EXPLORING AND ANALYSING THE CHALLENGES EXPERIENCED BY SECONDARY SCHOOL SCIENCE TEACHERS IN INDIA AND NEW ZEALAND IN THE USE OF PRACTICAL AND EXPERIMENTAL APPROACHES TO SCIENCE TEACHING

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Abstract

This study explores the challenges teachers face when implementing practical and experimental approaches in secondary science education. It begins with an overview of current literature examining the role of practical work in secondary school classrooms. It then narrows to two different education contexts – India and New Zealand, to explore differences in policy, school resources, teaching practices and curriculum frameworks. The study employs a systematic literature review methodology to critically analyse and compare existing relevant literature on practical science education in both contexts from 2011 to 2026. The thematic analysis identified three themes: the benefits of practical science teaching; resources and infrastructure constraints affecting practical science teaching; and teacher capacity, curriculum and policy support for effective practical science teaching. The finding highlights that practical and experimental science teaching can support students' conceptual understanding, scientific skills, engagement, motivation, and active learning. However, there are several barriers including limited laboratory facilities, shortages of equipment and funding issues. The findings also show that professional development, teacher confidence, supportive leadership, appropriate curriculum design, and adequate laboratory resources can enable more effective practical teaching. The findings also highlight differences between India and New Zealand in the educational conditions that shape teachers' practice.

Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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Chapter 1(Introduction and literature review)

1.0 Introduction

This chapter introduces the dissertation, which explores practical and experimental science teaching in secondary schools in India and New Zealand through a systematic literature review (SLR). Practical and experimental science teaching is recognised as an important part of science education because it supports students' understanding of scientific concepts and the development of practical and scientific skills.

Firstly, the chapter presents the rationale for the study and explains why this topic was chosen. The decision is informed by my professional experience as a secondary school chemistry teacher in India, together with my academic interest in science education.

The chapter then provides an overview of the literature related to science education and practical science teaching. It examines the goals of science education, the pedagogical approaches used to support science learning, and the role of practical and experimental activities in developing students' scientific understanding. The review also discusses the benefits and challenges associated with practical science teaching identified in previous research.

The chapter then outlines the purpose of the study and presents the research questions that guide the investigation. Attention is given to understanding the barriers, enablers, benefits, and strategies associated with the implementation of practical and experimental science teaching in secondary schools in India and New Zealand. The significance of the study is also discussed, highlighting its contribution to science education research, educational practice, and policy development.

Finally, the chapter identifies the research gap that this study seeks to address and provides an outline of the remaining chapters of the dissertation. Through comparing evidence from India and New Zealand, the study aims to develop a broader understanding of the factors that influence the successful implementation of practical science teaching and to contribute to improving science education in different educational contexts.

1.1 Rationale for the Study

My research topic is informed by my time as a secondary chemistry teacher in India, where I observed different challenges related to the implementation of practical and experimental approaches in science teaching. During my career I have come to see that there is no substitute for practical science when it comes to helping students grasp scientific concepts. I made it a point to run laboratory experiments and other hands-on investigations with my classes, and noted students were more engaged and motivated when they were doing the work themselves than when they were listening to an explanation or reading from a textbook. By being active participants in an experiment, they could make direct observations and put theory into a real-life. It became clear that those who might find an abstract concept difficult during a theoretical lesson would often show much better understanding once they had a chance to perform an experiment and talk through their results. This aligns with Oliveira and Bonito (2023) who assert that students who participate in experimental inquiry improve their theoretical and practical knowledge. Such experiences have convinced me that practical teaching is integral to good science education. Even though practical work is an acknowledged part of the curriculum, it is not always easy to implement in the classroom. You can be hampered by a lack of resources – be it equipment, chemicals or adequate facilities – which impacts on the quality of the work you can do. Then there are large class sizes to contend with; keeping an eye on safety and making sure every student is involved can be a challenge.

My experiences as a secondary science teacher, including observing the educational benefits of practical work and facing the challenges of implementing it in the classroom, made me want to look at what makes practical science teaching work in some places and not in others. When I moved to New Zealand to further my education, my interest in the subject only deepened. Here, I have experienced an education system that places a strong emphasis on student-centred and inquiry-based methods. In New Zealand, practical science is viewed as a means of developing students' problem-solving and critical-thinking skills, rather than simply demonstrating scientific concepts. Observing this approach has prompted me to think about how different educational environments influence the implementation of practical science teaching and how one country's experiences may compare with those of another.

So, I have decided to focus on India and New Zealand for both professional and personal reasons. The former is where I have my first-hand experience as a teacher; the latter offers a contrasting setting where the curriculum is supportive of practical investigation. With the growing need for young people to be scientifically literate and ready for the world beyond school, I believe there is value in examining how we can improve these outcomes for students and give teachers and policymakers some useful perspective.

In summary, this study is a natural fit for me, combining my background as a chemistry teacher with my current academic studies. Through a systematic review of the literature from India and New Zealand, I aim to develop a broader understanding of the benefits and challenges of practical science teaching while also reflecting on my own teaching practice. Therefore, my personal experience, together with the existing literature, has shaped the rationale for this study. The study critically examines the challenges experienced by secondary school science teachers in India and New Zealand when implementing practical and experimental science teaching. This provides the foundation for the research objectives, literature review, research questions, and the significance of the study.

1.2 Literature review

This literature review has been undertaken to position the study within the wider field of science education. It outlines the importance of science education and its main goals and explores the pedagogical approaches used to support science learning. It then narrows the focus to one specific approach, practical science, highlighting some of its advantages and challenges.

The review also focuses on practical and experimental science teaching, including the role of laboratory activities, hands-on experiences, and scientific investigations in science classrooms. It examines literature related to teachers' knowledge, confidence, skills, and professional learning in planning and implementing practical science lessons. Furthermore, the review considers the wider factors connected with practical science teaching, including curriculum expectations, assessment practices, teacher preparation, classroom settings, resources, infrastructure, and safety aspects. It examines how practical and experimental science teaching is discussed within these educational contexts and provides the theoretical and conceptual background for the study.

1.2.1 Goals of science education

The literature review begins by examining the goals of science education and how they provide the foundation for science teaching and learning in secondary schools. It also explores how these goals influence curriculum development and shapes the way science is taught in different educational contexts, including India and New Zealand.

Science education has two main goals, to ensure all students are scientifically literate – have a broad understanding of the major ideas of science and how it works and to prepare a minority of students for tertiary level science degrees and careers (Osborne & Dillon, 2008; PEAS, 2021). How curriculum is framed depends upon the predominant focus of the curriculum writers. For example, curriculum that are focused on teaching science as a career pathway tend to be discipline focused (Osborne & Dillon, 2008), while focusing on 'science for all' or scientific literacy tends to have a generalist approach, with students learning the basic ideas about how science works, so all students can be "critical consumers of scientific knowledge" (p. 8). For example, until recently, New Zealand has focused on scientific literacy, as "in science, students explore both how the natural physical world and science itself work so that they can participate as critical, informed, and responsible citizens in a society in which science plays a significant role" (Ministry of Education, 2007, p.17).

The New Zealand science curriculum emphasises the development of scientific literacy through both theoretical and practical learning experiences. Students are encouraged to investigate scientific questions, gather and evaluate evidence, communicate findings, and apply scientific knowledge to real-world issues. Practical activities and scientific investigations are viewed as essential components of science education because they help students develop inquiry skills, critical thinking, and a deeper understanding of scientific concepts (Ministry of Education, n.d.). This means that science may be taught differently depending on the curricular focuses. However, the current curriculum refresh in New Zealand is moving towards a more knowledge-rich approach, with greater emphasis on clearly defined scientific knowledge and subject content. The developing science curriculum aims to provide clearer learning expectations by identifying the knowledge students should develop at different stages while continuing to include scientific practices and investigations as part of science learning (Ministry of Education, 2025).

In India, science education has traditionally placed strong emphasis on theoretical understanding and examination achievement. However, curriculum documents such as the National Curriculum Framework emphasise that science learning should involve observation, exploration, experimentation, and connecting scientific concepts with students' everyday experiences rather than relying only on memorisation of content (National Council of Educational Research and Training [NCERT], 2005). Similarly, the National Education Policy 2020 promotes experiential learning and encourages the integration of practical activities to develop deeper understanding and scientific thinking among students (Ministry of Education, 2020). Although practical learning is recognised within curriculum expectations, research by Srivastava and Jangir (2025) and Thakur and Kadu (2024) indicates that science teaching in many Indian classrooms remains largely focused on theoretical knowledge, textbooks, and examination preparation. This creates a distinction between the intended curriculum, which promotes practical engagement with science, and classroom implementation, where practical activities may receive different levels of emphasis depending on the educational context.

1.2.2 Research-Informed Approaches to Effective Science Teaching

This section examines the different approaches that have been used to support effective science teaching. It focuses on the teaching approaches identified in the literature and explains how they contribute to students' learning and understanding of science.

Different teaching approaches have been identified in the literature to support students' understanding of scientific concepts and the development of scientific skills (Yao, 2023; Wang et al., 2025). Some approaches focus on the transmission of scientific knowledge through teacher explanations, while others encourage students to actively construct their understanding through investigation and discussion (Wang et al., 2025). At the secondary school level, science teaching can involve a range of approaches, including inquiry-based learning, practical and experimental activities, scientific investigations, and problem-solving tasks (Yao, 2023; Ministry of Education, 2025). These approaches encourage students to engage with science by asking questions, collecting and analysing evidence, developing models, and explaining ideas using scientific reasoning. Through these experiences, students develop both scientific

knowledge and the skills needed to participate in scientific practices (National Research Council, 2012; Teig et al., 2022). Inquiry-based and practical approaches are also recognised as important ways to support students' understanding by allowing them to explore scientific concepts through active involvement and meaningful learning experiences (Abd-El-Khalick et al., 2004).

International large-scale assessments also provide useful evidence about science teaching across different stages of schooling. A recent systematic review by Teig et al. (2022), drawing on data from the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), examined patterns in teaching practices across primary and secondary contexts. The authors identified that TIMSS mainly represents primary and lower secondary education, whereas PISA focuses on 15-year-old students in secondary education. Making this distinction is important because it helps clarify how science teaching approaches can differ across stages of schooling (Teig et al., 2022). Scientific practices include activities such as asking questions, using mathematical thinking, developing and using models, constructing explanations, and engaging in argumentation from evidence. These practices enable students to actively engage with scientific ideas by investigating phenomena, applying scientific knowledge, constructing explanations, and using evidence to support their thinking, thereby enhancing their understanding of science content and scientific practices (Erduran et al, 2020).

Practical work is an important aspect of science education (Erduran et al., 2020; Oliveira & Bonito, 2023). While all approaches contribute to science learning, practical work plays an important role in connecting scientific knowledge with hands-on experiences and scientific processes. Overall, practical work is an important component of science education as it connects scientific knowledge with hands-on experiences and supports students' understanding of scientific practices. The next section discusses the key terminology and concepts related to practical work.

1.2.3 Terminology Related to Practical and Experimental Science Teaching

It is important to define the terminology related to practical and experimental science teaching in this dissertation, as multiple terms are used to describe practical aspects of science

education. These include practical work, experiments, fair-testing, science inquiry, investigation, hands-on activities, laboratory work (Gericke, Högström, & Wallin, 2023; Moeed & Anderson, 2018). Gericke, Högström and Wallin (2023) note that in the UK practical work has generally been used while in the US laboratory work is more common.

In an early definition, Millar (2004) describes practical work as "any teaching or learning activity which at some point involves the students observing or manipulating the objects they are studying'' (p. 2). Gericke, Högström and Wallin's (2023) later definition of "practical science activities involving students manipulating and/or observing real objects, including empirical data collection within authentic science-teaching situations (usually in the school laboratory or classroom)" (p. 246) is very similar. Practical work undertaken in science laboratories may include virtual environments as a tool to enhance teaching and student learning (Durkaya, 2023).

This study adopts the definition of practical work provided by Gericke, Högström and Wallin (2023) in which practical work is any science activity involving students manipulating and observing real objects within authentic science teaching situations.

1.2.4 Advantages of practical work

The advantages of using practical work at secondary school are well established. Many researchers have confirmed that learning science is enhanced, and understanding is improved when students undertake practical experiments in science laboratories (Hofstein & Lunetta, 2004; Lunetta et al., 2007). Practical work can not only stimulate and motivate students to learn more about science but also positively impact students' achievement in science (Abrahams & Millar, 2008; Ekmekci & Serrano, 2022; Sanjito & Hyams-Ssekasi, 2025). One reason is that practical work provides students with first-hand demonstrations of scientific phenomena (Osborne, 2015, p. 21), which helps students build their conceptual understanding (Gericke et al., 2023).

Ekmekci and Serrano (2022) identify that practical work improves student motivation and academic achievement in science subjects. The literature suggests that practical science teaching provides significant opportunities for students to participate actively in inquiry. Abrahams and Millar (2008) found that practical work often increases student engagement

and interest in science. Hands-on activities make learning more interactive and enjoyable, which can improve participation and motivation, especially in secondary science classrooms.

Participating in practical work offers learners opportunities to learn how to undertake scientific investigations (Stoffels, 2005), mirroring the processes used by scientists in real-world contexts (Sanjito & Hyams-Ssekasi, 2025). However, as Oliveira and Bonito (2023, p. 13) note, it is the integration of "hands-on" practical skills with "minds -on" has the greatest effect on conceptual understanding. According to Singh-Pillay (2024), the reason for this is that practical work shifts students from being passive recipients of knowledge to active participants who formulate hypotheses and conduct investigations. It allows students to identify scientific processes, and enhance their practical skills, data analysis, hypothesis formation and critical thinking capabilities (Özer & Sarıbaş, 2023). Thus, practical work supports students in developing the tools to critically evaluate scientific claims and make informed decisions about socio scientific issues in everyday life (Moeed & Anderson, 2018, p. 6). Moreover, practical work assists in eliminating the gap between theoretical knowledge and real-world application. A major advantage highlighted by Millar (2004) is that practical work helps students understand the role of evidence in science. Students learn how data is collected, analysed, and used to support or reject scientific claims. This builds scientific reasoning and critical thinking.

In conclusion, the literature consistently shows that practical work plays a vital role in science education by enhancing conceptual understanding, developing scientific skills, promoting inquiry, and improving student engagement. However, its effectiveness depends on how well it is integrated with theory, guided by teachers, and linked to clear learning outcomes rather than being treated as isolated hands-on activities. When properly designed, practical work enables students to connect evidence with scientific explanations and develop a deeper understanding of the nature of science (Millar, 2004; Abrahams & Millar, 2008; Hofstein & Lunetta, 2004; Osborne, 2007). Although practical work provides many benefits for students' scientific understanding, engagement, and skill development, its implementation also involves several challenges and limitations. The following section discusses the disadvantages and constraints associated with practical work in science

education, including factors that may influence its effective implementation in secondary classrooms.

1.2.5 Disadvantages and limitations of practical work

While practical work is considered an important component of science education, researchers have also identified several challenges that may reduce its effectiveness in the classroom, such as practical and organisational challenges, management issues, and teacher confidence and pedagogical knowledge.

Many schools face limitations in terms of specialised instruments, chemicals, laboratory space, and equipment required to conduct effective science investigations (Oliver et al., 2021; Thakur & Kadu, 2024). In addition, preparing laboratory sessions, teaching practical content, and ensuring student safety can reduce the time available for completing curriculum requirements (Oliver et al., 2021). Furthermore, certain experiments involve hazardous chemicals, heat sources, or specialised equipment that may create safety concerns if not properly managed. As a result, teachers may restrict or modify practical activities, limiting students' opportunities to engage in hands-on scientific investigation (Hofstein & Lunetta, 2004). In many education systems, inadequate laboratory facilities, insufficient equipment, and limited funding restrict opportunities for meaningful practical science learning (UNESCO, 2021; Abrahams & Millar, 2008).

One major issue identified in the literature relates to the practical and organisational challenges associated with accessing and utilising science laboratories. Many schools face limitations in terms of specialised instruments, chemicals, laboratory space, and equipment required to conduct effective science investigations (Oliver et al., 2021). In addition, preparing laboratory sessions, teaching practical content, and ensuring student safety can reduce the time available for completing curriculum requirements (Oliver et al., 2021). Furthermore, certain experiments involve hazardous chemicals, heat sources, or specialised equipment that may create safety concerns if not properly managed. As a result, teachers may restrict or modify practical activities, limiting students' opportunities to engage in hands-on scientific investigation (Hofstein & Lunetta, 2004). In many education systems, inadequate

laboratory facilities, insufficient equipment, and limited funding restrict opportunities for meaningful practical science learning (UNESCO, 2021; Abrahams & Millar, 2008).

Practical work can also be challenging to manage effectively in large classroom settings. In such situations, student participation may become uneven, with some learners actively engaged while others remain passive observers (Abrahams & Millar, 2008). Large class sizes can create difficulties related to classroom management, safety supervision, and ensuring active participation during practical activities (Hofstein & Lunetta, 2004). These constraints may result in reduced frequency or simplification of laboratory-based learning, limiting students' engagement with authentic scientific investigation and inquiry processes (Millar, 2004; UNESCO, 2021). The lack of consistent access to practical science experiences may also influence students' opportunities to develop scientific skills and engage with science learning (NCERT, 2005).

Globally, science teaching and learning are influenced by several structural and pedagogical challenges that affect the implementation of practical work. Teachers' subject knowledge and pedagogical training are important factors in developing confidence to deliver effective experimental and inquiry-based science lessons (Osborne, 2007; Hodson, 1993). Effective practical science teaching requires more than strong subject knowledge; it also depends on teachers' pedagogical content knowledge (PCK), which combines understanding of scientific concepts with the ability to teach them effectively in classroom and laboratory settings (Hofstein & Lunetta, 2004; Abrahams & Millar, 2008). While subject knowledge enables teachers to understand scientific principles and experimental procedures, pedagogical knowledge supports teachers in designing, managing, and facilitating practical activities that promote student understanding rather than the completion of procedures.

Research suggests that teachers who lack confidence in applying this knowledge may experience difficulties in guiding inquiry-based learning, resulting in practical work becoming procedural rather than conceptual (Hofstein & Lunetta, 2004; Abrahams & Millar, 2008). In the context of practical science teaching, teachers need to make complex scientific ideas accessible, identify student misconceptions, and connect experimental observations with scientific concepts. Without this connection, students may complete experiments without

understanding their purpose or relevance (Millar, 2004). Furthermore, effective practical science teaching requires classroom management skills, safety awareness, and the ability to support student learning during investigations, particularly in large or resource-constrained classrooms.

1.3 Research Purpose and Questions

The purpose of this study is to analyse the challenges experienced by secondary school science teachers in India and New Zealand when implementing practical work. Despite the recognised benefits of practical and experimental science teaching, many teachers face challenges related to insufficient resources, time constraints, large class sizes, safety concerns, and limitations in implementing practical activities. This study aims to develop comprehensive knowledge about the challenges faced by teachers during practical and experimental approaches to science teaching. Existing research discussed above focuses on the wider field of science education; however, this study specifically focuses on the contexts of India and New Zealand.

By comparing these two educational contexts, this study aims to identify differences in policy, school resources, curriculum frameworks, teaching practices, and teacher capacity, including teachers' knowledge, confidence, and ability to implement practical science teaching effectively. In addition, the study aims to identify the strategies and practices highlighted in literature that support the successful implementation of practical work in science education. Through comparison of both countries, this research intends to highlight approaches that may improve teacher capacity to deliver meaningful practical learning experiences for students.

Hence, the purpose of this study is to contribute to existing knowledge about practical science education, teacher experiences from the perspectives of India and New Zealand, and the contribution of both countries to practical science teaching. The findings are expected to inform educators, curriculum developers, school leaders, and policymakers about the factors that influence practical science teaching and provide evidence-based recommendations to improve the quality and effectiveness of practical and experimental science education.

The study was guided by two research questions:

(1) What are the reported benefits, barriers and enablers of the implementations of practical and experimental science teaching in India and New Zealand secondary schools?

(2) How do differences in educational context and system shape teachers' ability to implement practical and experimental science teaching in India and New Zealand secondary schools?

1.4 Research Significance

This study is significant because it synthesises existing knowledge about practical and experimental science teaching in India and New Zealand. Practical science is recognised as an essential component of science education because it supports students' conceptual understanding, problem-solving abilities, inquiry skills, hands-on learning, and positive attitudes towards science (Oliveira et al., 2023). The study identifies the benefits, challenges, and factors that influence the successful implementation of practical work, including laboratory resources, teacher competence, curriculum requirements, policies, and school leadership. The findings provide valuable insights for science teachers, school leaders, curriculum developers, and policymakers by highlighting strategies that can strengthen teacher capacity and improve practical science experiences. By comparing India and New Zealand, this research contributes to the wider science education literature and provides knowledge that may support future improvements in practical teaching approaches and student learning outcomes.

1.5 Dissertation Outline

There are five chapters included in this thesis.

Chapter 1 (Introduction and Literature Review): This chapter introduces the rationale of the study, reviews relevant literature and key concepts, identifies gaps in the literature, and presents the research questions and significance of the study.

Chapter 2 (Methodology): This chapter outlines the study's research philosophy and the rationale for using a Systematic Literature Review. It defines the search parameters and the frameworks used to ascertain trustworthiness, details how data is extracted and analysed. Finally, it addresses the study's' ethical considerations.

Chapter 3 (Findings): This chapter outlines the themes found during the analysis of the literature.

Chapter 4 (Discussion): In Chapter four the findings are interpreted and the commonalities and differences between India and New Zealand in terms of implementing practical science teaching are examined. There is also consideration given to what these findings mean for policy and for the way science is taught.

Chapter 5 (Conclusion and Recommendations): Chapter five offers a summary of the study's principal findings and their wider import. Recommendations for the future in terms of research and educational practice are highlighted, while acknowledging the limitations of the work.

Chapter 2: Research methodology

2.1 Introduction

This chapter discusses the ontological, epistemological, and axiological assumptions underpinning the research. It outlines the research design of this study and explains why a Systematic Literature Review [SLR] was undertaken to explore the challenges described by Secondary science teachers in developing countries such as rural Indian and developed countries such as New Zealand in peer reviewed literature as they incorporate practical work in their teaching. It describes how data was collected, noting inclusion and exclusion criteria. It outlines how Preferred Reporting Items for Systematic review and Meta-analysis (PRISMA) was used for finalising the data, keywords, Boolean operators, data extraction and ethical consideration, to ensure a transparent and systematic process for identifying, screening and selecting the studies included in this review.

2.2 Research philosophy

This section outlines the ontological, epistemological, and axiological assumptions underpinning the study and explains their relevance to the research design. Ontology and epistemology are positional terms concerned with the theoretical underpinning of research. In research methodology, ontology is concerned with reality,

particularly in the field of social sciences or human reality whereas epistemology is concerned with how reality is understood or known (Boyask, 2026, p. 13).

This study adopts a relativist ontology, which assumes that there are multiple realities rather than one single truth (Crotty, 1998). In the context of this study, science teachers in different schools and countries may experience practical science teaching in different ways. For example, a teacher in a well-resourced New Zealand school may face different challenges from a teacher working in a rural Indian school. Therefore, this study recognizes that different realities exist and that each perspective is valuable.

Epistemology is concerned with how knowledge is created and understood. This study follows a constructivist epistemology, which suggests that knowledge is developed through people's experiences and interpretations (Bryman, 2016). This approach is particularly suitable for qualitative research because it facilitates an in-depth exploration of individuals' perspectives, meanings, and lived experiences (Lincoln et al., 2011).

Axiology refers to the role of values in research. In qualitative research, it is recognised that researchers bring their own interests and perspectives to the study (Saunders et al., 2019). In this research, I am interested in understanding the challenges and opportunities associated with practical science teaching.

Overall, relativist ontology, constructivist epistemology, and consideration of axiology are appropriate for this qualitative systematic literature review because they support an in-depth understanding of teachers' experiences and perspectives regarding practical science teaching.

2.3 Research design

This section will discuss the main method used to generate data – a Systematic Literature Review and the rationale for using it, then outline the frameworks used to ascertain trustworthiness – PRISMA and Critical Appraisal Skills Programme (CASP).

The main method used to generate data in this study is a Systematic Literature Review (SLR). According to Gough et al. (2024), a systematic review is "a review of existing research using explicit, accountable rigorous research methods" (p. 4). This approach uses predefined procedures to identify, select, evaluate, and synthesise relevant studies on a particular topic.

Furthermore, systematic reviews focus on examining the overall body of evidence rather than relying on individual studies. As Nordenbo et al., (2009) notes, “rather than looking at any study in isolation, we need to look at the body of evidence” (p. 22). Therefore, the current study uses a systematic literature review to identify, select, evaluate, and synthesise relevant studies and to examine the overall body of evidence related to the research topic.

Systematic literature reviews [SLR] developed in response to the need to identify which policies, programmes, and practices were supported by evidence and therefore should be implemented. By carefully collecting, evaluating, and synthesising existing studies, systematic literature reviews help provide a clear and trustworthy evidence base for researchers, decision-makers and policymakers (Hammersley, 2020; Nisbet & Broadfoot, 1980). Using this approach helped ensure that the review remained closely aligned with the research aims and research questions. while reducing the potential for bias during the selection and analysis of studies. The review was carried out in five stages: defining the review scope and research questions, developing the search strategy, screening and selecting relevant studies, extracting and analysing data, and finally synthesising and reporting the findings.

Systematic literature reviews (SLRs) are widely used in research because they go beyond simply summarising what previous studies say. Instead, they try to gather all relevant evidence in a structured way so that the overall findings are more reliable and easier to interpret. This is particularly useful when different studies report mixed or even conflicting results, as an SLR helps bring everything together in a more organised format (Tranfield et al., 2003; Xiao & Watson, 2019).

Another important role of SLRs is that they help identify gaps in existing literature. When studies are reviewed carefully, it becomes easier to see what areas are over-researched and need more attention. In this way, SLRs are useful for shaping future research directions and improving the focus of new studies (Xiao & Watson, 2019). They can also explore broader or more complex research questions that a single study may not be able to answer properly (Tranfield et al., 2003).

At the same time, SLRs are valued because they follow a clear and structured process, which helps reduce bias compared to traditional narrative reviews. This only works well if the process is clearly reported. Researchers need to explain how they searched for studies, how they selected them,and how the final findings were compiled (Page et al., 2021). Because of

this, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 framework is often used as a reporting guide to ensure that SLRs are presented in a transparent and complete way (Page et al., 2021). The PRISMA flow diagram is especially useful because it shows each step of the review process, making it easier for readers to follow the research process (Moher et al., 2009; Page et al., 2021).

2.4 Search strategy

A systematic search strategy was designed to ensure the comprehensive, transparent, and rigorous identification of relevant literature (MacFarlane et al., 2022). The search process was guided by the research aims, objectives, and research questions, enabling the collection of high-quality and academically relevant studies from appropriate databases.

Keywords were derived from research questions and objectives and included terms such as "secondary education", "experimental learning", "science practical teaching", "teacher challenges", "science pedagogy", and "laboratory teaching". To capture literature from the two geographical contexts under investigation, the terms "India" and "New Zealand" were also incorporated into the search strategy.

Boolean operators were used to refine and combine search terms. For example, search strings included combinations such as ("science practical teaching" AND "secondary education") AND ("India" OR "New Zealand"). This approach helped to improve the precision and relevance of the search results.

Peer-reviewed studies were identified through searches of Web of Science, Scopus, ERIC, Google Scholar, AUT online library and Taylor & Francis Online. These databases were selected because of their extensive coverage of educational research. In addition to peer-reviewed journal articles, books, grey literature was included to provide broader contextual and policy-related perspectives on science education. Grey literature sources comprised government reports, policy documents, educational organisation publications, curriculum frameworks, and official reports from education agencies in India and New Zealand. Examples included publications from the New Zealand Ministry of Education, the National Council of Educational Research and Training (NCERT), the Education Review Office (ERO), and reports from educational research organisations. The inclusion of grey literature helped capture practical insights, policy developments, and contemporary educational challenges that may not

be fully represented in academic journal articles. Incorporating these sources enhanced the comprehensiveness of the review and provided a deeper understanding of the practical and experimental science teaching context in both countries.

To ensure the relevance and currency of the evidence base, the search was limited to studies published within the last 15 years. The search results were further refined using predefined inclusion and exclusion criteria. Forward and backward citation searching was also conducted to identify additional relevant studies that may not have been captured through the database searches. This systematic approach ensured a comprehensive collection of literature relevant to the challenges of science teachers in practical and experimental teaching contexts in India and New Zealand.

2.5. PRISMA-framework

It is important that the methods and results of systematic reviews are reported in sufficient detail to allow users to assess the trustworthiness and applicability of the review findings (Page et al., 2021, p. 2). Therefore, an important facet of this research is ensuring that the data generation process is transparent, reproducible and rigorous. To support this process, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was selected to guide the research process (Page et al., 2021, p. 2). The PRISMA process includes four stages: identification, screening, eligibility and inclusion. Therefore, the screening and selection process in this study has been documented using the PRISMA framework (see Figure 2.1).

The process involves selecting relevant studies from the databases using a search strategy. The screening process is considered where duplicate articles are removed, and the remaining studies are screened based on the abstract and titles. The screening process assists in narrowing down the research (Ghamrawi et al., 2025). The eligibility criteria are selected where full-text assessments are included. All the articles focus on secondary science education and secondary school science teachers in New Zealand and India. Inclusion criteria are chosen as the most relevant for a high-quality study, which is reviewed based on the analysis and extraction.

The PRISMA flow diagram (please see Figure 2.1) has identified the research literature from the current databases. A total of 1473 articles were reviewed from the databases and other secondary sources searched. In the screening process, almost 1,153 articles were recorded as duplicates. In the screening process, the abstracts of 823 articles were reviewed. Of the 823 articles screened, 330 were selected for full-text assessment, while the remaining 493 were excluded because they did not focus on secondary education, practical science teaching, teacher-related perspectives, or empirical research. Following full-text assessment, a further 300 articles were excluded because they did not specifically address secondary science education. The remaining 30 studies were included in the final review. 30 articles were included in the final review because they were focused on secondary science education. These studies were selected because they met all inclusion criteria, including relevance to secondary science education and discussion of practical and experimental approaches. Therefore, the selected studies were considered suitable for addressing the research objectives of this review.

2.6 Assessing article quality by CAPS tool

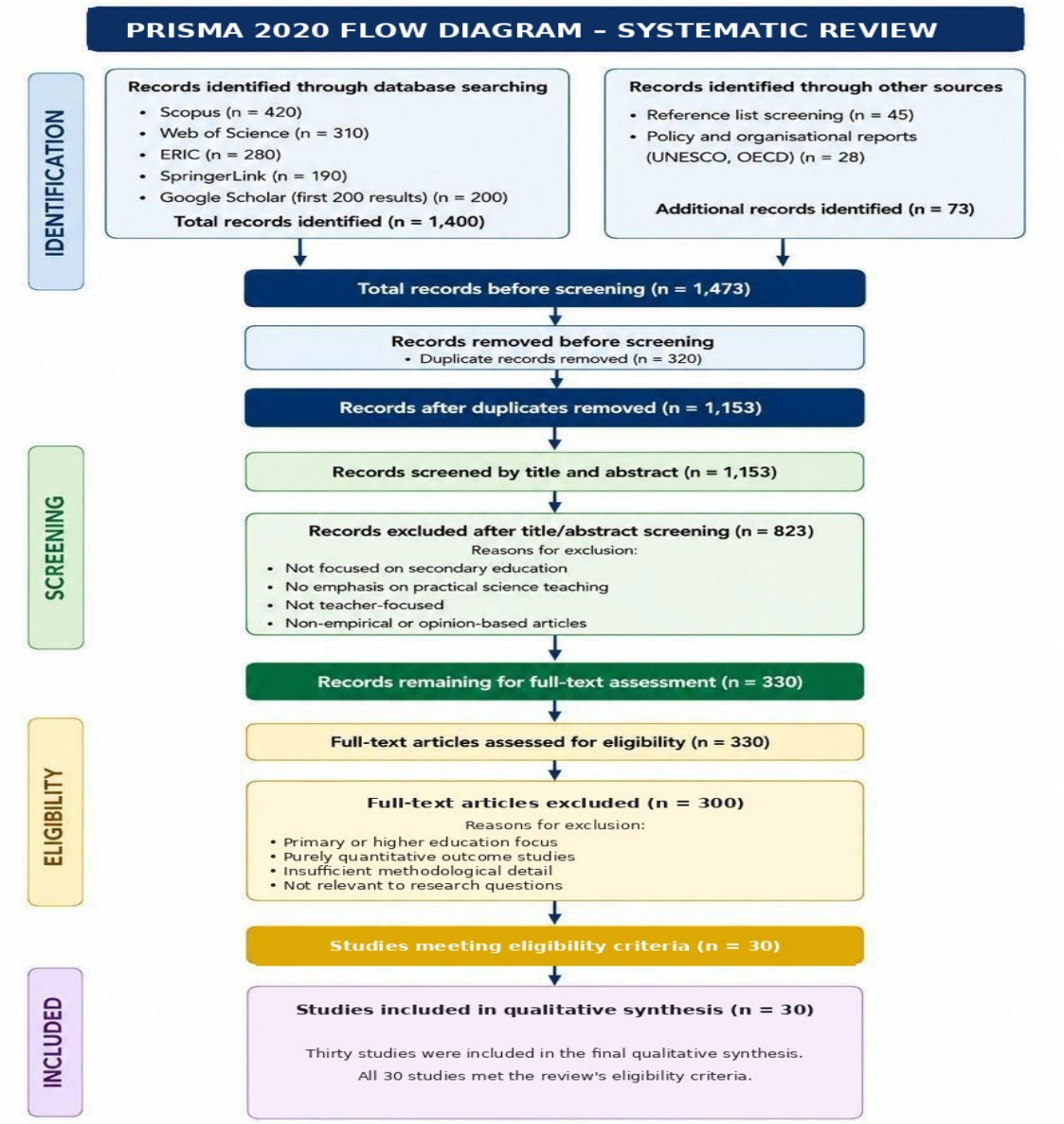
The Critical Appraisal Skills Programme (CASP) checklist was used in this study to evaluate the quality, credibility, and methodological rigour of the research articles included in the review. The use of a critical appraisal tool is an important step in a systematic literature review, as it helps ensure that the evidence included is relevant, trustworthy, and of sufficient quality. Bonfield et al. (2018) noted that the CASP checklist provides a structured approach for assessing peer-reviewed research and evaluating the quality of the evidence presented.

The CASP checklist was selected to support the data analysis process and to guide the systematic evaluation of the included studies. The checklist contains a series of questions that focus on key aspects of research quality, such as the clarity of the research aims, the suitability of the research design, data collection methods, ethical considerations, and the trustworthiness of the findings. Each criterion was assessed using the response categories Yes, No, or Can't Tell.

All selected articles were critically appraised using the CASP checklist to determine their methodological quality and overall contribution to the review. This process helped identify the strengths and limitations of individual studies and supported informed decisions about their inclusion in the final review.

Figure 2.1

PRISMA Framework Showing Flow in this Study



2.7 Data extraction

The data extraction process is an essential stage for systematic literature review because it helps researchers to collect, organize and synthesize suitable information from the selected articles. A structured data extraction process eliminates the risk of missing important

information and compares across the studies (Büchter et al., 2020). An example of a data extraction table is included below (see table 2.1).

The following table provides a summary of the selected studies, including their authors, publication dates, research aims, methodologies, key findings and recommendations. It also indicates whether each study was peer-reviewed. The selection process is guided by the PRISMA framework and CASP checklist.

Table 2.1 *Data Extraction Table Data Extraction Table*

S/No	Citation /authors and date of publication	Peer reviewed	Aim and objective	Methods used in the article reviewed	Results/Findings/Limitations/Recommendations
1.	Oliveira & Bonito (2023	**Yes**	To review factors affecting the implementation of practical science work in schools.	Literature Review	Resource availability and teacher preparation significantly influence practical science implementation.
2.	Kumar et al. (2024)	Yes	To investigate educational inequalities and their impact on learning opportunities.	Review Study	Resource disparities create unequal opportunities for practical science learning.
3.	Osborne (2015)	Yes	To examine the role and use of practical work in science education.	Review of research literature	Practical activities are often poorly implemented because of curriculum pressures, limited resources and inadequate support

2.8 Data analysis

Thematic analysis was employed to analyse the data collected through the systematic literature review. It is a structured flexible method for identifying and interpreting patterns across qualitative data and organising them into meaningful themes relevant to the research questions (Braun & Clarke, 2006).

The analysis followed the six-phase framework proposed by Braun and Clarke (2006). The process began by familiarising myself with the data through repeated reading of the selected studies to gain a comprehensive understanding of literature and identify recurring ideas and issues. Following this, initial codes were generated to organise significant concepts, findings, and observations relevant to the research questions. The coded data were then examined to identify patterns and relationships, enabling similar codes to be grouped into potential themes. These themes were subsequently reviewed and refined to ensure that they accurately represented both the coded extracts and the overall dataset. Once the themes had been finalised, each theme was carefully defined and named to reflect its central meaning and relevance to the research objectives. Finally, the findings were organised into a coherent narrative and presented in a systematic manner, supported by evidence from the reviewed studies and linked to the research questions and existing literature. This process ensured a transparent and rigorous analysis of the challenges associated with practical and experimental science teaching in secondary schools in India and New Zealand.

2.9 Ethical consideration

The study has followed only a secondary qualitative method; the study does not involve consent, confidentiality and anonymity. As no human participants were involved, ethical issues such as informed consent, confidentiality, and anonymity were not required. The review was based entirely on secondary sources, including peer-reviewed journal articles, books, and academic reports.

Maintaining academic integrity was an important consideration throughout the study. All ideas, findings, and information obtained from the literature were appropriately acknowledged through in-text citations and a reference list prepared in accordance with APA 7 guidelines. This helped ensure that the work of original authors was recognised and that plagiarism was avoided.

To ensure the credibility of the review findings, only studies that met the established inclusion and exclusion criteria were included. In addition, the quality of the selected studies was assessed using the CASP checklist. This process helped ensure that the evidence used in the review was relevant, reliable, and of sufficient quality.

Transparency was maintained by clearly outlining the search strategy, study selection process, inclusion and exclusion criteria, and quality appraisal procedures. Providing accurate references and citations also allows readers to trace the original sources and understand how the findings of the review were developed.

2.10 Summary

In summary, this chapter has evaluated the Systematic Literature review (SLR) methodology used in this study. Grounding the study in a constructivism research philosophy allowed for a deep understanding of the contextual realities. The chapter detailed the search strategies, inclusion and exclusion criteria, and the PRISMA framework. To ensure quality and credibility, keywords and CASP tools were used. Data was retrieved from credible databases such as Web of Science, Scopus, ERIC, Google Scholar, ProQuest and Taylor and Francis. Finally, a thematic coding process was followed to extract themes based on the research objectives, ensuring that meaningful findings were generated.

Chapter 3 Findings

3.1 Introduction

This chapter outlines the findings identified through the SLR undertaken to examine the factors that influence secondary school teachers' implementation of practical science activities in India and New Zealand. The study was guided by two research questions,

(1) What are the reported advantages, barriers, benefits, and enablers of implementing practical and experimental science teaching in secondary schools in India and New Zealand?

(2) How do differences in educational context and system shape teachers' ability to implement practical and experimental science teaching in India and New Zealand secondary schools?

This chapter starts with an overview of the included studies that were in the SLR. The findings are based on thematic analysis of the relevant peer-reviewed articles, educational reports and policy documents. The themes identified are the importance and benefits of practical science teaching, the impact of resource and infrastructure constraints on practical science teaching, and the role of teacher capacity, curriculum and policy support for effective practical science teaching. Each theme will be presented in a table to justify its inclusion in the theme and expanded in the written commentary with excerpts from the articles. Data from the general literature, India and New Zealand will be used to highlight similarities and differences

3.2 Overview of included studies

Table 3.1 below provides an overview of the methodological approaches used in the 30 included studies from 2011 to 2026. Qualitative, quantitative and mixed methods approaches were used in the selected studies. The methods used to generate data varied, ranging from survey, document analysis, classroom observations and interviews and focus groups.

Table 3.1

Summary of Review Studies

Study type	Number of studies	Methods
Qualitative	16	Interview, classroom observation, focus group, case studies and document analysis
Quantitative	6	Survey, statistical analysis, descriptive statistics
Mixed method	8	A combination of interviews, surveys and case study approach
Total	30	

3.3 Theme 1: Importance and benefits of practical science teaching

Table 3.2 presents an overview of Theme 1, highlighting the key sub-themes, associated codes and key authors identified in the literature regarding the importance and benefits of practical science teaching.

Table3.2 Theme 1 Overview

Main theme	Sub-theme	Key ideas/codes	Key Authors
1: Importance and benefits of practical science teaching	Improving student conceptual understanding	Linking theory with practice, understanding abstract concepts, real world application, science concepts and knowledge retention	Ghosh & Pramanik (2024); Hipkins & Bull (2015); Khan & Khan (2026); Moeed (2013); Rofe et al. (2015)
	Enhancing scientific skills and enquiry-based skills	Observation skills, problem solving, critical thinking, data analysis and scientific investigation	Agarkar (2017); Kumari, Mwesigye & Balimuttajjo (2024); Moeed (2013); Nargund-Joshi et al. (2011); Taylor (2023); Tolbert et al. (2025)

Developing student engagement and motivation	Interest in science, enjoyment of learning, participation, confidence building, positive attitude towards science	Agarkar (2017); Education Review Office (2021); Gluckman (2011); Lesetja & Photo (2026); Ministry of Education (2007); Rofe et al. (2015)

The first theme highlighted in the SLR was the importance and benefits of practical science teaching. It was found in 16 of the 30 articles. It will be explored through three subthemes.

3.3.1 Sub-theme 1: Improving Student Conceptual Understanding

The findings from the SLR indicate that practical science teaching plays an important role in improving students' conceptual understanding by connecting theoretical knowledge with direct observation, experimentation, and scientific reasoning. Across the included studies from India and New Zealand, practical activities were identified as an effective approach for helping students move beyond memorisation and develop a deeper understanding of scientific concepts.

In the Indian context, studies highlighted that laboratory activities and demonstrations support students in understanding abstract concepts in chemistry, biology, and physics by allowing them to observe scientific processes and apply theoretical knowledge in practical situations (Khan & Khan, 2026). Similarly, research in India emphasised that activity-based science learning encourages students to explore scientific concepts through experimentation rather than relying only on textbook-based learning and memorisation (Ghosh & Pramanik, 2024).

The New Zealand studies also reported that practical and inquiry-based skills support students' conceptual development by encouraging active participation, investigation, and evidence-based explanations. Teachers' use of scientific inquiry approaches enables students to construct their own understanding through questioning, observation, and reflection (Rofe et al., 2015). Furthermore, practical science teaching was associated with developing students' scientific literacy and improving their understanding of how scientific knowledge is generated through investigation (Hipkins & Bull, 2015).

Moeed (2013) also highlighted the potential of science investigation to support students' conceptual understanding. The study noted that practical investigation can help students learn scientific concepts by connecting concepts with the processes and outcomes of an investigation. This suggests that practical activities can provide students with opportunities to understand scientific ideas through direct engagement with investigation rather than learning

concepts only through theoretical instruction. However, Moeed (2013) also identified a concern that when practical investigations are strongly shaped by assessment requirements, teachers may place greater emphasis on procedural knowledge than on students' conceptual understanding.

The reviewed studies also identified that the effectiveness of practical activities depends on teachers' pedagogical knowledge, the availability of appropriate laboratory resources, and opportunities for meaningful scientific inquiry (Rofe et al., 2015).

Overall, the findings suggest that practical science teaching can strengthen students' conceptual understanding by giving them opportunities to see, investigate, and apply scientific ideas in meaningful situations. Evidence from both India and New Zealand indicates that moving beyond textbook-based learning towards practical and inquiry-based experiences can support deeper learning. At the same time, the findings show that the value of practical work depends on how well activities are designed, the resources available, and the teacher's ability to connect students' practical experiences with the scientific concepts being taught.

3.3.2 Sub-theme 2: Enhancing Scientific Skills and Inquiry-Based skills

This sub-theme indicates that practical science teaching is effective in developing scientific skills and promoting inquiry-based learning. Inquiry-based learning involves students taking an active role in the learning process by asking questions, investigating problems, gathering and analysing evidence, and developing explanations based on their findings. In practical science teaching, this approach allows students to develop scientific skills through direct involvement in investigations rather than simply following teacher instructions or predetermined experimental procedures.

In India, according to the National Council of Educational Research and Training (NCERT) protocols, students are encouraged to formulate observations and interpret findings like skills of a scientist (Nargund-Joshi et al., 2011). This reflects the emphasis on laboratory experimentation, where students actively engage in investigations and interact with experimental results (Kumari et al., 2024). For example, students may investigate plant growth under different environmental conditions and compare growth rates to identify patterns and draw conclusions. Similarly, practical activities in physics and chemistry laboratories help

Students develop problem-solving skills by conducting experiments, identifying errors, and analysing results. Agarkar (2017) emphasised that science education should help young people develop practical skills that they can use in real-life situations and should also encourage scientific thinking among different groups of people in society. This suggests that science education should move beyond the acquisition of theoretical knowledge and provide opportunities for students to develop the skills needed to apply scientific knowledge in practical situations. In this context, practical science teaching can support students in developing observation, experimentation, problem-solving, and evidence-based reasoning skills.

In the New Zealand context, practical science teaching promotes active and experimental learning. Tolbert et al. (2025) identified that the purpose of science education includes preparing students for science-related careers, building scientific literacy, and developing practical knowledge and scientific thinking skills. Students participate in practical activities across different scientific contexts, including field-based investigations of local ecosystems and water quality. Practical work enables students to apply scientific skills and knowledge in authentic learning environments rather than relying solely on examination-based assessment. From a New Zealand perspective, the findings indicate that practical investigations motivate students by connecting scientific concepts with meaningful, real-world contexts. Inquiry-based practical science teaching encourages students to take an active role in scientific investigations rather than simply following teacher instructions. (Rofe et al., 2015). Students are supported to identify the purpose of the investigation, discuss the experimental design, gather information from different sources, and make decisions about the evidence they would collect. They are also encouraged to analyse their findings and draw conclusions based on evidence (Rofe et al., 2015).

New Zealand teachers promote practical investigations to strengthen scientific inquiry, while secondary schools design teaching and learning programmes in alignment with the national curriculum (Taylor, 2023). Although teachers initially lacked confidence in teaching science, their confidence increased as they engaged in inquiry-based approaches and gradually provided students with greater responsibility during practical investigations. These findings suggest that inquiry-based practical science teaching not only strengthens students' scientific inquiry skills but also enhances teachers' confidence in delivering practical science lessons

(Rofe et al., 2015). New Zealand teachers promote practical investigations to strengthen scientific inquiry, while secondary schools design teaching and learning programmes in alignment with the national curriculum (Taylor, 2023).

The findings also showed that inquiry-based practical science encourages students to develop scientific thinking by actively exploring questions, investigating evidence, and constructing explanations through practical activities. Moeed (2013) explained that inquiry in science involves different but related aspects, including scientific inquiry, inquiry learning, and inquiry teaching. Scientific inquiry reflects the way scientists investigate the natural world using evidence, while inquiry learning focuses on students actively engaging in investigations to develop knowledge and problem-solving skills. Inquiry teaching refers to the pedagogical approaches teachers use to support students' investigations and encourage active participation in the learning process. Moeed (2013) further emphasised that practical activities do not automatically develop students' investigative skills or lead to meaningful learning. Students need opportunities to understand how scientific investigation is used to develop knowledge, rather than simply carrying out practical activities. The study also highlighted the importance of teachers having a sound understanding of scientific inquiry and investigation so that they can guide students effectively through the investigative process. This suggests that practical science teaching can enhance students' scientific skills when activities are purposeful and encourage students to investigate questions, use evidence, and develop explanations. Therefore, inquiry-based practical work can support students in developing investigative and scientific reasoning skills rather than simply following predetermined experimental procedures (Moeed, 2013).

Overall, the findings indicate that practical science teaching develops students' scientific and inquiry-based skills. It provides students with opportunities to investigate, observe, analyse, and apply scientific knowledge in both India and New Zealand. The findings also suggest that practical activities are most effective when students are actively involved in the investigation and are given opportunities to question, use evidence, analyse results, and develop explanations. Therefore, meaningful practical and inquiry-based learning can help students develop the scientific skills needed to apply knowledge beyond the classroom.

3.3.3 Sub-theme 3: Developing Student Engagement and Motivation

This sub-theme identifies that practical science teaching improves students' engagement and motivation towards learning science. Lesetja and Photo (2026) reported that teachers observed greater student interest when practical activities were linked to everyday phenomena. According to the authors, activities such as electrical circuits, water quality testing, and plant growth investigations encouraged students to explore scientific concepts through hands-on learning. They further noted that chemistry experiments involving colour changes and microscopic observations in biology stimulated students' curiosity and motivated them to participate actively in practical sessions. Agarkar (2017) emphasised the importance of science education in developing scientific understanding and interest among students in India, particularly in relation to the wider development of scientific knowledge and national development. Practical and activity-based experiences can therefore provide opportunities for students to explore scientific ideas, develop curiosity, and become more actively involved in learning. Thus, practical science teaching can contribute not only to students' understanding of scientific concepts but also to their interest and participation in science learning (Agarkar, 2017).

Further evidence from New Zealand also highlights the importance of engaging students through practical science experiences. An Education Review Office (2021) report found that students showed greater interest in science when learning involved hands-on activities using everyday materials and encouraged them to ask questions, investigate real-life problems, and explore their own ideas. For example, students used tomato sauce to clean coins and then generated further investigation questions about the role of vinegar and whether other substances would produce similar results. This approach encouraged curiosity, active participation, and scientific thinking while helping students relate science to everyday experiences. The report also highlighted that providing teachers with professional learning opportunities and increasing the use of practical investigations contributed to higher levels of student engagement and more positive attitudes towards science learning (Education Review Office, 2021).

Gluckman (2011) highlighted concerns about declining student interest in science and emphasised the importance of making science learning more engaging and relevant to students' lives and aspirations. Similarly, practical work can provide students with opportunities to explore scientific ideas through direct experiences, which can encourage greater participation and interest in science learning. Therefore, practical science teaching can contribute not only to students' understanding of scientific concepts but also to their engagement, interest, and motivation to learn science.

Rofe et al. (2015) also highlighted that student engagement increased when inquiry-based practical activities provided students with greater responsibility for their own learning. Rather than following a fixed set of instructions, students worked collaboratively to plan investigations, discuss experimental designs, collect and analyse evidence, and draw conclusions from their findings. Teachers guided the learning process while encouraging students to think critically, share their ideas, and make decisions throughout the investigation. The study also found that as teachers became more confident in teaching science through professional learning and classroom practice, they were better able to create engaging inquiry-based skills experiences that encouraged students to participate actively in practical science lessons.

The New Zealand science curriculum also promotes exploration across the physical, biological, and technological worlds while encouraging students to investigate natural phenomena (Ministry of Education, 2007). Furthermore, practical work helps students connect scientific concepts with authentic scientific experiences, making learning more meaningful.

Overall, the findings suggest that practical science teaching creates an interactive learning environment where exploration, participation, and collaboration can enhance students' engagement and motivation towards science learning. The evidence from India and New Zealand shows that students are more likely to become interested and actively involved when practical activities are connected to everyday experiences, provide opportunities for investigation, and allow students to take an active role in their learning. This suggests that well-planned practical science activities can make science learning more meaningful and encourage students to develop a stronger interest in the subject.

3.4 Theme 2: Resources and infrastructure constraints affecting practical science teaching

Another theme identified in the literature is resources and infrastructure constraints affecting practical science teaching. The sub-themes are equipment shortages, funding and time.

Table 3.3 provides an overview of Theme 2, outlining the key sub-themes, associated codes and supporting authors. It highlights the major resource and infrastructure constraints that affect the implementation of practical science teaching in secondary schools. It was found in 11 of the 30 articles reviewed.

Table 3.3

Theme 2 Overview

Main theme	Sub theme	Codes	Key Author
2. Resources and infrastructure constraints affecting practical science teaching	**Laboratory facilities and equipment availability**	Limited laboratory spaces, inadequate science laboratories, overcrowded classrooms, lack of laboratory technicians	Agarkar (2017); Durkaya (2023); Hiyan et al. (2025); Rofe et al. (2015); Taylor (2023)
	Financial support and funding for practical science teaching	Limited science budgets, resource allocation challenges, maintenance costs, restricted innovation and laboratory materials	Ghosh & Pramanik (2024); Nandy & Pramanik (2025); Sandretto & Jesson (2025); Vannier (2012)
	Time constraints in practical science teaching	Curriculum pressure, limited practical lesson duration, preparation and clean-up time and assessment demands	Moeed (2013); Thakur & Kadu (2024)

Sub theme 3.4.1: Laboratory Facilities and Equipment Availability

This sub-theme highlights that limited access to science laboratories and scientific

equipment may affect the implementation of practical science teaching. From the perspective of India, Durkaya (2023) noted that schools face challenges such as overcrowded classrooms, limited access to science laboratories, and insufficient laboratory space. These issues are particularly common in government and rural schools, where specialised laboratories for

Physics, chemistry, and biology are often unavailable. Agarkar (2017) also noted that some schools have laboratories that are either unavailable or inadequately equipped, creating difficulties for teachers in conducting practical activities. To address this issue, the National Council of Educational Research and Training (NCERT) developed laboratory kits and provided training to teachers on their effective use. However, providing laboratory equipment to all schools in India would require substantial financial resources because of the size of the school system (Agarkar, 2017). As an alternative, locally available materials were used to develop practical science activities, and teacher training was provided to support their use. This suggests that although practical science is recognised as an important part of science education, inadequate laboratory infrastructure, limited equipment, and financial constraints can restrict teachers' ability to conduct practical activities effectively.

Data identified in the SLR also showed that shortages of scientific equipment and materials may affect practical science teaching. Teachers in India have reported shortages of microscopes, electrical equipment, measurement instruments, and laboratory chemicals (Hiyan et al., 2025). As a result, students may have fewer opportunities to participate directly in experiments and develop practical scientific skills.

In comparison, New Zealand schools generally have better laboratory facilities and science infrastructure, although some schools may still experience difficulties in replacing older equipment or accessing specialised resources for activities (Taylor, 2023). For example, teachers undertaking environmental science projects may have limited access to water-testing kits. Laboratory materials may also become outdated or damaged, which can restrict teachers' ability to carry out practical activities effectively. Similar challenges have been reported in New Zealand Indigenous schools, where shortages of teaching resources, laboratory facilities, and science equipment may affect the delivery of science education (Rofe et al., 2015). Overall, the findings indicate that laboratory facilities and equipment were commonly reported as factors affecting the implementation of practical science teaching. The reviewed studies reported challenges related to the availability and condition of laboratory facilities and equipment in both India and New Zealand. These challenges included limited access to suitable laboratory facilities, inadequate equipment, and a lack of alternative resources for conducting practical science activities.

3.4.2 Sub-theme 2: Financial Support and Funding for Practical Science Teaching

The findings from the SLR identified that funding is an important factor influencing the implementation of practical science teaching. Evidence from the literature from both Indian and New Zealand perspectives identified that funding constraints are a significant barrier to the effective implementation of practical and experimental science teaching. Financial limitations reduce teachers' opportunities to provide students with meaningful hands-on learning experiences.

In the Indian context, the United Nations Educational, Scientific and Cultural Organization (UNESCO), in a comparative study of India, Singapore, and the United States, highlighted the relationship between investment in education and the development of science education (Nandy & Pramanik, 2025). Funding is particularly relevant to practical science education because laboratories require financial resources for equipment, chemicals, consumable materials, and ongoing maintenance (Ghosh & Pramanik, 2024). The reviewed studies reported that funding limitations in Indian secondary schools contributed to shortages of laboratory facilities and equipment and difficulties in maintaining existing resources (Ghosh & Pramanik, 2024). These challenges were particularly reported in government-funded schools, where limited budgets affected the availability of resources for practical science activities. Nandy and Pramanik (2025) also reported that funding opportunities could be inconsistent and competitive, resulting in differences in the level of laboratory provision between schools. Although external grants may provide additional resources, the findings indicate that access to such funding is not consistent across schools.

In comparison, New Zealand invests more resources in education and generally provides stronger support for science teaching (Vannier, 2012). However, funding challenges can still occur. According to the OECD report (2024), schools are often required to balance science-related spending with other educational priorities (Sandretto & Jesson, 2025). As a result, some schools may face difficulties in maintaining laboratory facilities or updating specialised resources such as digital sensors and biotechnology equipment. To address these challenges, some schools seek additional funding through STEM programmes and partnerships with community organisations, universities, and private sector initiatives. These funding sources have enabled schools to upgrade laboratory facilities, purchase modern scientific

equipment, and expand opportunities for practical science activities (Sandretto & Jesson, 2025).

Overall, the findings suggest that funding plays an important role in supporting practical science teaching in both contexts. While the impact of funding constraints appears more noticeable in India, particularly in government-funded schools, some New Zealand schools also experience challenges in maintaining and upgrading science resources. The findings also indicate that differences in financial support can affect schools' ability to maintain laboratory facilities, access appropriate equipment, and provide students with regular opportunities to engage in practical science activities.

3.4.3 Sub-theme 3: Time Constraints in Practical Science Teaching

In India, the National Education Policy (NEP) 2020 and the National Curriculum Framework (NCF) 2023 promotes experimental, competency-based, and practical learning approaches. However, research from Odisha, Bihar, Karnataka, Uttar Pradesh, Rajasthan, Tamil Nadu, and Maharashtra indicates that practical activities continue to be affected by examination-focused teaching, limited time, and syllabus-related pressures (Thakur & Kadu, 2024).

In New Zealand Moeed (2013) found that teachers viewed science investigations as a sequence involving planning, data gathering, processing, interpreting, and reporting. The findings indicated that these stages required teachers to allocate sufficient classroom time for students to complete science investigations. Time was therefore identified as a challenge in implementing practical science teaching, particularly when teachers needed to accommodate the different stages of the investigation within available teaching periods.

In addition, the influence of assessment requirements may lead teachers to follow a structured and sequential approach to investigations, which can further affect the time available for practical learning (Moeed, 2013).

Therefore, the findings identified limited classroom time as a barrier to providing students with sufficient opportunities to complete meaningful science investigations and practical activities.

3.5 Theme 3: Teacher capacity, curriculum and policy support for effective practical science teaching

This theme highlights how teacher capacity, professional development, curriculum, policy and school leadership influence practical science teaching. It was identified in 15 of the 30 reviewed articles.

Table 3.4 summaries the key sub-themes, codes and supporting authors.

Table 3.4

Theme 3 Overviews

Main theme	Sub theme	Code	Key Author
Impact of teacher capacity, professional development & confidence	Teacher knowledge, confidence and pedagogical capacity	Subject content knowledge; Pedagogical content knowledge; Understanding experimental methods; Inquiry-based teaching; Self-efficacy; Confidence in practical teaching; Classroom control concerns	Kumari, Mwesigye & Balimuttajjo, (2024): Malsawmtluanga & Hlondo (2024); Ministry of Education (2017); Rofe et al. (2015); Srivastava & Jangir (2025)
	Curriculum design and practical learning integration, educational policy and Government support	Inquiry based curriculum, competency learning, practical investigation, curriculum alignment, National curriculum policy, laboratory infrastructure, government funding, rural-urban disparities, policy implementation	Ghosh & Pramanik (2024); Martin et al. (2021); Moeed (2013); Sexton (2018); Taylor (2023); Thakur & Kadu (2024); Tripathi (2024)

	School leadership and institutional support	School culture, principal leadership, collaborative planning, teacher motivation, resource management, institutional commitment	Education Review Office (2021); Srivastava & Jangir (2025); Sweeney (2011); Thakur & Kadu (2024)

3.5.1 Sub-theme: Teacher Knowledge, Professional Development, and Confidence

This sub-theme highlights the importance of teachers' knowledge, professional development, and confidence in implementing practical and experimental science teaching in secondary schools. The reviewed studies indicate that effective practical science teaching requires teachers to have appropriate subject knowledge, pedagogical understanding, practical skills, and confidence to facilitate inquiry-based learning.

In the Indian context, the reviewed literature indicated that some Indian secondary schools provide limited opportunities for teachers to develop practical teaching skills, which may restrict their ability to effectively conduct laboratory-based activities (Srivastava & Jangir, 2025). According to Srivastava and Jangir (2025), rural schools in India often experience difficulties in accessing sufficiently trained science teachers, which can influence the quality of practical science education. Although professional development programmes are provided through organisations such as NCERT, SCERTs, and state education programmes (Kumari et al., 2024), limited training related to practical science pedagogy, laboratory management, and inquiry-based teaching remains a challenge (Malsawmtluanga & Hlondo, 2024).

In the New Zealand context, professional development plays an important role in improving teachers' confidence and capacity to implement inquiry-based practical science teaching. Teachers who initially lacked confidence in teaching science reported feeling more prepared after receiving guidance, collaborative support, and opportunities to participate in science activities themselves. Professional development enabled teachers to strengthen their understanding of the inquiry process, improve their pedagogical approaches, and support

students in planning investigations, analysing evidence, and drawing conclusions (Rofe et al., 2015).

The findings showed that professional learning and development (PLD) supported teachers to strengthen their knowledge and improve their science teaching practices. Teachers were motivated to apply and share practices gained through PLD and to support professional learning within their schools. The study also found that students became more engaged with science when teachers used a wider range of resources and learning experiences, including those gained through PLD (Education Review Office, 2021). Evidence from the PISA 2015 Science Context report indicated that 79% of New Zealand science teachers had participated in professional development during the three months preceding the assessment, compared with the OECD average of 51% (Ministry of Education, 2017). However, the report found no direct association between participation in professional development and higher student achievement, indicating that participation alone does not necessarily lead to improved learning outcomes (Ministry of Education, 2017).

Overall, the findings from both India and New Zealand indicate that teacher knowledge, professional development, and confidence are important for supporting practical science teaching. However, the New Zealand evidence particularly highlights the value of ongoing PLD, collaboration, mentoring, and opportunities for teachers to apply their learning in classroom practice.

3.5.2 Sub-theme 2: Curriculum, Educational Policy, and Government Support

The findings highlighted that curriculum design, educational policy, and government support play an important role in the implementation of practical science teaching. The studies emphasised that a curriculum integrating science inquiry and classroom learning can improve student engagement and conceptual understanding.

In India, according to NCERT, many teachers still prioritise theoretical board examinations, which can limit opportunities for developing investigative skills (Ghosh & Pramanik, 2024). Teachers have suggested that STEM approaches can improve scientific reasoning and critical thinking among students. Government initiatives such as Rashtriya Avishkar Abhiyan, Samagra Shiksha, NEP 2020, and Atal Tinkering Labs have been

introduced to strengthen practical science education through laboratory infrastructure, innovation, and resource development (Tripathi, 2024). States such as Karnataka, Delhi, and Telangana have also invested in science laboratories and digital resources. However, differences in resource availability remain across regions.

In New Zealand, the New Zealand Curriculum provides flexibility for teachers to integrate practical learning into local contexts and develop scientific capabilities such as gathering and interpreting evidence, using scientific language, and understanding scientific ideas (Ministry of Education, 2007). Schools in Auckland, Otago, and Wellington have implemented student-centred investigations that include local contexts, Māori knowledge, and environmental science (Taylor, 2023). The refreshed curriculum is also moving towards a more explicit and knowledge-rich approach, with clearer learning content and expectations for teachers and students (Ministry of Education, 2025). These curriculum expectations are relevant to practical science teaching because they can influence the content teachers prioritise and the opportunities provided for students to engage in practical and hands-on activities.

Curriculum policy also influences how science is taught across different school settings. Moeed (2013) discussed the challenges faced by Māori-medium schools in bringing together Māori ways of knowing and Western science within the science curriculum. The development of Pūtaiao as a Māori-medium science curriculum highlighted the importance of reflecting Māori knowledge, values, language, and ways of understanding science. Moeed (2013) also noted that science in mainstream schools is viewed as a practical subject, where hands-on learning and active participation are encouraged. Similarly, Martin et al. (2021) highlighted the importance of students' experiences of science during the middle years and suggested that the way science is presented within the curriculum can influence student engagement. Buntting and Soanes (2026) highlight the importance of curriculum design and policy support in shaping science education in Aotearoa New Zealand. Their study discusses the ongoing development of the national science curriculum and identifies the need for clearer curriculum direction, planning and sequencing to support teachers. The authors also emphasise that science education should provide opportunities for students to develop scientific thinking through questioning, exploration and engagement with scientific ideas and practices. In addition, the study shows that curriculum development is influenced by wider national policies and qualification

requirements, including the relationship between the national curriculum and NCEA. These findings suggest that effective practical science teaching requires curriculum policies that provide clear direction while allowing teachers sufficient flexibility to integrate inquiry, practical learning and scientific competencies into classroom practice. Together, these findings suggest that curriculum design needs to consider students' cultural and educational contexts while providing opportunities for practical and engaging science learning.

Government and educational support further contribute to practical science education through funding, curriculum development, digital resources, and STEM initiatives. The New Zealand Ministry of Education supports teachers through Network of Expertise programmes, the Science Learning Hub, and regional professional learning programmes, providing access to resources and professional support (Sexton, 2018). Government investment in digital technologies and school infrastructure has also supported scientific investigations and virtual laboratory experiences (Taylor, 2023).

Overall, the findings suggest that effective curriculum design, supportive educational policies, and sustained government investment are essential for strengthening practical science teaching. While both India and New Zealand have introduced initiatives to support practical learning, differences in implementation, resource availability, and regional support continue to influence the effectiveness of practical science teaching.

3.5.3 Sub-theme 3: School Leadership and Institutional Support

The findings highlighted school leadership and institutional support as factors influencing the implementation of practical science teaching. Effective school leadership was associated with supporting teachers, managing science resources, planning practical activities, and creating opportunities for collaboration. In the Indian context, Thakur and Kadu (2024) found that supportive principals and school leaders could encourage practical investigations through effective resource management, strategic planning, decision-making, and teacher support. Similarly, Srivastava and Jangir (2025) highlighted the importance of teacher support, training, and school-level management in the effective use of science resources, including secondary science kits. The study reported that states such as Rajasthan, Gujarat, Maharashtra, Tamil Nadu, Karnataka, and Uttar Pradesh had prioritised teacher training and laboratory

maintenance to support practical learning. Collaborative planning among science staff was also identified as supporting lesson quality through shared laboratory management and the development of practical assessment practices (Srivastava & Jangir, 2025).

In the New Zealand context, Sweeney (2011) identified supportive leadership as a factor associated with the implementation of scientific learning. The study reported that leadership support provided opportunities for teachers to develop their practice and engage with inquiry-based approaches to science teaching. Collaborative approaches within science departments were also identified as supporting teachers' professional learning and the development of inquiry-based teaching practices (Sweeney, 2011). These findings indicate that school-level support can contribute to teachers' opportunities to develop and implement practical science teaching.

Overall, the findings from India and New Zealand suggest that school leadership and institutional support are important conditions for effective practical science teaching. In India, the findings particularly highlight the importance of resource management, teacher support, training, laboratory maintenance, and collaborative planning. In New Zealand, the findings place greater emphasis on collaborative leadership, teacher autonomy, professional learning communities, and support for inquiry-based teaching. Therefore, effective school leadership can strengthen practical science teaching by creating the organisational conditions in which teachers have the resources, support, collaboration, and professional opportunities needed to implement practical science teaching.

3.6 Chapter Summary

This chapter presented the findings from the systematic literature review on practical and experimental science teaching in secondary schools in India and New Zealand. The review identified three main themes that influence the implementation of practical science teaching. These themes included the benefits of practical science teaching, resource and infrastructure challenges, and teacher capacity, professional development, confidence, and the role of curriculum, policy, and school support.

The findings showed that practical science teaching helps students develop a better understanding of scientific concepts, improves scientific skills, increases engagement, and

promotes active learning. At the same time, several challenges were identified, including limited laboratory facilities, shortages of equipment, funding issues, time constraints, and differences in teacher knowledge, professional development, and confidence. The findings also highlighted the importance of curriculum policies, government initiatives, and effective school leadership in strengthening practical science teaching.

Overall, the review suggests that while both India and New Zealand recognise the value of practical science teaching, teachers experience different challenges and opportunities depending on their educational context. The findings highlight that successful implementation of practical science teaching requires appropriate resources, teacher capacity, professional development opportunities, and strong curriculum, policy, and institutional support. The next chapter will discuss these findings in more detail by linking them to the research questions and existing literature and examining their implications for practical and experimental science teaching in secondary schools.

Chapter 4: Discussion

4.1 Introduction

The purpose of this chapter is to discuss and interpret the findings identified from the Systematic Literature Review, which explored a total of 30 studies from 2011 to 2026, in relation to the research questions that guided the review. The main research questions are:

(1) What are the reported benefits, barriers and enablers to the implementation of practical and experimental science teaching in India and New Zealand secondary schools?

(2) How do differences in educational context and system shape teachers' ability to implement practical and experimental science teaching in India and New Zealand secondary schools?
Initially, this chapter will summarise the main findings about the challenges experienced by secondary science teachers in New Zealand and India in incorporating practical experiences in the classroom. The discussion will then synthesise and interpret the findings to ascertain why these results occurred, offering comment on the broader science education field and the similarities and differences between India and New Zealand. Three main themes were identified in the findings chapter, examining the use of practical experiences in secondary science classrooms in India and New Zealand.

The first theme focused on the importance and benefits of practical science teaching. Practical activities were found to support students' conceptual understanding by connecting scientific knowledge with practical experiences. They also helped students develop scientific and investigative skills, as well as problem-solving abilities, while increasing their engagement and motivation towards science learning.

The second theme was resources and infrastructure constraints affecting practical science teaching. The findings showed that limited laboratory facilities, equipment and financial support can make it difficult for teachers to conduct practical activities effectively. Time constraints were also identified one of the challenges, as teachers may have limited time to prepare and carry out practical work alongside other curriculum requirements.

The third theme was teacher capacity, professional development and confidence. The findings indicated that teachers' knowledge, confidence and pedagogical capacity influence the effective implementation of practical science teaching. Curriculum design, practical learning

integration, educational policies and government support were also important. In addition, school leadership and institutional support can provide teachers with the resources, guidance and encouragement needed to conduct practical science activities effectively.

The discussion of these themes and subthemes provides an opportunity to interpret the findings in relation to the three research questions and to consider the reported benefits, barriers, enablers, strategies and resources identified in the literature from India and New Zealand. Together, the themes provide a basis for examining how educational contexts and system differences shape teachers' ability to implement practical and experimental science teaching in secondary schools in the two countries. These themes will be discussed through examining the data through the research questions and examining the findings through the wider literature.

4.2 Research Question 1: Outlining the benefits, barriers and enablers of implementation of practical and experimental science teaching

Exploring the first research question allowed me to identify the benefits, barriers and enablers of implementing practical and experimental science teaching in secondary schools in India and New Zealand. Each section will be explored and discussed in the light of wider literature in the field.

4.2.1 Benefits and Importance of Practical Science Teaching: This section focuses on the benefits and importance of practical science teaching identified across the literature. Theme one in the findings highlighted several benefits, including improving students' conceptual understanding, developing scientific skills, increasing students' engagement and motivation, and promoting active and experimental learning.

My findings showed that practical and experimental science teaching can improve students' understanding by connecting theoretical ideas with practical experiences. In the Indian context, studies highlighted that laboratory activities and demonstrations supported students in understanding abstract concepts in chemistry, biology, and physics by allowing them to observe scientific processes and apply theoretical knowledge in practical situations (Khan & Khan, 2026). This aligns with Erduran et al. (2019), who stated that practical science work is essential for developing meaningful science learning, with the development of

conceptual understanding being a primary benefit.

This finding is also consistent with the wider literature, where the advantages of practical work at secondary school are well established, and researchers have confirmed that science learning and understanding are enhanced when students undertake practical experiments in science laboratories (Hofstein & Lunetta, 2004; Lunetta et al., 2007). Similarly, Sanjito and Hyam-Ssekasi (2025) asserted that practical activities allow students to observe scientific principles in action and can help clarify theoretical ideas. They noted that experiments related to chemical reactions or physical forces can enable students to visualise scientific concepts that may otherwise be difficult to understand through theoretical teaching alone. This idea was mirrored by Gericke et al. (2023), who highlighted that practical work could provide students with opportunities to build their conceptual understanding through direct experience. The findings in my study are consistent with this idea and support the claim that practical work provides students with opportunities to build their understanding through direct experience rather than only receiving information from the teacher. This indicates that practical experiences can help students connect theoretical knowledge with scientific processes and develop a deeper conceptual understanding.

The findings also identified the development of scientific skills as an important benefit of practical and experimental science teaching. In the reviewed literature, scientific skills refer to students' ability to make observations, ask questions, conduct investigations, analyse data, interpret findings, and draw conclusions. Practical activities can provide opportunities for students to develop these skills through direct involvement in scientific investigations. For example, Moeed (2013) noted that practical investigations can help students learn scientific concepts by connecting concepts with the processes and outcomes of an investigation. This suggests that practical activities provide students with opportunities to understand scientific ideas through direct engagement with investigations rather than learning concepts only through theoretical instruction. This is also reflected in the Indian NCERT protocols, which encourage students to make observations and interpret their findings (Srivastava & Jangir, 2025). This finding is consistent with Erduran et al. (2020), who stated that practical science includes the development of manipulative skills and data handling, while practical work is also advocated for the development of scientific process skills. Therefore, the findings suggest that practical work can contribute not only to students' understanding of scientific concepts but also to their

ability to engage with scientific processes and develop skills needed to investigate and interpret scientific phenomena.

Another important benefit identified in the findings was the potential of practical work to enhance student engagement and motivation. Similarly, Lesetja and Photo (2026) reported that teachers observed greater student interest when practical activities were connected to everyday phenomena and involved hands-on learning. The authors also found that practical activities stimulated students' curiosity and encouraged more active participation in science learning. For example, Agarkar (2017) suggests that practical activities provide students with opportunities to take an active role in the learning process rather than simply receiving information from the teacher. This is consistent with the wider literature, which identifies student engagement and motivation as important benefits associated with practical science teaching (Erduran et al., 2020; Sanjito & Hyams-Ssekasi, 2025). Erduran et al. (2020) identified student motivation as one of the main objectives of practical science, alongside the development of manipulative skills and data handling. Similarly, Ekmekci and Serrano (2022) found that practical work can improve student motivation and academic achievement in science subjects. Therefore, the findings support the wider literature suggesting that practical activities can create opportunities for students to participate more actively in science learning, which may contribute to greater interest and motivation.

Another benefit identified in the findings is that practical science can support active, collaborative and experimental learning. The findings exemplified from this New Zealand article indicate that practical work can involve demonstrations and laboratory experimentation, providing students with opportunities to participate actively in the learning process (Sexton, 2018). Taylor (2023) further identified that group activities can further provide opportunities for students to design experiments, ask questions and draw conclusions. This is consistent with Al-Qoyyim and Kurniawan (2025), who asserted that cooperative learning could involve peer discussion, project-based learning and experimentation, including laboratory-based science activities

The findings also indicate that practical activities can provide students with opportunities to observe, investigate and interpret scientific phenomena while developing scientific skills. This is reflected in the NCERT protocols, which encourage students to use observation and investigation when engaging with scientific phenomena (Srivastava & Jangir,

2025). Practical work can also introduce students to scientific investigation in ways that reflect how scientific processes are undertaken in real-world contexts (Stoffels, 2005; Sanjito & Hyams-Ssekasi, 2025). This finding is consistent with Oliveira and Bonito (2023, p. 13), who noted that combining "hands-on" practical skills with "minds-on" learning has the greatest effect on conceptual understanding. Similarly, Singh-Pillay (2024) explained that practical work can move students beyond being passive recipients of knowledge by involving them in activities such as formulating hypotheses and conducting investigations. This is also consistent with Özer and Sarıbaş (2023), who found that practical work can support students in developing practical skills, analysing data, forming hypotheses and applying critical thinking. Therefore, the findings reinforce the view that the benefits of practical and experimental science teaching extend beyond completing experimental procedures, as these experiences can involve students more actively in scientific investigation and the development of scientific thinking skills.

Overall, the findings from the literature indicate that practical and experimental science teaching provides important benefits for students in both India and New Zealand. Across the two educational contexts, conceptual understanding, scientific skills, engagement, motivation and active participation were enhanced through practical experiences. Practical activities help students connect theory with direct experience and engage in scientific investigation, while collaborative and technology-based approaches can provide additional learning opportunities where resources permit. However, these benefits can be affected by the conditions in which practical science teaching is implemented. The next section examines the range of barriers and challenges that can limit the use of practical and experimental science teaching in schools.

4.2.2 Barriers to Practical and Experimental Science Teaching in Secondary Schools

Several barriers were identified in the systematic literature review that can limit Indian and New Zealand schools from providing regular and meaningful opportunities for students to participate in practical science activities. These barriers were grouped under the second theme, resources and infrastructure constraints affecting practical science teaching, and included infrastructure, equipment shortages, laboratory facilities, funding constraints, and time limitations. The findings suggest that adequate resources and infrastructure are important for supporting the effective implementation of practical science teaching.

The findings of this review highlight that limited laboratory resources are a key barrier to the implementation of practical science teaching in Indian schools. It is important to recognise that while schools may have access to laboratory equipment, there are other barriers that might restrict teachers utilising practical activities. These constraints are particularly evident in rural areas, where many government schools lack specialised laboratories and sufficient resources to support practical science activities (Remperas et al., 2025).

Specifically, many schools lack specialised laboratories (Agarkar, 2017) or essential equipment, often due to funding issues (Ghosh & Pramanik, 2024; Srivastava & Jangir, 2025). This deficiency can restrict teachers' ability to conduct effective experimental activities. These findings correspond to the wider literature, which notes that material and financial shortages can restrict opportunities for meaningful practical science learning (UNESCO, 2021; Abrahams & Millar, 2008). This is even more apparent in developing countries (Oliver et al. (2021

In comparison, New Zealand generally provides stronger educational resourcing and support for science teaching (Vannier, 2012), which means that most schools have access to laboratory facilities and specialised equipment (Sandretto & Jesson, 2025). Some may also have specialised equipment such as biotechnology equipment and digital sensors (Taylor, 2023). However, funding pressures can still affect schools when science-related expenditure competes with other educational priorities, especially in disadvantaged schools (OECD, 2024; Sandretto & Jesson, 2025).

Time limitations were also identified as a barrier to implementing practical and experimental science teaching, although this issue was reported in only two studies. Practical activities require time for preparation, conducting experiments, and discussion, which may be difficult to accommodate alongside curriculum requirements. Thakur and Kadu (2024) identified insufficient time and teaching-related pressures as challenges to implementing practical teaching. This suggests that, in some schools, limited instructional time may further restrict opportunities for practical science activities. The findings suggest that access to resources alone may not be sufficient to support effective practical science teaching. Taylor (2023) also noted that the effective use of practical resources can also be influenced by time allocation, teacher preparation, and the connection between activities and scientific concepts.

This is further reflected in the Indian context, where Srivastava and Jangir (2025) reported difficulties in accessing sufficiently trained science teachers, particularly in rural schools. Taken together, these findings indicate that effective practical science teaching depends not only on the availability of resources but also on teachers having the appropriate knowledge, preparation, and conditions to use them effectively. This is consistent with Anderson (2014) and Moeed and Anderson (2018), who suggest that practical work can be less effective when students do not make clear connections between their observations and underlying scientific concepts.

Therefore, the comparison between India and New Zealand suggests that while resource and infrastructure constraints are more pronounced in India, particularly in rural schools, access to resources alone does not guarantee effective practical science teaching.

4.2.3 Comparison of Resource and Infrastructure Barriers in both countries

The findings from both countries demonstrate similarities and differences in the barriers affecting practical and experimental science teaching. The main difference is the level and nature of resource constraints. In India, particularly in rural and government schools, barriers are more strongly associated with insufficient laboratory facilities, inadequate equipment, limited funding and space. In comparison, New Zealand demonstrates stronger infrastructure and resource provision, although challenges remain in relation to the effective use of practical activities, time, poorly trained staff and the connection between practical work and conceptual understanding. This comparison is consistent with Hofstein and Lunetta (2004) and Millar (2004), who argued that practical work can enhance learning when it is well structured and properly supported, but its effectiveness can be reduced when appropriate infrastructure and trained staff are lacking.

The findings therefore reinforce the view that effective practical science teaching requires more than simply providing laboratory equipment. Poorly trained staff may limit the effective use of available resources (Taylor, 2023). This is consistent with Anderson (2014) and Moeed and Anderson (2018), who emphasised the importance of connecting practical observations with underlying scientific concepts. In addition, weak connections between practical activities and scientific concepts may reduce their contribution to students' learning (Taylor, 2023). Therefore, although resource and infrastructure barriers are more pronounced

in India, the findings from both countries indicate that the availability of resources alone does not guarantee meaningful practical science learning.

Overall, the findings correspond to previous research showing that laboratory facilities, equipment, funding and time influence the implementation of practical science teaching. However, the comparison between India and New Zealand indicates that the nature and severity of these barriers differ across educational contexts. While Indian schools, particularly rural and government schools, face more fundamental resource and infrastructure limitations, the New Zealand context highlights the importance of how existing resources are used, poorly trained staff and making clear links between practical activities and conceptual understanding. This suggests that improving practical science teaching requires both adequate resources and the capacity to use them effectively. Alongside these barriers, the findings also identify factors that can support and strengthen the implementation of practical and experimental science teaching, which are discussed in the following section.

4.2.4 Enablers for Effective Practical and Experimental Science Teaching

The findings identified several factors that can support the implementation of practical and experimental science teaching, including teacher professional development, curriculum design, well-equipped laboratory and innovative teaching approaches. These factors were identified under Theme 3 in the findings chapter.

The most significant enabler identified across the findings was teacher professional development. In the Indian context, teachers' subject knowledge, pedagogical training, and opportunities to develop practical teaching skills were important for strengthening their confidence to implement practical and experimental science activities (Ghosh & Pramanik, 2024). However, while several teacher training initiatives have been introduced through national educational reform, teachers in rural schools and government-funded institutions reported limited opportunities to participate in laboratory-based training and specific professional learning (Nandy & Pramanik, 2025). In the New Zealand context, the Education Review Office (2021) found that teachers' knowledge and skills, developed through practical experience, can contribute to their confidence in planning and leading practical activities. Similarly, Rofe et al. (2015) found that guidance, collaborative support and opportunities to participate in science activities helped teachers strengthen their confidence and capacity to use inquiry-based approaches. These findings are consistent with the wider literature, where

Osborne (2007) and Hodson (1993) identify teachers' subject knowledge and pedagogical training as important factors in supporting effective science teaching and practical work. Gericke, Högström, and Wallin (2023) further argue that teacher confidence is influenced not only by individual motivation but also by systematic investment in professional learning. The findings reinforce the importance of continuous professional development in enabling teachers to develop the knowledge, practical skills and confidence required for effective practical science teaching.

Curriculum design and the integration of practical learning were also identified as important enablers in the findings. In India, the National Education Policy (NEP) 2020 and the National Curriculum Framework for School Education (NCF-SE) 2023 emphasise experiential learning, scientific investigation and the development of scientific skills (Ministry of Education, 2020; Ministry of Education 2025). This policy direction is consistent with the findings of this review, which identified curriculum design and practical learning as important conditions for supporting practical and experimental science teaching.

In New Zealand, the current New Zealand Curriculum (2007) provides schools with flexibility to design learning experiences that respond to students' local contexts and interests (Ministry of Education, 2007). However, the national curriculum is undergoing a phased refresh towards Te Mātaiaho, with the refreshed Science curriculum being introduced from 2027 (Ministry of Education, 2026). The refresh places greater emphasis on clearer and more structured expectations about the knowledge and learning students are expected to develop, while continuing to allow teachers to design learning programmes that reflect local contexts (Ministry of Education, 2025). This change is relevant to practical science teaching because curriculum expectations can influence the time, flexibility, and opportunities available for practical investigation. Taylor (2023) found that schools in Otago, Auckland, and Wellington used student-centred investigations and local contexts, including Māori knowledge, suggesting that curriculum design can support practical learning that is responsive to students and their communities. As the curriculum becomes more structured, maintaining opportunities for teachers to adapt practical activities to local contexts will remain important. Therefore, the findings highlight the importance of curriculum design and policy support in creating sufficient space for meaningful practical and experimental learning

Similarly, access to appropriate laboratory resources can support the implementation of practical science teaching. Hofstein and Lunetta (2004) highlighted the central role of the laboratory in science education and its contribution to students' learning through practical activities. A smaller finding also identified digital technology as an additional support for practical and inquiry-based science teaching by providing alternative ways to develop and deliver science learning (Kurup & Li, 2022). However, this was not a major finding in the reviewed literature. Therefore, access to appropriate laboratory resources remains important for practical science teaching, while digital technology may provide additional support where suitable resources are available.

The findings also emphasise the importance of professional learning. This may include school improvement processes, mentoring programmes, curriculum workshops, and professional learning communities (Wang et al., 2025). In New Zealand context, the Education Review Office (2021) found that through professional development teachers develop knowledge and which can strengthen their confidence in planning and implementing practical activities. Similarly, Rofe et al. (2015) highlighted the value of guidance, collaboration, and opportunities for teachers to participate in science activities in developing their capacity to use inquiry-based approaches. In the Indian context, Thakur and Kadu (2024) noted that educational leaders can support teachers' participation in professional development and encourage collaboration through cross-disciplinary STEM initiatives. These findings support the importance of ongoing professional learning in strengthening teachers' knowledge, confidence, and practical teaching skills. While professional development can happen organically, the value of supportive leadership cannot be understated.

Overall, the findings show that practical and experimental science teaching can improve students' conceptual understanding, scientific skills, engagement, motivation, and active participation. However, its implementation is affected by resource availability, teacher capacity, time, curriculum requirements, and school support. Resource and infrastructure barriers were more evident in India, particularly in rural and government schools, while New Zealand generally had better access to resources but still faced challenges in using them effectively. The findings also show that professional development, teacher confidence, supportive leadership, appropriate curriculum design, and adequate laboratory resources can

enable more effective practical teaching. Overall, effective practical science teaching requires not only resources but also the knowledge, confidence, and support needed to use them meaningfully.

4.3 Research question 2: Differences in educational context and system level shape teachers' ability to implement practical and experimental science teaching

The second research question examined how the differences in educational context and system factors impact secondary school teachers' abilities to develop practical and experimental science teaching. Before discussing the differences between India and New Zealand, it is important to explain what is meant by educational context and educational system in this study. Educational context refers to the conditions in which secondary science teachers work and teach, including the school setting, social and cultural factors, and local circumstances. Educational system refers to the structures and requirements that guide teachers' work, such as curriculum, assessment, teacher education, professional development, educational policies, school leadership, and government support. This section will outline and discuss the findings highlighted in the SLR in relation to the second research question, where are mainly drawn from theme 3.

(2) How do differences in educational context and system shape teachers' ability to implement practical and experimental science teaching in India and New Zealand secondary schools?

In the first instance the findings related to teacher capacity will be discussed, followed by professional development and teacher confidence. The findings will then be discussed in the light of wider literature The findings demonstrate that teachers' capacity to deliver practical science experiences are influenced not only by individual knowledge and skill but also the broader educational system including teacher education, school funding, curriculum design and assessment policies.

In this study, these factors are important because teachers' ability to use practical and experimental approaches is influenced not only by their own knowledge and confidence but also by the wider context and educational system in which they work.

Therefore, this research question examines how differences between the Indian and New Zealand educational contexts and systems shape teachers' ability to implement practical and experimental science teaching in secondary schools.

4.3.1 Teacher Education, Professional Learning and Teacher Capacity

The findings indicate that teacher preparation and professional learning are important parts of the educational system that shape teachers' ability to implement practical science teaching (Rofe et al., 2015). Rather than viewing teacher capacity only as an individual characteristic, the findings suggest that it develops through the professional learning opportunities and support available to teachers (Rofe et al., 2015).

In the Indian context, the reviewed literature indicates that opportunities for teachers to develop practical teaching knowledge and skills vary across school settings. Srivastava and Jangir (2025) reported difficulties in accessing sufficiently trained science teachers, particularly in rural schools. Professional development programmes are provided through organisations such as NCERT, SCERTs, and state education programmes (Kumari et al., 2024). However, the findings indicate that opportunities specifically focused on practical teaching approaches are not uniform across contexts (Kumari et al., 2024). This suggests that professional learning provision at national and state levels may be experienced differently by teachers depending on their school and regional context (Srivastava & Jangir, 2025).

In New Zealand, the reviewed literature identifies professional learning approaches that include guidance, collaboration, and opportunities for teachers to engage in science activities. Rofe et al. (2015) found that these forms of support contributed to the development of inquiry-based teaching practices. The Education Review Office (2021) also reported that professional learning and development supported teachers to strengthen their knowledge and apply new practices in their classrooms. In addition, the PISA 2015 Science Context report indicated that 79% of New Zealand science teachers had participated in professional development during the three months preceding the assessment, compared with an OECD average of 51% (Ministry of Education, 2017). However, the report found no direct association between professional development participation and higher student achievement (Ministry of

Education, 2017). This suggests that participation in professional development alone does not necessarily result in improved student outcomes (Ministry of Education, 2017).

The comparison therefore needs to consider the nature and organisation of professional learning, rather than simply the amount of training available. In India, the findings point to variation in access to practical and subject-specific professional learning, particularly across different school settings (Srivastava & Jangir, 2025). In New Zealand, the reviewed studies highlight collaborative and school-based forms of professional learning that provide opportunities for teachers to apply and share practices (Education Review Office, 2021; Rofe et al., 2015). However, the available evidence does not provide sufficient basis to claim that professional development is consistently stronger across all New Zealand schools. Instead, the findings suggest that teachers' opportunities to develop practical science teaching are influenced by the professional learning structures available within their educational context (Education Review Office, 2021; Rofe et al., 2015).

Teacher confidence can also be understood within these wider professional structures. Rofe et al. (2015) in New Zealand found that guidance, collaboration, and opportunities to engage with science activities supported teachers' development of inquiry-based practices. In India, Ghosh and Pramanik (2024) found a relationship between teacher self-efficacy and engagement with hands-on science teaching. These findings suggest that teacher confidence can develop through professional experiences and opportunities to engage with teaching approaches (Ghosh & Pramanik, 2024; Rofe et al., 2015). Therefore, professional learning structures can influence teacher capacity by providing opportunities to develop practical science pedagogy, apply new approaches, and work collaboratively with other teachers (Education Review Office, 2021; Rofe et al., 2015). This aligns with wider literature emphasising the importance of teachers' subject knowledge, pedagogical preparation, and confidence in supporting effective practical and inquiry-based science teaching (Osborne, 2007; Hodson, 1993).

4.3.2 Curriculum, Assessment and Pedagogical Expectations

The findings show that curriculum and assessment structures influence teachers' pedagogical choices. This is important for understanding differences between India and New

Zealand because teachers' classroom decisions are influenced by curriculum requirements and assessment expectations (Ghosh & Pramanik, 2024; Ministry of Education, 2007).

In India, the reviewed literature indicates that examination requirements influence science teaching. Ghosh and Pramanik (2024) reported that teachers often prioritise theoretical board examinations, which can limit opportunities for developing investigative skills. Thakur and Kadu (2024) similarly identified examination-focused teaching, syllabus pressure, and time constraints as factors affecting practical activities. These findings suggest that examination and syllabus requirements can influence the amount of time and flexibility teachers must use investigative approaches (Ghosh & Pramanik, 2024; Thakur & Kadu, 2024). Therefore, assessment expectations form an important part of the wider educational system influencing science teachers' pedagogical choices (Ghosh & Pramanik, 2024).

At the same time, India has introduced policies that support more experiential approaches to science education. The National Education Policy 2020 promotes experiential learning, interdisciplinary learning, digital learning, and scientific inquiry (Tripathi, 2024). Government initiatives such as Rashtriya Avishkar Abhiyan, Samagra Shiksha, and Atal Tinkering Labs have also supported practical, innovative, and experiential learning (Tripathi, 2024). However, the reviewed literature indicates that the implementation of these policies can vary across school and regional settings (Tripathi, 2024). This indicates that policy support does not automatically result in the same classroom practices across different educational settings (Ghosh & Pramanik, 2024; Tripathi, 2024).

In New Zealand, the curriculum provides opportunities for teachers to develop learning experiences that respond to local contexts and students' needs (Ministry of Education, 2007). Taylor (2023) identified examples of student-centred investigations in Auckland, Otago, and Wellington, including activities connected with local environmental contexts and Māori knowledge. Moeed (2013) also highlighted the role of Māori ways of knowing and language in science education. These findings indicate that curriculum structures can influence how teachers design and adapt science learning within different local contexts (Moeed, 2013; Taylor, 2023)

Buntting and Soanes (2026) discussed recent developments in New Zealand science education at a national symposium. Recent curriculum developments in New Zealand are also relevant to this discussion. The Ministry of Education (2025) identified clearer expectations for curriculum content and learning in science, highlighting the importance of strengthening coherence in teaching and learning science. These findings suggest that curriculum design needs to provide clear learning expectations while allowing opportunities for practical and inquiry-based science learning (Ministry of Education, 2025).

The comparison indicates a difference in the relationship between curriculum, assessment, and teachers' pedagogical choices. In India, the reviewed literature identifies examination and syllabus requirements as important influences on practical and investigative science teaching (Ghosh & Pramanik, 2024; Thakur & Kadu, 2024). In New Zealand, curriculum flexibility provides opportunities for teachers to adapt science learning to local contexts and students' needs (Ministry of Education, 2007; Taylor, 2023). Therefore, teachers' ability to implement practical science is influenced by how curriculum expectations, assessment requirements, and teacher decision-making operate within each educational system (Ghosh & Pramanik, 2024; Ministry of Education, 2007). This is consistent with wider literature, which suggests that the purpose and framing of science curriculum can influence how science is taught and what teachers prioritise (Osborne & Dillon, 2008).

4.3.3 School Leadership, Institutional Support and Teacher Autonomy

The findings further indicate that school leadership and institutional structures influence how educational policies and professional learning opportunities are translated into classroom practice (Education Review Office, 2021). School leadership can influence teachers' opportunities to collaborate, develop their practice, and implement practical science approaches (Srivastava & Jangir, 2025; Sweeney, 2011).

In India, Thakur and Kadu (2024) found that supportive principals and school leaders could encourage practical investigations through planning, decision-making, resource management, and teacher support. Srivastava and Jangir (2025) similarly highlighted the role of school management in supporting teacher training, laboratory maintenance, and the use of science resources. Collaborative planning among science teachers was also identified as

supporting practical teaching and assessment practices (Srivastava & Jangir, 2025). These findings suggest that school-level management plays a role in how educational expectations and practical teaching initiatives are implemented within schools (Srivastava & Jangir, 2025; Thakur & Kadu, 2024).

In New Zealand, Sweeney (2011) identified supportive leadership and collaboration within science departments as important for developing inquiry-based teaching practices. The Education Review Office (2021) also highlighted the role of school-based professional learning in supporting changes in teachers' classroom practice. These findings suggest that school leadership and collaboration can provide teachers with opportunities to develop their practice and engage with inquiry-based approaches (Education Review Office, 2021; Sweeney, 2011).

The findings therefore suggest that teacher autonomy is relevant to understanding differences between the two educational contexts. In New Zealand, curriculum flexibility provides opportunities for teachers and schools to adapt learning to local contexts (Ministry of Education, 2007; Taylor, 2023). In India, examination requirements and prescribed curriculum expectations identified in the reviewed literature can influence teachers' pedagogical choices (Ghosh & Pramanik, 2024; Thakur & Kadu, 2024). These differences do not indicate that teachers in one context are inherently more capable than those in the other. Rather, the findings suggest that teachers work within different policy, curriculum, and organisational conditions that influence the choices available to them (Ghosh & Pramanik, 2024; Ministry of Education, 2007; Thakur & Kadu, 2024).

4.3.4 Policy Implementation and the Relationship Between System and Classroom Practice

The findings also highlight a difference between policy intentions and their implementation in schools. Both India and New Zealand have curriculum and policy directions that support inquiry, practical learning, and student-centred approaches (Ministry of Education, 2007; Tripathi, 2024). However, the reviewed literature indicates that implementation is influenced by teacher preparation, school conditions, professional learning, and local educational contexts (Rofe et al., 2015; Taylor, 2023).

In India, NEP 2020 and related initiatives provide policy support for experiential and scientific learning (Tripathi, 2024). However, the reviewed studies identify continued examination pressures and differences in teacher and school-level support that can influence implementation (Ghosh & Pramanik, 2024; Thakur & Kadu, 2024). Therefore, policy reform alone may not be sufficient to change classroom practice when teachers' opportunities to develop and apply the approaches promoted by policy vary across settings (Ghosh & Pramanik, 2024).

The New Zealand evidence also indicates that curriculum and policy directions are implemented through teachers and schools rather than directly determining classroom practice (Ministry of Education, 2007; Taylor, 2023). Professional resources and learning opportunities, including the Science Learning Hub and Network of Expertise, provide additional support for science teaching (Sexton, 2018). Taylor (2023) also showed that teachers adapt science learning to local environmental and cultural contexts. These findings indicate that curriculum implementation involves teachers interpreting national expectations within their school and community settings (Taylor, 2023).

The findings therefore suggest that educational policy operates through several levels. National policies establish broad expectations, curriculum frameworks provide direction, schools interpret and organise these expectations, and teachers make pedagogical decisions within these conditions (Ministry of Education, 2007; Tripathi, 2024; Taylor, 2023). Differences across these levels can therefore influence teachers' ability to implement practical and experimental science teaching (Ghosh & Pramanik, 2024; Taylor, 2023).

4.3.5 Comparison of India and New Zealand

The comparison between India and New Zealand indicates that teachers' ability to implement practical and experimental science teaching is influenced by different educational structures and expectations. In India, the reviewed literature highlights examination-oriented expectations, variation in teacher preparation and professional learning, differences between school settings, and challenges in translating policy intentions into classroom practice (Ghosh & Pramanik; Thakur & Kadu, 2024). In New Zealand, the reviewed literature highlights curriculum flexibility, collaborative professional learning, local curriculum adaptation, and

school-level support for inquiry-based teaching (Education Review Office, 2021; Ministry of Education, 2007; Taylor, 2023). However, recent changes to the New Zealand curriculum in 2026 indicate a shift towards more explicit, subject-specific teaching, with less emphasis on curriculum flexibility and place-based learning. This shift suggests that the educational structures shaping teachers' approaches to practical science teaching are continuing to evolve in New Zealand

These differences should not be interpreted as a simple comparison between a weaker and stronger education system. The findings instead show that teachers work within different institutional and policy environments (Ghosh & Pramanik, 2024; Ministry of Education, 2007). In India, teachers may need to balance policies promoting experiential learning with examination and curriculum expectations (Ghosh & Pramanik, 2024; Tripathi, 2024). In New Zealand, curriculum flexibility provides opportunities for teachers to respond to local contexts, while curriculum and qualification changes continue to influence teaching practice (Ministry of Education, 2007; Buntting & Soanes, 2026).

The findings also suggest that teachers' capacity to implement practical science cannot be considered separately from the educational system in which they work (Rofe et al., 2015). Teacher preparation, professional learning, curriculum and assessment expectations, school leadership, and policy implementation interact to influence the opportunities available to teachers (Ghosh & Pramanik, 2024; Ministry of Education, 2007). The comparison therefore focuses not simply on teachers' individual capacity, but on the wider structures that influence how this capacity can be developed and applied in classroom practice.

Overall, the findings suggest that differences in educational systems shape teachers' ability to implement practical and experimental science teaching through curriculum, assessment, professional learning, leadership, and policy support (Ghosh & Pramanik, 2024; Ministry of Education, 2007). In India, examination requirements and differences in professional support influence teachers' pedagogical choices, while national reforms support experiential learning. In New Zealand, curriculum flexibility and collaborative professional learning provide opportunities for practical and inquiry-based approaches (Rofe et al., 2015). However, a return to more explicit teaching and learning in New Zealand is in progress with

curriculum changes. Overall, teachers' ability to implement practical science is shaped by both their individual capacity and the wider educational structures in which they work.

4.4 Chapter Summary

This chapter discussed the findings of the study in relation to the two research questions. The findings showed that practical and experimental science teaching can support students' conceptual understanding, scientific skills, engagement, motivation, and active learning. However, its implementation is influenced by factors such as laboratory resources, funding, time, teacher knowledge and confidence, professional learning, curriculum requirements, and school support.

The discussion also showed differences between India and New Zealand in the educational conditions that shape teachers' practice. In India, examination requirements, variation in professional learning, and differences in school-level support can influence teachers' opportunities to use practical and experimental approaches. In New Zealand, curriculum flexibility, collaborative professional learning, and opportunities to adapt learning to local contexts provide different conditions for teachers. Overall, the findings suggest that effective practical science teaching depends not only on teachers' individual capacity but also on the wider educational structures, expectations, and support within which teachers work.

Chapter 5: Conclusion and Recommendations

5.1 Conclusion

Chapter Four has discussed the findings identified in the systematic literature review. This chapter provides an overview of the main research aim, highlighting the research gap explored in this study and restates the research questions. A short summary and synthesis of the main findings are given, indicating the broader significance of the work. It then outlines the contributions to knowledge, the limitations of the SLR, and offers recommendations for future research studies to extend the work.

The main aim of this research was to explore and analyse the challenges experienced by secondary school science teachers in India and New Zealand in using practical and experimental approaches to science teaching. Previous studies have highlighted the importance of utilising practical work in science education (Kurup & Li, 2022). They noted that it is valuable for supporting effective science education by improving conceptual understanding and critical thinking. Through exploring the wider literature in the field, I was able to examine the existing knowledge about practical science teaching experiences in the secondary context. This led me to identify a research gap in the literature exploring similarities and differences experienced by secondary school science teachers in India and New Zealand in utilising practical science experiences. There is limited research comparing the barriers and teaching practices across these two educational settings.

The main research questions employed to explore similarities and differences across the two contexts were:

(1) What are the reported benefits, barriers and enablers to the implementation of practical and experimental science teaching in India and New Zealand secondary schools?

(2) How do differences in educational context and system shape teachers' ability to implement practical and experimental science teaching in India and New Zealand secondary schools?

This study employed a Systematic Literature Review to answer the research questions. Describe in two or three lines the search strategy, inclusion and databases. Once the data was generated it was analysed thematically. The themes identified in Systematic Literature

Review are the benefits of practical science teaching, resources and infrastructure constraints affecting practical science teaching, the impact of teacher capacity and professional development, and policy and curriculum strategies for practical science teaching. The findings were then discussed through the lens of wider literature.

The synthesis of the findings shows a clear consensus that practical science work is important for meaningful science learning. The evidence shows that practical work supports students' conceptual understanding, scientific skills, engagement, and motivation. However, these benefits depend on the conditions in which practical work is carried out. Limited laboratory resources, equipment, time, teacher confidence, professional development, curriculum demands, and assessment requirements can affect teachers' ability to use practical work effectively. At the same time, professional learning, school leadership, institutional support, appropriate resources, and curriculum flexibility can help teachers overcome these challenges.

The comparison between India and New Zealand shows that these factors are connected to the wider educational context. The evidence shows that many Indian secondary schools face greater challenges with laboratory facilities and resources, while New Zealand provides stronger institutional support, curriculum flexibility, and professional learning opportunities. The comparison also highlights how differences in educational contexts can shape teachers' opportunities to use practical and experimental approaches. This provides a broader understanding of practical science teaching by linking classroom practice with the wider school and education system.

Overall, the synthesis suggests that the benefits of practical science cannot be achieved through practical activities alone. Effective implementation also requires teacher capacity, professional development, adequate resources, supportive leadership, and suitable curriculum and policy conditions. These findings provide a basis for improving practical science teaching and supporting more meaningful classroom learning in both contexts.

5.2 Recommendations

Based on the findings, several recommendations are proposed to strengthen practical and experimental science teaching in secondary schools in India and New Zealand. These focus on resources, teacher development, school leadership, curriculum, and educational technology.

Improving infrastructure and resource provision:

There needs to be increased investment in laboratory infrastructure, teaching resources, and scientific equipment by the government and school authorities in India (Srivastava & Jangir, 2025). It is also recommended that Indian schools adopt low-cost experimental materials and digital simulation software to support learning. In the New Zealand setting, it is also important that schools receive sufficient funding to maintain and upgrade laboratory facilities to ensure equitable access.

Strengthen professional development and school leadership:

In both countries, professional development programmes should be strengthened to enhance teachers' practical pedagogical competencies, with a focus on laboratory safety, low-cost experimental approaches, digital simulations, and inclusive teaching (Rofe et al., 2015). Continuous professional development and mentorship can also support teacher motivation in implementing practical science lessons (Osborne, 2007). Alongside this, school leaders should foster a supportive culture for innovation and experimental learning by encouraging collaboration, providing sufficient time, and offering technical support for practical lessons (Thakur & Kadu ;2024).

Reform curriculum practices and integrate educational technology:

It is important that curriculum developers ensure practical work is appropriately integrated into science curricula and aligned with the resources available in schools. Collaboration among universities, scientific organisations, and government is also recommended to support curriculum development and sustainable science education. Where laboratory resources are limited, alternative practical activities using low-cost materials or digital technologies, such as virtual laboratories, augmented reality, and educational software, could be used alongside hands-on experiences (Taylor, 2023).

5.3 Limitations

Firstly, this research is based on secondary data collected from published journals, academic literature, and reports. Therefore, the findings depend on the methodological approaches and evidence of existing studies and do not include primary evidence from science teachers. This limits the study's ability to capture teachers' direct experiences of practical and experimental science teaching.

Secondly, the study focuses only on secondary school science education in India and New Zealand. The limited number of studies available from these two contexts restricts the geographical evidence and may limit the applicability of the findings to other national contexts and levels of education.

Thirdly, the studies included in the review used different methodological approaches and were conducted across different time periods. These differences created challenges in comparing and synthesising the findings. Changes in educational contexts and technological developments over time may also have influenced the findings.

Another limitation is that many of the studies in India did not clearly distinguish between government and private schools when examining the implementation of science practical work. This makes it difficult to understand how differences in school type, resources, and institutional conditions may influence practical science teaching.

Finally, most of the reviewed studies focused on laboratory facilities, equipment, and practical resources, with less attention given to the role of the science curriculum in shaping practical teaching. This is a limitation because curriculum requirements and the emphasis on theoretical learning may influence the opportunities teachers have to conduct practical and experimental activities.

5.4 Future Research Directions

Future research could extend the scope of this study by widening the time and including non-English journals to provide a broader range of evidence. Further studies could also include other similar countries, such as Pakistan or Australia, to provide a wider perspective on practical science teaching. Alternatively, research could examine the use of practical science experiences in primary and elementary schools.

One of the disadvantages of this study was that it only included secondary data. It would be valuable to collect data directly from teachers using primary research methods like surveys, interviews and case studies to ascertain teacher's perceptions on the value of practical work in science.

In addition, future research could investigate the effectiveness of innovative teaching approaches, such as AI, digital simulation tools, simulation technology, and virtual laboratories, in supporting students' understanding of science concepts and teachers' ease of implementation.

5.5 Chapter Summary

This chapter brought together the main findings of the systematic literature review and highlighted their significance for practical and experimental science teaching in India and New Zealand. The findings showed that practical science can support students' conceptual understanding, scientific skills, engagement, and motivation, but its effective implementation depends on resources, teacher capacity, professional development, school leadership, curriculum, and wider educational conditions. The chapter also presented recommendations, limitations, and future research directions, including primary research, wider geographical contexts, and the use of AI, digital simulations, and virtual laboratories. Overall, the chapter highlights the importance of strengthening the conditions that support teachers in implementing practical science teaching effectively.

5.6 Final Concluding Statement

In conclusion, this research highlights that practical and experimental science teaching plays an important role in supporting meaningful science learning, but its effective implementation depends on the conditions in which teachers work. The comparison between India and New Zealand shows that resources, teacher capacity, professional development, school leadership, curriculum, and wider educational systems can shape teachers' opportunities to use practical approaches. The study therefore highlights the importance of looking beyond classroom activities to the wider conditions that support teachers in implementing practical science teaching. Addressing these conditions can help strengthen teachers' capacity, improve students' learning experiences, and support more effective science education. Ultimately,

practical science teaching is most effective when teachers are provided with the resources, knowledge, support, and flexibility needed to use it meaningfully in their classrooms.

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