation to gender.

The present objective aimed to compare the perception of male and female secondary school science teachers toward science practical. The mean and standard deviation of the two groups were calculated separately. The mean difference of male and female teacher was tested by applying t-test and the details are presented in the following table No. 4.9.

H₀ 1 : There is no significant difference in the perception towards science practical between male and female science teachers

Table No. 4.9: Comparison of secondary school science teacher's perception towards science practical in relation to gender.

Gender	N	Mean	SD	t value	Level of Significance
Female	52	69.17	10.65	0.28	NS
Male	50	68.57	10.87		

Data analysis vide table 4.9 showed the mean perception score for female teachers (69.17) is slightly higher than for male teachers (68.57), with similar standard deviations (10.65 for females and 10.87 for males). However, the t-value of 0.28 indicates that the null hypothesis cannot be rejected, meaning that both male and female teachers did not differ in their perceptions level regarding science practical.

4.10. Objective No. 10: To compare the perception of secondary school science teachers towards science practical based on type of school management.

Comparison of teacher's perception towards science practical was also done based on the type of school management.

Classification of school management type: To compare the perception of science teachers towards science practical, the investigator identified four types of schools in based on their management type. They are, government school, deficit school, samagra school and private school. For comparison, the mean and standard deviation of the three age group were calculated and the mean difference were tested using ANOVA.

H₀ 2 : There is no significant difference in science teacher's perception towards science practical with reference to the type of school management.

Table No. 4.10: ANOVA table for mean comparison

Source of Variation	SS	df	MS	F- ratio	Level of Significance
Between Groups	248.36	3	82.78	0.676	N.S
Within Groups	11993.95	98	122.38		

Data depicted in table No. 4.10 showed the data analysed using ANOVA statistical technique. The sum of squares between groups and within groups was 248.36 and 11993.95 respectively. The mean square for between groups is 82.78 and within groups is 122.38. The F-ratio was found to be 0.676 which is not significant. Therefore, the null hypothesis "there is no significant difference in teachers' perceptions towards science practical across school management types cannot be rejected.

4.11. Objective No. 11: To compare the perception of secondary school science teachers towards science practical with reference to locale.

Comparison of teacher's perception towards science practical was also done with reference to locale.

H₀₃ : There is no significant difference in the perception towards science practical between rural and urban science teachers.

Table No. 4.11: Comparison of secondary school science teacher's perception towards science practical with reference to locale.

Locale	N	Mean	SD	t value	Level of Significance
Rural	32	67.06	12.5	0.95	NS
Urban	70	69.31	10.27		

The locality-based comparison between rural and urban teachers in table no. 4.9.3 showed that urban teachers have a slightly higher mean perception score (69.31) than rural teachers (67.06). However, the t-value of 0.95 remains statistically not significant. The null hypothesis stating "There is no significant difference in the perception of science practical between rural and urban science teachers." cannot be rejected, meaning that teachers from both rural and urban schools generally hold similar views about science practical.

CHAPTER -V

MAJOR FINDINGS, DISCUSSIONS, EDUCATIONAL IMPLICATIONS, RECOMMENDATIONS, SUGGESTIONS AND CONCLUSIONS

The present chapter deals with the major findings of the study and the discussions of the major findings. Educational implications and recommendations based on the findings are also presented in this chapter and the investigator suggested some topics for further research in this chapter.

5.1.0: MAJOR FINDINGS AND DISCUSSIONS

The major findings of the study are as follows:

5.1.1. To investigate the linkages between theoretical contents and prescribed practical of secondary school science subject in Mizoram

Findings on linkage between theoretical and practical content of class IX

Gaps in linkages between theory and practical contents in class IX physics were found. In class IX physics, important chapters like Force & Motion (Chapter 2) and Work & Energy (Chapter 4) were found to have no related experiment, while Chapter 3 (Gravitation and Floatation) had three related experiments from the prescribed practical. Alignment with theory cannot be clearly established for one experiment.

Theory and practical linkages was found in 2 chapters out of 4 chapters in chemistry section. It was also found that chapter 7 ‘Is Matter around us pure’ had five related experiments while Chapter 6 ‘Matter in Our Surroundings’ had one related experiment. However, Chapters 8 ‘Atoms & Molecules’ and chapter 9 ‘Structure of the Atom’ were found to had no related prescribed experiment.

In Biology section, the study found that 2 out of 6 chapters in Biology viz. Chapters 13 ‘Why Do We Fall Ill’ and chapter 14 ‘Natural Resources’ had no linkage with the prescribed practical. It was also found that chapters viz. chapter 10

‘Fundamental Unit of Life’, chapter 11 ‘Tissues’ and Chapter 12 ‘Diversity in Living Organisms’ had prescribed practical.

13 experiments out of 15 had linkage with the chapters in the textbook while 2 experiments had no linked chapters.

The study also revealed that the publishers for science textbook and practical manual for classes IX were different. Although the practical manual includes prescribed experiments covering all branches of science, there is no clear distinction between physics, chemistry, and biology experiments.

Findings on linkage between theoretical and practical content of class X

The study found that some chapters from physics chapters namely, Chapter 1 ‘Light’ and Chapter 3, ‘Electricity’ had related experiments Though, chapters like Chapter 2 ‘Human Eye’ Chapter 4 ‘Magnetism’ and Chapter 5 ‘Energy Sources’ had no prescribed practical.

It was also found that chemistry chapters viz. Chapters 8 ‘Metals & Non-Metals’ and chapter 9 ‘Acids, Bases & Salts’ had strongly aligned experiments, while Chapters 6 ‘Periodic Table’, Chapter 7 ‘Chemical Reactions’ and chapter 10 ‘Carbon Compounds’ had no prescribed practical. Among chapters under biology section, only two chapters viz. Life Processes Chapter 11 ‘Life Processes’ and Chapter 13 ‘How do Organisms Reproduce’ had prescribed experiments. It was also found that other chapters namely, Chapter 12 ‘Control & Coordination’, Chapter 14 ‘Heredity and Evolution’, Chapters 15 ‘Our Environment’ and chapter 16, ‘Management of Natural Resources’ had no prescribed experiments.

13 experiments out of 16 had linkage with the chapters in class X science textbook while 3 experiments had no link chapter.

The study further revealed that the publishers for science textbook and practical manual for classes X were different. Although the practical manual includes prescribed experiments covering all branches of science, there is no clear distinction between physics, chemistry, and biology experiments.

Discussions on findings related to findings on Theory-Practical linkages in secondary school Science

The findings of the present study revealed that the science textbook and the practical manual prescribed by the Mizoram Board of School Education (MBSE) were published by different publishers. This may be considered the main reason why there were some mismatching between theory and practical content of both class IX and class X science subject. A detail look into the findings also revealed that prescribed practicum for each branch of science viz. Physics, chemistry and biology are not in proportion. It was also found that while some chapters had more than one related prescribed practicum, some chapters did not have any prescribe practicum. As mentioned earlier, the reason behind this could be that the textbook and practical manuals were published by different publishers.

5.1.2. To analyse class period allotted for science practical in the weekly time table of the schools.

It was found that majority of the school did not include science practical period in their weekly time table. There were only few schools (19%) that have practical period in the weekly time table.

Among different types of school, government schools (11.11%) witnessed the least inclusion of practical class in the weekly time table while deficit schools were found to have highest inclusion (37.5%) of practical period in the time table.

It was also found that schools in urban area had higher inclusion (20.59%) of practical period in the time table than schools in rural area (15.6%).

As reported by one science teacher *“Having a dedicated practical class in the timetable is good, but for our students, it often becomes free time. They don’t understand the procedures, so we end up cramming practical just before exams—usually at the end of the session”*.

Discussions on findings related to allotment of science practical class in weekly time table

The present study revealed that most schools did not include practical class in their weekly timetable and conducted practical classes only just before promotional examination. This could be due to limited resources and budget constraints. The arrangement of practical classes before final examinations, rather

than integrating them throughout the academic session may lead to the belief that laboratory work and hands-on experiences are just extra activities and not the fundamental components of the learning process and this practice may hamper the understanding of underlying principles by students. In line with the findings of the present study, Kasiyoo, et.al. (2017) found that failure to allocate specific timetable slots for hands-on experiments hinder effective practical science instruction.

There could be a number of contributing factors for not including practical class in a weekly time table such as, lack of manpower, lack of laboratory equipment and chemicals, financial constraints, unavailability of science laboratory in the school, etc. While leaning towards the inclusion of practical class in a weekly time table, Berry, et.al. (1999), pointed out that despite the significant time allocated to laboratory activities, students exhibited minimal learning gains. Shana and Enas (2019) recommended that more opportunities shall be given to students to engage in practical science with necessary laboratory equipment for effective implementation of science education.

5.1.3. To study the implementation of prescribed science practical by secondary schools in Mizoram

Regarding the implementation of prescribed science practical in class IX physics, it was found that only very few teachers (less than 10%) conducted four experiments out of five prescribed experiments. Majority of the teachers failed to conduct prescribed practical in class IX physics. It was found that majority of the teachers failed to conduct prescribed practical in chemistry. A fair number of teachers (more than 20%) conducted two experiments in chemistry. The other three experiments in chemistry were conducted by very few teachers (10% or less). The study found that majority of the teachers failed to conduct prescribed practical in biology. It was found that only few numbers of teachers (less than 10%) conducted three experiments out of five prescribed practical in biology. The other two experiments were conducted by less than 15% of the teachers.

The findings in relation to class X practical found that 85.3% of science teachers conducted the experiment in physics section ‘Tracing the path of a ray of

light through a rectangular glass slab and measure the angle of incidence and angle of emergence'. It was also found that more than 20% of teachers conducted two experiments from physics. However, majority of teachers failed to conduct experiment on resistance related experiments. Among five experiments under chemistry portion, one experiment 'pH test, was conducted by all science teachers and a good number of teachers conducted two experiments viz. studying properties of acids & bases and properties of acetic acid. It was also found that majority of the teachers failed to conduct the remaining two experiments . It was found that a fair number of teachers (more than 30%) conducted three experiments out of five practical in biology. Majority of the teachers failed to conduct the remaining two prescribed practical in class X biology.

Discussions on findings related to implementation of prescribed science practical by MBSE in Class IX & X

The study found that basic experiments, such as pH tests and acid-base reactions, were widely conducted, while more complex experiment such as optics, electricity, and biology faced major execution challenges, this could be due to the unavailability of essential equipment, such as mirrors, circuits, and microscopes. Chemical reaction experiments, such as generating sulphur dioxide gas, were rarely performed, likely due to safety concerns and inadequate laboratory facilities. Constraints in school resources limited hands-on learning, particularly for complex experiments, potentially affecting students' understanding of theoretical concepts and the resource constraints faced by schools affect the conduct of practical in schools (Okafor 2016). The limited execution of experiments like generating sulphur dioxide gas due to safety concerns and inadequate laboratory facilities further emphasizes the need for better infrastructure and safety measures, as suggested by studies conducted by Akani (2015) and Banu (2011). It was observed that majority of the experiment listed for class IX & X were not conducted properly and the experiment within the syllabus were conducted selectively. Apart from the unavailability of resources, another big reason of conducting only few experiments could be that teachers in the schools deliberately select practical that they are comfortable with and as per convenience.

5.1.4. To study the relationship between the achievement of students in theory and practical.

It was found that there exist a moderately positive relationship between theory marks and practical marks in the HSLC examinations in the year 2019 to 2023. In terms of percentage, it was found that the theory marks taken together in the five years was 40.24% while it was 78.6% in practical. This finding indicates a huge achievement gap between theory and practical.

Discussion on the findings on relationship between the achievement of students in theory and practical

The findings revealed a positive relationship between theory marks and practical marks. However, the comparison of theory and practical marks in terms of percentage clearly shows a huge gap, students performed way better in practical as compared to theory. Keeping in view of the way practical examinations were conducted, this constant marks in practical during the reported period of five years may be a concern for research scholars and science educators and may raise question on the process of conducting science practical examination and the marking system.

It is well accepted that well-rounded education not only imparts theoretical knowledge but also encourages hands-on experience and practical skills. Findings from the studies like, Braund and Driver (2005), Aladejana and Aderibigbe (2007), and Bal-Taştan et al. (2018) revealed that practical work positively contributed to their general learning in science.

5.1.5. To analyse the profile of teachers teaching science subject in secondary schools of Mizoram.

In connection to the educational qualifications of science teachers, the study found that a good number of teachers (46.1%) across different types of school management hold master degree in science and of the different types of schools, deficit schools had highest percentage of master degree holder and government school had lowest percentage of master degree holder. It was found that half of the science teachers (50%) possessed Bachelor of science degree with highest

percentage seen in government school and lowest percentage in deficit school. A very few number of science teachers who possessed degrees other than M.Sc. and B.Sc. were found in private schools.

Regarding professional qualification, it was also found that majority of the teachers teaching science subject at secondary schools possessed a required professional qualifications viz. B.Ed. or M.Ed. All teachers in government and samagra schools had required professional qualifications, whereas majority of teachers in private school did not have required professional qualifications. The study also found that a very few teachers had D.El.Ed. qualification which is under qualification for secondary school.

The study found that regular appointment was relevant in government and deficit schools. A very few teachers in government schools were appointed in contractual basis. All teachers in samagra schools were recruited in co-terminus basis while teachers in private schools were appointed in line with the terms and conditions laid down by their respective schools.

It was found that majority of the teachers had below 10 years of experience and only few teachers had more than 21 years of experience of which government schools had the highest percentage of teachers having more than 21 years and above. No teachers in private schools and samagra schools had teachers with more than 21 years of experience.

Discussion on the profile analysis of science teachers in secondary schools of Mizoram

The analysis of the profile of science teachers in secondary schools of Mizoram revealed that all teachers hold either bachelor or master degree in science except in private schools. Only teachers with essential qualifications both academically and professionally were found in government, deficit and samagra schools while majority of the teachers in private school did not have required professional qualifications. Since academic qualification had a significant influence on the teachers' overall job satisfaction (Kuchy & Chakraborty, 2021), under qualified teachers are likely to have less job satisfaction. While private schools are also affiliated to the state board of school education, it is clear that the rules and

regulations regarding minimum qualifications prescribed by the NCTE and MBSE were not strictly enforced. To support the discussion, Kasiyoo, et.al. (2017) highlighted inadequate professional development opportunities to keep pace with educational reforms as obstacle hindering effective practical science instruction. Kaindume (2018) found that limited training on effective teaching strategies as one of the factors limiting teachers from engaging learners in practical work.

The appointment status of teachers may significantly influence job satisfaction, performance, and retention in the school. Regular teachers, with job security and long-term benefits may exhibit higher commitment, leading to consistent performance and lower turnover rates. The findings of the present study revealed that regular appointment was relevant to only teachers working in government and deficit schools. Kabungaidze et.al. (2013) found that tenure and specialization can predict employee turnover intentions and as evidenced from the findings of the present study, no teachers from samagra and private schools had over 20 years of teaching experience and this indicates high turnover rates in this schools and the reason could be their nature of appointment.

5.1.6. To study the challenges faced by science teachers in Mizoram.

The findings of the study revealed that only few science teachers across all school types reported challenges in relation to heavy theoretical content. Samagra school reported the highest percentage of teachers (20%) who considered heavy theoretical content as challenge. Among all types of school, heavy theoretical content was least perceived as challenge by private school teachers.

It was found that more than half of the teachers (51%) reported issues on science laboratory. Among the types of schools, majority of teachers from samagra and private schools (more than 60%) faced challenges related to science laboratory while a small portion of teachers from government and deficit schools reported challenges with regards to science laboratory.

The study revealed that inadequate practical equipment was a major issue reported by 76.5% of science teachers. It was found that majority of science teachers from all types of school except deficit school reported challenges related to practical equipment. Among these schools, all samagra school teachers (100%)

reported the problem related to practical equipment whereas only 37.5 % of teachers from deficit school considered having problems in relation to practical equipment.

Regarding the practical examination, it was found that only few science teachers (less than 25%) across all school types reported challenges in relation to the practical examination. Among all types of school, Private school reported the highest percentage of teachers (25%) who considered practical examination as challenge, whereas practical examination was least perceived as challenge by deficit school teachers.

It was found that only 10.8% of science teachers lacked subject expertise, across different type of school management. Private schools showed the highest proportion (25%) of teachers who considered subject mastery as challenge. Remarkably, teachers from both deficit and Samagra schools reported no issue on subject expertise.

In connection to the financial matters, it was found that majority of science teachers reported challenges in financial limitations. The study revealed that samagra schools reported the highest percentage of teachers (86.7%) who reported limitations in finance, followed by government school (72.7%). It was also found that the least problem on financial constrain was reported by teachers from private schools.

Discussion on the challenges and problems faced by science teachers in Mizoram

The findings of the present study revealed that teachers do not consider theoretical content of science subject not heavy and one of the teachers from the sample schools even reported that *“The syllabus of science for secondary school is so less that i can have sufficient time to conduct practical activities with students sometimes in the form of project”*. On the other hand, majority of the teacher failed to conduct practical experiment, there could be a number of reasons behind this, but it is obvious that it is not because of heavy theoretical content of science subject. According to Banu (2011), factors such as low teacher-student ratios and the absence of laboratory assistant contributed to teachers’ heavy workloads.

The findings of the present study also revealed that majority of the school faced issues related to science laboratory. The case is more severe among samagra and private schools. In line with the findings of the present study, Kasiyoa et.al (2017) in their study reported insufficient laboratory equipment and dedicated science facilities. The findings of Jalal (2019), Malathi and Rohini (2017) also revealed lack of laboratory tools, insufficient time allotment, large class size and absence of science training courses as challenges faced by science teachers. Despite this, some teachers in schools with little to no lab facility still manage to conduct experiments by improvising with available materials or even purchasing supplies with their own money. A teacher from samagra School said, *"Since we hardly have any lab equipment, I often rely on YouTube to find and show experiment videos to students."* Similarly, a Private School teacher stated, *"We lack many essential practical equipment, I sometimes purchase materials myself out of personal pocket and still ensure practical sessions are conducted."*

Though majority of the teachers in the present study reported issues relating to science laboratory, only few teachers reported challenges when it comes to practical examination and this has led to the need for further investigation and research regarding practical examination.

5.1.7. To construct and standardise teachers' perception scale towards science practical

The teacher's perception scale towards science practical was constructed and standardised. The perception scale consists of 33 items. The scale was constructed following Likert's five point scale and the maximum possible score is 165 while the minimum possible score is 33. The reliability of the scale was 0.82 (test-retest), 0.902 (cronbach's alpha) and 0.88 (split half). Norms was also provided for the newly constructed scale.

5.1.8. To find out the perception of secondary school science teachers toward science practical in Mizoram.

It was found that slightly more than half of the teachers possessed average perception towards science practical of which few of them comprising only 19.6% had a high perception. It was also found that 29.4% had low perception towards science practical.

Discussion on the findings relating to the study on perception of secondary school science teachers towards science practical in Mizoram

Keeping the condition of science laboratory and the way experiments in science are conducted, it is not surprising that only few teachers possessed high perception towards science practical in Mizoram. At the same time, more than a quarter of the science teachers surveyed had low perception towards science practical. The majority of the science teachers having average perception is in line with the findings of the study conducted by Winarto et al. (2019) on science teacher's perception of Science Practices Learning (SPL) where majority of the science teachers having a moderate perception. Science teachers were not be necessarily negative about or towards science practical, the reason for having low perception could include lack of resources, status of laboratory and the way experiments are conducted at the school level and the way examinations and evaluation are conducted for science practical. All these factors can contribute to the perception of science teachers towards science practical.

5.1.9. To compare the perception of secondary school science teachers towards science practical in relation to gender.

There is no significant difference in the perception towards science practical between male and female science teachers

5.1.10. To compare the perception of secondary school science teachers towards science practical based on the type of school management

There is no significant difference in science teacher's perception towards science practical with reference to school management type.

5.1.11. To compare the perception of secondary school science teachers towards science practical with reference to locale.

There is no significant difference in the perception towards science practical between rural and urban science teachers.

Discussion on the findings relating to comparison of perceptions based on gender, school management type, and locality

No significant difference was found between different selected demographic variables with regards to the perception of science teachers towards science practical. Though no significant difference was found between demographic variables, it was clear from the findings that majority of the science teachers do not have high perception towards science practical. If one practicum is prescribe for one theory chapter and if both theory and practical are in line with each other and if practical classes were included in the weekly timetable by all schools, if practical examination is conducted in a more systematic manner and if practicum is given more weightage, the perception of science teachers towards science practical may be improved.

5.2. EDUCATIONAL IMPLICATIONS OF THE STUDY

The present study holds significant educational implications for science teachers working in secondary schools in particular and the system of education in Mizoram for holistic development of science education in general.

The findings of the present study in relation to linkages between theory and practical aspect of science subject throw light on the gap between theory and practical aspect of science subject. This finding can help curriculum developer and teachers teaching at the school level in realising the need to improve the existing syllabus. This finding may inform the authorities to take necessary actions to address the gap between theory and practical in science subjects so that students can attain holistic development in science subjects. The findings of the present study also clearly reveal the need to make proper classification of practical based on the three branches of science, viz. physics, chemistry and biology. The findings also

suggest the need for uniformity regarding the number of practical prescribed for each chapter.

Analysing the time table of secondary schools on the inclusion of practical period in the weekly time table will reveal the reality of practical aspect of science at the grassroots level. The findings show how importance is given to the practical aspect of science as compared to theoretical content. A study of the implementation status of science practical may even predict the future performance of students in science subjects and may reveal how much importance is given to practical activities and how much it is neglected. This kind of information will serve as significant input in planning and reforming science education at secondary level of education. The baseline information on the implementation of science practical at secondary stage will also inform the authorities and the educators and even students on how to improve the situation and will help them in deciding what mechanism or intervention needs to be taken to improve the situation.

One of the objectives of the present study is to establish the relationship between the marks obtained in science theory and practical at HSLC examination. This finding may raise question on how theory and practical examinations are conducted and will inform the gap in theory and practical marks obtained by students. If students who did poorly in theory scored a very high percentage of marks in practical, it may indicate defective conduct of practical examination or otherwise.

One of the objectives of the study provide a clear understanding of the current profile of secondary school science teachers. This will bring into light the academic and professional qualifications of science teachers in the state of Mizoram. This will inform whether the minimum qualifications and standards for teachers laid down by the National Council for Teacher Education (NCTE) are met by the secondary science teacher in Mizoram. If students are not taught by qualified teachers, the quality of science education in particular and the quality of education in general may be questionable. The present study will tell us the nature of the

appointment of teachers. It may be difficult for a teacher to have job security and job satisfaction if a teacher is not permanently employed.

The study also reveals the various challenges faced by science teachers. Findings in relation to this will help policy makers and administrators in pinpointing the problems faced by science teachers at the secondary level and this in turn will help them in formulating policy for the solutions of the challenges faced by secondary science teachers.

The development and standardization of perception scale towards science practical for secondary school science teachers will serve as an important tool to measure the perception of science teachers about science practical. This tool can be used by anyone interested in finding out the perception of science teachers towards science practical. Knowing the perception of science teachers towards science practical will also enable us to understand how science teachers look at science practical in general and their views on the importance of connecting theory with practice.

5.3 RECOMMENDATIONS FROM THE STUDY

The following are the recommendations made in line with the findings of the study.

1. It is recommended that secondary science textbook should be prepared and published by the same investigator and publisher to ensure better connection or linkage between theoretical contents and practical activities. Each and every chapter in the textbook should have a related practicum and the number of practical activities prescribed for each chapter should be of the same value or uniform in terms of number.
2. In order to offer more hands-on experiences among the students, practical period should be allotted in the weekly timetable of the school at least once a week. Teachers should not only conduct practical classes to class X but should also be encouraged to introduce practical classes to class IX standard also. The reasons for not including practical period in the weekly time table of

the schools may be investigated and the authority may take initiatives to tackle the problems in line with the findings.

3. Teachers should be encouraged to conduct practical classes in all three branches of science at the secondary level, viz. physics, chemistry and biology. Practical experiments that are simpler in procedure and execution, which do not require sophisticated equipment, may be introduced. Teachers should be sensitised about the learning outcomes of science subject at secondary level. So that they will realize the importance of conducting practical classes for both classes IX and X.
4. Stricter and more structured practical examination system in both classes IX and X may be enforced by the Mizoram Board of School Education. It is suggested that more weightage of marks may be assigned for practical components. Authority must come up with innovative interventions to address the huge gap between the percentage of marks obtained by students in the theory paper and in practical in HSLC examinations.
5. Minimum qualification standards for teachers, be it academic or professional, must be strictly enforced uniformly across all types of schools. In-service teacher training specifically designed to cater to the needs of science teachers to conduct practical classes may be organised by the authority. Private school teachers should be encouraged to undergo teacher professional training courses relevant to secondary education.
6. There should be a balance between theoretical content and prescribed practical in secondary science subject. It is recommended that all schools affiliated to Mizoram Board of School Education must have an adequate and working science laboratory as prescribed by the affiliation regulation 2012 of MBSE. Affiliation should not be granted to those schools seeking affiliation unless they fulfil the norms laid down by MBSE. A mobile science laboratory may be temporarily established to address immediate problems and to improve access to laboratory facilities and practical equipment, particularly in underserved areas. These mobile units, consisting of well-equipped vans with portable laboratory setups, should follow a regular rotation schedule to serve schools without science laboratory.

7. It is recommended that Block Resource Centre (BRCs) be strengthened and equipped with a well-equipped science laboratory so that schools without proper facilities within the block can avail the resources at the block resource centre.
8. Overall, opportunities for hands-on learning experiences should be provided to the students so that students can apply and relate their learning to real-life experiences and to their immediate environment.

5.4 SUGGESTIONS FOR FURTHER RESEARCH

The following suggestions for further studies were laid down in accordance with the findings of the study

1. To conduct a comparative study on the integration of theory and practice across different Indian states.
2. To conduct a comparative study on different educational boards in India to identify best practices for aligning theoretical and practical content in science education.
3. A case study of a specific school that effectively implements practical periods in the timetable to identify their best practices.
4. A comparative study of schools that conduct practicals throughout the year versus those that conduct them just before the practical examination.
5. To construct and develop an achievement test on science practical for secondary school students.
6. To investigate the profile of teachers in other States of India
7. To find out the relationship between teachers' qualifications and practical teaching effectiveness in secondary science.
8. To study the Job satisfaction of science teachers working in different secondary schools.
9. To develop and standardize a scale to measure students' and teachers' perceptions of science practical in STEM education.
10. To compare the perception of science teachers based on teaching experience and subject specialization, as well as educational qualification.

11. To compare the perception of science teachers in Mizoram with those in other states to identify broader trends and contextual differences.

5.5 CONCLUSIONS

The study provides a comprehensive analysis of the current state of science education in Mizoram, focusing on the integration of theoretical and practical content, the implementation of practical classes, and the challenges faced by science teachers. The findings underscore the critical role of hands-on learning in enhancing students' conceptual understanding of scientific concepts. However, the study also reveals significant gaps and challenges that need to be addressed to improve the quality of science education in the region. One of the key findings is the strong connection between most practical experiments and their corresponding theoretical concepts in Class X science textbooks. This alignment reinforces the importance of integrating practical work with theoretical learning to promote a deeper understanding of scientific principles. However, the study also identifies inconsistencies in the alignment of certain experiments, which are only partially covered in textbooks and some experiments that are entirely absent from the curriculum, highlighting gaps in theoretical support. These findings suggest a need for curriculum designers and textbook investigators to revise and enhance educational materials to ensure a more balanced and coherent integration of theory and practice.

The analysis of weekly timetables reveals significant disparities in the inclusion of practical sessions across different school types and locations. Government and samagra schools have the lowest inclusion rates, while urban schools marginally outperform rural schools. The tendency to schedule practical sessions only at the end of the term further diminishes their potential impact on reinforcing theoretical learning throughout the academic year. This situation calls for educational administrators to standardize the allocation of science practical periods, ensuring that every student has regular access to practical learning experiences regardless of their school's management type or geographical location. The implementation challenges of prescribed science practical indicate that inadequate laboratory facilities and a lack of essential equipment are significant

barriers to effective science education. While basic experiments using common chemicals are widely conducted, some other experiment requiring complicated procedures and complex chemicals and equipment were rarely conducted. Addressing these infrastructural deficits through increased funding, improved laboratory resources, and targeted teacher training programs is imperative for fostering an environment where students can fully engage with both theoretical and practical aspects of science. The moderately positive correlation between theory and practical marks suggests that a stronger performance in one area is generally associated with better outcomes in the other. However, the observation that practical scores remain relatively stable despite fluctuations in theoretical marks indicates that practical assessments may serve as a more consistent indicator of student understanding. This finding highlights the importance of developing evaluation methods specifically for practical skills evaluation, thereby providing a more holistic measure of student achievement in science.

The differences in teacher profiles and the challenges faced by teachers have critical implications for teacher recruitment, training, and retention policies. The higher qualifications and stable employment conditions in government and deficit schools contrast sharply with the issues of job security and professional development in other school types. Addressing these disparities through stricter hiring standards, enhanced professional training, and the implementation of permanent employment policies is crucial for improving teaching quality, which in turn can positively influence student performance and overall educational outcomes in Mizoram.

In conclusion, the study highlighted the need for comprehensive reforms in science education in Mizoram. By addressing the gaps in curriculum alignment, improving laboratory infrastructure, regularizing practical classes, and enhancing teacher support, policymakers can create a more effective and engaging learning environment for students. The findings of this study provide valuable insights for educational administrators, curriculum designers, and policymakers to take targeted actions that will enhance the quality of science education and foster a deeper understanding of scientific concepts among students.

SUMMARY

Introduction:

Education has become essential for everyone's survival in contemporary society since it is a crucial key tool that allows people to learn and obtain information. Everyone desires quality education, but it must be encouraged in the right way from the beginning. A strong educational foundation offers enhanced perspectives on life and fosters a deeper understanding of the world. In present world, education serves as the keystone of intellectual and societal development. It is fundamentally logical, deeply embedded in human reasoning, and relies on the language structure to convey knowledge, ideas, and critical thinking skills. The importance of education is not only about the transfer of information; it shapes the way individuals perceive, analyse, and interact with the world around them. As society developed, education processes became modernized, reflecting the need for deeper understanding and application rather than rote memorization. As a result of this educational evolution, modern learning has become highly scientific. The shift toward a more analytical and scientific approach to learning has paved the way for the increasing importance of STEM (Science, Technology, Engineering, and Mathematics) education in contemporary curricula (Bybee, 2013). Science education, in particular, plays a pivotal role in bridging various disciplines, encouraging interdisciplinary learning, and fostering a deeper understanding of the world.

Science is a systematic exploration of the natural and physical world, driven by observation, inquiry, and experimentation. It involves formulating hypotheses, rigorously testing them through experiments, evaluating evidence, and refining our understanding based on new findings, leading to the continual advancement of knowledge. This process extends beyond the confines of laboratories and is integral to the development of essential skills and mindsets, which are vital for individuals seeking to lead rational and fulfilling lives. Learning Science enables one to gain valid knowledge about the world as well as acquire scientific values, capacities, and dispositions, such as curiosity, creativity, evidence-based thinking, and sound decision-making that facilitate making informed and good decisions benefitting the

individual and community (NCFSE, 2023). In a progressive and future-oriented society, science serves as a powerful force for liberation, enabling individuals to break free from the cycles of poverty, ignorance, and superstition. Developments in science and technology have revolutionized traditional sectors like agriculture and industry, while also giving rise to entirely new areas of employment. In today's rapidly evolving world, adaptability, innovation, and creativity have become the most essential skills for success. Thus, Science is a dynamic, expanding body of knowledge, covering ever-new domains of experience. These different imperatives have to be kept in mind in shaping science education (NCF, 2005).

Scientific practical refers to the practical application of scientific theories and principles in a controlled environment. These activities involve the manipulation of materials, instruments, and variables to test hypotheses, gather empirical evidence, and draw conclusions. Practical serves multiple purposes in scientific education, such as providing a platform for students to engage in inquiry-based learning, develop problem-solving skills, and foster scientific reasoning abilities. Hands-on experiments with measurements should be a key part of high school science classes to help students test and understand scientific concepts. While most educators agree that learning through activities is the best way to teach science, and textbooks now include some practical work, this approach hasn't made its way into most actual classrooms." Activities still tend to be regarded as a way to verify the ideas/principles given in the text, rather than as a means for open-ended investigations. (Position Paper of National Focus Group on teaching of science, 2006)

In the context of education, science practical offer a hands-on approach to learning that complements theoretical instruction. By actively engaging with materials and equipment, students can bridge the gap between abstract concepts and real-world applications. Hofstein and Lunetta (2004), state that science practicals provide a unique opportunity for students to experience science as a dynamic process, promoting an active learning environment that fosters curiosity and creativity. Further, practical learning makes learning more enjoyable, is believed to help pupils recall things more easily, and is frequently utilized to create interest and excitement among students. Thus, practical activities can assist in the development

of a wide range of transferable abilities. In other words, such abilities can increase the value of students' education and help them succeed in their chosen careers. Practical exercises are supposed to benefit students because they assist them in developing their conceptual grasp of science, allowing them to envision and make sense of complex scientific principles and ideas. Practical activity then becomes the foundation of deep learning

Theory and Practical aspects of science

The relationship between scientific theory and practical application is essential for the advancement of knowledge and its real-world application. Theories offer frameworks for understanding natural phenomena, while practical applications serve to validate and refine these theories through empirical evidence. This mutual relationship ensures that theoretical insights are grounded in reality and that practical endeavours are informed by sound reasoning. For example, the integration of practical experiences into traditional learning frameworks reflects a pedagogical progress that values contextualized learning alongside theoretical knowledge (Fantinelli et.al., 2024). Moreover, the balance between theory and practice is essential across various fields, as it enables the application of theoretical knowledge to solve real-world problems effectively.

The relationship between theory and practice is evident across various scientific disciplines. In physics, for example, theoretical models such as Newton's laws of motion and Einstein's theory of relativity provide the foundation for practical applications in engineering, technology, and space exploration. Experimental verification of these theories through practical experiments, such as the famous Michelson-Morley experiment supporting Einstein's theory of special relativity, solidifies their validity and broadens their practical implications. In biology, theoretical frameworks such as Darwin's theory of evolution and Mendelian genetics form the basis for practical applications in agriculture, medicine, and conservation. Practical experiments and observations, such as the breeding experiments conducted by Gregor Mendel, provide empirical evidence that supports and refines these theories, contributing to advancements in the understanding of genetic inheritance and the mechanisms of evolution.

Key Policies and Reforms in Science Education

With the growth of science education in India, significant policies and reforms have sought to enhance both accessibility and quality in the curriculum. These reforms have aimed to align educational practices with modern scientific standards and societal needs. For instance, post-independence efforts concentrated on creating an integrated educational framework that could move away from the colonial legacy, establishing a more equitable system of science education. Critical to these advancements has been the emphasis on fostering inquiry-based learning and enhancing practical skills among students. However, challenges persist, particularly with bureaucratic inertia and insufficient support for teachers, which hinder the effective implementation of these innovative policies. In this context, the analysis of educational reforms reveals that achieving substantial progress requires not only strong political will but also community engagement in educational practices (Little et al., 2010). Ultimately, these reforms must evolve to meet the demands of the 21st century, ensuring that science education keeps pace with global developments and local needs (Buckler et al., 2018).

The Indian Education Commission (1964–1966) further suggested integrating science into general education, improving teaching methods, and connecting science with agriculture and technology. The National Policy on Education (1986) stressed restructuring science education to develop problem-solving skills and relate scientific concepts to real-life applications in health, industry, and agriculture. The Scheme for Improvement of Science Education in Schools (1988), introduced by the Ministry of Human Resource Development, emphasized hands-on learning, which states that science teaching should go beyond theory, incorporating students' real-world experiences and practical experiments. The policy recommended well-equipped laboratories and science libraries in all secondary schools. However, Pareek (2019) found that many schools lacked proper labs, and teachers struggled with large class sizes and insufficient equipment, hindering effective science instruction. A study by the Azim Premji Foundation found that "many schools lack basic facilities such as laboratories, libraries, and computers" (Azim Premji Foundation, 2018). This lack of infrastructure hinders the ability of schools to provide hands-on learning experiences, which are essential for

science education. The curriculum and assessment methods used in secondary level science education in India are also in need of reform. The current curriculum is often criticized for being overly broad and shallow, with too much emphasis on rote memorization (Kumar, 2018). Additionally, the assessment methods used, such as board exams, can be high-stakes and stressful for students, which can discourage critical thinking and creativity. Despite these challenges, there are opportunities for improvement. One of the significant challenges facing secondary level science education in India is the lack of qualified teachers. According to a report given by the National University of Educational Planning and Administration (NUEPA), "the shortage of science and mathematics teachers is a major concern in Indian schools" (NUEPA, 2019). This shortage is particularly critical in rural areas, where schools often struggle to attract and retain qualified teachers.

The National Education Policy (NEP) 2020, aims to transform India's education system, including science education, by promoting experiential learning, critical thinking, and interdisciplinary approaches (Ministry of Human Resource Development, 2020). The policy also emphasizes the importance of teacher training and development, which is critical for improving the quality of science education. National Education Policy (2020) also outlines a new curricular structure of 5+3+3+4, with the latter four phases representing secondary education. The Secondary Stage will consist of four years of multidisciplinary education that expands upon the subject-focused approach of the Middle Stage. This phase emphasizes deeper learning, enhanced critical thinking skills, and greater consideration of students' future goals through increased subject flexibility and choice. For example, students may choose to leave formal schooling after Grade 10 and later return to complete Grades 11 to 12, either through vocational programs or specialized courses at different institutions.

Secondary Level Science Education in Mizoram

The foundation of formal education in Mizoram was laid by Christian missionaries, who introduced the Roman script with phonetic spelling in 1894. Their educational efforts began in 1901 with the establishment of schools in villages like Khawrihnim, Phulpui, and Chhingchhip. The initiative expanded

rapidly, with three additional schools opening in 1903 and seven more the following year. A significant milestone came in 1909 when the region's first middle schools were established in Aizawl and Serkawn. The educational landscape transformed further in 1944 with the creation of Mizoram's first high school in Aizawl, funded through community contributions. This development marked a turning point in the educational advancement of what is now known as Mizoram (Directorate of School Education, 2024).

In Mizoram, the school education system follows a structured stage-wise approach to ensure a smooth academic progression for students. The elementary stage comprises Classes I to VIII, laying the foundational groundwork in core subjects. Upon entering the secondary stage, which includes only Classes IX and X, students prepare for their first major external examination—the Class X board exam. However, before appearing for this board exam, Class IX students undergo internal summative assessments conducted by their respective schools, and only those who pass proceed to Class X. The next phase, known as the higher secondary stage (Classes XI and XII), allows students to specialize in streams such as Science, Commerce, or Arts, culminating in the crucial Class XII board examination. The board exams are held only at the end of Class X and XII, with no external examinations in other grades. Additionally, Science subjects follow a distinct evaluation pattern, incorporating practical examinations alongside theory. Both Class IX and X have separate practical syllabi, requiring students to perform experiments and laboratory work, ensuring a balanced assessment of theoretical knowledge and hands-on application.

According to the Scheme of Examination for HSLC examination (2019) published by MBSE; The evaluation for science subjects in class IX and class X includes both internal and external assessment. Internal assessment shall be based on the record of the candidate during his/her continuous assessment in the school and shall carry a maximum of 20 marks. Schools are expected to maintain regular records of students' achievement and progress. These records are subject to scrutiny by the Board when it deems fit. The external board examination for class IX was conducted by the Mizoram Board of School Education every year during February and March. Science theory carries 70 marks, including objective type, very short

answer type, short answer type I & II and long answer type questions. Science practical carries 10 marks, which shall be given by the external examiner at the time of practical examination. The guideline for practical examination highlighted that practical marks shall be given from practical exercise, viva voce and practical records (Mizoram Board of School Education, 2019).

Rationale of the study:

The importance of science practicals in learning science cannot be overstated. As highlighted by high school curriculum (2009), science practicals are expected to engage students in the development of their abilities, capabilities, create awareness of scientific knowledge, and provide an understanding of scientific topics (MBSE, 2009). Hands-on learning may facilitate and enhance the aptitude and understanding level of students in science subjects. It is generally accepted that practical is at the heart of science education. Without actual practice, learning science is akin to learning literature without reading books (Position Paper on National Focus Group on Teaching of Science, 2006). The education system today is more inclined towards examination-oriented learning, and even the practical examination is conducted not in line with the objectives set forth in the practical syllabus and sometimes may not serve the main purpose or objectives (NCFSE, 2023).

As per the objectives of science practical laid down by the High School curriculum (2009) at the secondary level, the practical activities try to engage the students in exploratory and hands-on activities that lead to the development of basic cognitive and psychomotor skills through language, observation, recording, differentiation, classification, inference, drawing, illustrations, design and fabrication, estimation, and measurement (MBSE, 2009). Practical examination as conducted by MBSE may or may not be in compliance with the prescribed syllabus, and this makes the present study extremely relevant to be taken up as a research topic.

The Position Paper on National Focus Group on Teaching of Science (2006) also highlighted the existence of a huge gap in science education, particularly between rural and urban students, as well as gender differences. The existing

inequalities in science education stem primarily from inadequate infrastructure, insufficient support systems, limited access to information and resources in rural areas, and a persistent urban-centric allocation of educational resources. Particularly, both science textbooks and educators often perpetuate gender stereotypes, mirroring broader societal biases. This situation demands deliberate, systematic efforts to eliminate gender prejudice from educational materials and teaching methodologies. These concerns underscore the necessity to examine science teachers' perspectives, instructional approaches, and student outcomes in secondary-level science education (NCFSE, 2023).

The Mizoram Board of School Education (MBSE) emphasizes practical engagement, yet practical exams may not always adhere to the prescribed syllabus. Science practicals at secondary stage, as assumed by the researcher, are sometimes neglected, raising concerns about their effectiveness. In order to ensure that science practicals are implemented successfully, there are various dimensions that need to be checked. The present study looked into challenges from different aspects, including adequacy infrastructure, sufficiency of lab facilities, and the challenges faced by science teachers. Understanding these aspects of science practical is crucial for improving science education and fostering meaningful student engagement. The study also examined the achievement of students in science theory and practical and also explored the correlation between the achievement of students in theory and practical. Keeping in view the issues and problems stated above, “A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram” is selected to be taken up for study.

The investigator aims to address the following questions after examining the challenges associated with science education at the secondary school level:

9. Is there a proper linkage between theoretical content and prescribed practical of secondary school science subjects in Mizoram?
10. Do schools allot adequate time for conducting science practical in their timetable?
11. Does the school follow the norms and regulations prescribed by regulating body for conducting practical?

12. What type of relationship exists between students' performance in science theory and practical?
13. What are the educational qualifications of secondary school science teachers?
14. What are the major challenges faced by science teachers in Mizoram?
15. What is the perception of secondary school science teachers toward science practical in Mizoram?
16. Is there any difference in perception of secondary school science teachers towards science practical with reference to gender, school management and locale?

Statement of the problem:

The present study is titled as “A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram”

Operational definition of the terms used:

- Linkage:** For the present study, linkage means connectedness and or interconnectedness of theory and practicum of science subjects under Mizoram Board of School Education
- Science:** Science is a systematic study of the natural and physical world through observation, experimentation, and evidence-based revision of knowledge. In the present study, science refers to one of the subjects of Secondary school, comprising of physics, chemistry and biology.
- Theory:** Theory in the present study refers to the theoretical content given in the secondary science textbook prescribed by the Mizoram Board of School Education.
- Practical:** For the present study, practical refers to the experimental activities of science for secondary schools prescribed by the Mizoram Board of School Education.
- Secondary school:** In the present study, secondary school means the schools which run standard 9th and 10th level (i.e. High School) under Mizoram Board of School Education.

Objectives of the study:

- 1) To investigate the linkages between theoretical contents and prescribed practical of secondary school science subject in Mizoram.
- 2) To analyse class period allotted for science practical in the weekly time table of the schools.
- 3) To study the implementation of prescribed science practical by secondary schools in Mizoram.
- 4) To study the relationship between the achievement of students in theory and practical.
- 5) To analyse the profile of teachers teaching science subject in secondary schools of Mizoram.
- 6) To study the challenges faced by science teachers in Mizoram.
- 7) To construct and standardise teachers' perception scale towards science practical.
- 8) To find out the perception of secondary school science teachers toward science practical in Mizoram.
- 9) To compare the perception of secondary school science teachers towards science practical in relation to gender.
- 10) To compare the perception of secondary school science teachers towards science practical based on type of school management.
- 11) To compare the perception of secondary school science teachers towards science practical with reference to locale.

Null hypotheses of the study:

The following are the research hypotheses laid down by the investigator for the study, which is framed in null form for testing purposes as follows:

- H₀ 1 There is no significant difference in the perception of science practical between male and female science teachers.
- H₀ 2 There is no significant difference in science teachers' perception towards science practical with reference to the type of school management.
- H₀ 3 There is no significant difference in the perception of science practical between rural and urban science teachers.

Review of related literature:

A total of 93 studies, spanning four decades (1984 to 2024), were reviewed to analyse various aspects of science education. The literature was categorized into four main themes: science education, curriculum, science textbook and pedagogy (30 studies), which explored teaching methodologies, curriculum design, and instructional strategies; science practical (25 studies), which examined the role, effectiveness, and challenges of hands-on experiments in science learning; perceptions of science teachers and students (20 studies), which investigated attitudes, confidence levels, and engagement in science education; and challenges faced by science teachers (18 studies), which highlighted issues such as resource constraints, pedagogical difficulties, and systemic barriers in delivering effective science instruction.

The findings from the reviewed literatures emphasize the vital role of science practical in education while also highlighting key obstacles such as limited resources, disconnects between theoretical knowledge and practical application, and challenges faced by educators. To address these issues, several recommendations have been suggested, including improving laboratory infrastructure through increased investment in science education facilities, enhancing teacher training programs to better equip educators for conducting practical lessons, and ensuring a stronger alignment between theoretical content and hands-on experiments to reinforce conceptual understanding. Additionally, providing sufficient administrative support can help manage teachers' workload, allowing them to focus more on delivering effective instruction. Refining pedagogical approaches to encourage student engagement and promote inquiry-based learning is also essential. These reviews emphasize the need for comprehensive reforms to strengthen the implementation of science practical, ensuring a more effective and enriching learning experience that bridges the gap between theory and practice.

Method of the study:

The present study adopted a descriptive survey method as it involves fact-finding inquiry into the current state of science education, particularly focusing the linkages between the theoretical content and practical aspects at the secondary level in Mizoram. The study also explored the challenges faced by science teachers. As an approach, the present study employs both quantitative and qualitative analysis techniques.

Population of the study:

The population of the study consisted of all Secondary School Science Teachers in Mizoram, as shown in Table 1

Table 1 : Status of Secondary Schools in Mizoram.

District	School management type				Total
	Government / Aided School	Deficit	Samagra	Private	
Aizawl	78	5	13	101	197
Champhai	34	0	5	18	57
Hnahthial	16	0	2	5	23
Khawzawl	12	0	2	14	28
Kolasib	22	1	13	10	46
Lawngtlai	22	0	11	30	63
Lunglei	40	1	19	34	94
Mamit	30	0	12	12	54
Saiha	18	1	9	13	41
Saitual	28	0	7	15	50
Serchhip	27	1	6	13	47
Total	327	9	99	265	700

Source: *Statistics of School Education 2022-2023*

Sample of the study:

For the present study, 100 out of 700 Secondary Schools were proportionately selected using stratified cluster sampling technique as follows:

Table 2 : Sample of the study:

District	Type of School Management				Total No. of schools	Total No. of science teachers
	Govt School	Deficit school	Samagr a funded School	Private School		
Aizawl	7	3	2	18	30	32
Lunglei	6	2	2	2	12	12
Siaha	3	0	1	1	5	5
Champhai	5	1	2	2	10	10
Kolasib	3	0	2	2	7	7
Serchhip	4	1	0	1	6	6
Lawngtlai	3	1	2	0	6	6
Mamit	3	0	2	1	6	6
Saitual	4	0	1	2	7	7
Khawzawl	3	0	1	2	6	6
Hnahthial	4	0	0	1	5	5
Total	53	8	15	32	100	102

Tools used for data collection:

The following tools are used in the present study.

5. To study perception of teachers, the investigator developed and standardized Perception Scale for Teachers towards science practical
6. Questionnaire on Teacher's Profile and Challenges to study various issues including profile of science teachers and teacher's challenges
7. Checklist for implementation of science practical
8. Focus Group Discussion (FGD)

Mode of data collection:

The investigator personally visited 100 schools and took permission from the concerned authorities to collect data. After getting approval, perception scale, checklist for implementation of science practical and questionnaires for collecting challenges faced by Science Teachers were distributed with thorough instructions beforehand. A focus group discussion among secondary school science teachers was also conducted to discuss the matters concerning science practical and challenges faced by science teachers.

Data analysis:

Considering the nature of the study, the characteristics of the data, and the research objectives, the investigator employed the following methods for data analysis:

- **Qualitative Data Analysis:** In order to study the linkage between theory and practical aspects of science, Classes IX and X science textbooks and science practical manual of MBSE were examined.
- **Descriptive Statistical Measures:** Measures such as central tendency, percentages, Stanine grades, and percentiles were utilized
- **Test of significance for mean difference:** ANOVA and t-test were applied to determine the significance of differences in mean scores among various groups categorized by gender, type of school management and locale.
- **Coefficient of Correlation:** The Pearson Product Moment Correlation method was used to examine the relationship between theory and practical marks of Class X students over the past five years.

Major findings and discussions of the study:

The following are the major findings and discussions of the study.

Objective No 1: To investigate the linkages between theoretical contents and prescribed practicals of secondary school science subject in Mizoram

Class-IX Science:

The prescribed class IX Secondary Science textbook of Mizoram Board of School Education published by Arya Publishing Company written by R.R. Mishra, A.P. Shreelatha, Neetu Sing, Yash Pal and Joginder Singh is currently in use. It consists of fifteen chapters, which were divided into various sections, with five chapters dedicated to Physics, four chapters focusing on Chemistry, and another six chapters on Biology. The practical manual currently used by Class IX students in Mizoram, titled “*New Experimental Skills in Science - IX*”, is based on the latest syllabus prescribed by Mizoram Board of School Education published by Geeta Publishing House, Pragati Complex, Idgah Chowk, Delhi–110006. The practical manual contains 15 experiments, each introduced with a general overview, followed by the aim of the experiment, a list of materials required, the underlying principles, the procedure for setting up and conducting the experiment, observations in tabular form, the results, and precautions to be observed during the process.

Gaps in linkages between theory and practical contents in class IX physics were found. In class IX physics, important chapters like Force & Motion (Chapter 2) and Work & Energy (Chapter 4) were found to have no related experiment, while Chapter 3 (Gravitation and Floatation) had three related experiments from the prescribed practicals. Alignment with theory cannot be clearly established for one experiment.

Theory and practical linkages were found in 2 chapters out of 4 chapters in the chemistry section. It was also found that Chapter 7 ‘Is Matter around us pure’, had five related experiments while Chapter 6 ‘Matter in Our Surroundings’, had one related experiment. However, Chapters 8 ‘Atoms & Molecules’ and chapter 9 ‘Structure of the Atom’ were found to have no related prescribed experiment.

In Biology section, the study found that 2 out of 6 chapters in Biology viz. Chapters 13 ‘Why Do We Fall Ill’, and chapter 14 ‘Natural Resources’ had no linkage with the prescribed practical. It was also found that chapters viz. chapter 10 ‘Fundamental Unit of Life’, chapter 11 ‘Tissues’ and Chapter 12 ‘Diversity in Living Organisms’ had prescribed practical.

The study also revealed that the publishers for science textbook and the practical manual for class IX were different. Although the practical manual includes prescribed experiments covering all branches of science, there is no clear distinction between physics, chemistry, and biology experiments in the prescribed manual.

Class-X Science:

The prescribed secondary science textbook of Mizoram Board of School Education, Mizoram, published by Arya Publishing Company written by R.R. Mishra, Neetu Sing, Yash Pal and Joginder Singh is presently used for class X in Mizoram. This textbook is organized into sixteen chapters, encompassing five chapters on physics, five on chemistry, and six on biology. The current science practical guide book used for class X is the “New Experimental Skills in Science - X” containing 15 experiments, which is prescribed by Mizoram Board of School Education published by Geeta Publishing House, Pragati Complex, Idgah Chowk, Delhi-110006.

The study found that some chapters from physics chapters, namely, Chapter 1 ‘Light’ and Chapter 3, ‘Electricity’, had related experiments. Though chapters like Chapter 2 ‘Human Eye’ Chapter 4 ‘Magnetism’ and Chapter 5 ‘Energy Sources’ have no prescribed practicals.

It was also found that chemistry chapters viz. Chapters 8 ‘Metals & Non-Metals’ and chapter 9 ‘Acids, Bases & Salts’ had strongly aligned experiments. Chapter 7 ‘Chemical Reactions’ had one related experiment, while Chapters 6 ‘Periodic Table’ and chapter 10 ‘Carbon Compounds’ had no prescribed practical.

Among chapters under biology section, only two chapters viz. Life Processes Chapter 11 ‘Life Processes’ and Chapter 13 ‘How do Organisms Reproduce’ had prescribed experiments. It was also found that other chapters,

namely, Chapter 12 ‘Control & Coordination’, Chapter 14 ‘Heredity and Evolution’, Chapter 15 ‘Our Environment’ and Chapter 16, ‘Management of Natural Resources’ had no prescribed experiments.

The study also revealed that the publishers for science textbook and practical manual for class X were different. Although the practical manual includes prescribed experiments covering all branches of science, there is no clear distinction between physics, chemistry, and biology experiments in the prescribed manual.

Discussions;

The findings of the present study revealed that the Science textbook and the practical manual prescribed by the Mizoram Board of School Education (MBSE) were published by different publishers. This may be considered the main reason why there was some mismatch between the theoretical and practical content of both Class IX and Class X Science subjects. A detailed look into the findings also revealed that prescribed practicum for each branch of science viz. Physics, chemistry and biology are not in proportion. It was also found that while some chapters had more than one related prescribed practicum, some chapters did not have any prescribed practicum. As mentioned earlier, the reason behind this could be that the textbook and practical manuals were published by different publishers.

Objective No. 2: To analyse class period allotted for science practical in the weekly time table of the schools.

It was found that the majority of the schools did not include a science practical period in their weekly timetable. There were only a few schools (19%) that had practical period in the weekly timetable.

Among different types of schools, government schools (11.11%) witnessed the least inclusion of practical class in the weekly time table, while deficit schools were found to have highest inclusion (37.5%) of practical period in the time table.

It was also found that schools in urban areas had a 78% higher inclusion (20.59%) of practical period in the time table than schools in rural areas (15.6%).

As reported by one science teacher, *“Having a dedicated practical class in the timetable is good, but for our students, it often becomes free time. They don’t understand the procedures, so we end up cramming practicals just before exams—usually at the end of the session”*.

Discussions:

The present study revealed that most schools did not include practical class in their weekly timetable and conducted practical classes only just before promotional examination. This could be due to limited resources and budget constraints. The arrangement of practical classes before final examinations, rather than integrating them throughout the academic session may lead to the belief that laboratory work and hands-on experiences are just extra activities and not the fundamental components of the learning process and this practice may hamper the understanding of underlying principles by students. There could be a number of contributing factors for not including practical class in a weekly time table such as, lack of manpower, lack of laboratory equipment and chemicals, financial constraints and unavailability of science laboratory in the school.

Objective No 3 : To study the implementation of prescribed science practical by secondary schools in Mizoram

Regarding the implementation of prescribed science practicals in class IX physics, it was found that only very few teachers (less than 10%) conducted four experiments out of five prescribed experiments. Majority of the teachers failed to conduct the prescribed practicals in class IX physics.

It was found that majority of the teachers failed to conduct the prescribed practicals in chemistry. A fair number of teachers (more than 20%) conducted two experiments in chemistry. The other three experiments in chemistry were conducted by very few teachers (10% or less).

The study found that the majority of the teachers failed to conduct prescribed practicals in biology. It was found that only a few numbers of teachers (less than 10%) conducted three experiments out of five prescribed practical in

biology. The other two experiments were conducted by less than 15% of the teachers.

The findings in relation to class X practical revealed that 85.3% of science teachers conducted one experiment in physics section ‘Tracing the path of a ray of light through a rectangular glass slab and measuring the angle of incidence and angle of emergence’. It was also found that more than 20% of the teachers conducted two experiments in physics. However, majority of teachers failed to conduct experiments on resistance related experiments.

Among five experiments under chemistry portion, one experiment, pH test, was conducted by all science teachers and a good number of teachers conducted two experiments viz., studying properties of acids & bases and properties of acetic acid. It was also found majority of teachers failed to conduct the remaining two experiments.

It was found that a fair number of teachers (more than 30%) conducted three experiments out of five practicals in biology. Majority of the teachers failed to conduct prescribed practicals in class X biology.

Discussions:

The study found that basic experiments, such as pH tests and acid-base reactions, were widely conducted, while more complex experiment, such as optics, electricity, and biology, faced major execution challenges. This could be due to the unavailability of essential equipment, such as mirrors, circuits, and microscopes. Chemical reaction experiments, such as generating sulphur dioxide gas, were rarely performed, likely due to safety concerns and inadequate laboratory facilities. Constraints in school resources limited hands-on learning, particularly for complex experiments, potentially affecting students' understanding of theoretical concepts and the resource constraints faced by schools affect the conduct of practical in schools (Okafor 2016). Apart from the unavailability of resources, another big reason for conducting only a few experiments could be that teachers in the schools deliberately select practical that they are comfortable with and as per their convenience.

Objective No. 4: To study the relationship between the achievement of students in theory and practical.

It was found that there exist a moderately positive relationship between theory marks and practical marks in the HSLC examinations in the year 2019 to 2023. In terms of percentage, it was found that the theory marks taken together in the five years was 40.24% while it was 78.6% in practical. This finding indicates a huge achievement gap between theory and practical in HSLC examinations.

One teacher from Samagra school stressed the importance of practical examiner as *“Practical examiners plays an important role while conducting science practicals. If students perform well in practical exams, they deserve full marks—this would make science practicals more meaningful and improve execution rates”*.

Discussions:

The findings revealed a positive relationship between theory marks and practical marks. However, the comparison of theory and practical marks in terms of percentage clearly shows a huge gap; students performed way better in practical as compared to theory. Keeping in view the way practical examinations were conducted, these constant marks in practical during the reported period of five years may be a concern for research scholars and science educators and may raise questions on the process of conducting science practical examination and the marking system.

Objective No 5: To analyse the profile of science teachers teaching science subject in secondary schools of Mizoram.

In connection to the educational qualifications of science teachers, the study found that a good number of teachers (46.1%) across different types of school management hold master degree in science and of the different types of schools, deficit schools had highest percentage of master degree holder and government school had lowest percentage of master degree holder. It was found that half of the science teachers (50%) possessed Bachelor of Science degree, with highest percentage seen in government schools and lowest percentage in deficit schools. A very few number of science teachers who possessed degrees other than M.Sc. and B.Sc. were found in private schools.

Regarding professional qualification, it was also found that majority of the teachers teaching science subjects at secondary schools possessed the required professional qualifications v.z. B.Ed. or M.Ed. All teachers in government and samagra schools had required professional qualifications, whereas majority of teachers in private school did not have the required professional qualifications. The study also found that a very few teachers had D.El.Ed. qualification, which is under qualification for secondary school.

The study found that regular appointments were relevant only in government and deficit schools. A very few teachers in government schools were appointed on a contractual basis. All teachers in Samagra schools were recruited on a co-terminus basis, while teachers in private schools were appointed in line with the terms and conditions laid down by their respective schools.

It was found that majority of the teachers had below 10 years of experience and only a few teachers had more than 21 years of experience, of which government schools had the highest percentage of teachers having more than 21 years and above. No teachers in private schools and samagra schools had teachers with more than 21 years of experience.

Discussions:

The analysis of the profile of science teachers in secondary schools of Mizoram revealed that all teachers hold either bachelor's or a master degree in science except in private schools. Only teachers with essential qualifications both academically and professionally were found in government, deficit and samagra schools, while majority of the teachers in private schools did not have the required professional qualifications. Since academic qualification had a significant influence on the teachers' overall job satisfaction (Kuchy & Chakraborty, 2021), underqualified teachers are likely to have less job satisfaction. While private schools are also affiliated to the state board of school education, it is clear that the rules and regulations regarding minimum qualifications prescribed by the NCTE and MBSE were not strictly enforced. The appointment status of teachers may significantly influence job satisfaction, performance, and retention in the school. Regular teachers, with job security and long-term benefits, may exhibit higher

commitment, leading to consistent performance and lower turnover rates. The findings of the present study revealed that regular appointments were relevant to only teachers working in government and deficit schools. Kabungaidze et.al. (2013) found that tenure and specialisation can predict employee turnover intentions and as evidenced from the findings of the present study, no teachers from samagra and private schools had over 20 years of teaching experience, and this indicates high turnover rates in these schools and the reason could be their nature of appointment.

Objective No. 6: To study the challenges faced by science teachers in Mizoram.

The findings of the study revealed that only few science teachers across all school types reported challenges in relation to heavy theoretical content. Samagra school reported the highest percentage of teachers (20%) who considered heavy theoretical content a challenge. Among all types of schools, heavy theoretical content was least perceived as a challenge by private school teachers.

It was found that more than half of the teachers (51%) reported issues on science laboratory. Among the types of schools, majority of teachers from samagra and private schools (more than 60%) faced challenges related to science laboratory while a small portion of teachers from government and deficit schools reported challenges with regards to science laboratory.

The study revealed that inadequate practical equipment was a major issue reported by 76.5% of science teachers. It was found that majority of science teachers from all types of school except deficit school reported challenges related to practical equipments. Among these schools, all samagra school teachers (100%) reported the problem related to practical equipment whereas only 37.5 % of teachers from deficit school considered having problems in relation to practical equipments

Regarding the practical examination, it was found that only few science teachers (less than 25%) across all school types reported challenges in relation to the practical examination. Among all types of school, Private school reported the highest percentage of teachers (25%) who considered practical examination as challenge, whereas practical examination was least perceived as challenge by deficit school teachers.

It was found that only 10.8% of science teachers reported lack of subject expertise. Private schools had the highest portion (25%) of teachers who considered lack of subject mastery as challenge. Remarkably, teachers from both deficit and Samagra schools reported no challenge in relation to subject expertise.

The study found that majority of the science teachers considered financial constraint as challenge for successful implementation of science practicals. The study revealed that samagra schools reported the highest percentage of teachers (86.7%) who reported challenge related to finance, followed by government school (72.7%). Among different types of school, private schools had the least percentage of teachers who reported finance as challenge.

Discussions

The findings of the present study revealed that teachers do not consider the theoretical content of science subject not heavy and one of the teachers from the sample schools even reported that *“The syllabus of science for secondary school is so less that i can have sufficient time to conduct practical activities with students sometimes in the form of project”*. On the other hand, majority of the teacher failed to conduct practical experiment; there could be a number of reasons behind this, but it is obvious that it is not because of heavy theoretical content of science subject. According to Banu (2011), factors such as low teacher-student ratios and the absence of laboratory assistants contributed to teachers’ heavy workloads.

The issues concerning to availability of science laboratory and equipment are more severe among samagra and private schools. In line with the findings of the present study, the findings of Malathi and Rohini (2017) also revealed a lack of laboratory tools, insufficient time allotment, large class size and absence of science training courses as challenges faced by science teachers. Despite this, some teachers in schools with little to no laboratory facilities still manage to conduct experiments by improvising with available materials or even purchasing supplies with their own money. A teacher from samagra School said, *"Since we hardly have any lab equipment, I often rely on YouTube to find and show experiment videos to students."* Similarly, a Private School teacher stated, *"We lack many essential practical equipment. I sometimes purchase materials myself out of personal pocket and still ensure practical sessions are conducted."*

Though majority of the teachers in the present study reported issues relating to science laboratory, only a few teachers reported challenges when it comes to practical examination and this has led to the need for further investigation and research regarding practical examination.

Objective No. 7: To construct and standardise teachers' perception scale towards science practical.

The teacher's perception scale towards science practical was constructed and standardised. The perception scale consists of 33 items. The scale was constructed following Likert's five point scale and the maximum possible score is 165 while the minimum possible score is 33. The reliability of the scale was 0.82 (test-retest), 0.902 (cronbach's alpha) and 0.88 (split-half). Norms were also provided following the Stanine norm for the newly constructed scale.

Table No. 3 : Norms for interpretation of perception based on stanine

Sl.No	Score range	Stanine Grade	Level based on stanine
1	86 & above	9	High Perception
2	80 to 85	8	
3	75 to 79	7	
4	69 to 74	6	Average Perception
5	64 to 68	5	
6	59 to 63	4	
7	53 to 58	3	Low Perception
8	48 to 52	2	
9	47 & below	1	

Objective No. 8: To find out the perception of secondary school science teachers toward science practical in Mizoram.

It was found that slightly more than half of the teachers possessed a positive perception towards science practical of which some of them had a highly positive

perception. It was also found that a small portion of teachers (13.7%) had a neutral perception. A good number of teachers (35.3%) had a negative perception towards science practical.

Discussions:

Keeping in view the condition of science laboratory and the way experiments in science are conducted, it is not surprising that only few teachers possessed high perception towards science practical in Mizoram. At the same time, more than a quarter of the science teachers surveyed had low perception towards science practical. Science teachers were not necessarily negative about or towards science practical; the reason for having low perception could include lack of resources, status of laboratory and the way experiments are conducted at the school level and the way examinations and evaluation are conducted for science practical. All these factors can contribute to the perception of science teachers towards science practical.

Objective No. 9: To compare the perception of secondary school science teachers towards science practical in relation to gender.

There is no significant difference in the perception towards science practical between male and female science teachers

Objective No. 10: To compare the perception of secondary school science teachers towards science practical based on type of school management.

There is no significant difference in science teacher's perception towards science practical with reference to school management type.

Objective No. 11: To compare the perception of secondary school science teachers towards science practical with reference to locale.

There is no significant difference in the perception towards science practical between rural and urban science teachers.

Discussions

No significant difference was found between different selected demographic variables with regard to the perception of science teachers towards science practical. Though no significant difference was found between demographic variables, it was clear from the findings that the majority of the science teachers do not have a high perception towards science practical. If one practicum is prescribe for one theory chapter and if both theory and practical are in line with each other and if practical classes were included in the weekly timetable by all schools, if practical examination is conducted in a more systematic manner and if practicum is given more weightage, the perception of science teachers towards science practical may be improved.

Educational implications of the study:

The present study holds significant educational implications for science teachers working in secondary schools in particular and the system of education in Mizoram for holistic development of science education in general.

The findings of the present study in relation to linkages between theory and practical aspect of science subject throw light on the gap between theory and practical aspect of science subject. This finding can help curriculum developer and teachers teaching at the school level in realising the need to improve the existing syllabus. This finding may inform the authorities to take necessary actions to address the gap between theory and practical in science subjects so that students can attain holistic development in science subjects. The findings of the present study also clearly reveal the need to make proper classification of practical based on the three branches of science, viz. physics, chemistry and biology. The findings also suggest the need for uniformity regarding the number of practical prescribed for each chapter.

Analysing the time table of secondary schools on the inclusion of practical period in the weekly time table will reveal the reality of practical aspect of science at the grassroots level. The findings show how importance is given to the practical aspect of science as compared to theoretical content. A study of the implementation status of science practical may even predict the future performance of students in

science subjects and may reveal how much importance is given to practical activities and how much it is neglected. This kind of information will serve as significant input in planning and reforming science education at secondary level of education. The baseline information on the implementation of science practical at secondary stage will also inform the authorities and the educators and even students on how to improve the situation and will help them in deciding what mechanism or intervention needs to be taken to improve the situation.

One of the objectives of the present study is to establish the relationship between the marks obtained in science theory and practical at HSLC examination. This finding may raise question on how theory and practical examinations are conducted and will inform the gap in theory and practical marks obtained by students. If students who did poorly in theory scored a very high percentage of marks in practical, it may indicate defective conduct of practical examination or otherwise.

One of the objectives of the study provide a clear understanding of the current profile of secondary school science teachers. This will bring into light the academic and professional qualifications of science teachers in the state of Mizoram. This will inform whether the minimum qualifications and standards for teachers laid down by the National Council for Teacher Education (NCTE) are met by the secondary science teacher in Mizoram. If students are not taught by qualified teachers, the quality of science education in particular and the quality of education in general may be questionable. The present study will tell us the nature of the appointment of teachers. It may be difficult for a teacher to have job security and job satisfaction if a teacher is not permanently employed.

The study also reveals the various challenges faced by science teachers. Findings in relation to this will help policy makers and administrators in pinpointing the problems faced by science teachers at the secondary level and this in turn will help them in formulating policy for the solutions of the challenges faced by secondary science teachers.

The development and standardization of perception scale towards science practical for secondary school science teachers will serve as an important tool to measure the perception of science teachers about science practical. This tool can be

used by anyone interested in finding out the perception of science teachers towards science practical. Knowing the perception of science teachers towards science practical will also enable us to understand how science teachers look at science practical in general and their views on the importance of connecting theory with practice.

Recommendations from the study:

The following are the recommendations made in line with the findings of the study.

9. It is recommended that secondary Science textbook should be prepared and published by the same investigator and publisher to ensure better connection or linkage between theoretical contents and practical activities. Each and every chapter in the textbook should have a related practicum and the number of practical activities prescribed for each chapter should be of the same value or uniform in terms of number.
10. In order to offer more hands-on experiences among the students, practical period should be allotted in the weekly timetable of the school at least once a week. Teachers should not only conduct practical classes to class X but should also be encouraged to introduce practical classes to class IX standard also. The reasons for not including practical period in the weekly time table of the schools may be investigated and the authority may take initiatives to tackle the problems in line with the findings.
11. Teachers should be encouraged to conduct practical classes in all three branches of science at the secondary level, viz. physics, chemistry and biology. Practical experiments that are simpler in procedure and execution, which do not require sophisticated equipment, may be introduced. Teachers should be sensitised about the learning outcomes of science subject at secondary level. So that they will realize the importance of conducting practical classes for both classes IX and X.
12. Stricter and more structured practical examination system in both classes IX and X may be enforced by the Mizoram Board of School Education. It is suggested that more weightage of marks may be assigned for practical

components. Authority must come up with innovative interventions to address the huge gap between the percentage of marks obtained by students in the theory paper and in practical in HSLC examinations.

13. Minimum qualification standards for teachers, be it academic or professional, must be strictly enforced uniformly across all types of schools. In-service teacher training specifically designed to cater to the needs of science teachers to conduct practical classes may be organised by the authority. Private school teachers should be encouraged to undergo teacher professional training courses relevant to secondary education.
14. There should be a balance between theoretical content and prescribed practicals in secondary science subject. It is recommended that all schools affiliated to Mizoram Board of School Education must have an adequate and working science laboratory as prescribed by the affiliation regulation 2012 of MBSE. Affiliation should not be granted to those schools seeking affiliation unless they fulfil the norms laid down by MBSE. A mobile science laboratory may be temporarily established to address immediate problems and to improve access to laboratory facilities and practical equipment, particularly in underserved areas. These mobile units, consisting of well-equipped vans with portable laboratory setups, should follow a regular rotation schedule to serve schools without science laboratory.
15. It is recommended that Block Resource Centre (BRCs) be strengthened and equipped with a well-equipped science laboratory so that schools without proper facilities within the block can avail the resources at the block resource centre.
16. Overall, opportunities for hands-on learning experiences should be provided to the students so that students can apply and relate their learning to real-life experiences and to their immediate environment.

Suggestions for further research:

The following suggestions for further studies were laid down in accordance with the findings of the study

12. To conduct a comparative study on the integration of theory and practice across different Indian states.
13. To conduct a comparative study on different educational boards in India to identify best practices for aligning theoretical and practical content in science education.
14. A case study of a specific school that effectively implements practical periods in the timetable to identify their best practices.
15. A comparative study of schools that conduct practicals throughout the year versus those that conduct them just before the practical examination.
16. To construct and develop an achievement test on science practical for secondary school students.
17. To investigate the profile of teachers in other States of India
18. To find out the relationship between teachers' qualifications and practical teaching effectiveness in Secondary Science"
19. To study the Job satisfaction of science teachers working in different Secondary Schools.
20. To develop and standardize a scale to measure students' and teachers' perceptions of science practical in STEM education.
21. To compare the perception of science teachers based on teaching experience and subject specialization, as well as educational qualification.
22. To compare the perception of science teachers in Mizoram with those in other states to identify broader trends and contextual differences.

Appendix-1 : High School Curriculum 2009 (Science)

HIGH SCHOOL CURRICULUM

w.e.f

2009



**MIZORAM BOARD OF SCHOOL EDUCATION
AIZAWL : 796012**

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SCIENCE CLASS - IX

Motion: Distance and displacement, velocity; uniform and non-uniform motion along a straight line; acceleration, distance-time and velocity-time graphs for uniform and uniformly accelerated motion, equations of motion by graphical method; elementary idea of uniform circular motion

Force and Newton's laws: Force and motion, Newton's laws of motion, inertia of a body, inertia and mass, momentum, force and acceleration, elementary idea of conservation of momentum, action and reaction forces

Gravitation and Floatation: Gravitation; universal law of gravitation, force of gravitation of the earth (gravity), acceleration due to gravity; mass and weight; free fall, thrust and pressure, Archimedes' principle, buoyancy, elementary idea of relative density
Work, Energy and Power Work done by a force, energy, power; kinetic and potential energy; law of conservation of energy

Sound: Nature of sound and its propagation in various media, speed of sound, range of hearing in humans; ultrasound; reflection of sound; echo and SONAR, structure of the human ear (auditory aspect only).

Matter in Our Surroundings: Definition of matter; Particle nature, solid, liquid and gas; characteristics - shape, volume, density; change of state-melting (absorption of heat), freezing, evaporation (Cooling by evaporation), condensation, sublimation.

Is Matter Around Us Pure: Elements, compounds and mixtures. Heterogenous and homogenous mixtures, colloids and suspensions.

Atoms and Molecules: atoms and molecules. Law of constant proportions. Atomic and molecular masses. Mole Concept, Relationship of mole to mass of the particles and numbers. Valency. Chemical formula of common compounds.

Structure of the Atom: Electrons, protons and neutrons; Isotopes and isobars.
Cell - Basic Unit of life : Cell as a basic unit of life; prokaryotic and eukaryotic cells, mul-ticellular organisms; cell membrane and cell wall, cell organelles; chloroplast, mitochondria, vacuoles, ER, golgi apparatus; nucleus, chromosomes - basic structure, number.

Tissues: Structure and functions of animal and plant tissues (four types in animals; meri-stematic and permanent tissues in plants).

Diversity in Living Organisms: Diversity of plants and animals - basic issues in scientific naming, basis of classification. Hierarchy of categories / groups, Major groups of plants (salient features) (Bacteria, Thalophyta, Bryophyta, Pteridophyta, gymnosperms and Angiosperms). Major groups of animals (salient features) (Non-chordates upto phyla and chordates upto classes).

Why Do We Fall I II: Health and its failure. Infectious and Non-infectious diseases, their causes and manifestation. Diseases caused by microbes (Virus, Bacteria and protozoans) and their prevention, Principles of treatment and prevention. Pulse polio programme.

Natural Resources: Air, Water, Soil. Air for respiration, for combustion, for moderating temperatures, movements of air and its role in bringing rains across India. Air, water and soil pollution (brief introduction). Holes in ozone layer and the probable damages. Bio-geo chemical cycles in nature; water, oxygen, carbon, nitrogen.

Improvement in Food Resources: Plant and animal breeding and selection for quality improvement and management; use of fertilizers, manures; protection from pests and diseases; organic farming.

PRACTICALS LIST OF EXPERIMENTS

1. **To prepare**
 - a) a true solution of common salt, sugar and alum
 - b) a suspension of soil, chalk powder and fine sand in water
 - c) a colloidal of starch in water and egg albumin in water and distinguish between these on the basis of
 - i) transparency
 - ii) filtration criterion
 - iii) stability
2. **To prepare**
 - a) a mixture
 - b) a compound

using iron filings and sulphur powder and distinguish between these on the basis of:

 - i) appearance i.e., homogeneity and heterogeneity
 - ii) behaviour towards a magnet
 - iii) behaviour towards carbon disulphide a solvent.
 - iv) effect of heat.
3. **To study the extent of cooling caused by evaporation on the following liquids, using a thermometer. Also to arrange these liquids in the increasing order of the extent of cooling produced**
 - i) Water
 - ii) Alcohol
 - iii) Ether
4. To verify laws of reflection of sound.
5. To determine the density of solid (denser than water) by using a spring balance and a measuring cylinder.

6. To establish the relation between the loss in weight of a solid when fully immersed in
 - i) tap water
 - ii) strongly salty water, with the weight of water displaced by it by taking at least two different solids.
7. To measure the temperature of hot water as it cools and plot a temperature-time graph.
8. To determine the velocity of a pulse propagated through a stretched string/slinky.
9. To prepare stained temporary mounts of (a) onion peel and (b) human cheek cells and to record observations and draw their labeled diagrams.
10. To identify parenchyma and sclerenchyma tissues in plants, striped muscle fibers and nerve cells in animals, from prepared slides and to draw their labeled diagrams.
11. To separate the components of a mixture of sand, common salt and ammonium chloride (or camphor) by sublimation.
12. To determine the melting point of ice and the boiling point of water.
13. To observe the onion peel cells placed in hypertonic solution under the microscope and draw labelled diagram of the same.
14. To study the characteristic of *spirogyra*/Agaricus, Moss/Fern, Pinus (either with male or female conre) and an Angiospermic plant. Draw and give two identifying features of groups they belong to.
15. To observe and draw the given specimens-earthworm, cockroach, bony fish and bird. For each specimen record
 - (a) one specific feature of its phylum
 - (b) one adaptive feature with reference to its habitat.

CLASS – X

1. Natural Phenomena

Convergence and divergence of light. Images formed by a concave mirror; related concepts; centre of curvature; principal axis. Optic centre, focus, focal length. Refraction; laws of refraction.

Image formed by a convex lens; functioning of a lens in human eye; problems of vision and remedies. Applications of spherical mirrors and lenses.

Appreciations of concept of refraction; velocity of light; refractive index; twinkling of stars; dispersion of light. Scattering of light.

2. How things work.

Effects of Current

Potential, Potential difference, Ohm's law; Series combination of resistors, parallel combination of resistors; Power: dissipation due to current; Interrelation between P, V, I and R.

Magnets: Magnetic field, field lines, field due to a current carrying wire, field due to current carrying coil or solenoid; Force on current carrying conductor, Fleming's left hand rule. Electromagnetic induction. Induced potential difference, Induced current. Direct current. Alternating current; frequency of AC. Advantage of AC over DC. Domestic electric circuits.

3. Materials

Chemical Substances - Nature and Behaviour

Acids, bases and salts: General properties, examples and uses.

Chemical reactions: Types of chemical reactions: combination, decomposition, displacement, double displacement, precipitation, neutralization, oxidation and reduction in terms of gain and loss of oxygen and hydrogen.

Metals and non-metals: Brief discussion of basic metallurgical processes. Properties of common metals. Elementary idea about bonding.

Carbon Compounds: Carbon compounds, elementary idea about bonding.

Saturated hydrocarbons, alcohols, carboxylic acids (no preparation, only properties).

Some Important chemical compounds: Soap-cleansing action of soap.

Periodic classification of elements: Gradations in properties: Mendeleev periodic table.

4. The world of the living

Our environment

Our environment: Environmental problems, their solutions. Biodegradable, non-biodegradable, **Ozone depletion** **Life Processes:** "living" things; Basic concept of nutrition, respiration, transport and excretion in plants and animals.

Control and Co-ordination in plants and animals: Tropic movements in plants; Introduction to plant hormones; control and co-ordination in animals: voluntary, involuntary and reflex action, nervous system; chemical co-ordination : animal hormones.

Reproduction : Reproduction in plants and animals. Need for and methods of family planning. Safe sex vs HIV, AIDS. Child bearing and women's health.

Heridity and evolution: Heridity; Origin of life: brief introduction; Basic concepts of evolution.

5. Natural Resources

Conservation of natural resources: Management of natural resources. Conservation and judicious use of natural resources. Forest and wild life, coal and petroleum conservation. People's participation. Chipko movement. Legal perspectives in conservation and international scenario.

The Regional environment: Big dams: advantages and limitations; alternatives if any. Water harvesting. Sustainability of natural resources.

Sources of energy: Different forms of energy, leading to different sources for human use: fossil fuels, solar energy; biogas; wind, water and tidal energy; nuclear energy. Renewable versus non - renewable sources.

PRACTICALS LIST OF EXPERIMENTS

1. To find the pH of the following samples by using pH paper/universal indicator.
 - i) Dilute Hydrochloric acid
 - ii) Dilute NaOH solution
 - iii) Dilute Ethanoic acid solution
 - iv) Lemon juice
 - v) Water
 - vi) Dilute Sodium Bicarbonate Solution.
2. To study the properties of acids and bases HCl & NaOH by their reaction with
 - i) Litmus solution (Blue/Red)
 - ii) Zinc metal
 - iii) Solid Sodium Carbonate
3. To determine the focal length of
 - a) Concave mirror
 - b) Convex lens
 by obtaining the image of a distant object.
4. To trace the path of a ray of light passing through a rectangular glass slab for different angles of incidence. Measure the angle of incidence, angle of refraction, angle of emergence and interpret the result.
5. To study the dependence of current (I) on the potential difference (V) across a resistor and determine its resistance. Also plot a graph between V and I.
6. To determine the equivalent resistance of two resistors when connected in series.
7. To determine the equivalent resistance of two resistors when connected in parallel.
8. To prepare a temporary mount of a leaf peel to show stomata.
9. To show experimentally that light is necessary for photosynthesis.
10. To show experimentally that carbon dioxide is given out during respiration.
11. To study (a) binary fission in Amoeba and (b) budding in yeast with the help of prepared slides.
12. To determine the percentage of water absorbed by raisins.

13. To prepare SO_2 gas, observe its following properties and draw inferences in respect of
- i) odour
 - ii) solubility in water
 - iii) effect on litmus paper
 - iv) action on acidified potassium dichromate solution.
14. a) To observe the action of Zn, Fe, Cu and Al metals on the following salt solutions,
- i) $\text{ZnSO}_4(\text{aq.})$
 - ii) $\text{FeSO}_4(\text{aq.})$
 - iii) $\text{CuSO}_4(\text{aq.})$
 - iv) $\text{Al}_2(\text{SO}_4)_3(\text{aq.})$
- b) Arrange Zn, Fe, Cu and Al metals in the decreasing order of reactivity based on the above result.
15. To study the following properties of acetic acid (ethanoic acid):
- i) odour
 - ii) solubility in water
 - iii) effect on litmus
 - iv) reaction with sodium bicarbonate

Appendix-2 : Teacher's Perception Scale towards Science Practical

TEACHER'S PERCEPTION SCALE TOWARDS SCIENCE PRACTICAL

Please fill in the following informations:

Gender : Male ☐ Female ☐ Others ☐

Age : _____

Designation : _____

Educational Qualification : B.Sc. ☐ M.Sc. ☐ Others ☐

Professional Qualification : D.El.Ed. ☐ B.Ed. ☐ M.Ed. ☐ Others ☐

Name of Schools : _____

Teaching Experience : _____ (in years)

District : _____

Locality : _____

Date : _____

INSTRUCTIONS

The scale consist of 33 statements. Read each statement carefully and decide your answer on any one of the five alternatives viz. strongly agree, agree, Undecided, disagree and strongly disagree. Put a tick mark in the corresponding alternative which is close to your answer.

Answer all the statements.

The answer will be kept confidential.

S/No	Items	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
1	The content of science practical is in line with the theoretical content taught in class.					
2	Sufficient time is allotted in the time-table to conduct all experiments prescribed in the syllabus.					
3	The instructions given in the practical book of secondary science subjects are comprehensive enough for conducting experiments.					
4	The practical contents in science subject of secondary stage is appropriate for the level					
5	Teachers have adequate theoretical knowledge required for conducting the practical experiments in secondary school science subject.					
6	Being well acquainted with the objectives of secondary school science practical is necessary					
7	Having a thorough understanding of the anticipated results of the secondary school science practical is essential					
8	I used to carry out science practical keeping in view the expected outcomes of the practical.					
9	Explaining the procedures involved before conducting the experiments is necessary.					
10	Teachers are readily available to address any issues that might arise during practical sessions					
11	It is important to correlate the practical experiments with the theoretical concepts taught in class					

S/No	Items	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
12	It is important to make sure that there is active participation from all students during the practical sessions.					
13	Teachers can assess student's understanding during the science practical sessions.					
14	Constructive feedback by teachers can improve student's performance in science practical sessions.					
15	Asking students to reflect on their observations of the experiments is necessary to check students understanding level.					
16	Providing freedom to students to explore alternative approaches during experiment can enhance student's engagement.					
17	It is ideal to cover all practical prescribed in the syllabus					
18	Cheating during experiment has to be controlled strictly					
19	Science practical activities allow students to develop their experimental skills.					
20	Practical activities of science subject offers opportunity for students to apply theoretical knowledge in practical settings.					
21	Science practical activities aid students in cultivating an understanding of the importance of safety protocols while conducting experiments					
22	Science practical activities make students aware about possible threats associated with experiment.					

S/No	Items	Strongly Agree	Agree	Undecided	Disagree	Strongly Disagree
23	Science practical activities prepare students for future scientific careers.					
24	Science practical at secondary level enhance the interest of students in science.					
25	Science practical activities promote the skills to work with others.					
26	Science practical activities provide opportunities for students to engage in hands-on learning.					
27	Science practical conducted in school provides curiosity to the students about scientific phenomena.					
28	It is necessary to have proper planning before conducting practical.					
29	School authority provides all required materials for science laboratory.					
30	Sufficient equipment and materials for conducting all practical are available in the school laboratory.					
31	Practical equipment available in school laboratory can adequately serve all students.					
32	Practical activities are really useful for explaining scientific concept effectively					
33	Practical activities foster skills like critical thinking, problem solving and teamwork among students					

TOTAL SCORE :

Appendix-3: Questionnaire on Teacher's Profile and Challenges

Name : _____

Contact No _____

Name of School : _____

Address : _____

Type of School : _____

Profile of Science Teacher

Gender : Male / Female

Graduation : BA / B.Sc / B.Com / Others

Master Degree : M.A / M.Sc / M. Com / Others

Professional Qualifications : D.El.Ed. / B.Ed. / M.Ed. / Others

Nature of Appointment : Regular / Contract / CSS / Others

Year of Experiences : _____

1. Do you conduct science practical regularly as per time table?

Class IX	Class X
Yes / No <i>If No, what is the reason?</i>	Yes / No <i>If No, what is the reason?</i>

2. Do you think the contents in secondary science textbook are well supported by the list of practical given in the syllabus?

Class IX	Class X
Yes / No <i>Give reason?</i>	Yes / No <i>Give reason?</i>

3. Is it possible to execute the practical which is already in the practical list?

Class IX	Class X
Yes / No <i>If No, what is the reason?</i>	Yes / No <i>If No, what is the reason?</i>

4. Major problems faced by teachers in conducting science practical

Problems	Yes	No	Clarification
Heavy theoretical content			
Challenges related to laboratory			
Challenges related to practical equipment			
Challenges related to practical examination			
Challenges related to subject expertise			
Challenges related to finance			

5. Is it possible to highlight connection between theory and practical in the classroom?

Class IX	Class X
Yes / No <i>Add comments?</i>	Yes / No <i>Add comments?</i>

6. Is there any practical equipment received/bought during the last three years?

Class IX	Class X
Yes / No <i>If Yes, please mention?</i>	Yes / No <i>If Yes, please mention?</i>

Appendix-4: Checklist for implementation of science practical

Name of School	:	_____
Address	:	_____
Type of School	:	_____
Profile of Science Teacher		
Gender	:	Male / Female
Graduation	:	BA / B.Sc / B.Com / Others
Master Degree	:	M.A / M.Sc / M. Com / Others
Professional Qualifications	:	D.El.Ed. / B.Ed. / M.Ed. / Others
Nature of Appointment	:	Regular / Contract / CSS / Others
Year of Experiences	:	_____

Mark 'YES' if practical is conducted and mark 'NO' if not conducted.

S/No	Name of Practical (Class X)	Yes	No	If No, give reasons
1.	Experiment on pH test			
2.	Studying the properties of acids and bases			
3	Determination of focal length of concave mirror			
4	Determination of focal length of convex mirror			
5	Tracing the path of a ray of light through a rectangular glass slab and measure the angle of incidence and angle of emergence			
6	Resistance of two resistors connected in series			
7	Resistance of two resistors connected in parallel			
8	Preparation of a temporary mount of a leaf peel to show stomata			
9	Photosynthesis experiment			
10	Experiment on respiration			
11	Studying binary fission in Amoeba & Yeast with the help of prepared slide.			
12	Determination of the percentage of water absorbed by raisins.			
13	Preparation of Sulphur dioxide (SO ₂) gas and observation of its properties			
14	Observation of action of Zn, Fe, Cu and Al metals			
15	Studying the properties of acetic acid			

Mark 'YES' if practical is conducted and mark 'NO' if not conducted.

S/No	Name of Practical (Class IX)	Yes	No	If No, give reasons
1.	Preparation of different types of solution			
2.	Differentiation between mixture & pure compound			
3	Carrying out chemical reactions on given compounds			
4	Laws of reflection of Sound.			
5	Determination of density of a Solid by using spring balance and a measuring cylinder.			
6	Relation between the loss in weight of a solid when fully immersed in water with the weight of water displaced by it			
7	Measuring the temperature of hot water as it cools and plot a temperature-time graph			
8	Determining velocity of a pulse propagated through a stretched string/slinky			
9	Preparation of stained temporary mount of onion peel & human cheek cells			
10	Identification of parenchyma and sclerenchyma tissues in plants and identification of striped muscle fibres in animals and nerve cell (Neuron) from prepared slides			
11	Separation of components of a mixture of Sand, Common Salt and Ammonium Chloride (or camphor) by sublimation.			
12	Determination of melting point of a ice and the boiling point of water			
13	To test the presence of starch in a given sample of food			
14	Studying the characteristics of (i) Spirogyra (ii) Moss or Fern (iii) Pinus (iv) An Angiospermic plant-Mustard and Onion;			
15	Observation and drawing of the given specimens			

Appendix-5: Questions/points for Focus Group Discussion (FGD)

1. Do you think the prescribed practical align well with the theoretical content in the syllabus? Can you share any examples where they do or do not connect effectively?
2. Do students find it easier to grasp theory after performing related practical? Share your observations.
3. Are you satisfied with the time allotted for science practical in your weekly time table? Elaborate.
4. Do you conduct all prescribed practicum for science subject? If not, give reason why?
5. What support (resources, training, and infrastructure) would help in better implementation of practical?
6. Do you face pressure to prioritize theory over practical due to board exams? How does this affect your teaching?
7. Are there cases where students excel in practical but struggle in theory (or vice versa)? What could be the reasons?
8. What are the biggest obstacles you face in conducting science practical? (e.g., lack of labs, materials, large class size, time constraints)
9. How do you manage when essential equipment or chemicals are unavailable?
10. Do you personally enjoy teaching practical classes? Why or why not?

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BRIEF BIO-DATA OF THE CANDIDATE

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Title of Thesis	: A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram

Research Article (1)



"Hysteria, thy name is woman": Pathologizing Femininity in Margaret Atwood's Alias Grace Author(s): Ms. Anshul Dhankar, Dr. Devendra Kumar Sharma Country: India Research Area: Sociology > Linguistic / Literature DOI: 10.36948/ijfmr.2025.v07i02.39247	 PDF
Study of Determinants of Proactive Environmental Strategies in Power and Cement Sectors Author(s): Mr. Shaid ul islam, Prof. vishakha vishakha Country: India Research Area: Engineering DOI: 10.36948/ijfmr.2025.v07i02.39253	 PDF
Analysis of the Achievement of Secondary School Students of Mizoram in Science Theory And Practical Author(s): Mr. HT Malsawmtluanga, Dr. Vanlalruatfela Hlondo Country: India Research Area: Sociology > Education DOI: 10.36948/ijfmr.2025.v07i02.39256	 PDF
Exploring Effective Communication Dynamics in Young Adult Sibling Dyad Relationships: An Indian Perspective Author(s): Ms. Sherin Simon Chacko, Ms. Miriam Priti Mohan Country: India DOI: 10.36948/ijfmr.2025.v07i02.39260	 PDF
Customized Banking Services: Pride or Hide Author(s): Mr. Sandeep Vilas Jogul, Dr. Sernmadevi M Country: India Research Area: Sociology > Banking / Finance DOI: 10.36948/ijfmr.2025.v07i02.39275	 PDF
The Long-Term Impact of Early Childhood Education on Academic Performance - A Narrative Literature Review Author(s): Yanhao Shao, Sijing Wang, Ming Yi Country: Malaysia Research Area: Sociology > Education DOI: 10.36948/ijfmr.2025.v07i02.39283	 PDF
A Comparative Study: The Association of Individual Relationship, Perceived Emotional Intimacy and Relationship Satisfaction Author(s): Ms. Tanvi Sathe, Dr. Kamathenu UK Country: India Research Area: Sociology > Philosophy / Psychology / Religion DOI: 10.36948/ijfmr.2025.v07i02.39299	 PDF

Analysis of the Achievement of Secondary School Students of Mizoram in Science Theory and Practical

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Abstract

The purpose of the study was to analyse Mizoram Class X students' performance in science. The HSLC results of Mizoram Board of School Education for the past five years in science subject were examined using a descriptive study. A detail record of marks of the previous five years were collected from MBSE. The sample of the study consists of 92386 students who appeared for the HSLC examination during the last five years (2019–2023). An analysis of the results from the previous five years revealed that theory and practical marks have a 0.54 correlation co-efficient, which is a moderately positive association. The fact that those who perform better on the practical also perform better on the scientific theory could be observed. Additionally, it was shown that there have been no appreciable changes in the average science theory grade during the past five years. The records from the previous five years, however, show a gradual increase in the practical marks.

Keywords: Achievement, Secondary school, Student, Theory, Practical.

INTRODUCTION:

Education has become essential for everyone's survival in today's society since it is the only weapon that allows people to learn and obtain information. Everyone wants to have a good education in today's world. It is something that must be instilled in the right way from the beginning. A good education offers us a better perspective on life and a better grasp of what is going on around us.

Science is a broad field of study that investigates the structure and behaviour of the physical and natural world via observation and experimentation. The following three fields of science education are the most common; Biology, chemistry, and physics. Science education refers to the teaching and learning of science to school children, college students, and general public adults. Science education encompasses research in science content, science process (the scientific method), social science, and instructional methodology. Students' understanding of science is expected to develop throughout their schooling and beyond, according to scientific education standards. Physical, life, earth, space, and human sciences are among the classical areas covered by the standards. While science education has a reputation for just teaching facts by rote, it has increasingly focused on teaching science concepts and resolving misconceptions that students may have about science concepts or other subject in recent years. Constructivist philosophy has had a considerable influence on science teaching since the 1980s. Constructivism in science education is based on a large body of study regarding student science thinking

and learning, with a special focus on how teachers may help students transition to canonical scientific thinking. Constructivism emphasises the learner's active role, the importance of present knowledge and understanding in mediating learning, and the value of instruction that gives learners with the best possible direction. Research on scientific teaching and learning has become increasingly influential in science education practise. Science education research employs a diverse set of approaches drawn from a variety of fields of science and engineering, including computer science, cognitive science, cognitive psychology, and anthropology. The goal of scientific education research is to describe or characterise what constitutes science learning and how it is accomplished.

India has a long and illustrious history in the fields of pure and applied sciences education. Science has always been a subject of study in India, dating back to the ancient times. Unfortunately, during the medieval period, most of the knowledge was lost. After independence, India's science education advanced dramatically. Following independence, the critical relevance of science for economic progress and social transformation became clear. The importance of science education cannot be overstated in the context of developing modern science and technology as a living and active force. In the realms of scientific research and technological innovation, science education is critical and vital.

Background of the study

Formal education in Mizoram started with the arrival of Christian missionaries. The Christian Missionaries introduced the Roman scripts in 1894 with a phonetic form of spelling. They started opening schools in few villages, such as Khawrihnim, Phulpui and Chhingchhip 1901. In 1903, three more schools were opened and seven more in the next year. In 1909, the first ever Middle Schools were opened in Aizawl and Serkawn respectively. In 1944, the first High School was started in Aizawl by public donations. The opening of High School marked a new epoch of event in the educational progress in the hilly area, now called Mizoram. (Directorate of School Education, n.d.)

The National Achievement Survey (2015) for Class X students in the subject of Science conducted by the National Council of Education Research and Training (NCERT) showed that average performance of students in the state of Mizoram was much lower than the national average. Again, a study report on 'Regional Plan and Status of Science Education in Schools in the North Eastern Region (NER)' by North Eastern Development Finance Corporation Ltd. (NEDFi) with Academic Inputs from Indian Institute of Technology Guwahati (IITG) and Support from Homi Bhabha Centre for Science Education, TIFR, Mumbai, October 2017 shows the state's level in comparison to neighbouring states. The average scores in Nagaland, Meghalaya, and Mizoram were lower than the regional norm.

The organisation of school education in Mizoram was reorganised in accordance with the expectations set forth in the National Policy on Education (NPE) 1986/1992 (Education Reforms Commission, 2010). The framework has been reorganised as follows - Primary (I-V), Upper Primary (VI-VIII), Secondary (IX-X) and Higher Secondary (XI-XII). Education Reforms Commission (2010) also recommended SCERT and MBSE to be re-examined in light of science advancements to guarantee that the process of science is prioritised over the outcome of science. Further, every school should be required to have a scientific laboratory and mathematics kits that are appropriate for the conceptual needs of different stages of schooling. This may necessitate reorienting the State's current courseware.

REVIEW OF RELATED LITERATURE

The following literature and past studies were reviewed:

The study conducted by Bradley (2005) explored the issues involved in the theoretical bases, rationale

and implementation of practical work in junior secondary science programs. The researcher has carried out a multi-stage field study using both qualitative and quantitative methods to achieve the objectives of the study. Science practicals are defined for the purposes of this study and a new Theoretical Model for Science Practical is proposed. The model enables the description and statement of purpose of eight types of science practicals. The target population of the study is Australian science teachers and students. The model provides a theoretical basis for the development of the survey instrument, Science Practical Inventory (SPI), to investigate students' perceptions of the use of practicals in science learning. The results of this study include implications for science curricula and recommendations for further research and are generalizable to science teachers and students in Australia.

Zohmingliani (2011) studied 'Status of science education in Mizoram: A critical study' and concluded that despite the government's efforts, science education continues to advance steadily. It is clear that the state has a long way to go in terms of science education growth and development. The state has no defined policy for science education until the last academic session included by the study. No effective monitoring system to check the practical work on science was laid down and a very low enrolment in science education from HSSLC was experienced. At the high school level, the student-to-teacher ratio was incredibly high. The nearly equal number of teachers and students at the college level, on the other hand, demonstrates how costly science education was for the state at the time the survey was done. The uneven distribution of theory and practical work from high school till college level was highly undesirable.

Banu (2011) studied the role of practical work in teaching and learning physics at secondary level in Bangladesh. The major findings of the study include that teachers used mostly transmissive pedagogy to assist students to understand physics concepts and theories. Teachers and students in non-government schools faced comparatively more difficulties than those in government schools. Low teacher/student ratios and no positions for laboratory assistants were reasons given for teachers' intense workloads. This study implies a need to provide government and non-government schools with necessary equipment for doing practical work; to appoint sufficient teachers with higher studies and training that includes practical work in physics; to create positions for laboratory assistants; to set up classrooms with a smaller number of students; and to develop awareness of the value of practical work among school administration and among physics teachers.

Abrahams I et. al. (2013) wrote a paper on 'The assessment of practical work in school science'. The article reviews how practical work, including practical skills, is currently assessed summatively in school science. Whilst practical skills in school science are clearly valued as being of importance, there is a lack of clarity as to what these skills actually are and how they might, most effectively, be validly assessed. Countries vary greatly in the extent to which they employ what we term 'Direct Assessment of Practical Skills' (DAPS) or 'Indirect Assessment of Practical Skills' (IAPS). Each of these approaches has advantages and disadvantages but it can be concluded that too great a reliance on IAPS reduces the likelihood that practical work will be taught and learnt as well as it might be.

NAS, 2015 was conducted by NCERT for Class X students (same batch of the present study) reported that average performance of students in the state i.e. Mizoram was significantly lower than the national average in Science subject. Average performance of students from rural areas in the state does not differ significantly from those in urban areas in Science subjects. Average performance of girls in the state does not differ significantly from that of boys in Science subjects. Thus, there is need for improvement of 64.8 % in Science subject. There are no students who score 75 % and more in Science subject.

The study on the influence of practical work in the laboratory on the academic performance of secondary school students in physics in Idemili south Local Govt. area was conducted by Okafor in 2016. A descriptive survey design was utilized and questionnaire consisting of 13 items was employed based on the structured research questions, using simple percentage analysis technique. Finding from the study revealed that physics laboratories in Idemili South Local Government Area (IDSLGA) in Anambra Secondary Schools are inadequate and ill - equipped. Based on the findings, it was recommended that the government should make provision for science laboratories and ensure regular training of physics teachers. Also physics teachers should expose physics students to constant practical work to enhance their understanding and performance.

Shana and Enas (2019) investigated the impact of science practical work on students' science achievement. The purpose of this quasi-experimental study is to evaluate the overall effect of practical work on students' academic attainment in science. Participants were selected from tenth grade students (chemistry and biology) and eleventh grade students (chemistry), then divided into groups. The control groups were taught using traditional methods of teaching science, while the same content was given to the experimental groups using intensive practical work. Pre and post-tests were given to all groups. The mean score comparison revealed a significant difference in the attainment scores of the experimental over the control groups. It is thus recommended that students be given ample opportunity to be engaged in practical lessons in secondary schools. This entails that the administration of schools supplies their labs with all equipment needed for practical work to be effectively implemented

Ferreira and Morais (2020) conducted a study on Practical Work in Science Education: Study of Different Contexts of Pedagogic Practice. The study investigates differentiated teaching practices of practical work in distinct social contexts and with different experienced teachers, at the level of the Portuguese high school science education. Four teaching practices were analysed in terms of the level of complexity of both scientific knowledge and cognitive skills and in terms of their structural and interactional characteristics. The results showed that the social context of the school together with teachers' academic qualification and professional development seem to influence science teachers' practices in practical work contexts. Schools placed in the lower levels of national external assessment and also whose students came from social sectors with fewer resources, showed to have teachers' practices characterised by lower levels of complexity of both scientific knowledge and cognitive skills, a valuing of the horizontal discourse and implicit evaluation criteria.

RATIONALE OF THE STUDY

The importance of science practical in learning science cannot be overstated. It is believed that science practical engages students in the development of their abilities, capabilities, creating awareness to the scientific knowledge and may provide understanding of scientific topics. Hands-on learning may facilitate and enhance the aptitude and understanding level of students in science subject. It is generally accepted that practical is at the heart of science education. Without actual practice, learning science is akin to learning literature without reading books. The education system today is more inclined towards examination-oriented and even practical examination is conducted not in line with the objectives set forth in the practical syllabus and sometimes may not serve the main purpose or objectives. As per the objectives of science practical laid down by Mizoram Board of School Education (MBSE) at secondary level, the practical activities try to engage the students in exploratory and hands-on activities that lead to the development of basic cognitive and psychomotor skills through language, observation, recording,

differentiation, classification, inference, drawing, illustrations, design and fabrication, estimation and measurement (High School Curriculum, 2009). Practical examination as conducted by MBSE may or may not be in compliance with the prescribed syllabus and this makes the present study extremely relevant to be taken up as a research topic.

Practical work is fundamental in science teaching and learning. Despite the fact that a good number of research have looked into the definitions, typologies, and aims of practical work, only few have an in-depth study about the theoretical and practical aspects of science subject at secondary level in Mizoram. Therefore, the study concerning towards the correlation between the achievement of secondary school students in theory and practical of science subject is extremely necessary.

OBJECTIVES OF THE STUDY

Keeping in view the concerns and issues related to the linkages of Theory and Practical in secondary school science, the following are the objectives of the study

1. To find out the correlation between achievement of secondary school students in science theory and science practical.
2. To compare the last five year result of HSLC under Mizoram Board of School Education

OPERATIONAL DEFINITION OF THE TERMS USED:

Linkage: For the present study, linkage means connectedness and or interconnectedness of theory and practicum of science subject under Mizoram Board of School Education

Science theory: The content of the science textbook mandated by the MBSE for secondary level school science is referred to as science theory in this study.

Science practical: The activities in school which concerns with practical experience and observation rather than theory in science subject.

Secondary school: In the present study, secondary school means the schools which runs standard 9th and 10th level under Mizoram Board of School Education.

METHODOLOGY AND PROCEDURES

Method of study

The study is descriptive in nature and survey method is employed as the method of study.

Sample of the study

The sample of the study includes all the HSLC candidates during the last five years (2019-2023) comprising of 92386 students.

Mode of data collection

Secondary data were collected where the investigator personally visited Mizoram Board of School Education and took permission from the concerned authorities. For analysis of HSLC result, records of five years mark in science subject from statistical cell of MBSE were collected.

Data analysis

Data collected were analysed using Pearson product moment method to find out the correlation between Theory and Practical marks

ANALYSIS AND RESULTS OF THE STUDY

Objective No. 1 : Correlation between achievement of secondary school students in science theory and science practical.

The correlation between achievement of secondary school students in science theory and science practical is analysed by using Pearson product moment correlation.

Table 1. Correlation between Theory and Practical achievement in science subjects

Parameters	N	Mean	Co-efficient of Correlation
Theory	92386	28.17	0.543
Practical		7.87	

The correlation coefficient between theory and practical marks was found to be 0.543, indicating a moderately positive correlation, according to Table No. 1. The result suggests that there is a connection between scientific theory and application. Students who did better in the practical also perform better in the theory.

Objective No. 2 : Comparison of last five year result of HSLC under Mizoram Board of School Education

The year wise analysis of theory and practical mark in science were done by calculating the average marks for each academic year with the pass percentage in science subject. The correlation between theory and practical marks for each year was also calculated using Pearson Product Moment Correlation.

Table 2: Analysis of five years HSLC result of MBSE in science subject

Year		Theory marks	Practical marks	Co- efficient of correlation between Theory & Practical
2019	Average mark	28.06	7.61	0.544
	Pass %	75.35%		
2020	Average mark	25.21	7.77	0.53
	Pass %	71.11%		
2021	Average mark	31.06	7.96	0.58
	Pass %	85.56%		
2022	Average mark	29.54	7.87	0.56
	Pass %	75.93%		
2023	Average mark	26.99	8.12	0.517
	Pass %	73%		

From table No 2, it was shown that the average marks of science theory in 2019 is 28.06, 25.21 in 2020, 31.06 in 2021, 29.54 in 2022 and 26.99 in 2023. The highest average marks of 31.06 was seen in 2021 and lowest marks of 25.21 in 2020. It can be concluded that there have been no appreciable changes in the average science theory marks during the past five years. The records of marks in practical from the previous five years, however, showed a gradual increase with the lowest of 7.61 in 2019 and highest of

8.12 in 2023. Additionally it was found that pass percentage was highest in the year 2021 (85.56%) where the highest average mark was seen and the lowest pass percentage (71.11) was seen in the year 2020.

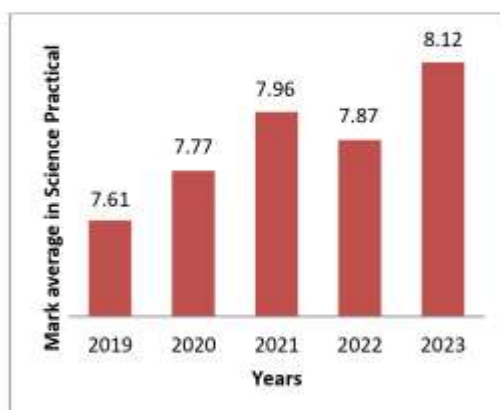


Fig: Five years average marks of theory

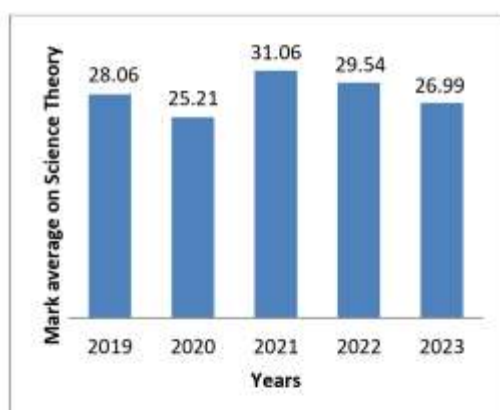


Fig: Five years average marks of practical

Discussion:

The present study has great importance in the context of education and academic assessment. It implies that there exists a visible and favorable relationship between the comprehension of scientific theory and its practical application among students. This insight has several implications. Firstly, educators and educational institutions can use this information to refine their teaching methods and curricula, emphasizing the integration of theory and practical application. Additionally, it highlights the importance of a well-rounded education that not only imparts theoretical knowledge but also encourages hands-on experience and practical skills. Moreover, this correlation underscores the need for assessments that take both theory and practice into account, ensuring a comprehensive evaluation of a student's grasp of a subject.

The overall observation with regards to comparison of five years result indicates that there have been no significant changes in the average science theory marks over these five years. This stability in average scores might suggest that the educational system has maintained a relatively

consistent standard in teaching and assessing theoretical knowledge in science. Conversely, the practical marks have displayed a gradual and consistent increase over the same time frame. This progressive improvement in practical marks could be attributed to various factors, such as enhanced teaching methods, updated laboratory equipment, or greater emphasis on hands-on learning experiences.

Notably, the pass percentage is closely related to the average marks, with 2021 displaying the highest pass rate of 85.56% coinciding with the year of the highest average marks. Conversely, 2020 saw the lowest pass rate of 71.11%, corresponding with the lowest average marks in science theory. This correlation underscores the importance of maintaining a balanced and effective educational approach that ensures not only higher average marks but also a greater number of students successfully passing their assessments. Overall, these findings provide a comprehensive view of the academic performance in science theory and practical components over the past five years.

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Analysis of the Profile of Science Teachers and Challenges in Conducting Science Practical in Secondary Schools of Mizoram

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Vanlalruatfela Hlondo**

Abstract

The study aimed to analyse the profile of science teachers in secondary schools of Mizoram, focusing on their educational and professional qualifications, nature of appointment, and teaching experience across different school management types—Government, Deficit, Samagra, and purely Private. The study also examined the challenges faced by science teachers in conducting science practicals, such as syllabus load, practical timetable constraints, availability of laboratory equipment, financial issues, and subject expertise. The findings highlight significant disparities in qualifications, job security, and resources, particularly affecting Samagra and Private Schools. The study provides insights into the need for policy interventions to improve quality of science education in Mizoram.

Keywords: Profile, Challenge, Science teachers and Secondary schools

Background of the study

Science education encompasses the teaching and learning of science for individuals across various age groups, including children, college students, and the general public. As a core subject in schools, science integrates knowledge from disciplines such as Biology, Chemistry, Physics, and Earth Sciences, as well as Mathematics, Computational Sciences, and, where applicable, Social Science and Vocational Education.

The National Curriculum Framework (NCF, 2005) emphasizes that the objectives of secondary-level science education should include engaging students in learning science as a unified discipline, equipping them with hands-on skills to design

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advanced technological modules, and encouraging them to analyze issues related to the environment and health. These objectives highlight the need for a robust science education system that not only imparts theoretical knowledge but also fosters critical thinking, problem-solving, and innovation.

Secondary school science teachers' qualifications, employment status, and the challenges faced by them in conducting practical experiments are critical factors that influence the quality of science education. In Mizoram there are different school management types viz. Government, Deficit, Samagra, and Private Schools, each with distinct standards in terms of teacher recruitment, training, and infrastructure.

The effectiveness of science teaching in Mizoram is frequently hindered by inadequate resources, financial constraints, and shortage of qualified teachers. These challenges are particularly pronounced in rural and remote areas, where schools often lack well-equipped laboratories and up-to-date teaching-learning materials. Furthermore, the disparity in teacher training status across different school management types make the issue more prominent and may lead to uneven educational outcomes. An in-depth analysis of these factors is essential to identify gaps and propose intervention that can enhance the quality of science education in the state.

Review of related literature

Braund and Driver (2005) investigated students' perceptions of practical science in primary and secondary schools, focusing on progression and continuity in learning. The study highlighted the difficulties students faced during the transition from primary to secondary education, particularly in science. Findings revealed that a significant proportion of both primary and secondary students believed practical work positively contributed to their general learning in science.

Mijung Kim and Aik-Ling Tan (2011) explored the difficulties faced by elementary pre-service teachers in teaching inquiry-based practical work. The study examined teachers' decision-making processes and internal conflicts regarding their abilities and beliefs about science teaching. The study identified multiple challenges influencing pre-service teachers' practical work. These included time constraints, inadequate materials, curriculum demands, and pedagogical assumptions. The study emphasized the importance of understanding teachers' internal negotiations regarding the role of science education and practical work in classrooms and society.

Paywand Jalal (2019) investigated challenges faced by science teachers in implementing practical work. The study assessed the availability of laboratory facilities and science materials in basic schools while also evaluating the capability of

laboratory tools. Conducted in Kurdistan Region Government (KRG) basic schools, the study involved 250 science teachers who participated through a structured questionnaire. The study indicated that most schools lacked laboratory tools, and over half of the teachers faced difficulties due to inadequate access to laboratory aids and materials, absence of science training courses, and various governmental and practical constraints. Despite these challenges, teachers expressed a strong desire to integrate practical work into their teaching process. The study highlighted differences in teachers' opinions based on years of experience and underscored the need for improvements in laboratory facilities and training.

Sevinç Nihal Yeşiloğlu and Fitnat Köseoğlu (2020) examined epistemological problems underlying pre-service chemistry teachers' aims in using practical work in school science. The findings categorized participants' aims into six themes: providing learning through discovery, verifying scientific theory, making scientific theories concrete, developing students' scientific process skills, fostering an understanding of the nature of science, and enhancing curiosity and motivation toward science. The study discussed epistemological problems associated with these aims and recommended explicit integration of epistemology into science teaching approaches and practical work methodologies.

Arnejo et al. (2021) examined students' perceptions of science laboratory functionality in Zamboanga del Sur National High School. The study sought to determine whether students viewed functional science laboratories as advantageous or disadvantageous. Results indicated that students recognized the importance of functional laboratories, though they faced difficulties in physics, biology, and chemistry experiments. STEM students seldom used laboratories for experiments but acknowledged the benefits of functional labs, especially for those pursuing medical courses in college. The study concluded that STEM students found it challenging to learn specialized subjects without laboratory facilities.

Rationale of the study

A comprehensive understanding of the profile of science teachers and the obstacles they encounter in conducting practical activities is vital for enhancing the quality of science education in Mizoram. However, the efficacy of science education is frequently undermined by inequities in teacher qualifications, insufficient infrastructure, and financial limitations. This study aims to address these challenges by investigating disparities in the academic and professional qualifications of science teachers across various school management types. The study further seeks to explore employment status and the teaching experience of science teachers as these factors play a pivotal role in delivering quality instruction. The study also aims to explore the challenges faced by science teachers in conducting practical experiments.

Analysis of the Profile of Science Teachers and Challenges in Conducting Science Practical in Secondary Schools of Mizoram

Zohmingliani (2011), in her doctoral research, highlighted the absence of a clear policy for science education in Mizoram, as well as the lack of a robust monitoring mechanism, particularly for evaluating science practical work. She noted that the disproportionate emphasis on theory over practical work from high school to college levels is highly detrimental. In light of these issues, the researcher is interested to investigate the status of science teachers and the challenges they face in conducting science practicals. Consequently, the present study, titled “Analysis of the Profile of Science Teachers and Challenges in conducting Science Practical in Secondary Schools of Mizoram,” was undertaken.

Statement of the problem

The statement of the problem is titled as “Analysis of the Profile of Science Teachers and Challenges in conducting Science Practical in Secondary Schools of Mizoram.”

Operational terms used in the study

Science Teacher Profile: Science Teacher profile in the present study refers to the educational qualifications, professional training, nature of employment, and teaching experience.

Science Practicals: Hands-on experimental activities conducted in laboratories to enhance conceptual understanding. In the present study, science practical refers to the practicals conducted at secondary stage of education

Challenges : In the present study, challenges means problems and issues faced by science teachers in conducting science experiment.

Objectives of the study

1. To analyse the profile of teachers teaching science subject in the secondary schools of Mizoram.
2. To identify the challenges faced by science teachers in conducting science practical in Mizoram

Method of the study

The present study was carried out with the intention of analysing the profiles of secondary school science teachers in Mizoram, as well as the challenges faced by them in conducting science practicals. Hence, the researcher has employed descriptive survey for the study.

Population and sample of the study

The population of the study consisted of all Secondary Schools and Science Teachers in Mizoram. Stratified random sampling technique was employed in the present study. A total of 100 Secondary schools were selected keeping in mind the type of management. All science teachers from the selected 100 schools formed the sample of the study.

Tools used for data collection: A questionnaire was developed to study the major challenges faced by science teachers was used to collect data.

Mode of data collection and data analysis: The investigator personally visited 100 schools and took permission from the concerned authorities to collect data. After getting approval, questionnaire was administered to the science teacher after which interviews were conducted.

Analysis and interpretation

Objective No. 1: *To analyse the profile of teachers teaching science subject in the secondary schools of Mizoram*

The Profile of teachers by types of school management is presented in table no. 1.

Table No. 1 : Profile of Science Teachers

		Type of School Management								Total (N=102)	
		Government (N=47) Total		Deficit (N=8)		Samagra (N=15)		Private (N=32)			
Educational qualification	M.Sc.	18	(38.3%)	7	(87.5%)	9	(60%)	13	(40.6%)	47	(46.1%)
	B.Sc.	29	(61.7%)	1	(12.5%)	6	(40%)	15	(46.9%)	51	(50.0%)
	B.E	0	(0.0%)	0	(0.0%)	0	(0.0%)	3	(9.4%)	3	(2.9%)
	Others	0	(0.0%)	0	(0.0%)	0	(0.0%)	1	(3.1%)	1	(1.0%)
Professional Qualification	M.Ed.	1	(2.1%)	0	(0.0%)	1	(6.7%)	0	(0.0%)	2	(2.0%)
	B.Ed.	46	(97.9%)	7	(87.5%)	14	(93.3%)	11	(34.4%)	78	(76.5%)
	D.El.Ed.	0	(0.0%)	1	(12.5%)	0	(0.0%)	1	(3.1%)	2	(2.0%)
	None	0	(0.0%)	0	(0.0%)	0	(0.0%)	20	(62.5%)	20	(19.6%)

Analysis of the Profile of Science Teachers and Challenges in Conducting Science Practical in Secondary Schools of Mizoram

Nature of appointment	Regular	45	(95.7%)	8	(100%)	0	(0.0%)	0	(0.0%)	53	(52%)
	Con-tract	2	(4.3%)	0	(0.0%)	0	(0.0%)	0	(0.0%)	2	(2%)
	CSS	0	(0.0%)	0	(0.0%)	15	(100%)	0	(0.0%)	15	(14.7%)
	Private	0	(0.0%)	0	(0.0%)	0	(0.0%)	32	(100%)	32	(31.4%)
Teaching Experience	10 yrs and below	19	(40.4%)	4	(50%)	12	(80%)	28	(87.5%)	63	(61.8%)
	11 to 20 yrs	18	(38.3%)	3	(37.5%)	3	(20%)	4	(12.5%)	28	(27.5%)
	21 yrs and above	10	(21.3%)	1	(12.5%)	0	(0.0%)	0	(0.0%)	11	(10.8%)

As shown in Table No. 4.5, the majority of science teachers hold either an M.Sc. (46.1%) or B.Sc. (50%) degree. Government schools have a larger proportion of B.Sc. degree holders (61.7%), while Deficit Schools have a higher percentage of M.Sc. holders (87.5%). In Samagra Schools, 60% of science teachers have an M.Sc. degree, while 40% hold a B.Sc. degree. Private Schools showed a more balanced distribution, with 40.6% holding an M.Sc. and 46.9% holding a B.Sc. Additionally, a small percentage of science teachers in Private Schools (9.4%) hold a B.E. (Bachelor of Engineering) degree, which is absent in other school categories. Only 1% of science teachers belong to the "Others" category i.e. Bachelor in Arts, found only in Private Schools.

A B.Ed. (Bachelor of Education) qualification is the most common professional qualification, held by 76.5% of science teachers as per norms provided by NCTE Regulation 2014. Government (97.9%), Deficit (87.5%), and Samagra Schools (93.3%) have a high proportion of science teachers with a B.Ed., whereas in Private Schools, only 34.4% have B.Ed. degree, indicating a significant gap in professional training. Only 2% of science teachers hold an M.Ed. (Master of Education), suggesting a very low rate of higher professional qualifications among science teachers. A small percentage (2%) have D.El.Ed., found only in Deficit and Private Schools. Notably, 19.6% of science teachers in Private Schools have no professional teaching qualification. This suggests that Private Schools employ a higher number of unqualified science teachers compared to other types of management.

Majority of science teachers (52%) hold regular positions, mainly in Government (95.7%) and Deficit Schools (100%). However, in Samagra Schools, no science teachers have regular appointments, with 100% under CSS (Centrally Sponsored

Scheme) they are employed with co-terminus with the scheme. In Private Schools, all science teachers (100%) fall under private appointments. Only 2% of science teachers are on a contract basis, found exclusively in Government Aided schools.

Most science teachers have 10 years or less experience (61.8%), particularly in Private Schools (87.5%) and Samagra Schools (80%), suggesting a younger teaching workforce in these schools. Government Schools have a relatively balanced distribution, with 40.4% having less than 10 years of experience, 38.3% between 11-20 years, and 21.3% above 21 years. Deficit Schools show a similar trend, with a moderate number of science teachers (50%) in the early career stage. The number of highly experienced science teachers (21+ years) is quite low (10.8%) overall, with the highest percentage in Government Schools (21.3%). Private Schools have no science teachers with more than 21 years of experience, indicating high teacher turnover.

Objective No. 2: *Challenges faced by science teachers in execution of science practicals in Mizoram*

Table No. 2 : Problems of Science Teachers

Problems	Yes/ No	Govt. School (N=47)	Deficit School (N=8)	Samagra School (N=15)	Private School (N=32)	TOTAL (N=102)
Issues related to syllabus load	YES	8 (17%)	1 (12.5%)	3 (20%)	3 (9.4%)	15 (14.7%)
	NO	39 (83%)	7 (87.5%)	12 (80%)	29 (90.6%)	87 (85.3%)
Practical time allotment in the Time table	YES	34 (72.3%)	5 (62.5%)	12 (80%)	19 (59.4%)	70 (68.6%)
	NO	13 (27.7%)	3 (37.5%)	3 (20%)	13 (40.6%)	32 (31.4%)
Problems related to practical equipment	YES	35 (74.5%)	3 (37.5%)	15 (100%)	25 (78.1%)	78 (76.5)
	NO	12 (25.5%)	5 (62.5%)	0 (0%)	7 (21.9%)	24 (23.5%)
Issues related to practical examination	YES	7 (14.9%)	1 (12.5%)	3 (20%)	8 (25%)	19 (18.6%)
	NO	40 (85.1%)	7 (87.5%)	12 (80%)	24 (75%)	83 (81.4%)

Analysis of the Profile of Science Teachers and Challenges in Conducting Science Practical in Secondary Schools of Mizoram

Issues related to subject expertise	YES	3 (6.4%)	0 (0%)	0 (0%)	8 (25%)	11 (10.8%)
	NO	44 (93.6%)	8 (100%)	15 (100%)	24 (75%)	91 (89.2%)
Issues related to finance	YES	34 (72.3%)	4 (50%)	13 (86.7%)	15 (46.9%)	66 (64.7%)
	NO	13 (27.7%)	4 (50%)	2 (13.3%)	17 (53.1%)	36 (35.3%)
Problems related to laboratory	YES	18 (38.3%)	3 (37.5%)	11 (73.3%)	20 (62.5%)	52 (51%)
	NO	29 (61.7%)	5 (62.5%)	4 (26.7%)	12 (37.5%)	50 (49%)

The above table no. 2 presents the challenges faced by science teachers in issues related to syllabus load, time table, availability of equipment, examinations, subject expertise, financial problems, and laboratory across the different school types.

One of the least significant problems reported by science teachers is syllabus load. Only 14.7% of science teachers across all school types found it challenging. Among them, Samagra School science teachers reported the highest difficulty (20%), followed by Government Schools (17%), Deficit Schools (12.5%), and Private Schools (9.4%). This suggests that the syllabus is generally manageable for most science teachers.

Issues concerning allotment of time for practical in the time table are widespread, with 68.6% of science teachers facing difficulties in scheduling?. The problem is most prevalent in Samagra Schools (80%), Government Schools (72.3%), Deficit Schools (62.5%), and Private Schools (59.4%).

The availability of practical equipment is another significant challenge, with 76.5% of science teachers reporting issues. Samagra Schools are the most affected, with all science teachers (100%) from Samagra school appealed a lack of adequate equipment. Private Schools (78.1%) and Government Schools (74.5%) also face serious shortages, while Deficit Schools experience relatively fewer problems (37.5%).

The issues regarding practical examinations are reported by only 18.6% of science teachers. The issue is most prominent in Private Schools (25%), followed by Samagra Schools (20%), Government Schools (14.9%), and Deficit Schools (12.5%). The majority of science teachers do not find practical examinations particularly problematic.

Analysis of the Profile of Science Teachers and Challenges in Conducting Science Practical in Secondary Schools of Mizoram

Issues related to subject expertise	YES	3 (6.4%)	0 (0%)	0 (0%)	8 (25%)	11 (10.8%)
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Concerns related to subject expertise are the least reported, with only 10.8% of science teachers facing issues. Private Schools have the highest complaints in connection with subject expertise (25%), while no science teachers from Deficit or Samagra Schools expressed concerns. This suggests that, overall, science teachers in most schools are adequately qualified to handle practical subjects.

Issues related to financial problems are significant concerns, affecting 64.7% of science teachers. The highest percentage of financial difficulties is reported in Samagra Schools (86.7%), followed by Government Schools (72.3%), Deficit Schools (50%), and Private Schools (46.9%). The data indicates that financial constraints are a major barrier, particularly for purchasing required practical equipment in Government and Non-government schools

Lastly, laboratory problems are reported by 51% of science teachers, with Samagra Schools experiencing the highest percentage (73.3%), followed by Private Schools (62.5%), Government Schools (38.3%), and Deficit Schools (37.5%). This suggests that many schools lack proper laboratory infrastructure and resources, which can hinder students' learning experiences in science subject.

Findings and discussions

Findings in relation to Secondary Schools Science Teacher's Profile in Mizoram

Educational Qualification: Most science teachers in government and deficit schools hold B.Sc. or M.Sc. degrees. Private schools, however, have a more diverse teaching workforce, including a small percentage of B.E. and other degree holders.

Professional Qualification: Government and deficit schools employed a high percentage of B.Ed.-qualified teachers, while private schools have a significant proportion of unqualified science teachers (19.6%).

Nature of Appointment: Regular appointments are predominant in government and deficit schools, whereas Samagra schools fully rely on CSS funded employees, and private schools operate solely with privately appointed teachers.

Teaching Experience: Government schools have a balanced mix of experienced and early-career science teachers. In contrast, private and Samagra schools primarily employ young teachers with high turnover rates.

Discussions

The study highlighted significant disparities in the qualifications and experience of science teachers across Mizoram's school types. Government and deficit schools employ teachers with higher professional qualifications, such as B.Ed. degrees, while

private schools often rely on unqualified teachers. This raises concerns about the quality of science education in private institutions, echoing findings by Childs and McNicholl (2007), who noted that teachers lacking pedagogical knowledge struggle to deliver effective lessons. Additionally, government and deficit schools offer more stable teaching positions, whereas Samagra and private schools depend on contractual or temporary staff, leading to high turnover rates. Research by Salvan and Hambre (2020) suggests that teacher stability is crucial for consistent student outcomes, emphasizing the need for addressing these disparities.

Findings in relation to Challenges faced by Science Teachers in Mizoram

Science teachers across all school types faced challenges, including a lack of practical equipment and financial constraints. Issues related to laboratory facilities and scheduling practical classes are particularly prevalent in government and Samagra schools. However, concerns regarding subject expertise and syllabus load were relatively minor. The findings emphasized the need for better resource allocation, improved scheduling, and increased financial support to enhance the quality of science practical education.

Discussions

A key challenge is the lack of practical equipment and financial constraints, particularly in government and Samagra schools. Inadequate laboratory resources and difficulties in scheduling practical classes hinder hands-on learning, aligning with Braund and Driver (2005), who emphasized the importance of practical work in enhancing students' understanding of scientific concepts. Financial constraints, limited materials, and large class sizes further intensify these issues, as noted by Malathi and Rohini (2017) and Jalal (2019). While Mizoram's teachers revealed sufficient subject knowledge, infrastructure deficiencies limit their ability to conduct effective practical sessions. The study emphasizes the need for improved resource allocation, better scheduling, and increased financial support for practical science education. Arnejo et al. (2021) highlighted the benefits of well-equipped laboratories, reinforcing the necessity for functional labs in Mizoram's schools. Policymakers should prioritize investments in laboratory infrastructure, provide professional development for teachers, and ensure equitable resource distribution across school types.

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Name & Institutional Address of the Supervisor	Dr. Vanlalruatfela Hlondo, Department of Education, Mizoram University, Aizawl, Tanhril-796004	
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CHAPTER 1, 2 & 3

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Degree : Doctor of Philosophy

Department : Department of Education

Title of Thesis : A Study of Linkage between Theory and
Practical Aspects of Science at Secondary
Schools of Mizoram.

Date of Admission : 18.08.2021

Approval of Research Proposal

1. Date of DRC : 30.03.2022
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3. School Board : 10.06.2022

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Registration No & Date : MZU/Ph.D./1809 of 18.08.2021

Extension (If any) : Nil

(Prof. LALBIAKDIKI HNAME)

Head

Department of Education

ABSTRACT

A STUDY OF LINKAGE BETWEEN THEORY AND PRACTICAL ASPECTS OF SCIENCE AT SECONDARY SCHOOLS OF MIZORAM

**AN ABSTRACT SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY**

H.T. MALSAWMTLUANGA

MZU REGISTRATION NO: 1500109

Ph.D. REGISTRATION NO: MZU/Ph.D./1809 of 18.08.2021



DEPARTMENT OF EDUCATION

SCHOOL OF EDUCATION

NOVEMBER, 2025

ABSTRACT

A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram

By

H.T. Malsawmtluanga

MZU Registration No: 1500109

Ph.D. Registration No: MZU/Ph.D./1809 of 18.08.2021

Department of Education

Supervisor

Dr Vanlalruatfela Hlondo

Assistant Professor

Department of Education, Mizoram University

Submitted

**In partial fulfilment of the requirement of the Degree of Doctor of Philosophy in
Education of Mizoram University, Aizawl.**

ABSTRACT

Introduction:

Education has become essential for everyone's survival in contemporary society since it is a crucial key tool that allows people to learn and obtain information. Everyone desires quality education, but it must be encouraged in the right way from the beginning. A strong educational foundation offers enhanced perspectives on life and fosters a deeper understanding of the world. In present world, education serves as the keystone of intellectual and societal development. It is fundamentally logical, deeply embedded in human reasoning, and relies on the language structure to convey knowledge, ideas, and critical thinking skills. The importance of education is not only about the transfer of information; it shapes the way individuals perceive, analyse, and interact with the world around them. As society developed, education processes became modernized, reflecting the need for deeper understanding and application rather than rote memorization. As a result of this educational evolution, modern learning has become highly scientific. The shift toward a more analytical and scientific approach to learning has paved the way for the increasing importance of STEM (Science, Technology, Engineering, and Mathematics) education in contemporary curricula (Bybee, 2013). Science education, in particular, plays a pivotal role in bridging various disciplines, encouraging interdisciplinary learning, and fostering a deeper understanding of the world.

Science is a systematic exploration of the natural and physical world, driven by observation, inquiry, and experimentation. It involves formulating hypotheses, rigorously testing them through experiments, evaluating evidence, and refining our understanding based on new findings, leading to the continual advancement of knowledge. This process extends beyond the confines of laboratories and is integral to the development of essential skills and mindsets, which are vital for individuals seeking to lead rational and fulfilling lives. Learning science enables one to gain valid knowledge about the world as well as acquire scientific values, capacities, and dispositions, such as curiosity, creativity, evidence-based thinking, and sound decision-making that facilitate making informed and good decisions benefitting the

individual and community (NCFSE, 2023). In a progressive and future-oriented society, science serves as a powerful force for liberation, enabling individuals to break free from the cycles of poverty, ignorance, and superstition. Developments in science and technology have revolutionized traditional sectors like agriculture and industry, while also giving rise to entirely new areas of employment. In today's rapidly evolving world, adaptability, innovation, and creativity have become the most essential skills for success. Thus, Science is a dynamic, expanding body of knowledge, covering ever-new domains of experience. These different imperatives have to be kept in mind in shaping science education (NCF, 2005).

Scientific practical refers to the practical application of scientific theories and principles in a controlled environment. These activities involve the manipulation of materials, instruments, and variables to test hypotheses, gather empirical evidence, and draw conclusions. Practical serves multiple purposes in scientific education, such as providing a platform for students to engage in inquiry-based learning, develop problem-solving skills, and foster scientific reasoning abilities. Hands-on experiments with measurements should be a key part of high school science classes to help students test and understand scientific concepts. While most educators agree that learning through activities is the best way to teach science, and textbooks now include some practical work, this approach hasn't made its way into most actual classrooms." Activities still tend to be regarded as a way to verify the ideas/principles given in the text, rather than as a means for open-ended investigations. (Position Paper of National Focus Group on teaching of science, 2006)

In the context of education, science practical offer a hands-on approach to learning that complements theoretical instruction. By actively engaging with materials and equipment, students can bridge the gap between abstract concepts and real-world applications. Hofstein and Lunetta (2004), state that science practicals provide a unique opportunity for students to experience science as a dynamic process, promoting an active learning environment that fosters curiosity and creativity. Further, practical learning makes learning more enjoyable, is believed to help pupils recall things more easily, and is frequently utilized to create interest and excitement among students. Thus, practical activities can assist in the development

of a wide range of transferable abilities. In other words, such abilities can increase the value of students' education and help them succeed in their chosen careers. Practical exercises are supposed to benefit students because they assist them in developing their conceptual grasp of science, allowing them to envision and make sense of complex scientific principles and ideas. Practical activity then becomes the foundation of deep learning

Theory and practical aspects of science

The relationship between scientific theory and practical application is essential for the advancement of knowledge and its real-world application. Theories offer frameworks for understanding natural phenomena, while practical applications serve to validate and refine these theories through empirical evidence. This mutual relationship ensures that theoretical insights are grounded in reality and that practical endeavours are informed by sound reasoning. For example, the integration of practical experiences into traditional learning frameworks reflects a pedagogical progress that values contextualized learning alongside theoretical knowledge (Fantinelli et.al., 2024). Moreover, the balance between theory and practice is essential across various fields, as it enables the application of theoretical knowledge to solve real-world problems effectively.

The relationship between theory and practice is evident across various scientific disciplines. In physics, for example, theoretical models such as Newton's laws of motion and Einstein's theory of relativity provide the foundation for practical applications in engineering, technology, and space exploration. Experimental verification of these theories through practical experiments, such as the famous Michelson-Morley experiment supporting Einstein's theory of special relativity, solidifies their validity and broadens their practical implications. In biology, theoretical frameworks such as Darwin's theory of evolution and Mendelian genetics form the basis for practical applications in agriculture, medicine, and conservation. Practical experiments and observations, such as the breeding experiments conducted by Gregor Mendel, provide empirical evidence that supports and refines these theories, contributing to advancements in the understanding of genetic inheritance and the mechanisms of evolution.

Key Policies and Reforms in science education

With the growth of science education in India, significant policies and reforms have sought to enhance both accessibility and quality in the curriculum. These reforms have aimed to align educational practices with modern scientific standards and societal needs. For instance, post-independence efforts concentrated on creating an integrated educational framework that could move away from the colonial legacy, establishing a more equitable system of science education. Critical to these advancements has been the emphasis on fostering inquiry-based learning and enhancing practical skills among students. However, challenges persist, particularly with bureaucratic inertia and insufficient support for teachers, which hinder the effective implementation of these innovative policies. In this context, the analysis of educational reforms reveals that achieving substantial progress requires not only strong political will but also community engagement in educational practices (Little et al., 2010). Ultimately, these reforms must evolve to meet the demands of the 21st century, ensuring that science education keeps pace with global developments and local needs (Buckler et al., 2018).

The Indian Education Commission (1964–1966) further suggested integrating science into general education, improving teaching methods, and connecting science with agriculture and technology. The National Policy on Education (1986) stressed restructuring science education to develop problem-solving skills and relate scientific concepts to real-life applications in health, industry, and agriculture. The Scheme for Improvement of Science Education in Schools (1988), introduced by the Ministry of Human Resource Development, emphasized hands-on learning, which states that science teaching should go beyond theory, incorporating students' real-world experiences and practical experiments. The policy recommended well-equipped laboratories and science libraries in all secondary schools. However, Pareek (2019) found that many schools lacked proper labs, and teachers struggled with large class sizes and insufficient equipment, hindering effective science instruction. A study by the Azim Premji Foundation found that "many schools lack basic facilities such as laboratories, libraries, and computers" (Azim Premji Foundation, 2018). This lack of infrastructure hinders the ability of schools to provide hands-on learning experiences, which are essential for science education.

The curriculum and assessment methods used in secondary level science education in India are also in need of reform. The current curriculum is often criticized for being overly broad and shallow, with too much emphasis on rote memorization (Kumar, 2018). Additionally, the assessment methods used, such as board exams, can be high-stakes and stressful for students, which can discourage critical thinking and creativity. Despite these challenges, there are opportunities for improvement. One of the significant challenges facing secondary level science education in India is the lack of qualified teachers. According to a report given by the National University of Educational Planning and Administration (NUEPA), "the shortage of science and mathematics teachers is a major concern in Indian schools" (NUEPA, 2019). This shortage is particularly critical in rural areas, where schools often struggle to attract and retain qualified teachers.

The National Education Policy (NEP) 2020, aims to transform India's education system, including science education, by promoting experiential learning, critical thinking, and interdisciplinary approaches (Ministry of Human Resource Development, 2020). The policy also emphasizes the importance of teacher training and development, which is critical for improving the quality of science education. National Education Policy (2020) also outlines a new curricular structure of 5+3+3+4, with the latter four phases representing secondary education. The secondary stage will consist of four years of multidisciplinary education that expands upon the subject-focused approach of the Middle Stage. This phase emphasizes deeper learning, enhanced critical thinking skills, and greater consideration of students' future goals through increased subject flexibility and choice. For example, students may choose to leave formal schooling after Grade 10 and later return to complete Grades 11 to 12, either through vocational programs or specialized courses at different institutions.

Secondary level science education in Mizoram

The foundation of formal education in Mizoram was laid by Christian missionaries, who introduced the Roman script with phonetic spelling in 1894. Their educational efforts began in 1901 with the establishment of schools in villages like Khawrihnim, Phulpui, and Chhingchhip. The initiative expanded rapidly, with three

additional schools opening in 1903 and seven more the following year. A significant milestone came in 1909 when the region's first middle schools were established in Aizawl and Serkawn. The educational landscape transformed further in 1944 with the creation of Mizoram's first high school in Aizawl, funded through community contributions. This development marked a turning point in the educational advancement of what is now known as Mizoram (Directorate of School Education, 2024).

In Mizoram, the school education system follows a structured stage-wise approach to ensure a smooth academic progression for students. The elementary stage comprises Classes I to VIII, laying the foundational groundwork in core subjects. Upon entering the secondary stage, which includes only Classes IX and X, students prepare for their first major external examination—the Class X board exam. However, before appearing for this board exam, Class IX students undergo internal summative assessments conducted by their respective schools, and only those who pass proceed to Class X. The next phase, known as the higher secondary stage (Classes XI and XII), allows students to specialize in streams such as Science, Commerce, or Arts, culminating in the crucial Class XII board examination. The board exams are held only at the end of Class X and XII, with no external examinations in other grades. Additionally, Science subjects follow a distinct evaluation pattern, incorporating practical examinations alongside theory. Both Class IX and X have separate practical syllabi, requiring students to perform experiments and laboratory work, ensuring a balanced assessment of theoretical knowledge and hands-on application.

According to the Scheme of Examination for HSLC examination (2019) published by MBSE; The evaluation for science subjects in class IX and class X includes both internal and external assessment. Internal assessment shall be based on the record of the candidate during his/her continuous assessment in the school and shall carry a maximum of 20 marks. Schools are expected to maintain regular records of students' achievement and progress. These records are subject to scrutiny by the Board when it deems fit. The external board examination for class IX was conducted by the Mizoram Board of School Education every year during February and March. Science theory carries 70 marks, including objective type, very short

answer type, short answer type I & II and long answer type questions. Science practical carries 10 marks, which shall be given by the external examiner at the time of practical examination. The guideline for practical examination highlighted that practical marks shall be given from practical exercise, viva voce and practical records (Mizoram Board of School Education, 2019).

Rationale of the study:

The importance of science practicals in learning science cannot be overstated. As highlighted by high school curriculum (2009), science practicals are expected to engage students in the development of their abilities, capabilities, create awareness of scientific knowledge, and provide an understanding of scientific topics (MBSE, 2009). Hands-on learning may facilitate and enhance the aptitude and understanding level of students in science subjects. It is generally accepted that practical is at the heart of science education. Without actual practice, learning science is akin to learning literature without reading books (Position Paper on National Focus Group on Teaching of Science, 2006). The education system today is more inclined towards examination-oriented learning, and even the practical examination is conducted not in line with the objectives set forth in the practical syllabus and sometimes may not serve the main purpose or objectives (NCFSE, 2023).

As per the objectives of science practical laid down by the High School curriculum (2009) at the secondary level, the practical activities try to engage the students in exploratory and hands-on activities that lead to the development of basic cognitive and psychomotor skills through language, observation, recording, differentiation, classification, inference, drawing, illustrations, design and fabrication, estimation, and measurement (MBSE, 2009). Practical examination as conducted by MBSE may or may not be in compliance with the prescribed syllabus, and this makes the present study extremely relevant to be taken up as a research topic.

The Position Paper on National Focus Group on Teaching of Science (2006) also highlighted the existence of a huge gap in science education, particularly between rural and urban students, as well as gender differences. The existing inequalities in science education stem primarily from inadequate infrastructure,

insufficient support systems, limited access to information and resources in rural areas, and a persistent urban-centric allocation of educational resources. Particularly, both science textbooks and educators often perpetuate gender stereotypes, mirroring broader societal biases. This situation demands deliberate, systematic efforts to eliminate gender prejudice from educational materials and teaching methodologies. These concerns underscore the necessity to examine science teachers' perspectives, instructional approaches, and student outcomes in secondary-level science education (NCFSE, 2023).

The Mizoram Board of School Education (MBSE) emphasizes practical engagement, yet practical exams may not always adhere to the prescribed syllabus. Science practicals at secondary stage, as assumed by the researcher, are sometimes neglected, raising concerns about their effectiveness. In order to ensure that science practicals are implemented successfully, there are various dimensions that need to be checked. The present study looked into challenges from different aspects, including adequacy infrastructure, sufficiency of lab facilities, and the challenges faced by science teachers. Understanding these aspects of science practical is crucial for improving science education and fostering meaningful student engagement. The study also examined the achievement of students in science theory and practical and also explored the correlation between the achievement of students in theory and practical. Keeping in view the issues and problems stated above, “A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram” is selected to be taken up for study.

The investigator aims to address the following questions after examining the challenges associated with science education at the secondary school level:

1. Is there a proper linkage between theoretical content and prescribed practical of secondary school science subjects in Mizoram?
2. Do schools allot adequate time for conducting science practical in their timetable?
3. Does the school follow the norms and regulations prescribed by regulating body for conducting practical?

4. What type of relationship exists between students' performance in science theory and practical?
5. What are the educational qualifications of secondary school science teachers?
6. What are the major challenges faced by science teachers in Mizoram?
7. What is the perception of secondary school science teachers toward science practical in Mizoram?
8. Is there any difference in perception of secondary school science teachers towards science practical with reference to gender, school management and locale?

Statement of the problem:

The present study is titled as "A Study of Linkage between Theory and Practical Aspects of Science at Secondary Schools of Mizoram"

Operational definition of the terms used:

- Linkage:** For the present study, linkage means connectedness and or interconnectedness of theory and practicum of science subjects under Mizoram Board of School Education
- Science:** Science is a systematic study of the natural and physical world through observation, experimentation, and evidence-based revision of knowledge. In the present study, science refers to one of the subjects of Secondary school, comprising of physics, chemistry and biology.
- Theory:** Theory in the present study refers to the theoretical content given in the secondary science textbook prescribed by the Mizoram Board of School Education.
- Practical:** For the present study, practical refers to the experimental activities of science for secondary schools prescribed by the Mizoram Board of School Education.
- Secondary school:** In the present study, secondary school means the schools which run standard 9th and 10th level (i.e. High School) under Mizoram Board of School Education.

Objectives of the study:

- 1) To investigate the linkages between theoretical contents and prescribed practical of secondary school science subject in Mizoram.
- 2) To analyse class period allotted for science practical in the weekly time table of the schools.
- 3) To study the implementation of prescribed science practical by secondary schools in Mizoram.
- 4) To study the relationship between the achievement of students in theory and practical.
- 5) To analyse the profile of teachers teaching science subject in secondary schools of Mizoram.
- 6) To study the challenges faced by science teachers in Mizoram.
- 7) To construct and standardise teachers' perception scale towards science practical.
- 8) To find out the perception of secondary school science teachers toward science practical in Mizoram.
- 9) To compare the perception of secondary school science teachers towards science practical in relation to gender.
- 10) To compare the perception of secondary school science teachers towards science practical based on type of school management.
- 11) To compare the perception of secondary school science teachers towards science practical with reference to locale.

Null hypotheses of the study:

The following are the research hypotheses laid down by the investigator for the study, which is framed in null form for testing purposes as follows:

- H₀1 There is no significant difference in the perception of science practical between male and female science teachers.
- H₀2 There is no significant difference in science teachers' perception towards science practical with reference to the type of school management.
- H₀3 There is no significant difference in the perception of science practical between rural and urban science teachers.

Review of related literature:

A total of 93 studies, spanning four decades (1984 to 2024), were reviewed to analyse various aspects of science education. The literature was categorized into four main themes: science education, curriculum, science textbook and pedagogy (30 studies), which explored teaching methodologies, curriculum design, and instructional strategies; science practical (25 studies), which examined the role, effectiveness, and challenges of hands-on experiments in science learning; perceptions of science teachers and students (20 studies), which investigated attitudes, confidence levels, and engagement in science education; and challenges faced by science teachers (18 studies), which highlighted issues such as resource constraints, pedagogical difficulties, and systemic barriers in delivering effective science instruction.

The findings from the reviewed literatures emphasize the vital role of science practical in education while also highlighting key obstacles such as limited resources, disconnects between theoretical knowledge and practical application, and challenges faced by educators. To address these issues, several recommendations have been suggested, including improving laboratory infrastructure through increased investment in science education facilities, enhancing teacher training programs to better equip educators for conducting practical lessons, and ensuring a stronger alignment between theoretical content and hands-on experiments to reinforce conceptual understanding. Additionally, providing sufficient administrative support can help manage teachers' workload, allowing them to focus more on delivering effective instruction. Refining pedagogical approaches to encourage student engagement and promote inquiry-based learning is also essential. These reviews emphasize the need for comprehensive reforms to strengthen the implementation of science practical, ensuring a more effective and enriching learning experience that bridges the gap between theory and practice.

Method of the study:

The present study adopted a descriptive survey method as it involves fact-finding inquiry into the current state of science education, particularly focusing the linkages between the theoretical content and practical aspects at the secondary level in Mizoram. The study also explored the challenges faced by science teachers. As an approach, the present study employs both quantitative and qualitative analysis techniques.

Population of the study:

The population of the study consisted of all secondary school Science Teachers in Mizoram, as shown in Table 3.1

Table 1 : Status of secondary schools in Mizoram.

District	School management type				Total
	Government / Aided School	Deficit	Samagra	Private	
Aizawl	78	5	13	101	197
Champhai	34	0	5	18	57
Hnahthial	16	0	2	5	23
Khawzawl	12	0	2	14	28
Kolasib	22	1	13	10	46
Lawngtlai	22	0	11	30	63
Lunglei	40	1	19	34	94
Mamit	30	0	12	12	54
Saiha	18	1	9	13	41
Saitual	28	0	7	15	50
Serchhip	27	1	6	13	47
Total	327	9	99	265	700

Source: *Statistics of School Education 2022-2023*

Sample of the study:

For the present study, 100 out of 700 secondary schools were proportionately selected using stratified cluster sampling technique as follows:

Table 2 : Sample of the study:

District	Type of School Management				Total No. of schools	Total No. of science teachers
	Govt School	Deficit school	Samagr a funded School	Private School		
Aizawl	7	3	2	18	30	32
Lunglei	6	2	2	2	12	12
Siaha	3	0	1	1	5	5
Champhai	5	1	2	2	10	10
Kolasib	3	0	2	2	7	7
Serchhip	4	1	0	1	6	6
Lawngtlai	3	1	2	0	6	6
Mamit	3	0	2	1	6	6
Saitual	4	0	1	2	7	7
Khawzawl	3	0	1	2	6	6
Hnahthial	4	0	0	1	5	5
Total	53	8	15	32	100	102

Tools used for data collection:

The following tools are used in the present study.

1. To study perception of teachers, the investigator developed and standardized Teacher's Perception Scale towards Science Practical
2. Questionnaire on Teacher's Profile and Challenges to study various issues including profile of science teachers and teacher's challenges
3. Checklist for implementation of science practical
4. Focus Group Discussion (FGD)

Mode of data collection:

The investigator personally visited 100 schools and took permission from the concerned authorities to collect data. After getting approval, perception scale, checklist for implementation of science practical and questionnaires for collecting challenges faced by Science Teachers were distributed with thorough instructions beforehand. A focus group discussion among secondary school science teachers was also conducted to discuss the matters concerning science practical and challenges faced by science teachers.

Data analysis:

Considering the nature of the study, the characteristics of the data, and the research objectives, the investigator employed the following methods for data analysis:

- Qualitative data analysis: In order to study the linkage between theory and practical aspects of science, Classes IX and X science textbooks and science practical manual of MBSE were examined.
- Descriptive Statistical Measures: Measures such as central tendency, percentages, Stanine, and percentiles were utilized
- Test of significance for mean difference: ANOVA and t-test were applied to determine the significance of differences in mean scores among various groups categorized by gender, type of school management and locale.
- Coefficient of Correlation: The pearson product moment correlation method was used to examine the relationship between theory and practical marks of Class X students over the past five years.

Major findings and discussions of the study:

The following are the major findings and discussions of the study.

Objective No 1: To investigate the linkages between theoretical contents and prescribed practicals of secondary school science subject in Mizoram

Class-IX Science:

The prescribed class IX secondary science textbook of Mizoram Board of School Education published by Arya Publishing Company written by R.R. Mishra, A.P. Shreelatha, Neetu Sing, Yash Pal and Joginder Singh is currently in use. It consists of fifteen chapters, which were divided into various sections, with five chapters dedicated to Physics, four chapters focusing on Chemistry, and another six chapters on Biology. The practical manual currently used by Class IX students in Mizoram, titled “*New Experimental Skills in Science - IX*”, is based on the latest syllabus prescribed by Mizoram Board of School Education published by Geeta Publishing House, Pragati Complex, Idgah Chowk, Delhi–110006. The practical manual contains 15 experiments, each introduced with a general overview, followed by the aim of the experiment, a list of materials required, the underlying principles, the procedure for setting up and conducting the experiment, observations in tabular form, the results, and precautions to be observed during the process.

Gaps in linkages between theory and practical contents in class IX physics were found. In class IX physics, important chapters like Force & Motion (Chapter 2) and Work & Energy (Chapter 4) were found to have no related experiment, while Chapter 3 (Gravitation and Floatation) had three related experiments from the prescribed practicals. Alignment with theory cannot be clearly established for one experiment.

Theory and practical linkages were found in 2 chapters out of 4 chapters in the chemistry section. It was also found that Chapter 7 ‘Is Matter around us pure’, had five related experiments while Chapter 6 ‘Matter in Our Surroundings’, had one related experiment. However, Chapters 8 ‘Atoms & Molecules’ and chapter 9 ‘Structure of the Atom’ were found to have no related prescribed experiment.

In Biology section, the study found that 2 out of 6 chapters in Biology viz. Chapters 13 ‘Why Do We Fall Ill’, and chapter 14 ‘Natural Resources’ had no linkage with the prescribed practical. It was also found that chapters viz. chapter 10 ‘Fundamental Unit of Life’, chapter 11 ‘Tissues’ and Chapter 12 ‘Diversity in Living Organisms’ had prescribed practical.

The study also revealed that the publishers for science textbook and the practical manual for class IX were different. Although the practical manual includes prescribed experiments covering all branches of science, there is no clear distinction between physics, chemistry, and biology experiments in the prescribed manual.

Class-X Science:

The prescribed secondary science textbook of Mizoram Board of School Education, Mizoram, published by Arya Publishing Company written by R.R. Mishra, Neetu Sing, Yash Pal and Joginder Singh is presently used for class X in Mizoram. This textbook is organized into sixteen chapters, encompassing five chapters on physics, five on chemistry, and six on biology. The current science practical guide book used for class X is the “New Experimental Skills in Science - X” containing 15 experiments, which is prescribed by Mizoram Board of School Education published by Geeta Publishing House, Pragati Complex, Idgah Chowk, Delhi-110006.

The study found that some chapters from physics chapters, namely, Chapter 1 ‘Light’ and Chapter 3, ‘Electricity’, had related experiments. Though chapters like Chapter 2 ‘Human Eye’ Chapter 4 ‘Magnetism’ and Chapter 5 ‘Energy Sources’ have no prescribed practicals.

It was also found that chemistry chapters viz. Chapters 8 ‘Metals & Non-Metals’ and chapter 9 ‘Acids, Bases & Salts’ had strongly aligned experiments. Chapter 7 ‘Chemical Reactions’ had one related experiment, while Chapters 6 ‘Periodic Table’ and chapter 10 ‘Carbon Compounds’ had no prescribed practical.

Among chapters under biology section, only two chapters viz. Life Processes Chapter 11 ‘Life Processes’ and Chapter 13 ‘How do Organisms Reproduce’ had prescribed experiments. It was also found that other chapters, namely, Chapter 12 ‘Control & Coordination’, Chapter 14 ‘Heredity and Evolution’, Chapter 15 ‘Our

Environment’ and Chapter 16, ‘Management of Natural Resources’ had no prescribed experiments.

The study also revealed that the publishers for science textbook and practical manual for class X were different. Although the practical manual includes prescribed experiments covering all branches of science, there is no clear distinction between physics, chemistry, and biology experiments in the prescribed manual.

Discussions;

The findings of the present study revealed that the Science textbook and the practical manual prescribed by the Mizoram Board of School Education (MBSE) were published by different publishers. This may be considered the main reason why there was some mismatch between the theoretical and practical content of both Class IX and Class X Science subjects. A detailed look into the findings also revealed that prescribed practicum for each branch of science viz. Physics, chemistry and biology are not in proportion. It was also found that while some chapters had more than one related prescribed practicum, some chapters did not have any prescribed practicum. As mentioned earlier, the reason behind this could be that the textbook and practical manuals were published by different publishers.

Objective No. 2: To analyse class period allotted for science practical in the weekly time table of the schools.

It was found that the majority of the schools did not include a science practical period in their weekly timetable. There were only a few schools (19%) that had practical period in the weekly timetable.

Among different types of schools, government schools (11.11%) witnessed the least inclusion of practical class in the weekly time table, while deficit schools were found to have highest inclusion (37.5%) of practical period in the time table.

It was also found that schools in urban areas had a higher inclusion (20.59%) of practical period in the time table than schools in rural areas (15.6%).

As reported by one science teacher, *“Having a dedicated practical class in the timetable is good, but for our students, it often becomes free time. They don’t*

understand the procedures, so we end up cramming practicals just before exams—usually at the end of the session”.

Discussions:

The present study revealed that most schools did not include practical class in their weekly timetable and conducted practical classes only just before promotional examination. This could be due to limited resources and budget constraints. The arrangement of practical classes before final examinations, rather than integrating them throughout the academic session may lead to the belief that laboratory work and hands-on experiences are just extra activities and not the fundamental components of the learning process and this practice may hamper the understanding of underlying principles by students. There could be a number of contributing factors for not including practical class in a weekly time table such as, lack of manpower, lack of laboratory equipment and chemicals, financial constraints and unavailability of science laboratory in the school.

Objective No 3 : To study the implementation of prescribed science practical by secondary schools in Mizoram

Regarding the implementation of prescribed science practicals in class IX physics, it was found that only very few teachers (less than 10%) conducted four experiments out of five prescribed experiments. Majority of the teachers failed to conduct the prescribed practicals in class IX physics.

It was found that majority of the teachers failed to conduct the prescribed practicals in chemistry. A fair number of teachers (more than 20%) conducted two experiments in chemistry. The other three experiments in chemistry were conducted by very few teachers (10% or less).

The study found that the majority of the teachers failed to conduct prescribed practicals in biology. It was found that only a few numbers of teachers (less than 10%) conducted three experiments out of five prescribed practical in biology. The other two experiments were conducted by less than 15% of the teachers.

The findings in relation to class X practical revealed that 85.3% of science teachers conducted one experiment in physics section ‘Tracing the path of a ray of

light through a rectangular glass slab and measuring the angle of incidence and angle of emergence’. It was also found that more than 20% of the teachers conducted two experiments in physics. However, majority of teachers failed to conduct experiments on resistance related experiments.

Among five experiments under chemistry portion, one experiment, pH test, was conducted by all science teachers and a good number of teachers conducted two experiments viz., studying properties of acids & bases and properties of acetic acid. It was also found majority of teachers failed to conduct the remaining two experiments.

It was found that a fair number of teachers (more than 30%) conducted three experiments out of five practicals in biology. Majority of the teachers failed to conduct prescribed practicals in class X biology.

Discussions:

The study found that basic experiments, such as pH tests and acid-base reactions, were widely conducted, while more complex experiment, such as optics, electricity, and biology, faced major execution challenges. This could be due to the unavailability of essential equipment, such as mirrors, circuits, and microscopes. Chemical reaction experiments, such as generating sulphur dioxide gas, were rarely performed, likely due to safety concerns and inadequate laboratory facilities. Constraints in school resources limited hands-on learning, particularly for complex experiments, potentially affecting students' understanding of theoretical concepts and the resource constraints faced by schools affect the conduct of practical in schools (Okafor 2016). Apart from the unavailability of resources, another big reason for conducting only a few experiments could be that teachers in the schools deliberately select practical that they are comfortable with and as per their convenience.

Objective No. 4: To study the relationship between the achievement of students in theory and practical.

It was found that there exist a moderately positive relationship between theory marks and practical marks in the HSLC examinations in the year 2019 to 2023. In terms of percentage, it was found that the theory marks taken together in the

five years was 40.24% while it was 78.6% in practical. This finding indicates a huge achievement gap between theory and practical in HSLC examinations.

One teacher from Samagra school stressed the importance of practical examiner as *“Practical examiners plays an important role while conducting science practicals. If students perform well in practical exams, they deserve full marks—this would make science practicals more meaningful and improve execution rates”*.

Discussions:

The findings revealed a positive relationship between theory marks and practical marks. However, the comparison of theory and practical marks in terms of percentage clearly shows a huge gap; students performed way better in practical as compared to theory. Keeping in view the way practical examinations were conducted, these constant marks in practical during the reported period of five years may be a concern for research scholars and science educators and may raise questions on the process of conducting science practical examination and the marking system.

Objective No 5: To analyse the profile of science teachers teaching science subject in secondary schools of Mizoram.

In connection to the educational qualifications of science teachers, the study found that a good number of teachers (46.1%) across different types of school management hold master degree in science and of the different types of schools, deficit schools had highest percentage of master degree holder and government school had lowest percentage of master degree holder. It was found that half of the science teachers (50%) possessed Bachelor of Science degree, with highest percentage seen in government schools and lowest percentage in deficit schools. A very few number of science teachers who possessed degrees other than M.Sc. and B.Sc. were found in private schools.

Regarding professional qualification, it was also found that majority of the teachers teaching science subjects at secondary schools possessed the required professional qualifications v.z. B.Ed. or M.Ed. All teachers in government and samagra schools had required professional qualifications, whereas majority of teachers in private school did not have the required professional qualifications. The

study also found that a very few teachers had D.El.Ed. qualification, which is under qualification for secondary school.

The study found that regular appointments were relevant only in government and deficit schools. A very few teachers in government schools were appointed on a contractual basis. All teachers in Samagra schools were recruited on a co-terminus basis, while teachers in private schools were appointed in line with the terms and conditions laid down by their respective schools.

It was found that majority of the teachers had below 10 years of experience and only a few teachers had more than 21 years of experience, of which government schools had the highest percentage of teachers having more than 21 years and above. No teachers in private schools and samagra schools had teachers with more than 21 years of experience.

Discussions:

The analysis of the profile of science teachers in secondary schools of Mizoram revealed that all teachers hold either bachelor's or a master degree in science except in private schools. Only teachers with essential qualifications both academically and professionally were found in government, deficit and samagra schools, while majority of the teachers in private schools did not have the required professional qualifications. Since academic qualification had a significant influence on the teachers' overall job satisfaction (Kuchy & Chakraborty, 2021), underqualified teachers are likely to have less job satisfaction. While private schools are also affiliated to the state board of school education, it is clear that the rules and regulations regarding minimum qualifications prescribed by the NCTE and MBSE were not strictly enforced. The appointment status of teachers may significantly influence job satisfaction, performance, and retention in the school. Regular teachers, with job security and long-term benefits, may exhibit higher commitment, leading to consistent performance and lower turnover rates. The findings of the present study revealed that regular appointments were relevant to only teachers working in government and deficit schools. Kabungaidze et.al. (2013) found that tenure and specialisation can predict employee turnover intentions and as evidenced from the findings of the present study, no teachers from samagra and private schools had over

20 years of teaching experience, and this indicates high turnover rates in these schools and the reason could be their nature of appointment.

Objective No. 6: To study the challenges faced by science teachers in Mizoram.

The findings of the study revealed that only few science teachers across all school types reported challenges in relation to heavy theoretical content. Samagra school reported the highest percentage of teachers (20%) who considered heavy theoretical content a challenge. Among all types of schools, heavy theoretical content was least perceived as a challenge by private school teachers.

It was found that more than half of the teachers (51%) reported issues on science laboratory. Among the types of schools, majority of teachers from samagra and private schools (more than 60%) faced challenges related to science laboratory while a small portion of teachers from government and deficit schools reported challenges with regards to science laboratory.

The study revealed that inadequate practical equipment was a major issue reported by 76.5% of science teachers. It was found that majority of science teachers from all types of school except deficit school reported challenges related to practical equipments. Among these schools, all samagra school teachers (100%) reported the problem related to practical equipment whereas only 37.5 % of teachers from deficit school considered having problems in relation to practical equipments

Regarding the practical examination, it was found that only few science teachers (less than 25%) across all school types reported challenges in relation to the practical examination. Among all types of school, Private school reported the highest percentage of teachers (25%) who considered practical examination as challenge, whereas practical examination was least perceived as challenge by deficit school teachers.

It was found that only 10.8% of science teachers reported lack of subject expertise. Private schools had the highest portion (25%) of teachers who considered lack of subject mastery as challenge. Remarkably, teachers from both deficit and Samagra schools reported no challenge in relation to subject expertise.

The study found that majority of the science teachers considered financial constraint as challenge for successful implementation of science practicals. The

study revealed that samagra schools reported the highest percentage of teachers (86.7%) who reported challenge related to finance, followed by government school (72.7%). Among different types of school, private schools had the least percentage of teachers who reported finance as challenge.

Discussions

The findings of the present study revealed that teachers do not consider the theoretical content of science subject not heavy and one of the teachers from the sample schools even reported that *“The syllabus of science for secondary school is so less that i can have sufficient time to conduct practical activities with students sometimes in the form of project”*. On the other hand, majority of the teacher failed to conduct practical experiment; there could be a number of reasons behind this, but it is obvious that it is not because of heavy theoretical content of science subject. According to Banu (2011), factors such as low teacher-student ratios and the absence of laboratory assistants contributed to teachers' heavy workloads.

The issues concerning to availability of science laboratory and equipment are more severe among samagra and private schools. In line with the findings of the present study, the findings of Malathi and Rohini (2017) also revealed a lack of laboratory tools, insufficient time allotment, large class size and absence of science training courses as challenges faced by science teachers. Despite this, some teachers in schools with little to no laboratory facilities still manage to conduct experiments by improvising with available materials or even purchasing supplies with their own money. A teacher from samagra school said, *"Since we hardly have any lab equipment, I often rely on YouTube to find and show experiment videos to students."* Similarly, a private school teacher stated, *"We lack many essential practical equipment. I sometimes purchase materials myself out of personal pocket and still ensure practical sessions are conducted."*

Though majority of the teachers in the present study reported issues relating to science laboratory, only a few teachers reported challenges when it comes to practical examination and this has led to the need for further investigation and research regarding practical examination.

Objective No. 7: To construct and standardise teachers' perception scale towards science practical.

The teacher's perception scale towards science practical was constructed and standardised. The perception scale consists of 33 items. The scale was constructed following Likert's five point scale and the maximum possible score is 165 while the minimum possible score is 33. The reliability of the scale was 0.82 (test-retest), 0.902 (cronbach's alpha) and 0.88 (split-half). Norms were also provided following the Stanine norm for the newly constructed scale.

Table No. 3 : Norms for interpretation of perception based on stanine

Sl.No	Score range	Stanine Grade	Level based on stanine
1	86 & above	9	High Perception
2	80 to 85	8	
3	75 to 79	7	
4	69 to 74	6	Average Perception
5	64 to 68	5	
6	59 to 63	4	
7	53 to 58	3	Low Perception
8	48 to 52	2	
9	47 & below	1	

Objective No. 8: To find out the perception of secondary school science teachers toward science practical in Mizoram.

It was found that slightly more than half of the teachers possessed a positive perception towards science practical of which some of them had a highly positive perception. It was also found that a small portion of teachers (13.7%) had a neutral perception. A good number of teachers (35.3%) had a negative perception towards science practical.

Discussions:

Keeping in view the condition of science laboratory and the way experiments in science are conducted, it is not surprising that only few teachers possessed high perception towards science practical in Mizoram. At the same time, more than a quarter of the science teachers surveyed had low perception towards science practical. Science teachers were not necessarily negative about or towards science practical; the reason for having low perception could include lack of resources, status of laboratory and the way experiments are conducted at the school level and the way examinations and evaluation are conducted for science practical. All these factors can contribute to the perception of science teachers towards science practical.

Objective No. 9: To compare the perception of secondary school science teachers towards science practical in relation to gender.

There is no significant difference in the perception towards science practical between male and female science teachers

Objective No. 10: To compare the perception of secondary school science teachers towards science practical based on type of school management.

There is no significant difference in science teacher's perception towards science practical with reference to school management type.

Objective No. 11: To compare the perception of secondary school science teachers towards science practical with reference to locale.

There is no significant difference in the perception towards science practical between rural and urban science teachers.

Discussions

No significant difference was found between different selected demographic variables with regard to the perception of science teachers towards science practical. Though no significant difference was found between demographic variables, it was clear from the findings that the majority of the science teachers do not have a high perception towards science practical. If one practicum is prescribe for one theory

chapter and if both theory and practical are in line with each other and if practical classes were included in the weekly timetable by all schools, if practical examination is conducted in a more systematic manner and if practicum is given more weightage, the perception of science teachers towards science practical may be improved.

Educational implications of the study:

The present study holds significant educational implications for science teachers working in secondary schools in particular and the system of education in Mizoram for holistic development of science education in general.

The findings of the present study in relation to linkages between theory and practical aspect of science subject throw light on the gap between theory and practical aspect of science subject. This finding can help curriculum developer and teachers teaching at the school level in realising the need to improve the existing syllabus. This finding may inform the authorities to take necessary actions to address the gap between theory and practical in science subjects so that students can attain holistic development in science subjects. The findings of the present study also clearly reveal the need to make proper classification of practical based on the three branches of science, viz. physics, chemistry and biology. The findings also suggest the need for uniformity regarding the number of practical prescribed for each chapter.

Analysing the time table of secondary schools on the inclusion of practical period in the weekly time table will reveal the reality of practical aspect of science at the grassroots level. The findings show how importance is given to the practical aspect of science as compared to theoretical content. A study of the implementation status of science practical may even predict the future performance of students in science subjects and may reveal how much importance is given to practical activities and how much it is neglected. This kind of information will serve as significant input in planning and reforming science education at secondary level of education. The baseline information on the implementation of science practical at secondary stage will also inform the authorities and the educators and even students on how to improve the situation and will help them in deciding what mechanism or intervention needs to be taken to improve the situation.

One of the objectives of the present study is to establish the relationship between the marks obtained in science theory and practical at HSLC examination. This finding may raise question on how theory and practical examinations are conducted and will inform the gap in theory and practical marks obtained by students. If students who did poorly in theory scored a very high percentage of marks in practical, it may indicate defective conduct of practical examination or otherwise.

One of the objectives of the study provide a clear understanding of the current profile of secondary school science teachers. This will bring into light the academic and professional qualifications of science teachers in the state of Mizoram. This will inform whether the minimum qualifications and standards for teachers laid down by the National Council for Teacher Education (NCTE) are met by the secondary science teacher in Mizoram. If students are not taught by qualified teachers, the quality of science education in particular and the quality of education in general may be questionable. The present study will tell us the nature of the appointment of teachers. It may be difficult for a teacher to have job security and job satisfaction if a teacher is not permanently employed.

The study also reveals the various challenges faced by science teachers. Findings in relation to this will help policy makers and administrators in pinpointing the problems faced by science teachers at the secondary level and this in turn will help them in formulating policy for the solutions of the challenges faced by secondary science teachers.

The development and standardization of perception scale towards science practical for secondary school science teachers will serve as an important tool to measure the perception of science teachers about science practical. This tool can be used by anyone interested in finding out the perception of science teachers towards science practical. Knowing the perception of science teachers towards science practical will also enable us to understand how science teachers look at science practical in general and their views on the importance of connecting theory with practice.

Recommendations from the study:

The following are the recommendations made in line with the findings of the study.

1. It is recommended that secondary science textbook should be prepared and published by the same investigator and publisher to ensure better connection or linkage between theoretical contents and practical activities. Each and every chapter in the textbook should have a related practicum and the number of practical activities prescribed for each chapter should be of the same value or uniform in terms of number.
2. In order to offer more hands-on experiences among the students, practical period should be allotted in the weekly timetable of the school at least once a week. Teachers should not only conduct practical classes to class X but should also be encouraged to introduce practical classes to class IX standard also. The reasons for not including practical period in the weekly time table of the schools may be investigated and the authority may take initiatives to tackle the problems in line with the findings.
3. Teachers should be encouraged to conduct practical classes in all three branches of science at the secondary level, viz. physics, chemistry and biology. Practical experiments that are simpler in procedure and execution, which do not require sophisticated equipment, may be introduced. Teachers should be sensitised about the learning outcomes of science subject at secondary level. So that they will realize the importance of conducting practical classes for both classes IX and X.
4. Stricter and more structured practical examination system in both classes IX and X may be enforced by the Mizoram Board of School Education. It is suggested that more weightage of marks may be assigned for practical components. Authority must come up with innovative interventions to address the huge gap between the percentage of marks obtained by students in the theory paper and in practical in HSLC examinations.
5. Minimum qualification standards for teachers, be it academic or professional, must be strictly enforced uniformly across all types of schools. In-service teacher training specifically designed to cater to the needs of science teachers

to conduct practical classes may be organised by the authority. Private school teachers should be encouraged to undergo teacher professional training courses relevant to secondary education.

6. There should be a balance between theoretical content and prescribed practicals in secondary science subject. It is recommended that all schools affiliated to Mizoram Board of School Education must have an adequate and working science laboratory as prescribed by the affiliation regulation 2012 of MBSE. Affiliation should not be granted to those schools seeking affiliation unless they fulfil the norms laid down by MBSE. A mobile science laboratory may be temporarily established to address immediate problems and to improve access to laboratory facilities and practical equipment, particularly in underserved areas. These mobile units, consisting of well-equipped vans with portable laboratory setups, should follow a regular rotation schedule to serve schools without science laboratory.
7. It is recommended that Block Resource Centre (BRCs) be strengthened and equipped with a well-equipped science laboratory so that schools without proper facilities within the block can avail the resources at the block resource centre.
8. Overall, opportunities for hands-on learning experiences should be provided to the students so that students can apply and relate their learning to real-life experiences and to their immediate environment.

Suggestions for further research:

The following suggestions for further studies were laid down in accordance with the findings of the study

1. To conduct a comparative study on the integration of theory and practice across different Indian states.
2. To conduct a comparative study on different educational boards in India to identify best practices for aligning theoretical and practical content in science education.
3. A case study of a specific school that effectively implements practical periods in the timetable to identify their best practices.

4. A comparative study of schools that conduct practicals throughout the year versus those that conduct them just before the practical examination.
5. To construct and develop an achievement test on science practical for secondary school students.
6. To investigate the profile of teachers in other States of India
7. To find out the relationship between teachers' qualifications and practical teaching effectiveness in Secondary Science"
8. To study the Job satisfaction of science teachers working in different Secondary Schools.
9. To develop and standardize a scale to measure students' and teachers' perceptions of science practical in STEM education.
10. To compare the perception of science teachers based on teaching experience and subject specialization, as well as educational qualification.
11. To compare the perception of science teachers in Mizoram with those in other states to identify broader trends and contextual differences.

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