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**Integrating Education for Sustainability
into Secondary Science Classes:
Practices and Perceptions of New Zealand Teachers**

A thesis
submitted in the fulfilment
of the requirements for the degree
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ABSTRACT

Global challenges like climate change and biodiversity loss necessitate a collective shift towards sustainable living. Education for Sustainability aims to equip students with the essential knowledge, skills, attitudes and agency to meet sustainability goals and forge a better future. It is a holistic approach, yet single-subject school structures at the secondary level mean it must be integrated into subjects such as science. However, there is limited research, particularly in New Zealand, on how this integration is practiced in secondary science classes.

Grounded in an interpretivist paradigm, this study interviewed five New Zealand secondary science teachers to understand their conceptualisations of sustainability and sustainability education. It explored how their understanding was translated into practice through detailed descriptions of lessons and units. The study provides insights into how these teachers integrate sustainability across junior science, the new National Certificate of Educational Achievement Level One science standards, and senior science subjects, while also elaborating on the benefits they believed students received and the challenges they faced in this integration.

This research found that these New Zealand teachers had a broad understanding of sustainability and recognised key components of sustainability education. They saw sustainability as a way to make science engaging and to develop scientific literacy among their students. To incorporate sustainability into science, they had all designed units which included place-based approaches, integrated topics, considered multiple perspectives, and interwove mātauranga Māori, or New Zealand indigenous knowledge. The boundaries of science as a subject, senior-level assessment requirements, and the time needed for some sustainability-focused activities were noted as challenges to sustainability's integration.

The research recommends that for the effective integration of sustainability, support is required, particularly regarding teacher education and the provision of resources that exemplify sustainability in science. Furthermore, curriculum and assessment changes designed to incorporate sustainability must remain clear about the required science content to ensure students are robustly prepared for senior science studies.

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CHAPTER 1 – INTRODUCTION

Chapter One covers the rationale for researching how New Zealand secondary school science teachers understand and practice sustainability-focused education. The study is introduced, followed by a discussion of the experiences that prompted my interest in this aspect of science education. The specific research questions that guided the study are outlined and the significance of the study is discussed before providing an outline of the chapters included in this thesis.

1.1 Research Background

The world faces many global challenges, such as climate change, pollution and loss of biodiversity. The need to address these collectively and move towards more sustainable living patterns is vital. New Zealand has committed to international sustainability agreements, such as the 2030 Agenda for Sustainable Development (Office of the Auditor General New Zealand, 2020). Educational approaches, such as Education for Sustainability (EfS), are recognised to equip people with the knowledge, skills, attitudes and agency needed for an improved future and to help meet these global goals (Tilbury, 1995; United Nations Conference on Environment and Development [UNCED], 1992). Ideally, EfS would underpin all school curriculum areas, encouraging interdisciplinary approaches to highlight the complexity and interconnectivity of issues (Eilks, 2015). However, since most New Zealand secondary schools use separate-subject structures, this thesis examined sustainability's integration within one subject; science.

Science likely holds a uniquely pivotal role in sustainability; while scientific and technological development contribute to many environmental and sustainability-related problems, they also offer potential solutions (Eilks, 2015). However, science education faces its own challenges; both trust in science and engagement with science education are declining (Pimentel & Osborne, 2025; The Royal Society, 2024). Developing scientific literacy is seen as one way to improve science education, enabling students to acquire meaningful skills and competencies to understand

scientific knowledge and apply them to make informed decisions (Organisation for Economic Cooperation and Development [OECD], 2024). Embedding Education for Sustainability (EfS) into science education connects students to the science behind real-world problems, making the subject meaningful and relevant to their lives while simultaneously developing sustainability skills.

In order to integrate sustainability into their curriculum, science teachers will need knowledge of sustainability and of EfS, as well as its associated teaching approaches. However, New Zealand-based research suggests teachers may have a limited understanding of sustainability and EfS (Birdsall, 2014; Brignall-Theyer et al., 2009; Chalmers, 2011), leading to concerns about their preparedness to teach it effectively. While these studies are over a decade old, international research continues to note a lack of sustainability understanding among teachers (Basheer et al., 2022). Despite this limited awareness, the current curriculum, together with recent developments, expects teachers to incorporate sustainability-related content and thinking into their teaching (Ministry of Education, 2007, 2023). Yet there is relatively little research into how teachers are enacting this in practice, especially in New Zealand. For this reason, it was timely to investigate the teaching of sustainability in New Zealand secondary school science—specifically, what teachers are currently doing in their science lessons.

1.2 Personal Connection to this Study

In 2001, during my final year of a Bachelor of Science, I was introduced to Green Chemistry, then a new and exciting prospect. It offered a fresh perspective, advocating a renewed vision for chemical processes and industry and I began to realise the environmental and societal impact of scientists and their funders. My prior education had often focused on the benefits of chemical industry – pharmaceuticals, fertilisers, food production and power generation – without ever really considering the downside. Though tempted to pursue Green Chemistry at a Master's level, I went on to train as a chemistry teacher. However, the skills I gained - considering the wider implications of chemical processes and the possibility of alternatives - stayed with me.

Over the next 20 years, I taught science and chemistry in schools both in New Zealand and overseas. During this time, I encountered then Government Science Advisor Peter Gluckman's 2011 report, which highlighted science education's dual purpose: preparing some students for future science careers while equipping all with skills and knowledge to engage with everyday scientific contexts (Gluckman, 2011). I often pondered how this could be practically achieved within a diverse classroom and what skills were needed to thrive in an unknown future. Then came the Covid-19 pandemic and the subsequent social media response revealed a widespread misunderstanding and distrust of science that I was unprepared for. Prompted by a desire to teach science in a way that may begin to address this problem, I enrolled in postgraduate study the following year.

For my first master's paper, I explored teaching with socio-scientific issues (SSI), as the New Zealand Curriculum refresh suggested its inclusion in new National Curriculum of Educational Achievement (NCEA) science standards. While impressed by the rationale, I felt many documented SSI units lacked sufficient science content knowledge to progress students to senior levels. I also saw environmental consideration as a crucial future skill, which SSI didn't consistently integrate. Recalling Green Chemistry from my early university days, I noted that although it hadn't officially entered the New Zealand Curriculum, Green Chemistry Education (GCE) was gaining international momentum. While GCE offered many merits and moved closer to what I envisioned, I sought broader teaching strategies applicable to all secondary school science areas. This search led me to sustainability-focused education, which has formed the basis for this thesis.

Before starting postgraduate study, my understanding of sustainability education was limited. I had not spent years researching it or advocating for its place in the curriculum. My only exposure to the term 'Education for Sustainability (EfS)' was through my children's school, where I assumed it meant recycling and gardening. However, my research suggested that EfS could offer real potential to strengthen both my teaching and student learning. My focus has always been on improving science teaching, so this research takes a practical approach—exploring how science teachers integrate

sustainability to enrich their curriculum and practice. It also considers how EfS may help improve scientific literacy and trust in science by equipping students with the skills and understanding needed to navigate an increasingly complex world. The emphasis in EfS on values and the interconnection between environmental, socio-cultural, and economic issues also resonated with what I had initially learned through Green Chemistry— the vital relationship between science, society, and the moral responsibility of scientists.

Beyond the academic and pedagogical implications of my research, there is a personal motivation that drives my work: my role as a mother and a future grandmother. I have a deep-seated desire to ensure that the world my children and grandchildren inherit is a healthy, beautiful, and sustainable one. I hope their future is not defined by the relentless cycle of consumerism, but by a deep appreciation for the natural world. Through a better understanding of science, and its connection to the environment and society, I hope today's students, the peers of my children, want to preserve the planet not out of obligation, but out of a genuine love for the world around them.

1.3 Research Aims

The research aimed to gain insights into secondary school science teachers' understanding of sustainability and its integration into their science curriculum. The overarching research question was:

- How and why do secondary school science teachers incorporate sustainability into their science lessons in New Zealand?

Secondary questions were developed to ensure varying aspects of the main question were addressed. These questions included:

- How do teachers understand sustainability and sustainability education?
- What approaches do teachers report they use when they incorporate sustainability into their teaching?
- What do these teachers perceive to be the benefits for students and barriers for teachers in integrating sustainability within science education?

1.4 Research Significance

This research offers insights by exploring five New Zealand science teachers' understanding of both sustainability and sustainability education. It describes actual teaching examples of sustainability-focused units across various science curriculum levels, providing evidence of how teachers integrate EfS into their practice. The study also links these teaching tasks to the development of scientific literacy, demonstrating how EfS could potentially enhance students' understanding of sustainability competencies and strengthen their scientific skills. Given the limited existing research on sustainability within science education in New Zealand, these findings fill a critical gap by showcasing practical implementation.

The study is significant for different sectors within education. For other teachers seeking to integrate sustainability into their curricula, the findings provide real-world examples and strategies. For policy writers, particularly those reviewing the secondary science curriculum, this research offers evidence of what sustainability in science education can look like in practice as well as the challenges teachers may face in its implementation. The academic community may also find interest in these findings, as they suggest that teachers do not necessarily need to articulate precise definitions of sustainability to design and deliver worthwhile lessons.

Although situated in New Zealand, the findings of this study could offer insights to the international science education community. The study's context, which was characterised by a broad and open national science curriculum and a senior secondary assessment system that allows schools some flexibility to choose achievement standards, provides a relevant case study for educators in other countries with similar systems. Using sustainability as an example, these findings can inform discussions about the benefits and challenges of implementing a curriculum framework that affords a significant degree of autonomy to teachers and schools in designing their science programs.

1.5 Thesis Overview

This thesis is organised into five chapters. Chapter One introduces the research, providing a brief background to the study. It includes my personal motivation for completing the research, outlines the aims of the study, including the research questions, and explains the significance of this work.

Chapter Two reviews the relevant literature. It begins by considering the purpose of science education and some limitations of current teaching models. Education for Sustainability (EfS) is discussed followed by rationale for the inclusion of EfS in science education. The review moves to an exploration of teaching approaches to integrate sustainability before outlining the current position of EfS in New Zealand schooling. The literature review culminates by considering the challenges faced by teachers as they bring sustainability into their curricula.

The research methodology is described in Chapter Three. The theoretical framework is touched on and the research questions are outlined. Data collection and analysis are described including participant selection, the development of interview questions and the thematic analysis used to interpret the data. The ethical issues are considered, and the chapter concludes with a discussion of the quality of the research.

Chapter Four presents the key findings of this research. It begins by examining science teachers' understanding of both sustainability and sustainability education. Examples of sustainability-focused units within science are then described across three curriculum levels: NCEA Level One, junior sciences, and senior specialist sciences. Finally, this chapter details findings related to teachers' beliefs about the benefits of sustainability-focused education for students, alongside the challenges they face in its implementation.

Chapter Five discusses and summarises the findings from Chapter Four and makes links between the findings and the relevant literature. The thesis concludes by considering the limitations of this research as well as its implications together with recommendations for future areas of attention or research.

CHAPTER 2 – LITERATURE REVIEW

2.1 Introduction

Science education faces a dilemma: while predictions suggest 80% of future jobs will be science-related (Youth Employability Aotearoa [YEA], 2021), student engagement continues to decline (Engineering NZ, 2024; Fensham, 2009; Millar, 2007; The Royal Society, 2024). This issue is compounded by the rise of misinformation (Osborne & Allchin, 2024), which reveals students' limited ability to assess information credibility (Breakstone et al., 2021b). Simultaneously, global environmental crises demand urgent action, highlighting science's dual role in both creating and solving these challenges (United Nations [UN], 2015). Addressing these issues requires high-quality science education (UNCED, 1992) that develops scientific literacy and empowers students to critically engage with the world. This chapter explores the rationale for scientific literacy development, arguing that integrating sustainability can strengthen science curricula and meet international sustainability goals, guiding students toward future action taking behaviours. Sustainability's role in the New Zealand Curriculum is examined, alongside practical approaches to its integration. The chapter concludes by considering the challenges facing sustainability implementation.

2.2 The Nature of Science Education

Historically, science education focused on preparing capable students for careers in science and technology (Fensham, 2009). While this remains important, views shifted in the 1950s, emphasising that science should be accessible to all students, not just future scientists (Westwell & Panizzon, 2012). Today, there is consensus that science education serves two purposes: preparing some students for further science education and careers, while also equipping all learners with the capabilities to engage with science as informed citizens of the world (Millar, 2007; Gluckman, 2011; Osborne & Allchin, 2024). This broader aim, often framed as fostering scientific literacy (SL) (Hurd, 1958), is now a central goal in many countries' education policies, including New Zealand's (Ministry of Education, 2007).

Durant (1994, p.129) succinctly defines SL as “what the public should know about science.” The 2025 Programme for International Student Assessment (PISA) framework expands, describing scientifically literate individuals as those who can:

- explain phenomena scientifically;
- construct and evaluate designs for scientific enquiry and interpret scientific data and evidence critically;
- research, evaluate, and use scientific information for decision-making and action (OECD, 2024).

Thus, being scientifically literate involves more than having knowledge; it requires an understanding of scientific process, application of science in real-world contexts, and making responsible and informed decisions. This raises two questions: are the goals of SL being achieved, and does SL, and science education more broadly, need to evolve further to prepare students for the complex sustainability challenges facing the world?

2.2.1 Rationale for Developing Scientific Literacy

Osborne and Allchin (2024) argue that it is impossible for one to acquire all the knowledge needed to comprehensively understand every diverse sustainability or science-related situation. However, by developing SL, students may become “competent outsiders” (Feinstein, 2011), possessing sufficient knowledge to understand issues and judge information credibility without necessarily understanding the complex theoretical underpinnings. In a sense, developing SL helps students become competent outsiders, understanding some science, but importantly, recognising credible scientific knowledge and using it to engage meaningfully with everyday issues.

To critically engage with scientific and sustainability issues, students must develop the ability to judge the trustworthiness of scientific information. Advances in technology have accelerated the spread of information, including mis- and disinformation, raising concerns about declining trust in science (Pimentel & Osborne, 2025). To tackle this problem, Longbottom and Butler (1999) argue that exposing students to scientific practices may help them appreciate that scientific knowledge is generated via robust, rational methods. Pimentel and Osborne (2025) found that students explicitly taught

research-related concepts like “conflict of interest” and “scientific consensus” were better at evaluating online scientific information. During the Covid-19 Pandemic, Herman et al. (2024) covered the idea that scientific knowledge is continually revised as further learning occurs with a class they lectured. Presenting this tentative aspect of science led to improved trust in science and greater resistance to mis/disinformation among course participants. These findings give weight to Longbottom and Butler’s (1999) claims that understanding how science works may help students better judge information credibility, thus developing SL.

In developing SL, students may gain other valuable skills and capabilities. These include critical thinking, reasoning, creativity, open-mindedness, rationality, data and information analysis, along with scientific process skills such as hypothesising, measuring and recording (Gluckman, 2011; Osborne & Allchin, 2024; Westwell & Panizzon, 2012). One Australian study aimed to enhance argumentation skills in Year 10 students across four schools (Dawson & Venville, 2022). Using socio-scientific issues like climate change, gene technology and forensic testing, all students were taught the underlying science theory but only some received additional lessons in argumentation skills (experimental group). After teaching, the students wrote a reasoned argument justifying their decision regarding a novel socio-scientific issue. In many instances, the experimental group constructed better arguments. In cases where no improvement was observed, the researchers noted a distinct lack of argumentation teaching. Research suggests that focusing on SL can, therefore, foster skills like argumentation and critical thinking, helping students make reasoned decisions—a skill transferable beyond school and important for sustainability-related choices.

In fact, developing decision-making skills is an SL priority; it helps ensure citizens can use scientific knowledge to inform their choices and actions in ways that benefit themselves, the welfare of society and the environment (Harlen, 2010). Longbottom and Butler (1999) add that informed decision-making is essential for a healthy, democratic nation as issues can be discussed with a degree of input and understanding by the non-expert population. To make informed decisions on issues with a scientific basis, Gluckman (2011) asserts that everyone will require some basic science

knowledge which they can apply in the everyday world, thus reinforcing the rationale for students to become “competent outsiders” (Feinstein, 2011). While teaching theoretical science concepts remains essential, considering concept relevance may help guide science education to develop knowledge and skills which will enable students to engage with everyday science and the pressing need to address sustainability-related concerns.

2.2.2 Issues Integrating Scientific Literacy into Science Education

Despite attention on SL, it is suggested that science education remains over-focused on the scientific-career preparation; Osborne and Allchin (2024) argue that the needs of students intending to study science post-school dictate the nature of the school science curriculum. Though it is estimated that 80% of future jobs will be science-related, only 5.5% of the population will require science knowledge to the level taught in most science courses for their jobs (Osborne & Allchin, 2024). While the need to teach theoretical science is not being challenged, a continued overfocus on content may deprioritise initiatives to develop SL, thus neglecting the needs of the majority.

What does this mean for science education and students? Westwell and Panizzon (2012) believe an overfocus on theory risks presenting science as irrelevant, boring and “removed from the reality of their everyday lives” (p.3). If students find most of their science course lacking purpose, they may fail to engage, and SL may not develop. An overfocus on content may even disadvantage the future scientists, failing to develop in them the additional skills and competencies required for success in modern science environments (Gluckman, 2011). Establishing a middle ground between the two goals must, therefore, be a central focus of any science education that vows to prepare all students to be scientifically literate citizens (Osborne & Allchin, 2024).

Whether future scientists or everyday citizens, SL models envisage students using science beyond school (OECD, 2024). However, Feinstein (2011) states there is little evidence that science education currently impacts the everyday use of science, arguing that people do not spontaneously transfer abstract ideas learnt at school to concrete situations. Layton et al. (1993) note citizens rarely frame problems in scientific terms,

even when clear scientific components, such as genetic disorders or gas emissions, are present. In this study it would have been easy to blame inadequate science education, but the participant pool was large and the problems diverse, leading Layton et al. to conclude that decision-making is more focused on personal benefit rather than scientific evidence. The findings suggest science education must make science personally relevant and self-beneficial to increase the likelihood citizens will apply it in decision-making.

Millar (2007) notes that schooling often provides limited opportunities for students to genuinely apply their knowledge in practical, personally relevant everyday situations. The literature abounds with suggestions to remedy this; Longbottom and Buttler (1999) assert that by interacting with the real world, children will develop the confidence and skill needed to apply scientific theories to the world around them; Hodson (2010) suggests that issues-based approaches which ground content in socially relevant contexts are motivating and enable students to construct understanding that is personally relevant; Layton et al. (1993) recommend teachers begin by identifying real problems where science is used and provide students opportunities to navigate these issues. Together, these approaches suggest that by practising using science in everyday situations, students will be more likely to apply knowledge and solve future problems, such as those with a sustainability-focus, beyond the classroom.

Aside from limited opportunities to engage with meaningful, everyday problems, traditional science education, with its focus on contrived laboratory tasks, may misrepresent contemporary science. As Gilbert (2017) notes, modern scientific research is large in scale, multidisciplinary, highly collaborative, and requires quick communication to the public. However, school science has not kept pace, often providing minimal scope for “genuinely open enquiry” (Millar, 2007, p.26). This approach not only limits the development of essential skills but also risks presenting an oversimplified or inaccurate depiction of science, which can “damage the reputation of science” (Longbottom & Butler, 1999, p.474) and erode public trust. Therefore, to develop scientific literacy and address the interdisciplinary nature of real-world

problems, science education must be reoriented to reflect the collaborative and cross-disciplinary nature of modern science.

2.2.3 Limitations of Scientific Literacy Models

Balancing the development of SL with the goal of preparing students for future science studies is a persistent challenge and compounding this, some suggest that current SL models require expansion to adequately prepare students for the future (Kumar and Choudary, 2024). This section overviews some key issues facing models for scientific literacy development, including the focus on social development, socio-cultural and ethical dimensions, and real-world applications.

Former New Zealand chief science advisor Peter Gluckman championed science education as a means to develop "a smart country where knowledge and innovation sit at the heart of economic growth and social development" (Gluckman, 2011, p.1). Innovation, which is visibly driven by scientific advancement, involves creating new or improving existing ideas, products, or processes to improve global outcomes (Mulgary & Albury, 2003). While curiosity, creativity, and clarity are considered key drivers of innovation (Walsh, Knott & Collins, 2022), a large-scale U.S. survey found that schools often lack opportunities for students to develop these skills (Discovery Education, 2024). Although SL already advocates for scientific enquiry (OECD, 2024), it could be expanded to consistently emphasise the need for students to create solutions to scientific problems. This approach would allow for a more meaningful application of knowledge, moving students toward innovative, action-oriented behaviour and helping realise Gluckman's vision for social development and addressing sustainability issues.

Scientific and sustainability issues are embedded in societal context thus SL should include socio-cultural dimensions to avoid decontextualisation of science (Mansour & Wegerif, 2013). Roth and Lee (2002) argue that SL is not an individual pursuit but collective, emerging when diverse knowledge, expertise and attitudes are pooled. Offering interactive learning experiences that may highlight the collective nature of knowledge, better reflecting the realities of "what it means to do science" and broadening student perspective (Sammel, 2014, p. 850). Tolbert (2023) further

emphasises this socio-cultural dimension. She states that future New Zealand scientists will not only work across disciplines but alongside Māori and indigenous leaders, requiring skills in the assimilation of different types of knowledge. Strengthening the socio-cultural component of scientific literacy will enable students to see diverse perspectives, experience other knowledge sources and work collaboratively acknowledging others' ideas and perspectives.

To better prepare students for the future, science education and SL must continue to evolve. Literature often refers to SL models transitioning from Visions I to II to III (Bybee, 2015; Sjöström and Eilks, 2018; Valladares, 2021). Vision I concerns learning scientific content and processes for future application (Bybee, 2015), aligning with producing future scientists. Vision II focuses on the usefulness of scientific knowledge in everyday life and society, strengthening socio-cultural dimensions (Bybee, 2015). Vision III suggests students critically engage with real-world problems by considering diverse perspectives and alternative forms of knowledge (Valladares, 2021), envisaging student engagement geared towards social action to address global concerns (Sjöström & Eilks, 2018). Moving towards Vision III requires change, so students have opportunities to consider the differing values, beliefs and agendas which underlie issues (Sammel, 2014) and undertake meaningful action.

2.2.4 Section Summary

This section outlined the place of scientific literacy in science education, firstly highlighting tensions with scientific content for space in curricula and, secondly, calls for its further development. This section argued that to prepare students for the future, science education must provide opportunities for students to acquire scientific knowledge, apply it in ways that are meaningful and work collaboratively, considering diverse ways of understanding to actively address issues that are important for society. The following section introduces Sustainability Education as one possible means for achieving these goals.

2.3 Sustainability Education

The world faces numerous problems, such as climate change, environmental degradation, resource depletion and social inequity. It is widely agreed that humans must work collectively to address these problems, and education has been viewed as one of the most effective means that society possesses for confronting the challenges of the future (UNESCO, 1997). Over the last fifty years, environmental and sustainability focused education initiatives have gained attention as methods to address these problems. This chapter introduces sustainability and Education for Sustainability, describing the rationale for this educational approach. Its benefits for students are considered, before concluding with some limitations and challenges.

2.3.1 Sustainability and Sustainability Education

Sustainability is seen to comprise three interconnected dimensions, ecological, socio-cultural and economic, known as the “three pillar model of sustainability’ (Eilks, 2015, p.151). It is temporal in nature, with no endpoint due to the ongoing relationship between the pillars (Birdsall, 2014). Defining sustainability is challenging (Birdsall, 2014), complicated by its similarity to ‘sustainable development’. Sustainable development, defined as “development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs” (World Commission on Environment and Development, 1987), can be seen as promoting economic growth, without necessarily regarding its impact on people and the planet (Irwin, 2007). In contrast, Riemer and Harre (2017) define sustainability as “managing oneself in a manner that promotes human and ecological flourishing, both in the present and for the future” (p.114), suggesting human action to improve society and the environment lie at its heart. It is this definition which guides this thesis. Acknowledging that sustainability may mean different things to different people is important as research indicates people use personal value systems to define it (Fien & Tilbury, 2002; Sterling, 1996). These individual beliefs may influence the way sustainability is approached in education.

In terms of sustainability education, the Tbilisi Declaration was signed in 1977 by 66 nations, including New Zealand. It formally stated the need for global engagement with

Environmental Education to solve problems affecting the planet (Croft, 2017). As perspectives broadened, recognising the relationship between the wellbeing of human communities, environmental issues, and economic and social development (Bolstad, 2003), educational approaches with a sustainability focus were pursued to emphasise these inter-related components (Tilbury, 1995). A number of approaches have been developed, including Education for Sustainable Development, Education for Sustainability (EfS) and Learning for Sustainability. Each interprets sustainability slightly differently but all share commonalities in their pedagogical approach. EfS is used in New Zealand and is the term used in this thesis. The following section outlines the nature of EfS.

2.3.2 Rationale and Benefits of Education for Sustainability

Education for Sustainability (EfS) aims to foster transformative change that will move societies towards more sustainable ways of living (Brignall-Theyer et al., 2009). For transformation to occur, education must do more than impart knowledge of sustainability issues; it must prompt students to act. Thus, EfS aims to be empowering and equip all learners with knowledge, skills, values and agency to make informed decisions and take action to address global challenges (UNESCO, 2020; Mulà & Tilbury, 2025). To help achieve these goals, EfS advocates for learning which is holistic, interdisciplinary, participatory, encourages critical thinking, considers multiple perspectives, reflects on values systems, is socially critical and is action-oriented (Eilks, 2015; Ministry of Education, 2024; Taylor et al., 2003; Tilbury, 1995). The ways these components contribute to the development of action competence is further discussed.

Action competence is central to EfS. For students to act towards solving sustainability issues, they will need knowledge and skills, a willingness to act, and self-efficacy (Jensen, 2000, Sass et al., 2020). Knowledge, in this sense is multi-dimensional, encompassing not only an understanding of sustainability issues, but knowledge of relevant stakeholder perspectives, knowledge of students' own values, and knowledge of possible solutions to the problem (Jensen, 2000). Skills include critical and system thinking, problem solving, as well as empathy for viewpoints different from their own

(UNESCO, 2017; Sass et al., 2023). The willingness aspect involves motivation and self-efficacy, having confidence in one's ability to act and in the impact of the action (Bandura, 1977 in Sass et al., 2023). EfS education aims to help develop different types of knowledge, to support students in becoming action takers.

To develop these action-taking capabilities, EfS encourages relevant and participatory learning experiences. Evidence shows children enjoy learning about and in the environment (Ballantyne, Fien, & Packer, 2001; Gough & Sharpley, 2005) and active, hands-on learning can develop critical thinking and link the curriculum content to real life (Tilbury, 1995). Exploration of local contexts and issues is seen as especially relevant for students (Fien, 2001) and this personal connection may increase self-esteem and motivation (Blatt, 2014), important precursors for becoming willing to act. Prabawa-Sear and Dow (2018) highlight the value of positive emotive experiences for students; by participating in locally relevant activities which make a difference, the doom and gloom aspect accompanying many sustainability issues may be negated, empowering students towards more future action-taking.

Solving complex problems requires an understanding of diverse knowledge and perspectives. EfS is a holistic framework, recognising that socio-cultural, economic, and environmental systems are connected (Sterling, 2001; Tilbury, 1995) and these pillars should be interwoven to broaden student understanding of issues (Parry & Metzger, 2023). EfS suggests using interdisciplinary learning with a focus on human interaction to help students connect ideas (Eilks, 2015; Ministry of Education, 2024). This type of learning, which is holistic and incorporates different sources of knowledge, is vital to inspire students to make changes (Ministry of Education, 2024; Rieckmann, 2017).

EfS encourages students to consider multiple perspectives and acknowledge that people come from myriad backgrounds and cultures, possessing diverse knowledge, skills, experiences, and values. Eilks (2015) emphasises the role of values in sustainability-related education, adding that students need to reflect on their own personal values. Learning that critically reflects on the different worldviews and social

practices that promote unsustainable ways of living, will be required to inspire students to make changes (Ministry of Education, 2024; Rieckmann, 2017). Ferkany and Whyte (2013) argue that it is vital students have opportunities to engage in democratic activities as they will be the decision-makers of the future. By considering these dimensions, students can become more socially critical and better equipped to navigate complex societal issues.

Individual action alone will unlikely be sufficient to mitigate global problems. EfS promotes the role of collective action so wider systems within organisations can change (Soll, 2019). EfS advocates for cross-school approaches to sustainability (Sterling, 1996) and envisions communities of learners (teachers, pupils, students, researchers), who all identify with a relevant issue and work to find options for action and intervention (Eilks, 2015). Therefore, EfS is an approach which strives to transcend individual values and attitudes, and instead, develop in students the capabilities which support constructive change within communities, industries, and even at a global level (Tilbury, 1995).

2.3.3 Sustainability Education – Tension in the Curriculum

Despite considerable international focus, sustainability is still situated at the curriculum's periphery, particularly at secondary level (Kuzich et al., 2015). This section suggests it is the conception of EfS, compounded by school structures and assessment demands, which pose challenges for the integration of EfS.

EfS aims to develop awareness, knowledge, skills and values through engagement with meaningful issues. It is a “framework of principles or a philosophy of practice” (Marinova and McGrath, 2004, p.277) rather than a standalone subject or set of knowledge outcomes (Tilbury, 1995). Teachers, used to teaching well-defined subject matter, may find this challenging to conceptualise and put into practice. Research supports this suggestion; Parker, Noronha and Bongers (2023) found university chemistry lecturers often perceived Green Chemistry to be a separate topic rather than an overarching philosophy, guiding safer, less wasteful processes. Not surprisingly, the lecturers who viewed Green Chemistry this way struggled to find time to teach it.

Incorrectly viewing sustainability as a topic places it in competition with other topics for curriculum time where it may miss out.

In fact, 'lack of time' is the most frequently identified barrier facing teachers when implementing EfS (Wilson, 2012); teachers note that when new material enters the curriculum, nothing is ever removed (Brignall-Theyer et al., 2009). In many countries, including New Zealand, curricula are described as "overcrowded" (Majoni, 2017) and Owens (2008) adds that teachers already face challenges trying to cover the full examinable curriculum, and to find time to engage in cross-curricular themes, hands-on activities, investigate environmental issues and create opportunities for action-taking is near on impossible. Sappaile et al. (2025) further suggest that many skills EfS hopes to cultivate, such as critical thinking and problem solving, require adequate time to develop. For teachers to engage with these activities, curriculum time must be considered, otherwise EfS will likely be sidelined and students will miss out on sustainability-related education.

Standardised assessments can influence the curriculum and public perception. Kuzich et al. (2015) note that compulsory and easily examined subjects are often prioritised. Since sustainability is not compulsory in New Zealand (Croft, 2017) and its subjective nature makes direct assessment challenging (Wilson & von der Heidt, 2013), it may be sidelined, leading to a perception sustainability is less important than traditional subjects (Sterling, 2004). Three New Zealand studies echo this sentiment. Students saw optional environment-focused subjects as intended for "the very enthusiastic" or for "dropouts from the academic stream" (Brignall-Theyer et al., 2009, p.21), views that diminish the perception of sustainability education. Similarly, staff gave one school's new "Sustainable Futures" course "negative comments", regarding it as "not a serious course" (Cowie et al., 2004, p. 228). Eames et al. (2010) found sustainability, particularly in high schools, was often relegated to an environmental club or optional extracurricular activity, further diminishing its impact and status. Though 15-20 years old, these studies suggest that without formal assessment recognition, sustainability education risks marginalisation, highlighting the need for current research and possible

integration with prioritised subjects to help reposition it as a worthwhile and legitimate component of education.

The separate-subject structure of many secondary schools poses a further challenge for sustainability. Guided by its three-pillar model, EfS necessitates that all subject disciplines contribute equally to sustainability understanding, awareness, and action, thus it is best supported through cross-curricular approaches (Wade, 2008). However, sustainability is not evenly distributed across the curriculum and is predominantly covered within the social science subjects (Benavot, 2014). Longbottom and Butler (1999) assert that to understand real-world environmental issues complex background science is required and failing to include this knowledge may oversimplify or trivialise problems. Moreover, Birdsall (2014) asserts that sustainability must be situated within contexts to help people better understand the concept. Therefore, science education should further support the integration of sustainability so students are equipped with knowledge and skills which will help them to understand and address global problems.

2.3.4 Section Summary

EfS offers benefits for students such as the development of critical thinking and action competence. Importantly, it aims to empower students to make changes which will lead to more sustainable ways of living. However, EfS faces tension; it is not compulsory, difficult to assess, is unevenly spread across curriculum and may be mistakenly seen as teachable content, leading to sustainability's marginalisation in schools. Integrating sustainability as an underlying approach, rather than a separate topic, could prevent it from being seen as an optional add-on, thereby giving it greater priority and improving attitudes. Specifically embedding sustainability in science education provides a context for students to acquire the necessary scientific knowledge and competencies to better engage with sustainability issues.

2.4 Integrating Science Education and Sustainability Education

Though scientific literacy (SL) and Education for Sustainability (EfS) have different aims and focuses, they share compatible goals of equipping students with the necessary

knowledge and skills to understand and address complex, real-world issues. Currently, SL fosters critical thinking and a deep understanding of scientific concepts, so individuals can make informed decisions and engage in discussions about global challenges. The literature then gains momentum, moving SL towards a vision which values different, diverse knowledge sources and advocates for action-taking opportunities. Similarly, EfS emphasises systems thinking and the interconnectedness of environmental, socio-cultural, and economic factors, encouraging learners to consider the broader implications of their actions on the planet and society. This section discusses the affordances of integrating scientific literacy and sustainability education in school curriculums.

2.4.1 Science and Sustainability – A Reciprocal Relationship

Education for Sustainability (EfS) encourages engagement with global and local issues, such as climate change and pollution. Many such problems have strong scientific components, which citizens are expected to understand well enough to make informed decisions and tackle these complex challenges (Alsop & Hicks, 2013; Lang and Wiek, 2021). Science education offers conceptual tools that could deepen students' understanding of contexts under investigation. These tools include “big science ideas” (Ministry of Education, 2025), such as matter conservation, the nature of chemical changes and energy conversion, and key concepts in ecology, genetics, plants and animal physiology. Therefore, science education, particularly one that fosters development of ‘competent outsiders’, may equip students with the knowledge and tools to critically engage with sustainability-related issues (McFarlane & Ogazon, 2011).

EfS has been found to support the understanding of science concepts, which is a crucial educational outcome. Dupuis and Durham (2024) compared the science achievement of students attending Green Schools in the USA with those who had not. Green School students participated in school-wide, inquiry-driven sustainability programs and the study analysed 23 years of assessment data, controlling for factors like economic background. Initially, Green Schools served more advantaged populations, but as participation grew, enrolments became more economically diverse. The study found that Green School students often outperformed their peers in science

assessments, with greater gains linked to longer program involvement. This suggests that sustainability-focused teaching may enhance science outcomes. However, this benefit was not consistent; schools serving more economically disadvantaged students did not show similar gains. The authors attributed this to barriers such as competing academic priorities, limited access to resources, and lack of support, which likely led to inconsistent implementation of Green School principles. However, this study lends weight to the suggestion science and sustainability may enhance each other.

SL development and EfS are further compatible in the importance they place on practical learning experiences. Science education is recognised for offering hands-on learning activities in the laboratory (Woolnough & Allsop, 1985) while EfS supports experiential and participatory practices (Eilks, 2015). Designing science experiments that include a sustainability focus may help experiments be less contrived, making science topics more relevant and appealing to students (Hodson, 2003). A sustainability theme may also bring science outside the class, strengthen students' relationship with the environment and help them value nature (Hodson, 2010). Moreover, scientific experimentation can produce evidence about the causes of sustainability-related problems or the effectiveness of solutions (Caniglia et al., 2017), substantiating claims made with regard to many sustainability-focused issues. Opportunities to participate in the collection of meaningful, real-world data may help students gain trust in the scientific process, and experience firsthand environmental consequences, and ultimately move society towards more sustainable ways of living.

Slaughter (2012) cautions that while scientific progress may offer solutions to sustainability-related problems, it is ultimately human values and choices that will shape its direction. These comments necessitate the evolution of SL toward Vision III, a transformative approach that extends beyond acquiring scientific knowledge to include critical thinking, social activism, and ethical responsibility (Valladares, 2021). Vision III emphasises empowering learners to engage with socio-scientific issues and drive positive change (Bencze, 2017). It shares common goals with EfS, such as fostering critical awareness, promoting active citizenship, and encouraging students to address real-world environmental and social challenges. Both aim to cultivate informed,

responsible individuals capable of contributing to a more just and sustainable future. Furthermore, a combined approach may help prepare future scientists to act with greater ethical responsibility.

2.4.2 Integrating Sustainability into Science Education

The literature provides strong rationale for developing scientific literacy and for the importance of sustainability education, emphasising the role of both in fostering informed and responsible citizens. While there is advocacy for integrating sustainability into science curricula, there is less documentation on how this is implemented in practice. Research often suggests models or frameworks (Eilks, 2015) rather than showing practical strategies. Studies that focus on teaching practice tend to be conducted at tertiary level (Blatti et al., 2019), in teacher training programmes (Feldman & Nation, 2015) or within environmental science courses (Baines, 2018) where sustainability ideas may naturally be embedded. Understanding how to embed sustainability may be an issue; Waltner et al. (2020) found that while over 100 German science and social science teachers had high levels of sustainability understanding, almost half said they lacked the knowledge to implement it in their classes. Therefore, there is a pressing need to find quality examples of how sustainability is practised within secondary school science education. This section outlines some methods for practically integrating EfS into science education, including socio-scientific issues, cross-discipline approaches and Green Chemistry Education.

2.4.2.1 Teaching with Socio-scientific Issues

The teaching of socio-scientific issues (SSI) may be one way to incorporate sustainability. SSI present students with current, real-world problems which require a background understanding of science to make informed decisions (Stolz et al., 2013). The approach aims to develop scientific literacy and can also accommodate values of sustainability education through the selection of issue to be investigated. The literature reveals that teaching with SSI can address scientific content knowledge, increase reasoning skills (Fowler et al., 2009), and stimulate emotional growth and moral development (Sadler et al., 2007), via research, critical analysis and discussion of relevant, meaningful issues (Zeidler and Kahn, 2014).

The consideration of multiple perspectives is integral to informed decision-making and is a skill both EfS and teaching with SSI aim to enhance. Newton and Zeidler (2020) demonstrated this using SSI embedded in the context of sustainable wolf management in the USA national parks. The student teacher participants were assigned stakeholder perspectives, engaged in tasks to build understanding of the perspective and participated in a mock town council to discuss and recommended courses of action. The research found notable improvements in the participants' abilities to consider other perspectives. In addition, they developed greater awareness of the complexities of animal management, finding the context interesting and meaningful. Teaching with SSI can introduce sustainability ideas into science education and develop skills, such as perspective taking, to help students become scientifically literate citizens.

A sustainability focus may extend teaching with SSI to empower students to take action. The Roxbury Environmental Empowerment Project (REEP) (Agyeman, 2006) exemplifies how SSI in education can move beyond the classroom to foster youth-led activism. By engaging students with local, real-world issues, in this case the connection between public transport, air pollution and asthma, REEP demonstrates how EfS and science education can be interwoven to develop students' science knowledge, critical thinking, civic engagement, and action competence (Agyeman, 2006). The significance of the project lies in the way it gave students agency - they selected the issues to tackle, determined the course of action, and were deeply motivated by the direct impact these issues had on their lives. This connection between personal experience and scientific inquiry enabled students to see themselves as active contributors within their communities as well as in broader scientific discussion.

Using SSI offers one possible way to integrate sustainability into science. However, not all SSI are directly linked to sustainability concerns. Issues like euthanasia involve ethical debates but lack an explicit connection to ecological or social sustainability. Furthermore, EfS extends to consistently prioritise ideas of action competence, values development, and transformative change. So, while SSI and EfS can overlap, one does not automatically lead to the other without deliberate pedagogical design.

2.4.2.2 Cross-Curricula Approaches

EfS acknowledges all school subjects contribute to sustainability understanding and supports cross-disciplinary and school-wide teaching. Combining two or more subjects is, therefore, a further way to bring EfS into curricula. Blending drama and science, Oedegaard (2023) used role-play to explore sustainability-focused socio-scientific issues. The approach enabled students to explore the perspectives and values of various stakeholders, acting out appropriate courses of action. Oedegaard argues this may help prepare them for real-world situations; they can be immersed in the narratives of different people and try-out various actions, experiencing the reactions of others. Cross-disciplinary approaches can powerfully bridge subject boundaries, allowing them to merge and mutually enhance each other without losing their individual essence.

2.4.2.3 Green Chemistry Education

Though not strictly EfS, Green Chemistry Education (GCE) shares similar goals, and its approach as a lens or mindset offers suggestions for incorporating sustainability. GCE is guided by 12 chemical design principles (Anastas & Warner, 1998) that promote safer, more sustainable chemicals and industrial processes. In secondary schools, it applies principles like replacing toxic reagents, using micro-scale experiments, and incorporating everyday materials to increase safety and reduce costs (Eilks, 2015). GCE enhances scientific literacy by fostering critical thinking and connects chemistry, the environment, and society to encourage sustainable behavioural change (Cann, 2009; Holfelder, 2019). Overall, GCE presents a valuable framework for making chemistry education both relevant and responsible.

Growing research illustrates GCE's secondary school implementation. For example, students who designed green alternatives to traditional experiments showed greater environmental awareness and developed argumentation skills (Taha et al., 2019). Another study used a hypothetical hurricane event where students designed green paint alternatives to lessen environmental impact (Ballard & Mooring, 2021). This learning was hands-on and situated within a relevant, real-world context to raise

student awareness of the role of chemistry, both positive and negative, in society. GCE also offers avenues for interdisciplinary or cross-curricular learning; in a high school agricultural science course Kohn (2019) used non-toxic biofuels to integrate chemical processes within biological systems while Mellor et al. (2018) developed an online GC simulation requiring students to design safer chemical products while balancing functionality with biological and environmental toxicity. These examples highlight the interdisciplinary potential of Green Chemistry to support holistic sustainability education, though its grounding in chemical processes may limit its applicability beyond chemistry and offer less scope for students to take meaningful action.

2.4.3 Section Summary

Section 2.3 has described the rationale for embedding sustainability into science education, demonstrating their reciprocal relationship. Science offers sustainability legitimacy in the curriculum, theoretical knowledge to understand issues and opportunities for practical learning which may generate data useful in engaging with sustainability-related dilemmas. EfS can help contextualise science, make it relevant to students and bring an ethical, values-based dimension to science. The section then describes ways EfS may be implemented in science, via the use of socio-scientific issues, cross-curricula teaching and Green Chemistry Education. This thesis now shifts to consider sustainability within a New Zealand context.

2.5 Sustainability within The New Zealand Curriculum

The New Zealand Curriculum was released in 2007 (Ministry of Education, 2007) and has expanded online over the past 18 years. Currently, it is also undergoing a refresh, and where new curriculum material is available, this is included here. However, it is likely some statements made in this thesis may no longer be applicable when the new curriculum is released. The following section outlines the position of sustainability in the New Zealand Curriculum, some ways it is approached within schools and some challenges to its integration.

2.5.1 Overview of The New Zealand Curriculum

The New Zealand Curriculum provides a broad framework and common direction for schools to design their own curriculum (Ministry of Education, 2007). It articulates the overarching vision for education and is structured into three components: values, key competencies, and learning areas, all of which are cohesively underpinned by eight guiding principles. Individual schools are expected to design a curriculum which is meaningful and relevant to their community and to provide teachers with the scope to design a classroom curriculum which best meets the needs, talents, and interests of individual learners (Ministry of Education, 2007).

2.5.2 Sustainability in The New Zealand Curriculum

The New Zealand Curriculum envisions Education for Sustainability (EfS) as a holistic approach that promotes environmental and social well-being. It aims to develop confident, connected, and actively involved learners by embedding key concepts such as sustainability, interdependence, equity, and participation for change (Ministry of Education, 2024). The curriculum views EfS not as a standalone subject but a transformative lens for exploring all learning areas and emphasises the interconnectedness of environmental, social, cultural, and economic dimensions. It encourages considering multiple perspectives, including mātauranga Māori, and acknowledges the significance of Te Tiriti o Waitangi. The curriculum also advocates for a school-wide approach that connects people to place and fosters critical inquiry, supporting students in developing behaviours that contribute to a more sustainable future. While aligning with global interpretations of EfS, it maintains a distinct New Zealand perspective by honouring indigenous knowledge and the deep connections between land, people, and sustainability (Ministry of Education, 2024).

References to sustainability permeate the 2007 version of the New Zealand Curriculum, evident in the curriculum's overarching vision, principles, values, key competencies and learning areas. Explicit references to sustainability include:

- **Vision** – young people who will seize the opportunities offered by new knowledge and technologies to secure a sustainable social, cultural, economic, and environmental future for our country;

- **Principles - “Future Focus”** students should look to the future by exploring such significant future focused issues as sustainability;
- **Values - “Ecological Sustainability”** including care for the environment;
- **Key Competencies – “Participating and Contributing”** students who participate and contribute to communities understand the importance of balancing rights, roles, and responsibilities and of contributing to the quality and sustainability of social, cultural, physical, and economic environments.
- **Learning Areas – e.g. Science** when using their knowledge of chemistry, students are better able to understand science-related challenges, such as environmental sustainability. (Ministry of Education, 2007).

Additionally, a full section on EfS is included in New Zealand Curriculum Online, and the National Certificate of Educational Achievement (NCEA) Level Two and Three offers EfS as a subject. The following section explores how sustainability may be approached in New Zealand schools.

2.5.3 Sustainability in New Zealand Schools

Sustainability has been an integral feature of the New Zealand Curriculum for 18 years and looks set to retain its prominence in the revised curriculum. While not yet compulsory, many schools in New Zealand have taken steps towards integrating sustainability into their curricula. Schools may approach this differently and this following section explores sustainability’s implementation via teaching of values and competencies, relationships with outside providers, place-based approaches, engagement with pro-environmental activities and the teaching of EfS within the National Certificate of Educational Achievement (NCEA).

2.5.3.1 Values and Competencies

The New Zealand Curriculum ties sustainability to its overarching principles, values, and competencies. Thus, it should infuse all areas of the curriculum. However, if the values and competencies are not well prioritised within individual schools, or their implementation is challenging, sustainability may not be incorporated. As a result,

students may fail to receive education in an area considered instrumental in helping New Zealand to achieve their vision for the future and meet international obligations.

Research into the implementation of the curriculum values and key competencies has been conducted. Notman et al. (2012) found that teachers were familiar with the values and could provide evidence of their application. However, they also discovered that teachers felt least confident in implementing the ecological sustainability value compared to the other curriculum values. Teachers who lack confidence in an area tend to teach it less, while teachers with strong knowledge teach more effectively, involving students in meaningful discussion and activities (Jones and Carter, 2007; Stronge, 2018). Low teacher confidence in this value may result in sustainability learning receiving less coverage in New Zealand schools.

Sustainability ideas are also present in the curriculum Key Competencies. When introduced in 2007, it was envisioned the competencies would integrate across the curriculum, underpinning and strengthening all learning areas (Ministry of Education, 2007). Hong (2012) argues that a competency-based curriculum requires changes in the way content knowledge is taught, and teachers may find this challenging to navigate. Currently, evidence seems to suggest that the incorporation of sustainability via competencies or values is challenging and may not go far enough in ensuring EfS is embedded into curricula.

2.5.3.2 Outside Providers

Programmes run by outside providers bring sustainability-related learning to New Zealand schools. Enviroschools, launched nationally in 2001, provides schools and teachers with resources, knowledge and ideas to encourage student participation and decision making (Eames et al., 2010). Reviews of the Enviroschools programme have been positive with teachers reporting increases in students' critical thinking, knowledge development, engagement with learning and action-taking behaviours (Eames et al., 2010, Wypych & Field, 2021). However, Enviroschools is optional and currently 53% of primary schools and 38% of secondary schools are involved. In the Waikato region (Enviroschools, 2023). The two reviews note the programme is harder to implement in

secondary schools due to larger school sizes, subject-based school structures, and lower levels of teacher knowledge in some areas. Consequently, moves to include sustainability are often in the form of an extracurricular club (Eames et al., 2010). These findings add further support for the need to embed sustainability into school curricula rather than relying on optional programmes to ensure the access to EfS learning is widespread.

2.5.3.3 School-Wide Initiatives which promote Action-Taking

Many New Zealand schools offer students opportunities to engage with environmentally-focussed activities such as recycling, waste management, gardening, and tree planting (Birdsall, 2014; Brignall-Theyer et al., 2009; Cowie et al., 2004). These practical activities are often widely understood by teachers and easy to implement (Mogensen & Schnack, 2010). For students they provide EfS benefits – they are participatory, action-based, involve school-wide collaboration, and promote pro-environmental behaviour.

While valuable inclusions in school programmes, some issues have been raised regarding these types of action-taking activity (Birdsall, 2010; McLaren & Hammond, 2005). Action-taking initiatives may be direct or indirect; direct action has direct impact on a problem, such as recycling, while indirect action aims to influence others to act in a particular way such as via a campaign (Jensen & Schnack, 1997; Kollmuss & Agyeman, 2002). Literature suggests some direct actions may address only the symptoms of issues, such as waste, rather than tackling underlying causes (Birdsall, 2010; Chalmers, 2011). The onus for change falls on the individual, and the complex social, political, and economic structures that contribute to environmental problems may be overlooked (Birdsall, 2010). Opportunities for students to question, think critically, and make informed decisions may then be missed (Mogensen, 1997). Furthermore, some authors suggest teacher or school-initiated action programmes tend towards indoctrination and the pushing of ideologies (McClaren & Hammond, 2005). To safeguard against this, students could decide which problems to tackle and how this is best achieved, whether it be directly or indirectly, collectively or individually

(Jensen, 2002). Given action is seen as necessary for a sustainable future, the need to explore how New Zealand teachers navigate action-taking is required.

2.5.3.4 Place-Based Approaches

Place-based Education is seen as a way forward for sustainability and environment-focused education in New Zealand schools (Penetito, 2004). These approaches aim to connect learning to students' immediate environments and lived experiences. Māori students may already have an affinity for place-based learning and these approaches may be culturally affirming for students (Penetito, 2004; Education Council of New Zealand, 2011). Penetito (2004) suggests that place-based approaches should aim to foster in students a love for the place they live and all that it encompasses. By forming strong place-based connections, students can become “place-makers”, those who sustain, transform and create the type of places they wish the world to comprise (Bolstad, 2004, p.229). Place-based approaches encourage students to think critically about the world around them and may empower them to act for improved future outcomes thus integrating sustainably into the curriculum.

2.5.3.5 Education for Sustainability – NCEA Standards

In 2008, steps to further establish sustainability in the New Zealand secondary school curriculum were taken; EfS achievement standards were offered at Level Two and Level Three of the National Certificate of Educational Achievement (NCEA) to encourage localised learning within cross-curricula courses (Ministry of Education, 2024). These new standards aimed to draw from different disciplines, enhance student engagement, realise the potential of all learners and reorient learning purpose away from traditional modes of assessment (Birdsall & Glasgow, 2014). Teachers and students in one school offering the standards, indicated that student engagement was high, the learning was relevant, and students believed the hands-on activities lead to a deeper understanding of the material (Birdsall & Glasgow, 2014). While the EfS standards offer a possibility for sustainability integration across the curriculum, challenges have also been encountered.

New Zealand's NCEA qualification supports a separate subject curriculum, with students needing to obtain a minimum number of credits per subject for subject endorsements or university entry. To meet these requirements, schools could offer full EfS courses, but this counters visions of EfS as an educational orientation, rather than standalone subject, (Ministry of Education, 1999) and requires students to potentially choose EfS over other subjects. Alternatively, adding EfS to existing courses may require removing other standards, which is unlikely if they are needed for educational progression or to meet credit quotas. The result has been a low uptake of EfS; in 2022, 57 education providers offered Level Three EfS, compared to 399 offering biology and 290 teaching geography, subjects which overlap EfS. Only 0.1% of all NCEA Level Two students and 0.5% of all Level Three students undertook a full 14+ credit EfS course (New Zealand Qualifications Authority, 2022). Teaching sustainability is beneficial, and the current EfS standards provide strong learning pathways. However, few students are currently accessing the EfS standards and steps may need to be taken at policy level to ensure EfS reaches more students without impacting study in other courses.

This section highlighted various approaches to EfS in New Zealand: integrating curriculum competencies and values, utilising external providers, implementing environmentally focused initiatives, place-based education and offering it as an NCEA subject. However, each approach faces challenges in ensuring all students access sustainability-related learning. As sustainability is an overarching curriculum vision intended for integration across all subject areas, the following section specifically examines its place within the New Zealand science curriculum.

2.5.4 New Zealand Science Education and Sustainability

Within a New Zealand context, there is minimal research focused specifically on sustainability in science education, particularly at secondary level, reinforcing suggestions that integrating sustainability post-primary school is challenging (Eames et al., 2010). This section describes current research relating to sustainability in New Zealand science education covering approaches used at both primary and secondary level.

2.5.4.1 Science, Technology, Engineering and Maths

STEM, or Science, Technology, Engineering and Maths, is an educational approach that combines these disciplines. As it is problem oriented and can highlight the relationship between science and society, it offers opportunities for sustainability integration. One study integrated sustainability into a primary STEM project through an “egg drop” challenge (Coutts, York & Mower, 2022). Alongside science principles like gravity and force, the sustainability of construction materials was explored. The researchers found that while students were engaged and able to explain the science behind their design choices, they struggled to articulate what sustainability meant or justify their material selection accordingly. Though conducted in a primary school setting, this study contributes in two ways; it demonstrates a straightforward way to bring a sustainability angle to a common experiment but also highlights a lack of student sustainability understanding. The findings underscore the need for further research to show how sustainability can be meaningfully integrated in ways that will enhance understanding.

2.5.4.2 Action Competence

Birdsall (2010) aimed to develop action competence and sustainability understanding in 11-12 year olds through an integrated, cross-curricular approach. A learning programme was designed which incorporated Jensen's (2002) knowledge dimensions: understanding sustainability issues, stakeholder perspectives, how to effect change, and future visions. Students studied a local lake's environmental aspects (water quality, ecosystems) and its social role as a recreation spot. At two points, students articulated their desired future for the lake and planned the individual and collective action to achieve their vision. The study found that students were unlikely to include stakeholder perspectives in their decision making and concluded that all knowledge dimensions must be explicitly taught to be precursory for action-taking. Though the programme reported benefits for students, it took 16 weeks and formed the basis for learning across all curriculum areas. To achieve a similar programme within a secondary school environment would be challenging, which emphasises the need for updated research regarding the implementation of EfS within a single-subject secondary school structure.

A second study, conducted by Arthur (2011) sought to develop student action competence, albeit using a different approach. Secondary school environmental science students completed an NCEA EfS achievement standard requiring them to design and carry out a personal, sustainability-related action. Arthur used an adapted action competence model (Eames et al., 2010) to develop students' skills at being reflective, seeing interconnectedness, and having visions for a sustainable future—all crucial for supporting action competence. Most students successfully completed their projects, implementing actions that closely aligned with their personal values and cultural backgrounds, clearly demonstrating EfS elements. However, the study also highlighted an implementation challenge: many students lacked the confidence and skills needed to independently navigate complex sustainability issues. As with my study, Arthur's research was conducted with senior science students, though the Environmental Science context may have made integration of sustainability easier than in broader general science. Nonetheless, it highlights how the EfS standards could be used within science education.

2.5.4.3 Socio-Scientific Issues

Socio-scientific issues (SSI) are one possible approach for the integration of EfS. Though research exists on teaching SSIs within New Zealand secondary science, it often lacks a clear sustainability component. For example, Saunders and Rennie (2011) developed a framework for exploring SSI, aiming to enhance scientific literacy and ethical thinking when dealing with controversial topics. Using a flowchart, teachers guided students through a multi-step process: from becoming aware of an issue, to exploring the background science, to reflecting on their own and others' values and perspectives, and finally to making an informed decision. Teachers found the framework easy to implement, and felt students made gains in scientific knowledge and ethical decision-making ability. The model makes a useful contribution in supporting teachers to navigate controversial or value-laden issues in the classroom. However, many SSIs explored (e.g., euthanasia) lacked a direct sustainability focus, and the study primarily evaluated the framework usability rather than the specific units of work. SSI is a viable means for teaching sustainability, but it must be issue and

context appropriate. Additionally, research providing deeper insights into how teachers deliver the lessons and units is needed.

2.5.4.4 Indigenous Knowledge and Mātauranga Māori

Integrating Indigenous knowledge, such as New Zealand's unique mātauranga Māori, into science education provides a rich, relevant context for learning and may ease sustainability's integration (Zidny et al., 2020). The transdisciplinary nature of sustainability supports a holistic worldview, similar to many Indigenous world views (Parsons, Nalau & Fisher, 2017). For instance, mātauranga Māori encompasses holistic environmental understandings, developed over centuries, and offers valuable insights into ecosystem stewardship (Moeed, 2020). The integration of indigenous knowledge systems may lead to more effective and meaningful strategies to address socio-ecological challenges, as they are based on processes which better align with Indigenous groups' priorities (Agrawal, 1995). By incorporating this perspective alongside science, educators can foster a comprehensive approach to solving environmental challenges (Parsons, Nalau and Fisher, 2017), cultivating critical thinking and socio-cultural appreciation to empower students to develop inclusive, locally relevant solutions.

While a growing body of research explores how mātauranga Māori can enhance resource management and scientific research (McAllister, Hikuroa, & Macinnis-Ng, 2023; Wilkinson et al., 2020), its inclusion into secondary school curricula is less studied. Moeed (2020) argues that like EfS, Māori worldviews emphasise interconnectivity and can support scientific literacy development by encouraging students to make connections between different science concepts. A project using sustainable waterway management as a shared learning context exemplified this (Callaghan et al., 2018). Wai Māori (freshwater), with its deep connection to Māori identity and spirituality (Ruru, 2018), provided an ideal theme for Year 6 students from a Māori special character school to collaborate with Year 9 mainstream secondary students. Students conducted water assessments, learnt from both scientific and cultural experts, and lead action projects. The researchers believed the project broke

barriers between mātauranga Māori and science by combining equally valid sources of knowledge, allowing younger students to contribute rich te ao Māori knowledge while older students contributed scientific inquiry skills and science understanding. This collaboration demonstrated how integrating Mātauranga Māori into school science can enrich learning and offer powerful opportunities to connect sustainability education with both cultural and scientific knowledge systems.

This sub-section overviewed the rather limited research on sustainability within New Zealand science education. It described how a traditional technology challenge may be given a new sustainability focus and outlined studies which aimed to develop action competence, support ethical decision-making using SSI and incorporate mātauranga Māori. Science education is an ideal environment for sustainability teaching and learning, yet these findings highlight significant gaps in the research evidence for how this can be done.

2.5.5 Moving Forward - The NCEA Curriculum Refresh

The New Zealand Curriculum is currently undergoing a refresh. One new NCEA Level One science achievement standard is called “Demonstrate understanding of a science-informed response to a local issue” (Ministry of Education, 2023). This standard seeks to enhance key components of scientific literacy by embedding science within local, real-world, decision-making contexts, encouraging students to understand the role science plays. The standard has potential to integrate EfS as well as mātauranga Māori, New Zealand’s indigenous knowledge system.

Both sustainability and scientific literacy are at the forefront of this new NCEA standard. It aims to develop critical thinking by requiring students to consider both a science perspective and other viewpoints, such as mātauranga Māori, Pacific knowledges, or economic and political perspectives. This multi-perspective approach helps students appreciate the diverse influences on decision-making without forcing comparisons between knowledge systems. The standard supports sustainability by encouraging analysis of local issues, where science-informed responses are weighed

alongside cultural and societal perspectives. It also fosters socially responsible science practice through the concept of kaitiakitanga, highlighting care and guardianship, in addressing local concerns. This new standard strives for students to use scientific ideas to engage in informed, ethically grounded decision-making, in turn supporting the inclusion of locally relevant sustainability issues (Ministry of Education, 2023).

This new science standard has only been offered for one year, meaning research into how teachers are interpreting and implementing it is both timely and vital.

Understanding how educators combine science knowledge with the standard's emphasis on multiple perspectives, mātauranga Māori, and sustainability will provide valuable insights into its effectiveness, and the support teachers may need. As such, this research may inform future curriculum development and guide professional learning.

2.5.6 Section Summary

Section 2.4 has covered the place of sustainability in the New Zealand Curriculum. It outlined how sustainability may be brought into schools and classrooms; by teaching values and competencies, via outside providers, through school-based initiatives such as recycling, using place-based approaches and as an EfS achievement standard. Approaches designed to specifically integrate sustainability into science were covered, such as STEM projects, the development of action competence, teaching with SSI and through the inclusion of mātauranga Māori. The section concluded by briefly considering the current curriculum refresh and the possibilities this may offer for sustainability. It was noted that currently research relating to sustainability with the New Zealand science curriculum is limited, underscoring the need for work in this area.

2.6 Integrating Sustainability – The Role of Teachers

Thus far, the literature has shown that despite its potential, sustainability is hard to include in secondary curricula. Time constraints, the prioritisation of assessable, mainstream subjects, and school structures, can result in EfS run by outside providers

or as extra-curricular clubs rather than integrated into the curriculum. Though these factors undoubtedly impact its integration, there is also a clear lack of research illustrating how teachers practise EfS within subjects such as science. Therefore, the role teachers play in curriculum decisions warrants consideration.

Hattie (2009) suggested that teachers remain the most important factor in education reform and research across education contexts consistently shows that what educators think, believe and understand about sustainability and Education for Sustainability (EfS) will influence their curriculum decision making (Ferguson et al., 2021). This section draws on both international and New Zealand research to consider the role of teachers; how they conceptualise sustainability and EfS and how their beliefs regarding sustainability and its place in education may impact curriculum integration.

2.6.1 Teachers' Understanding

This sub-section considers the current literature relating to teachers' understanding of sustainability and of sustainability education. It then considers the relationship between EfS understanding and subsequent teaching practice.

2.6.1.1 Teachers' Understanding of Sustainability

Studies have found teachers to be overwhelmingly positive about teaching sustainability, recognising its value within school curricula. (Birdsall, 2014; Brignall-Theyer et al., 2009; Smithsonian Institute, 2023). However, these same studies indicate that teachers' understanding of sustainability may be limited or overly simplistic. Birdsall (2014) found that New Zealand primary teacher trainees primarily identified environmental factors, with little reference to economic or socio-cultural dimensions. Few recognised sustainability's temporal, future-focused context, leading Birdsall to conclude that the concept was not well understood. Providing a secondary school perspective, Brignall-Theyer et al., (2009) found that five teachers and principals framed sustainability as "maintaining the natural environment for future generations" (p.7). Though this was a small sample, it reinforced claims that the environmental component is best understood, additionally reflecting some appreciation of sustainability's temporal component. Internationally, both Burmeister and Eilks (2013)

and Burmeister, Schmidt-Jacob, and Eilks (2013) found that German trainee and experienced chemistry teachers lacked knowledge of sustainability, relied heavily on media sources for information, and focused mainly on environmental aspects. Though these studies are over a decade old, recent literature suggests little progress in expanding teachers' sustainability knowledge.

In 2022, a study of 271 pre- and in-service Israeli teachers found their overall awareness of sustainability to be very low, with experienced teachers having slightly greater awareness than less experienced or trainee teachers (Basheer et al., 2023). The study participants noted that they had not been exposed to sustainability topics during their own education leading Basheer et al. (2023) to suggest that a lack of sustainability-related content in tertiary courses was in part responsible for the difference in awareness between experienced and less experienced teachers. They recommended this be addressed so teachers gain the knowledge to properly promote sustainability for the next generation. As teachers' understanding of sustainability will influence their teaching, these findings suggest the need for updated, local research into teaching understanding of sustainability.

2.6.1.2 Teachers' Understanding of Sustainability Education

Sustainability education is distinctly different from sustainability, as it involves the approaches taken to equip learners with the knowledge, skills, values, and agency to address global challenges (UNESCO, 2020). The literature suggests exploring teachers' understanding of EfS is challenging as they may be unfamiliar with the term or misunderstand it. Studies have found that when questioned, teachers often focus on the broader concept of sustainability rather than specific teaching practices, using the terms interchangeably (Evans et al., 2023, Hobson, 2020). Furthermore, some teachers have misinterpreted EfS, believing it was about making sure education itself "was long-term and sustainable" by focusing on teacher recruitment issues or the maintenance of resources (Evans et al., 2012, p.6; Prabawar-Sear & Dow, 2018). These findings highlight a fundamental gap in awareness. Prabawa-Sear and Dow (2018) argue that definitions of EfS have largely belonged to scholars and advocate for a stronger focus on the educational dimensions of EfS. This argument is highly relevant to the current

research, which seeks to understand how sustainability education is practiced, irrespective of teachers' definitions of the approach.

As with sustainability, teachers' understanding of EfS may be superficial. In a study of five New Zealand primary school teachers, Chalmers (2011) described their EfS knowledge as simplistic. The teachers primarily focused on raising awareness of environmental issues and while some acknowledged the importance of attitudinal or behavioural change, they did not elaborate on how this would be achieved. Chalmers' findings aligned with other research; one New Zealand study found raising environmental awareness to be teachers' primary EfS approach (Cowie et al., 2004) while a review of Green Chemistry Education, reported that 40 of the 45 reviewed studies identified raising environmental awareness as a central teaching method (Chen et al., 2020). While awareness-raising is an explicit component of sustainability education, it alone is often insufficient to provoke meaningful action (Cutter-Mackenzie & Smith 2003; Shallcross & Robinson, 1999). These findings suggest that deeper pedagogical understanding would be needed by teachers to move students from awareness to action.

Reflecting a slightly more developed understanding, Hobson (2020) reported that three New Zealand teachers—one secondary and two primary—who had a particular interest in sustainability, shared the belief that EfS involved promoting care for the environment. In 'caring for the environment' these teachers may have begun to recognise action-taking and values-driven elements of EfS but the study did not elaborate if this were the case. Notably, no teacher in Chalmers' (2011) or Hobson's (2020) New Zealand-based studies referenced the economic or socio-cultural dimensions of sustainability, prompting Chalmers to express concern that this could result in a "narrow and limited scope when implementing EfS" (p.29). Together, these studies suggest EfS as a term is not well defined by New Zealand teachers.

Internationally, teachers hold varied interpretations of EfS. In Australia, Evans et al. (2012) categorised pre-service teacher understanding into four progressive levels. Category one teachers misunderstood the term, while category two teachers viewed

EfS narrowly as a body of knowledge about the environment to be transmitted to students. Category three teachers also held ecologically focused views but recognised the need for hands-on, locally relevant activities, demonstrating some pedagogical consideration. In contrast, category four teachers displayed a sophisticated understanding of EfS, recognising the importance of cross-curricular integration, the potential for students to gain higher-order thinking skills, and the interconnectedness of ecological and social systems. That teachers spanned the four levels shows the varied understanding which may exist, a necessary consideration for the teaching of EfS.

2.6.1.3 From Understanding to Practice

The relationship between a teacher's understanding of EfS and their subsequent classroom practice warrants examination. It raises questions about whether a deep conceptual grasp of EfS is necessary for effectively embedding sustainability into the curriculum, or whether other factors play a role. This sub-section examines how varying levels of EfS understanding may influence sustainability-related curriculum decisions and implementation.

Understanding of EfS likely influences the range of EfS approaches used by teachers. Working with 10 secondary and one primary teacher from Australia, Canada, and Scotland, Evans et al. (2023) found that teachers who viewed EfS as “teaching and thinking about sustainability issues” subsequently taught science-based content to provide information (p. 376). In contrast, teachers who defined EfS as “broad and complex; linked to justice, reciprocity, community and relationships,” emphasised interdisciplinary teaching and the connectivity of varied themes such as land, environment, identity, and health (p. 377). The findings indicate that teachers' understanding of EfS may influence how they approach its teaching; viewing EfS as ‘about issues’ often translated to content delivery, while recognising its systemic nature encouraged interdisciplinary approaches. However, the study also observed a gap between teachers' stated views and their actual practices—some who claimed EfS was holistic still relied on traditional pedagogies. While a greater knowledge of EfS may

result in varied EfS approaches in the classroom, this study suggests other factors may also influence teachers' sustainability-related practice.

Teachers have varying levels knowledge and diverse interpretations of both sustainability and EfS, which raises an important question: how much understanding is needed to teach sustainability effectively? Taylor et al. (2003) asked social science teachers unfamiliar with the term EfS to explain the concept. Despite having no formal exposure to EfS, the teachers identified core components such as promoting student action and emphasising social justice. The researchers also observed elements of EfS present in their teaching, suggesting that some educators may possess an intuitive grasp of sustainability principles. While these were social studies teachers, likely more familiar with social justice and economic perspectives, the study offers a valuable insight: even without explicit training, teachers may inherently engage with aspects of EfS pedagogy. Given that recent New Zealand literature suggests teachers have a limited understanding of sustainability, further research is needed to explore whether New Zealand teachers, despite some conceptual gaps, demonstrate a similar intuitive approach to EfS.

Though two decades old, one New Zealand study offers some evidence that teachers may possess a more developed understanding of EfS approaches than indicated by definitions alone. In a large-scale project spanning primary and secondary school, Bolstad, Cowie, and Eames (2004) found that while only 20% of respondents explicitly mentioned student action-taking when defining environmental education, one-third included it in their teaching programmes. Where direct action-taking was not possible, other activities allowed students to plan for action, bringing the number of teachers explicitly including this component to over a third. These findings suggest that relying solely on teacher definitions might not fully capture their breadth of understanding nor what they implement in practice, re-emphasising the need for updated research into current classroom practices as well as research that looks beyond one-off definitions to gain deeper insight into their pedagogical approaches.

This subsection considered how teachers define sustainability and EfS, highlighting varied understanding of the terms. In New Zealand, definitions are often simplistic, and the two terms may be used interchangeably. This poses challenges for both research and the translation of EfS into practice. However, the literature also suggests a potential nuance: teachers who may not be able to formally define EfS could still have a more refined understanding that is only evident when examining their practice.

2.6.2 Teacher Challenges in Integrating Sustainability into Science Education

The integration of sustainability has not been straightforward, and Section 2.3.3 identified time constraints, the single-subject structure of secondary schools, and the prioritisation of compulsory, assessable subjects as key challenges. This final section considers teacher views on embedding sustainability, identifying the value they place on sustainability and the very nature of teaching sustainability as key challenges.

2.6.2.1 The Value of Sustainability Education

New Zealand teachers have considerable autonomy regarding curriculum construction (Hood, 2019), particularly until senior secondary level, and could integrate sustainability if they chose. Chalmers (2011) notes that because EfS is not mandatory in New Zealand, its implementation depends on the enthusiasm and initiative of individual schools or teachers. As teaching sustainability requires engagement with approaches that may be new and different, it has been suggested that only highly motivated teachers may make the effort (Stables & Scott, 2002). In contrast, those who find these approaches challenging will deprioritise sustainability's relevance (Cotton et al., 2007). Teacher commitment and personal motivation, may therefore, play a pivotal role in whether and how sustainability is embedded in classroom practice.

Not only must teachers be motivated to integrate sustainability, but research suggests they must personally value what it offers (Hart, 2003). When reviewing the New Zealand Curriculum values, Notman et al. (2012) found that personal perceptions of values often acted as a barrier. Teachers reported incorporating the values they personally deemed important, leading the authors to conclude that to implement values, teachers must first genuinely believe in them. As ecological sustainability was the least

implemented value, this study highlights an issue: teachers may not personally see the value in teaching sustainability.

International studies suggest that teachers place greater value on other curriculum requirements, rather than simply devaluing sustainability. Swedish science teachers, teaching a mandatory sustainability-focused course, prioritised science content over sustainability competencies (Brommesson et al., 2025). EfS was explicitly supported via their curriculum, yet content delivery held greater value, limiting holistic approaches. Similarly, Dutch secondary school science teachers mostly “promoted evidence-based instruction without addressing political, ethical or value-laden dilemmas” when teaching sustainability (Stouthart et al., 2025, p.29). Many teachers in this study believed acquisition of scientific knowledge would “naturally lead to the development of values which prompt students to act” (p. 30) while others felt competency-based teaching had no place in science education. Sustainability continues to face competition not just for curriculum time but for recognition from teachers, highlighting the role teachers’ beliefs may play in its integration.

The value teachers place on sustainability may also influence how they model sustainability-related behaviour. Teachers who adopt sustainable lifestyles set powerful examples for students, fostering interest in environmental issues, a sense of responsibility, and a willingness to take action (Hastürk & Çol, 2024). Similarly, the success of approaches like Green Chemistry relies on teachers valuing and modeling principles such as waste management in their classrooms (Corrigan et al., 2014). Therefore, teachers' personal values and the ways they choose to interact with the environment, can shape their pedagogical approach to sustainability teaching and the behaviours they model.

2.6.2.2 The Challenge of Sustainability Education

EfS aims to be integrative and holistic, developing skills, attitudes and behaviours, and its implementation may require a distinct pedagogical shift for teachers (Shpak & Vasques, 2023). They may need to adapt to new teaching approaches such as integrated learning or developing action competency. This section explores challenges

teachers may experience due to the nature of EfS, namely teaching outside one's subject speciality and navigating controversial or ethical issues.

(a) Teacher Subject Expertise

EfS is a holistic approach requiring engagement with ethical, political, and socio-cultural dimensions, as well as science. However, science teachers may omit aspects of sustainability they deem irrelevant, or outside their subject's scope. Borg et al. (2014) found that the ecological dimension was most recognised by science teachers practicing EfS, followed by the economic and social dimensions. That science teachers mainly incorporated ecological contexts, such as climate and the environment, is most likely a result of their backgrounds as science teachers (Arntzen, Scheie & Haug, 2025). Many teachers report low self-efficacy in dealing with economic or political aspects, with some feeling unequipped or believing these components have no place in science education (Boeve-de Pauw et al., 2022; Stouthart et al., 2025). Therefore, a key challenge is where teachers draw the boundaries of science education and their confidence to move beyond them.

(b) Navigating Controversial and Ethical Issues

Developing sustainability-related competencies requires the integration of cognitive, social and emotional, and behavioural learning. UNESCO's (2021) global survey of primary and secondary teachers revealed that most teachers are comfortable facilitating the cognitive aspects, but are less confident supporting the social, emotional, and behavioural components. Other findings lend support; secondary school teachers often lack conviction in the value of programmes involving socio-emotional learning, hindering their uptake and success (Lendrum et al., 2013). Given EfS's strong emphasis on socio-emotional development, teacher attitudes and confidence in this area are therefore critical to its successful integration into the curriculum.

Teacher hesitancy in incorporating socio-emotional components is problematic as EfS is inherently value-laden and involves controversial, ethical issues. Sustainability discussions can evoke negative emotions like worry or guilt in students (Ojala, 2021),

requiring teachers to navigate these in ways which promote hope and agency (Gardiner & Rieckmann, 2015; Hicks, 2014). Many issues can be controversial, with diverse views and values existing within a classroom (Ojala et al., 2025). While tolerance is an EfS goal, mishandling may cause tension or divisions to the detriment of student learning (Rickinson & Lundholm, 2008). Students may become “issued-out” (Hobson, 2020, p.24) and disengage if problems seem overwhelming. Navigating these emotional challenges can cause teachers’ apprehension (Stouthart et al., 2025), adversely impacting their curriculum decisions to integrate sustainability.

Pro-environmental behaviour is shaped by the values people assign to such actions making EfS value laden (Birdsall, 2014). However, some argue that sustainability discourses are predominantly influenced by the perspectives of middle-class, tertiary-educated urban policymakers and environmentalists, raising questions of whose values are being taught (Beasy, 2019)? Research shows teachers hold varied views on the place of values in education. Some Australian teachers are comfortable navigating values, believing it of paramount importance (Taylor et al., 2003). In contrast, some UK teachers report lacking confidence and expertise in managing value-based discussion (Levinson et al., 2001) while other teachers have said they avoid the topic altogether, fearing they risked imposing personal beliefs (Stouthart et al., 2025). Teaching values is challenging and controversial. However, it is arguably through emphasising the role of value-laden, ethical dilemmas that science education can shift closer to a more comprehensive vision of Scientific Literacy (Arntzen et al., 2025; Sjöström, 2025).

2.7 Chapter Summary

Science Education arguably serves two purposes: preparing some students for science careers while ensuring all students are ‘scientifically literate’ - able to use science to explain the world and make informed decisions. However, student engagement with science is declining, highlighting a need to increase its relevance for students. It is also apparent that students require science knowledge and skills to address global problems and take action for a more sustainable future. Education for Sustainability (EfS) offers a pathway for students to develop knowledge, skills and foster values and

attitudes that will prompt them to work towards improved outcomes. In the New Zealand Curriculum, sustainability is a core part of the vision for learners, indicating that EfS should infuse the entire curriculum. Yet this faces challenges from school structures, competition with other subjects and attitudes from stakeholders (teachers, students, parents and school institutions) that deprioritise it.

Integrating sustainability with science education may give it greater prominence and enhance science education itself. Sustainability ideas and approaches can make science relevant and help reorient scientific literacy to provide skills required for the future. Various approaches may achieve this including socio-scientific issues, Green Chemistry Education, cross-curricula teaching and mātauranga Māori, New Zealand's unique indigenous knowledge. Recent assessment changes have already integrated sustainability and Mātauranga Māori into NCEA Level One science achievement standards, providing possibilities for teachers.

Despite these opportunities, integrating sustainability into science education can be challenging due to the nature of EfS. Teachers may prioritise science content and skills/practice, feel uncomfortable with controversial, values-driven discussion, be reluctant to incorporate material from outside science, or struggle with implementing integrated teaching. This thesis explores the practice of some teachers who are addressing these challenges and considers their understandings of sustainability education and the value they place on it. By examining the practice of teachers who are actively incorporating sustainability into science in quite significant ways, this research aims to identify key features of sustainability-related teaching within New Zealand science lessons. The following chapter describes the research questions and how this research was carried out.

CHAPTER 3 – METHODOLOGY

3.1 Introduction

This chapter describes the research methodology which has guided this study, covering both what was done and the rationale for doing so (Leavy, 2017). In this study, five teachers were interviewed twice each and the data from both sets of interviews were analysed. This chapter presents the research question and outlines the overall research design. The methodological framework is described, followed by the data collection and analysis methods along with the ethical considerations relevant to this research. Finally, issues relating to the quality of the research are discussed.

3.2 Research Question

A research project is built on the foundation of its research questions; establishing research questions makes it possible to select appropriate research methods (Blaikie, 2007). The overarching question for this project was:

- How and why do secondary school science teachers incorporate sustainability into the science lessons in New Zealand?

The research purpose was to gain insights into secondary school teachers' understanding of sustainability education and how they practised it. Examples of teaching practice provided information on the approaches teachers used to incorporate sustainability into their teaching. To help answer the main questions, secondary questions were developed.

- How do teachers understand sustainability and sustainability education?
- What approaches do teachers' report they use when they incorporate sustainability into their teaching?
- What do these teachers perceive to be the benefits for students and barriers for teachers in integrating sustainability within science education?

The desire to answer these questions and understand the teachers' experiences, drove the methodology and supporting methodological framework.

3.3 Methodological Framework and Research Design

A paradigm is a worldview through which New Zealand teacher's conceptions of sustainability and its incorporation into science education are examined in this thesis. The paradigm that drove this study was derived from the research outlined in Chapter Two and also from my own experiences of the world (Harmon, 2018). Together with the research aims, these guided the approaches taken to gather data and interpret the findings (Guba, 1990).

3.3.1 The Interpretive Paradigm

Interpretive research aims to understand subjective human experience. Such approaches are characterised by beliefs that humans socially construct their reality, that reality is complex, that situations are fluid and evolving and that multiple interpretations of a situation may exist (Cohen et al., 2018). The role of an interpretive researcher is, therefore, to strive to understand people's interpretations of their own experiences (Leavy, 2017), or in other words, "see the world through the eyes of the participants" (Cohen et al., 2018, p.20). Interpretive approaches frequently use participant interviews to generate qualitative data (Mackenzie & Knipe, 2006) from which theories emerge (Cohen et al., 2018). These theories do not attempt to be universal or generalisable, rather they are built directly from the data to offer insights into the participants' behaviour (Cohen et al., 2018).

In this study, I sought to understand the participants' understanding of sustainability education, how they taught it and their rationale for doing so. As I relied upon the teachers' personal views of the situation the research best aligned with an interpretive approach. An underlying assumption of this project was that "science" and "sustainability" could mean different things among practising science teachers. Thus, this study embraced the notion that multiple interpretations of phenomena can exist. It was acknowledged that society and culture influence perceptions of sustainability which in turn impacts the choice, selection, and decision to include various topics relating to sustainability in teaching (Hamwy et al., 2023). Furthermore, knowledge of the interpretive paradigm helped guide my own thinking regarding data interpretation; it highlighted that, as a practising teacher, my own understanding of sustainability, its

position in the curriculum, and views on the ways it may be taught could influence the meaning I drew from the data.

This research is grounded in an interpretivist paradigm, reflecting an ontological belief that reality is socially constructed and multiple, rather than singular and objective. I acknowledge that each teacher's understanding of sustainability, and how they express and enact it in their teaching, is shaped by their unique experiences, values, and contexts. Epistemologically, I take a subjectivist stance; I rely on teachers' accounts of what they know and do in relation to sustainability education, while also acknowledging that such accounts may not capture the full extent of their practice or awareness. My role as the researcher is to interpret the participants' narratives, understanding that my analysis represents one possible interpretation among many, influenced by my own perspective and interactions with the data.

3.3.2 Qualitative Data

Interpretive research, aiming to generate meaning, lends itself to the collection of qualitative data (Leavy, 2014). I wished to give the teachers the opportunity to verbally describe, unconstrained by pre-determined response options, the ways they embedded sustainability in their science curricula, thus the collection of qualitative data was seen as appropriate. As I also believe that data can be interpreted in multiple ways, a qualitative approach fits with my methodological position. I recognise that the findings presented reflect the meaning I have drawn from the teachers' responses based and these are based on my world view and knowledge of sustainability education and other equally valid interpretations are likely to exist.

3.4 Data Collection - Sampling, Participants and Setting

The following section introduces the participants, outlines the sampling method used to select them as well as describing the setting for the research.

3.4.1 Sampling

To meet the research aims, participants who were actively integrating sustainability into science education were required, hence identifying appropriate participants was important (Sargeant, 2012). Quality research depends on quality data; therefore, a suitable sampling strategy needed to be adopted to identify participants who would meet the research focus (Cohen et al., 2018).

A purposive sampling method was used to select the participants. This non-probability sampling technique meant some members of the population were excluded while others were included, dependent on participants meeting predetermined selection criteria (Cohen et al., 2018). Ball (as cited in Cohen et al., 2018) states that purposive sampling allows researchers to gather data from knowledgeable people who can provide in-depth information and insights into the issue at hand. Given the research aimed to identify clear examples of sustainability teaching within science education, purposive sampling was deemed most suitable to find teachers who could exemplify informed practice in the area.

Sample size was another consideration. The study aimed to obtain rich, qualitative data, not to find statistically significant relationships, and thus a large sample was not required. Patton (2002) says “there are no rules for sample size” (p.244), an idea reiterated by Cohen et al. (2018) who suggest the number of participants depends on the purpose, and to an extent, the style of the research with factors such as cost and time also requiring consideration. As the research aimed for an in-depth exploration of teachers’ sustainability knowledge as well as being a post-graduate research project with time and financial constraints, a small sample of five teachers was considered suitable.

3.4.2 Participant Selection

The selection criteria required the teacher participants to be:

- Teaching both junior science and either senior biology, chemistry or physics in a mainstream, New Zealand secondary school environment.

- Able and willing to share specific examples of the integration of sustainability into their practice.

Education for Sustainability (EfS) is seen as being the most compatible with social sciences and life sciences such as ecology and biology (Uitto & Saloranto, 2017). However, it was my belief that chemistry and physics education also offer much to EfS. Therefore, these criteria ensured representation of the three senior specialist areas in the hope of finding examples of sustainability within chemistry and physics. Junior science curricula typically include ecology and biology topics but also chemistry and physics. As such, selecting teachers who also taught junior science provided a second opportunity to access examples of sustainability in physics and chemistry topics as well as those from the life sciences.

Participants were sought via networking with previous teaching colleagues, supervisor contacts and Enviroschools' facilitators. Various New Zealand science teacher Facebook pages were used to advertise the research and to identify teachers who had participated in sustainability-related discussion threads. Additionally, biographies of previous winners of science teaching awards and *Education Gazette* articles were searched to identify teachers integrating sustainability into science education. All study participants were recruited via supervisor contacts or through social media and webpage searches.

Fifteen potential participants were contacted directly via email, either by me or my supervisors, leading to eight short scoping interviews to assess participant suitability. These informal scoping interviews outlined the research purpose, allowing teachers to decide whether they fit the criteria and would feel comfortable participating. Three teachers chose not to continue; one felt they did not have the specific experience, another had primarily made contact to recommend a colleague for the study, and the third had hoped the study would provide an opportunity to be upskilled in sustainability education. The remaining five teachers all described detailed lessons incorporating sustainability and were invited to participate in the formal interview stage, which they accepted.

3.4.3 The Participants

Table 3.1 provides an overview of the five teachers who went on to participate in the formal interview stages.

Table 3.1 Participants and their backgrounds

Name	Years teaching	Senior science subject	Position of Responsibility
Ben	<7	Chemistry	Head of Faculty (HOF) Science
Sarah	15-25	Chemistry	Assistant HOF Science
Harry	15-25	Chemistry	HOF Science
Heather	>25	Physics	Specialist classroom teacher
Andrew	15-25	Biology	HOF Science

While the data represents the opinions and teaching practices of these specific teachers and may not be transferable to other contexts, it should be noted that the sample reflects diversity in gender, number of years teaching, and in senior subject specialisation. In addition, the teachers reside across the length of New Zealand, and no teachers taught in the same region. This was intentional as geographical location was deemed important; the New Zealand Curriculum emphasises the development of locally relevant curricula (Ministry of Education, 2007).

3.4.4 Research Setting

The interviews took place in Term Three of the school year (late July to late September, 2024) as teachers were preparing for practice examinations. All interviews were conducted one on one, in classrooms or home offices, and in English, in which the teachers were all proficient. The interviews were all online; four of the five participants, along with the researcher, had their videos turned on. Four of the five teachers were trained in New Zealand; three had only taught in New Zealand while one had also taught for a short period overseas. The fifth teacher had originally trained and taught overseas but had been living and teaching in New Zealand for a number of years. In describing the research setting, I have aimed to provide a context from which to assess the

research findings (Lincoln & Guba, 1985) and acknowledge the connection between the data and the socio-cultural setting in which they are grounded.

3.5 Data Collection - Interviews

Data were collected via two separate interviews, distinct from the initial scoping interview. The selection of this data collection method was deliberative; the tools chosen were deemed most suitable to help meet the purpose of this study and answer the research questions (Cohen et al., 2018; Leavy, 2017). This process is described in the following section.

3.5.1 Interviews

I wished to understand the teachers' knowledge of sustainability as constructed by the participants themselves (Cohen et al., 2018). Therefore, I chose to interview the teachers to obtain rich qualitative data where the teachers were not constrained to predetermined responses (Leavy, 2017). As Cohen et al., (2018) explain, interviews can offer "a flexible tool for data collection, enabling multi-sensory channels of communication to be used, including verbal, non-verbal, spoken and heard" (p.854). As interviews are flexible, the participants could describe their ideas and teaching examples from their own point of view and issues could be explored in detail through the use of probing questions, allowing me to begin to see how people frame and connect their ideas and experiences (Hochschild, 2009; Adams, 2015).

Interviews range from highly structured, where questions are predetermined and there is minimal room for modifications, to non-directed, where participants have freedom to discuss any aspects of the topic they chose (Cohen et al., 2018). Semi-structured interviews were used in this research. The initial interview questions (detailed in the following section, 3.5.2) were standardised and pre-determined, so teachers spoke on issues directly relating to the research, but the questions were also broad, offering opportunities to discuss unanticipated issues (Dunwoodie, Macaulay and Newman, 2023). Using a set of structured questions was also helpful for data analysis, enabling me to compare participant responses, and facilitate the cohesive organisation of the

data so key themes could emerge (Cohen et al., 2018). The wording and question order varied slightly, depending on the interview flow, and additional questions were asked to clarify responses and gain insights into issues as they arose (Adams, 2015).

The teachers were interviewed twice, approximately three weeks apart, firstly using the same question set followed by individualised questions developed from the initial interview. Read (2018) notes that participants may not always be consciously aware of or have considered their knowledge and experiences, and research suggests teachers lack understanding of sustainability (Birdsall, 2010; Basheer et al., 2022). Therefore, it was hoped that the reflection period between interviews may have prompted teachers to recall further teaching examples they initially discounted. In a similar manner, researchers are not always aware of what they do not know and may need to “build questions based on emerging observations” (Cohen et al., 2018, p.510). The time between interviews allowed me to commence initial data analysis and notice issues, unique to each participant, to follow up with further inquiry.

3.5.2 Interview Questions

The research questions were developed based on broad issues raised in the literature. Lincoln and Guba (1985) suggest that structured questions are useful when a researcher is aware of what they do not know. To an extent, this applied to this study; I knew I was unaware of the ways teachers were approaching sustainability, and their underlying rationale, and developed questions to target these areas. The subsequent interview questions were designed to elicit responses that would provide data to help answer the research question of “How and why do secondary school science teachers incorporate sustainability into the science lessons in New Zealand?”. Table 3.2 (next page) shows the link between the interview questions and their corresponding sub-questions.

The finalised initial interview questions were the result of much discussion between my supervisors and me. The questions were reviewed and rephrased and the final set was designed to target the research questions from multiple angles while inviting additional, unanticipated opinions or ideas.

Table 3.2 Interview questions

Research Questions	Interview Questions
1. How do teachers understand sustainability and sustainability education?	<ul style="list-style-type: none"> • What does sustainability mean to you? What are your views on the importance of this concept? Where does your knowledge/understanding of this come from? • Could you please elaborate on why you believe these (specific) practices are beneficial for students? (Note: responses to this question also contributed to the third sub-question.)
2. What approaches do teachers report they use when they incorporate sustainability into their teaching?	<ul style="list-style-type: none"> • What do you see as the place of sustainability within science education in our schools? At junior and senior level? • Could you please share some examples of how you integrate ideas and concepts of sustainability into your teaching? • “Action-taking” is considered a big part of sustainability. Has your science course included any opportunities for students to do something towards more sustainable practices? Or do you see room for this?
3. What do these teachers perceive to be the benefits for students and barriers for teachers in integrating sustainability within science education?	<ul style="list-style-type: none"> • As a science teacher, what do you see to be the key purposes for science education? • Could you describe any factors that may limit or prevent you from teaching sustainability the way you envision? • In your view, how might teaching for sustainability contribute to the purposes of science education?

Common themes emerged across the initial interviews, that of teaching time constraints and the place of values in teaching. These emerging themes helped shape

the second interview questions, which were participant-specific but shared commonalities. For instance, in her second interview, Sarah was asked:

A key theme in your first interview was around high moral values and helping students to become good people, which tied in with sustainability. What are some ways curriculum could bring in values or help students become good people in science education?

This question initiated a discussion of values while connecting with Sarah's personal views of what it meant to be a good person. Both interviews were recorded using Google Meet and were digitally transcribed using Google Meet's inbuilt AI transcriber. I checked the accuracy of the transcripts with the audio recordings and amended any inconsistencies. The transcripts from the first interview were returned to the teachers for verification before their second interview. The findings from these interviews were then analysed, as outlined in the following section.

3.6 Data Analysis

Guided by an interpretive framework, analysis of the data aimed to understand the teachers' conceptualisation and implementation of sustainability within science education (Cohen et al., 2018) while acknowledging that multiple interpretations may exist. As the interviews yielded qualitative data, thematic analysis was used to systematically analyse the transcripts (Leavy, 2017) so patterns within the data could be identified, analysed and reported (Braun and Clark, 2006). The analysis and interpretation are described in the following section.

3.6.1 Thematic Analysis

Data analysis began almost immediately as initial thoughts began to form. After cleaning up the transcripts, I systematically read them to identify responses which seemed noteworthy, important to the participant or aligned with literature themes (Kalpokaite & Radivojevic, 2019). During this pre-analysis, I familiarised myself with the data (Braun & Clarke, 2006) and these initial observations helped develop the second

interview questions. As such, this first phase was integral to the analysis process, guiding the construction of the second interview questions and enabling me to note relevant ideas.

The second phase involved coding the data, breaking it into smaller “chunks” (Leavy, 2017, p.147) and assigning codes - short descriptive labels - to categorise each datum unit (Miles, Huberman, & Saldaña, 2014). The selection of codes and codable data items was influenced by which aspects of the participants’ responses seemed useful in answering the research questions and was in turn influenced by my reading of relevant research (Braun & Clarke, 2013). The code development was a non-linear process, moving between the data and key literature ideas. Manual coding with multiple read-throughs ensured the wider context and deeper meanings were less likely to be overlooked (Gibbs, 2007).

Once coded, the extracts were grouped by broader themes, based on similarities or relationships linking the coded items (Braun & Clarke, 2006). Once organised in tabular format, sub-themes became apparent, which further defined the coded items (Braun & Clarke, 2006). Table 3.3 shows an example of the relationship between themes, subthemes and codes. The teacher quotations which represent the codes are reported, where relevant, in Chapter Four. A full list of themes and subthemes can be found in Appendix C.

Table 3.3 Themes and codes

Theme	Sub-theme	Codes
Understanding of sustainability	Environment and resources	<ul style="list-style-type: none"> • Use and/or management of resources • Conservation of environment and resources for the future • Minimising environmental harm.

A refinement process followed as themes were reviewed (Braun and Clarke, 2006). For instance, ‘sustainability in education’, initially a sub-theme under the main theme of

'teachers' understanding of sustainability', became a distinct theme of its own. As such, new codes were devised, and transcripts were re-coded until the data fit well within the themes (Braun and Clark, 2006). Initial paragraph writing then commenced to begin weaving the themes together in a cohesive way.

The analysis process was deductive; data were systematically analysed within existing theoretical frameworks, to expand and add to existing theories (Gilgun, 2015). For example, Birdsall's (2014) categorical dimensions measuring teachers' sustainability understanding influenced the selection of codes used to analyse the teachers' sustainability understanding in this study. Similarly, Chapter Two, outlines established frameworks for scientific literacy and EfS from the Programme for International Student Achievement (PISA) and the New Zealand Curriculum. These provided a basis for the codes used when analysing the teachers' lesson descriptions, while allowing for other themes to emerge deductively from the data.

Thematic analysis sat well alongside my interpretive approach. It offered a methodical and systematic way to organise data while remaining flexible, allowing me to report on the rich diversity of participants' experiences in an in-depth manner (Braun & Clarke, 2006). Furthermore, thematic analysis views researcher subjectivity as integral to the study rather than a threat to validity (Terry et al., 2017), important as the study relied on my interpretations of teaching practice within a science education and sustainability framework.

3.7 Ethical Considerations

Ethics involves morality, integrity, fairness and truthfulness and is essential in social research to ensure no harm is done (Leavy, 2017). Ethical issues were considered throughout this research, from participant-researcher interactions to data dissemination and the consideration of the benefits of the research (Hesse-Biber & Leavy, 2011). All researchers acknowledge ethical codes (Cohen et al., 2018); this research was informed by the code of ethics from the University of Waikato and was granted approval by the University of Waikato Division of Education Human Research

Ethics Committee (Appendix B). The key ethical concerns identified as relevant to this research include minimisation of harm, informed consent, the participants' right to privacy and confidentiality, and the potential benefits of the research. This section outlines how each was addressed in the research.

3.7.1 Minimisation of Harm

Ethical codes of practice aim to ensure no harm comes to those involved in research; in other words, participants should not be damaged "physically, psychologically, emotionally, professionally or personally (Cohen et al., 2018, p.127) during the process. While harm cannot ever be completely minimised and what constitutes harm is arguably "a matter of judgement" (Hammersley and Traianou, 2012, p.57), careful consideration was given to the potential impact of this research on those involved.

Some teachers may feel self-conscious discussing their teaching practice or their personal views on sustainability. To help prevent feelings of discomfort, the study aimed to be asset-focused and show teachers' practice in a positive way. The use of selection criteria ensured teachers with suitable interests and capabilities were identified, while the initial scoping interview aimed to instil confidence and assure teachers that their knowledge and experiences were applicable to the research. In addition, I aimed to keep the interviews to under one hour to avoid interviewee-fatigue (Cohen et al., 2018) and further minimise the potential for participant harm.

Prior to undertaking this research thesis, I did not know any of the participants nor live in the same region of New Zealand. However, as we were all practicing secondary school teachers, living in a socially connected world, the possibility for future professional contact exists. To help ensure any future contact with the participants is positive, it was stated in the information letter (Appendix A) that participation or non-participation would not impact any future working relationship we may have.

3.7.2 Informed Consent and the Right to Withdraw

In line with ethical standards, participants gave voluntary, informed consent prior to the project's commencement (Cohen et al., 2018). To ensure informed consent, an information letter outlining the research process was provided (Appendix A). Four teachers returned signed consent forms, while one gave verbal consent, recorded during the interview. However, as Baumrind (1985) notes, it is impossible to communicate "a full disclosure of everything that could possibly affect a given subject's decision to participate" (p.165). Therefore, participants were given the right to withdraw (Cohen et al, 2018; Leavy, 2017) up to two weeks after their second interview, by which time they had received their first interview transcript. Zylinska (2005, p.59) highlights a "surprise element" in social research and despite best efforts to communicate risks, unanticipated issues can emerge. The right to withdraw gave teachers time to experience and reflect on the process and opt out if desired. In this study, no teachers withdrew. Consent was voluntary and free from coercion; no payment was offered, and as noted in Section 3.7.1, participation had no bearing on future relationships between the participants and myself.

3.7.3 Right to Privacy, Confidentiality and Anonymity

Sieber (1992) suggests that maintaining privacy and confidentiality before and after research offers a way to protect participants from harm. In this project, the recruitment process and the gathering of qualitative data via one-on-one interviews potentially invaded the teachers' privacy as they were required to reveal their identity and share other personal information (Cohen et al., 2018) such as their opinions and beliefs regarding sustainability and science teaching.

To help protect the participants' privacy, their identities were kept as anonymous as possible, given the data collection method. Participants were aware that the research was overseen by supervisors, and that three people would know their identity. During recruitment, potential participants were asked to make contact via email rather than responding to public posts, to help protect their identity. In the instances where a teacher was recommended, the third party was thanked but not informed whether the teacher went on to participate. All interviews were conducted one-on-one, in closed

rooms to help protect participants from identification. To further ensure their anonymity, pseudonyms were used in the findings and care was taken to avoid reporting identifying details which may have enabled readers to guess identities (Nachmias & Nachmias, 1992).

The research invited teachers to share their personal opinions, beliefs and teaching anecdotes and so additional steps were taken to protect the privacy of the teachers. During the interviews, I heeded the words of Wellington (2015) who cautions that while probing interview questions allows for deep exploration of issues, over-probing can be intrusive to participants. The data collected in these interviews was also kept confidential; it was stored on a password-protected computer and digital, A.I. transcribing software was used to remove the involvement of third-party transcribers.

3.7.4 Benefits of the Research

Research should be worthwhile, otherwise it is a waste of time, thus consideration was given to the benefits and the beneficiaries of the research (Cohen et al., 2018). The five teachers gave up their free time and were not rewarded in any monetary sense, but it is hoped they received other benefits. These may have included the opportunity to further their own understanding by reflecting on their teaching within a sustainability framework as well as the satisfaction of directly contributing to the understanding of sustainability education in New Zealand. Also gaining direct benefit, is myself, the researcher. While the research will result in the completion of a post-graduate qualification it is the associated learning and understanding of sustainability teaching pedagogy that give the most benefit.

Beyond benefits to the five participants and researcher, it is hoped the examples of sustainability teaching are of direct benefit to science teachers, who may become more informed and motivated by the teaching examples outlined. Policy makers may also benefit as the findings provide evidence of progress in this area, especially in terms of the NCEA curriculum refresh, as well as highlighting areas where further attention may be required. In a flow-on effect, students and the wider community may also benefit; students from enhanced learning opportunities that may arise through improved

teaching or curriculum changes and communities where, ultimately, the next generation of citizens may behave in more sustainable ways.

3.8 Quality issues

This thesis was interpretive and qualitative in nature. Thus, the research process has been assessed in terms of trustworthiness rather than validity or reliability (Shenton, 2004). Issues which may have arisen due to the sampling process, data collection and data analysis are discussed along with steps taken to minimise the impact on the quality of the data and its analysis.

3.8.1 Sampling Process

It is an inherent feature of qualitative research that the findings will be specific to a small group within a specific context (Shenton, 2004). This is true of this project; the findings are specific to this group of five New Zealand science teachers and do not imply anything about the sustainability knowledge of science teachers in the wider population. However, other researchers in similar situations may be interested if the findings could be applicable to their positions. Therefore, descriptions of the selection criteria, selection process, the participants backgrounds and the research setting have been provided, so readers are free to make their own assessments as to the degree to which these findings are transferable to other contexts (Shenton, 2004).

3.8.2 Data Collection

Fowler (2013) reports that the quality of data collected via interview can be impacted if the participants misunderstand the questions, don't know or can't recall the answers, choose not to disclose an answer or give answers they believe are more socially desirable than their own true answer. In addition, the interviewer's relationship with the participants may influence the responses given (Cohen et al., 2018). The impact of these factors on the trustworthiness of the data and the steps taken to mitigate them are further considered.

When discussing their sustainability lessons, teachers often commented on work they were not currently teaching; either it was taught earlier in the year or, depending on their classes, perhaps not taught for a year or two. Therefore, the data reflect the teachers' memories of the teaching, and had the interviews occurred at a different time, lesson details may have varied (Cohen et al., 2018). The inclusion of a second interview helped make the data more dependable as it gave teachers an opportunity to recall and add further details (Shenton, 2004). Additionally, all the teachers referred to or read from their schemes of work suggesting that, if repeated, the teachers would provide similar descriptions, giving a degree of consistency.

Research suggests that the teachers may have given socially desirable answers (Roxas & Lindsay 2011) or described idealised versions of their lessons, different from what they actually did (Faddar et al., 2018). To improve data credibility, several measures were taken. The initial, scoping interview prepared the participants and helped establish a rapport between myself and the teachers (Shenton, 2004), where my position as an interested and passionate colleague was apparent. The teachers shared 'supporting evidence', giving some proof of classroom lessons, while the second interview allowed for cross-referencing against the initial data (Shenton, 2004). As the teachers were genuinely positive about sustainability, willingly participated, shared evidence and a relaxed relationship existed, it is hoped that the data collected is an honest and credible reflection of the teachers' true beliefs (Shenton, 2004).

Researchers enter interviews with their own preconceived ideas and Denscombe (1995) notes that interviewer neutrality is a chimera. I was cautious with question wording to avoid "putting words into their [participants] mouths" (Cohen et al., 2018, p. 273). Though not necessarily more experienced in EfS practice, I may have been more widely read in EfS theory and it is possible I introduced specific jargon or phrasing that may not have been the participants' own words. Thus, the teachers may have acquired new EfS language or been prompted to research new ideas based on what was discussed. If the interview were repeated, the data may then differ due to the learning opportunity the initial interviewed afforded.

3.8.3 Data Analysis

The use of coding for data analysis resulted in the inclusion of some data items and the exclusion of others. Usually, this was intentional as I selected items which I believed best answered the research questions, thus, my subjective judgements were part of interpretive analysis. However, it is possible that some items were mistakenly omitted or included, mis-coded or, the code boundaries blurred as the analysis progressed, resulting in inconsistent coding (Cohen et al., 2018). To detect such errors, the transcripts were re-read multiple times (Braun & Clarke, 2006). As this was individual, post-graduate research, I did not perform inter-coder checks (Cohen et al., 2018) but had frequent discussions with my supervisors, who brought their experience and perceptions to the data analysis (Shenton, 2004). For instance, their suggestions saw me return to the literature to help redefine the concept of ‘action taking’ within EfS pedagogy. Therefore, my supervisors’ expertise helped ensure a more accurate recording of the teachers’ perceptions and practice, lending credibility to the data analysis (Shenton, 2004).

The deductive approaches taken in this data analysis may also have impacted the research quality. I entered the process with particular questions I wished to answer, and it is possible, as Glaser (1998) points out, that I may have looked specifically for data to answer these questions and fit my preconceived ideas. As a result, I may have seen patterns or relationships where none actually existed (St Pierre & Jackson, 2014) or discounted data which seemed to not fit. To help increase trustworthiness, the teachers were emailed a short description of how I intended to report on their teaching, providing the opportunity to confirm my interpretations and suggest amendments (Shenton, 2004).

3.9 Chapter Summary

Chapter Three has covered the overall research design, including the interpretative framework which guided this process. Five teachers were purposefully selected to explore their conceptualisation of sustainability and its integration into science education. Semi-structured interviews were identified as a suitable tool to collect this

qualitative data, and the development of the interview questions has been described. Using a deductive, thematic analysis, the participants interview transcripts were coded and the coded items then grouped by common themes to construct my interpretation of sustainability with science education. Key ethical issues relating to this research were covered and the chapter concluded with a discussion on quality issues pertinent to this thesis research method.

CHAPTER 4 – FINDINGS

4.1 Introduction

Chapter Three outlined the research methodology which guided this project. Data were collected from five teachers via two semi-structured interviews each and were analysed using a thematic analysis approach. Chapter Four presents the findings from these interviews and covers five main themes; the teachers' understanding of sustainability, their understanding of sustainability education, examples of their sustainability-related teaching, the benefits they believe students receive, and the challenges encountered when incorporating sustainability into their courses.

4.2 Teachers' Understanding of Sustainability

Research suggests teachers have a narrow view of sustainability, focusing primarily on the environment and missing the broader socio-cultural and economic dimensions (Birdsall, 2014; Evans et al., 2012). Given sustainability understanding could influence its integration into the curriculum, this section reports the different ways these teachers described sustainability. Of note, the data showed that sustainability meant different things to different people. However, clear themes emerged: that the teachers primarily discussed sustainability in terms of the natural environment; that, to varying degrees, they appreciated that sustainability involved the interconnectedness of systems; and that some teachers see sustainability as a philosophy or viewpoint.

4.2.1 Future Preservation of the Environment

Some teachers in this study conceptualised sustainability in terms of managing the Earth's resources. Andrew commented that many resources are finite and emphasised the need for careful recycling to avoid exhausting supply. Heather and Ben went further, linking resource use to environmental impact. For instance, Heather described sustainability as "approaching the use of resources in such a way as not to deplete them, not to cause damage to Mother Earth, to the ecosystems, to the environment." Ben added that sustainability involved "utilising resources in a meaningful way that would not have a negative impact on the environment or ourselves." These comments

highlight differences in how teachers view resource use: Andrew saw it as acceptable if resources are preserved, while Ben adopted a stricter view, prioritising the complete avoidance of negative impacts. This range of perspectives suggests that sustainability is interpreted along a spectrum, which may influence how it is taught in the classroom.

The teachers also appreciated sustainability's temporal component (Birdsall, 2014) and that the environment and Earth's resources should be preserved beyond their own lifetimes. Ben was clear that sustainability involved "preserving the environment for future generations, and the stakes they have within their land" and Andrew highlighted that "the resources we have are kind of finite, if we don't take care of recycling them that will be the last of the supply". These comments suggest the teachers have developing understandings of sustainability, considering the concept beyond its immediate environmental and ecological links.

4.2.2 Sustainability Comprising Multiple Systems

Sustainability is often seen to comprise interconnected dimensions: economic, environmental, social and cultural (Eilks, 2015; Sterling, 2001; Tilbury, 1995). Like other research findings (Basheer et al., 2022; Birdsall, 2014; Burmeister & Eilks, 2013a), the teachers in this study primarily focused on the environmental dimension and did not explicitly mention the other dimensions in their definitions. However, it was clear they recognised the role of humans within sustainable systems. Harry emphasised that "we have to somehow leave the world no worse than we found it. We have a responsibility to not trash the place and leave it a mess", while Andrew noted "during human's time on the planet, we've got good at finding resources and quickly consuming them, we're coming to realise they are quickly being used up and creating other implications". Both Harry and Andrew noted humanity's potential to adversely impact the environment rather than passively be impacted, showing they believed people held responsibility for their actions, indicating an appreciation of the social component of sustainability.

Sustainability-related issues are complex, comprising interconnected systems, and two teachers, Ben and Andrew, explicitly identified sustainability's systemic nature. Andrew believed that sustainability was "about understanding a system's approach; when we use a resource in one way, it can have an impact on other systems or other

parts of a system down the track”. Ben discussed the multi-systemic nature of sustainability at length, mentioning the idea and returning to it throughout the interview:

I think the idea of sustainability is interesting in the sense that it’s multi-layered. There’s different levels to sustainability and sometimes when we talk about it, we are only looking at a snapshot of a given moment and that might not give us the full context.

He followed this with:

Understanding sustainability, is understanding what the complex issue is, and it really takes time to tease out what that system looks like and then think about solutions that could impact that system.

An appreciation of the systemic nature of sustainability may lead to teachers designing curricula that connects multiple ideas, providing students with a broader understanding of complex material.

Though the teachers did not explicitly reference the three-pillar model of sustainability, social dimensions were discussed and two mentioned a systems approach. Lesson examples, discussed in Section 4.5, provide further evidence that these teachers had greater awareness of social, cultural, and economic dimensions than indicated by their sustainability definitions.

4.2.3 Sustainability as a Worldview

Aligning with themes identified in the literature (Marinova & McGrath, 2004; Ministry of Education, 2023; Tilbury, 1995), three teachers conceptualised sustainability not as a topic or standalone entity but as a lens, worldview or approach to how they could view both science education and life in general. Sarah conceptualised sustainability as “a part of science as opposed to something that sits alongside science” and as “a lens through which science can be taught”. She felt sustainability was more akin to a key competency, rather than a subject area, stating that “part of being a good person is thinking about sustainability”, indicating she saw values and attitudes as sustainability

components. Harry also contributed, revealing an intricate understanding of the philosophical nature of sustainability:

Sustainability sort of underpins what we're doing. So, it's not its own thing, it's sort of a foundation,....it's sort of like the philosophy behind it if you like. It's more a way of thinking is how I sort of see it.

Two teachers built on the idea of sustainability as a worldview, discussing human's place in world. Both Heather and Sarah stressed that humans must see themselves as part of the natural world, not separate to or above, with Sarah stating,

We should be thinking of the world around us as not something that is there for us, just for our resource and our purpose, but actually something we're part of and so we need to treat all the things within it in a mindful and careful way.

Heather elaborated, introducing the importance of indigenous ideas and worldviews:

There is a tendency for humankind to think they stand above the environment. In the modern Western one [worldview], it's a kind of a pyramid effect with all the layers of nature underneath and then man on the top. Whereas I like the indigenous worldview more because it's like a circle. We're just part of that circumference. We're not in the middle of the circle, if you see what I mean, we are a part, and I believe indigenous people have it right. We are part of, not above and on top of, so we are part of that ecosystem and that world interconnectedness. If we destroy or damage, shall I say the circumference of the circle, then we've destroyed our own future prospects as well.

Though she did not specifically mention sustainability dimensions, Heather saw sustainability as having interconnected components with a strong cultural dimension. She was aware that different cultures may hold different views on sustainability and saw this as relevant:

I think sustainability might be a little bit more than just, on the physical and material plane, sustainability might also have a spiritual aspect to it as well. That's where we are looking at indigenous knowledge systems, they have a lot of value in terms of sustainable use of resources.

Three teachers offered more detailed descriptions of sustainability as a worldview and mentioned the importance of values. As such, the values component of sustainability was selected for further discussion in the second interview, and this is reported in Section 4.6.

4.2.4 Section Summary

Teachers in this study had diverse conceptualisations of sustainability. Some viewed it in terms of resource preservation while others emphasised responsible resource management and recycling. The temporal component was noted, and the need to safeguard environmental resources for future generations. Some teachers also recognised sustainability's systemic nature and the role of human actions. Several teachers viewed sustainability not as a standalone topic but as a worldview or lens through which science and life should be approached. This perspective, informed in part by indigenous worldviews, emphasised values, interconnectedness, and the role of humans as part of the natural world. These diverse interpretations likely influenced how teachers incorporated sustainability into their teaching.

4.3 Sustainability Education

Education for Sustainability (EfS) encompasses the practices and strategies educators use to integrate sustainability into the curriculum (Tilbury, 1995). As previous research suggests teachers may not recognise or may misinterpret the term 'Education for Sustainability' (Evans et al., 2012; Prabawa-Sear & Dow, 2018), it was avoided during interviews. Instead, teachers were asked how sustainability fitted into education. As in Evans et al.'s (2023) study of Australian, Canadian and Scottish teachers, these New Zealand teachers spoke of both sustainability and sustainability-teaching interchangeably, often moving between the two without clearly distinguishing them. While no teacher used the phrase 'Education for Sustainability', they did describe methods aligning with EfS. Other EfS approaches were evident in their lessons descriptions but not explicitly noted as part of sustainability teaching, so are explored later in Section 4.5. Components such as interdisciplinary teaching, action-taking, and

raising awareness were explicitly acknowledged as central to sustainability-focused teaching and are discussed in this section.

4.3.1 Interdisciplinary Approaches in Sustainability Education

While only two teachers specifically touched on a systems view when defining sustainability, all indicated sustainability education spanned subject areas and contexts. The teachers realised that effective sustainability teaching blended content areas, but each teacher had slightly different visions of how this looked in practice. Sarah saw greater need to connect the topics covered within senior chemistry explaining,

Batteries fits so nicely with oxidation reduction, but we don't really look at batteries or how they're manufactured or what happens with the waste or where that comes from or what effect that has on soils. But we could do that, and we could look then at soils, fit it into the aqueous systems, then we're mining and there's acids in the soils and so that changes what's precipitating.

Her example demonstrates how material from separate topics, Redox and Aqueous Solutions, could be synthesised and contextualised with a clear environmental sustainability theme. Moving beyond one science subject, Harry had introduced a new Year 11 course, "Sustainability and Science", explaining that it purposefully looked to blur the line between Chemistry, Physics and Biology to achieve a more holistic approach. He stayed within the science learning area but saw potential for greater overlap between the sciences.

Three teachers extended into curriculum areas outside science. Ben and Heather both noted the problem "subject silos" posed to incorporating sustainability, with Ben adding that it was the connections between the silos that were important. Heather also spoke extensively, observing,

Sustainability is not within one box, so it's not siloed, it's across the subjects. I don't think you can ever track, a sustainability thread shall I call it, all the way back to its roots, through just one subject.

Despite having no preparation time, Heather supported her statement with multiple examples of how a "sustainability thread" could span curriculum areas. She described how sustainable fabrics, such as bamboo, could be studied in Fabric Technology, linked to botany in Biology, and further explored through comparisons with synthetic fibres and even the extraction of oil as a raw material, connecting Chemistry. She concluded by noting,

And I haven't even thought about this really, it just popped into my head. The fact that it popped in so quickly tells me there'd be a lot more places as well where it could be done.

The fact that Heather's bamboo fabric example came from outside her specialist subject area of Physics—and how quickly she connected it to other school subjects — suggests a well-developed understanding of the cross-curricular nature of sustainability and how it could be effectively implemented in teaching.

Sarah's school had introduced a cross-curricular teaching programme for Year 9 students in 2025, aiming to embed Mātauranga Māori and connect learning across subjects. They used local mana whenua migration and settlement of Aotearoa to contextualise their Year 9 curriculum, with a similar approach continuing into Year 10. Year 9 focuses on what knowledge is needed to establish a new settlement, while Year 10 considers how to make that settlement sustainable. The Year 10 theme of "action-taking" encourages students to "ask questions about the world around us and what does that mean in terms of the choices we make in living as good humans in this world." This integrated, culturally grounded approach, with action-taking elements reflects a meaningful application of EfS principles. Additionally, Sarah was the only teacher to move beyond secondary school, noting sustainability had a place in all education, from kindergarten through high school, further reflecting an understanding of the cross-curricular and holistic aspect of EfS.

4.3.2 Raising Student Awareness

Raising awareness of issues is one component of EfS (UNESCO, 2020; Mulà & Tilbury, 2025) and all five teachers identified it as a feature of their sustainability-focussed teaching. However, they often extended the idea beyond merely learning about an

issue. On multiple occasions Harry discussed “awareness” in a more direct sense - as simply noticing the world – and many of his examples reflected his belief that teaching sustainability involves raising personal, immediate awareness. He explained “it’s important we understand what’s around us, because noticing things is the first step to actually wanting to look after them.” When it was pointed out to Harry that “noticing” was apparent in his lessons, he replied, “Yes, that’s what I’m trying, to try to get them to just start to notice.” From these statements it is evident, Harry purposefully plans opportunities for students to connect with the world around them in his teaching practice.

For some teachers, raising awareness was inextricably linked to other core components of EfS, such as locally focused teaching and the consideration of differing perspectives. For instance, Ben felt that his sustainability-focused teaching was an “effective way to connect it to our own local context, to see what is actually available in our own backyards”. Heather also emphasised the local aspect, explaining that one purpose of her Year 11 sustainability unit was to raise awareness of issues relevant to the community:

This unit wasn’t Uni [university preparation] focused, it was community focused. So they [the students] know when they go work in that mine what damage was done and how the mine is trying to remediate it. They’re aware of their employers standing with the local iwi. Its all just community connected.

Her approach highlighted not only the environmental impacts of the mining issue and the associated science concepts but also the differing opinions within the community and how they had motivated action. Her comments, along with similar examples from other teachers, suggest a shared understanding that sustainability education extends beyond identifying problems to include raising awareness of the broader, interconnected social, scientific, and ethical dimensions involved.

4.3.3 Action Taking within Sustainability Education

Efs aims to empower students to act individually and collectively to bring about change (Jensen, 2000; Sass et al., 2020; Soll, 2019). Both Andrew and Sarah felt sustainability

education should be solutions-focused. Andrew stated that teaching sustainability should prompt students to ask:

Why is this an issue in the first place? And then what could be some possible social actions that you could do to facilitate change. Ultimately, we need people to take action, to kind of get us out, well to manage the situation.

Sarah also mentioned action taking, seeing it as an important progression beyond teaching isolated science content:

Instead of this is the chemistry of it, or the science of it, but actually doing it through that lens of taking action or what can we do about it, or why does it matter? That's when learning becomes beneficial from a sustainability point of view and empowers students to think.

Two teachers mentioned action-taking outside the context of their lesson descriptions, suggesting they associate this component with sustainability-focused teaching and explicitly realise its value for students.

4.3.4 Section Summary

Across the five teachers, sustainability education was viewed as cross-curricular, focused on raising awareness, and including opportunities for action-taking, though not every teacher highlighted all three components. These educators broadened awareness beyond just issues to encompass one's immediate environment and diverse perspectives. Action-taking, despite often being challenging to implement (Owens, 2008), was explicitly deemed essential by two teachers, adding a solution-focused dimension to problem-solving.

4.4 Teaching Examples of Sustainability in Science Education

This section describes examples of lessons and units that the teachers believe demonstrate the incorporation of sustainability into their science curriculum. These units have been grouped into three sections: NCEA Level One Science (Year 11), senior science subjects (Years 12-13), and junior science (Years 9-10). Each section includes

an overview of the lesson or unit and a discussion of how elements of Education for Sustainability (EfS) integrate to help enhance Scientific Literacy (SL). In most cases—unless otherwise noted—the identification of EfS or SL components was inferred by me during data analysis.

4.4.1 NCEA Level One Science

New NCEA Level One Science achievement standards were introduced in 2024. The following examples have been selected to demonstrate how three teachers interpreted the specification for AS91920, “Demonstrate a Science Informed Response to a Local Issue”, and translated this into a unit of work. Each unit demonstrates how beginning with a real-world sustainability issue can support the teaching of science content, the development of SL and, in addition, potentially promote future-oriented action-taking advocated by EfS approaches.

4.4.1.1 Heather: Controversy of Local Mining

Heather’s term-long unit focused on the impact of a local mining operation on the water quality and eco-systems in a local river. Relevant science content, scientific practices, the perspectives of local iwi and community members, together with remediation strategies to minimise environmental impacts, were included in the unit. Heather summarised “this unit aimed to create an awareness and link through to their [the students’] community”.

This unit integrated chemistry and biology concepts, exploring open cast mining and the oxidation of iron pyrite resulting in acid mine drainage in a local river. Students assessed river health using whitebait distribution, density and diversity. They studied the impact of acid mine drainage on the life processes of reproduction and gas exchange, learning about skeletal malformations in developing whitebait larvae and structural changes to fish gills. Chemistry concepts, including acid-base and precipitation reactions, were covered as the students examined the mine’s initial remediation process of “limestone dosing” to neutralise the acid. In addition, the students learnt about the workings of sumps, installed by the mine to address

precipitation in the river. The unit's varied science content enhanced student understanding of the environmental issue.

Beyond science content, the learning activities also developed Nature of Science capabilities. Students analysed real-world scientific data, such as whitebait hatching rates and river pH, engaging with authentic scientific practices. The mine trip provided education outside the classroom and the chance to see real-time data generation as mine staff monitored river quality and took action when needed. Hands-on learning via a fish head dissection and building of a model sump occurred, additionally integrating technology. By reading and watching media footage, students considered multiple perspectives from local iwi, community activists and mine owners, weighing these against environmental impacts to write informed responses. This locally relevant topic enhanced scientific literacy with a clear sustainability theme by requiring application of science ideas in everyday situations and engagement with scientific practices.

Heather's unit has also used an approach which may empower students to take action towards a more sustainable future. This topic raised awareness of a relevant issue, a key component in EfS, as the whitebait industry is of socio-cultural and economic significance to the town. As Heather shared;

There is so much to this sustainability story, because this town depends upon, like this is the White Bait Town, so economically as well, and for jobs.

As part of their learning, the students saw how community action raised awareness, prompting the mine to remedy the situation. This learning highlighted how action could bring about change and that science and technology could offer solutions to problems. Students learned this was not a story of "doom and gloom" and that knowledge gained could enable them be the next generation of "action takers". As Heather explained, many students have ties to the mine, or related jobs, and have whānau who are white-baiters. Having seen the poor opinion of the mine held by the public and the impact on fish and whitebait may help ensure similar situations do not arise in the future.

4.4.1.2 Sarah: Water Management in a Large City

Sustainable water practices in a large city were the focus of Sarahs' Level One assessment. The unit focused on the management of healthy drinking water, including studying where water comes from and how it impacts ecosystems. The context was problematised using the current water shortage issue facing this city. The students compared a Te ao Māori point of view with a Western science perspective regarding making water healthy for human consumption and then considered how water could be recycled to be used again.

In terms of science, chemistry, biology and some geology, helped deepen student understanding of water catchment and treatment practices in a large New Zealand city. Students studied the water cycle and related ecosystems at two points in time - before and after the building of a dam. The students discovered how dams were built, the reasons for building dams, and the process involved in transporting and treating water for consumption. Through this water analysis, particle chemistry as well as microbial teachings were introduced. In addition, the students compared this method of obtaining and using rainwater to that of transporting and treating water brought in from a river outside their region.

The rich, varied learning activities, clearly incorporated elements of EfS and enhanced scientific literacy, leveraging a local context. As Sarah explained,

The ranges are literally on our back doorstep. So, it's perfect for us to be able to be there or at least people know what it is and so it's good for connections as well.

Students visited the dam, observing the impact humans had had on the landscape. A constructed-but-never-filled dam was also present, enabling students to imagine the effect filling this dam would have today, thus connecting with the social and temporal dimensions of sustainability. This activity also connected to the focus issue of water shortages and decision-making regarding possible solutions; invest in water recycling technologies or bring water in from outside the region?

To make decisions regarding this problem, students engaged in data analysis and considered multiple perspectives and sources of knowledge. They compared two water sourcing methods, considering the energy costs of transporting water and the additional treatments needed. These tasks added an economic dimension, a sustainability pillar important in decision making (Tilbury, 1995), while data analysis may help develop scientific literacy. Furthermore, a cultural Te ao Māori perspective was introduced, with students learning about different types of water and how obtaining *wai-ora* (clean water) might require restoration of the water's *mauri* or "lifeforce." Sarah's unit intertwined environmental, socio-cultural and economic dimensions, using scientific data to enable students to make informed decisions.

4.4.1.3 Ben: Impact of Climate Change on Ecosystems

Climate change provided the overarching context for Ben's year-long NCEA Level One course and roughly each term corresponded to one of the three sciences. His NCEA assessment focused on healthy waterways, incorporating biology, ecology and physics ideas. The students had some flexibility in topic choice, for instance some looked at climate effects on tuna migration while others focused on algal bloom, water quality and ecosystems. As per the standard requirement, the students considered multiple perspectives and used data to support their assessed response.

Content-wise, the carbon cycle, combustion, greenhouse gases and the nitrogen cycle were covered. Their impacts on either tuna migration, or the development of algal blooms were explored as was the impact of introduced species such as *Caulerpa* on water quality and biodiversity. Ben's contextual and integrated approach allowed for the introduction of physics; water clarity was assessed using light tubes and wave principles were covered. Physics formulae were used to calculate the distance of light penetration beneath the *Caulerpa* and algae demonstrating how science ideas can be integrated to support understanding of climate change and water systems

Ben collaborated with an outside provider to offer his students varied, hands-on learning experiences. Students spent a day with local iwi learning water sampling techniques. Ben explained,

They themselves [local iwi] were learning the techniques so that they could be effective citizen scientists. And so, they were then sharing that knowledge with the kids.

Ben emphasised the importance of hearing “a local iwi voice”, and of the “interplay between these ideas and science” to help make informed decisions. This experience enhanced scientific literacy development and met EfS principles by combining scientific processes, such as data collection, with socio-cultural perspectives, to support informed decision making.

Other effective strategies supported sustainability and science learning. Ben’s students constructed mind maps throughout the year, connecting science concepts to climate change to develop systems thinking. Ben expressed a desire to “enhance students’ cognitive engagement”, and selected this visually impactful tool because,

The kids start to form this idea of this picture, of this jigsaw kind of thing starting to come together, seeing how the systems are interacting. And once they have that really solid idea of what those connections look like in their head, then we can start moving to the next stage, which is addressing some of the issues in terms of how do we come up with sustainable solutions?

Mind-mapping scaffolded the synthesis of multiple information sources and conflicting opinions preparing the students to make informed decisions and develop sustainable solutions.

Spoken word poems were another effective teaching activity, showing the potential for future action-taking. Assisted by an outside provider, students turned their informed responses into a poem focusing on “why should people get involved, want to take care of the environment and create a sustainable ecosystem”. The activity provided a different assessment mode and integrated English to strengthen literacy. Ben felt the activity was “really cool, we had some good writers” and had time not been a barrier, he envisioned the students could “present it at assembly and talk about the ideas on what they’ve learned or even have a small showcase somewhere”. Such presentations would

enable the students to take indirect action by raising awareness of local issues in their community, potentially driving others towards more sustainable future behaviour.

4.4.1.4 Mātauranga Māori in NCEA Level One Science

The three NCEA Level One examples demonstrated ways mātauranga Māori could be incorporated into the science curriculum. Aligned with the Achievement Standard, each unit required students to consider local iwi perspectives and incorporate them into their response. Integrating Mātauranga Māori also introduced concepts closely tied to environmental sustainability. For example, Sarah’s unit explored healthy water and the restoration of mauri, Ben’s discussed *pātaka kai* and customary fishing protocols, and Heather used water systems to introduce *kaitiakitanga* or guardianship. Heather explained:

The traditional worldview of the rivers, it’s not really about exploitation of resources. It was like an ancestor, part of the whakapapa, considered to be a well-beloved ancestor.

Heather’s comments illustrate how a teacher’s conceptual understanding of sustainability— in her case, cautious resource use and high regard for “Mother Earth” (see Section 4.2)—can shape their practice. Integrating indigenous knowledge allowed students to explore the issue through a broader, sustainability-grounded lens than might be offered in a purely Western science framework.

Integrating mātauranga Māori was also seen as contentious. One teacher noted incorporation of mātauranga Māori was initially viewed as “key” to the new standards, but “pushback” had since occurred. They described debate around recolonising, “by taking Māori concepts and applying them in a non-Māori sort of lens” and feeling that while intentions were well-meaning the consequences had not been thought through. Acknowledgement of *kaitiakitanga*, “in any context of guardianship”, was how they were choosing to assess this component of the standard. This finding indicates integration of indigenous knowledge may not be straight-forward or without controversy and that caution may be required when proceeding in this direction.

4.4.2 Senior Sciences

Bringing sustainability into the senior sciences was seen as a challenge, yet the teachers offered insights into how it could be achieved, albeit in small ways. For Harry, the pressures of exam preparation meant that sustainability at the senior level was often “just various conversations here and there, just trying to spread the awareness”. Sarah saw sustainability as a way to make connections between the senior level content and everyday life, giving the example of mining-related acid run-off and its impact on water systems. However, she explained that there was only time to;

Just touch on it, because I think it’s super interesting, but it was literally, like, a lesson. And not any action taken, not diving deeper.

While these teachers felt they were limited at senior science level, they were able to use sustainability-ideas to raise awareness and link science to relevant, everyday phenomena.

4.4.2.1 Senior Chemistry

Ben provided two examples exemplifying Green Chemistry principles, an approach grounded in sustainability. At NCEA Level Two, he used blue and green ammonia production as alternatives to traditional brown ammonia synthesis to teach AS 91163 “Demonstrate understanding of the chemistry used in the development of a current technology” and introduce a sustainability angle. This topic highlighted the chemical industry-environment relationship - exploring alternative syntheses showed that change was possible, and science can provide solutions. The students also weighed up production processes based on energy consumption, introducing an economic dimension to their decision-making and aligning with EfS. While mainly chemistry-focused, Ben’s work highlights the flexibility and potential within the NCEA standards for the incorporation of EfS.

Electrochemistry offered another avenue for sustainability in the senior chemistry curriculum. When teaching REDOX chemistry, Sarah’s class made charcoal and aluminium batteries, discussing “what goes into a battery, where does it come from”, as well as covering metal mining and resultant acid-runoff. While Sarah stressed this

was just touched on, it shows the potential to link the current chemistry curriculum to environmental issues. Ben also used batteries to incorporate sustainability. Mindful of his departmental budget, he included microscale experiments in petri dishes to teach galvanic cell explaining the experiments opened discussions such as:

getting rid of a smaller volume is so much easier than a large volume of copper, for example, because copper is a toxic metal". And "if we are managing these resources well, then we can use them for longer periods of time.

These approaches covered curriculum content and introduced some Green Chemistry Principles, such as cost consideration, toxicity, and waste and resource management, to potentially broaden students' views on the implication of industrial processes.

4.4.2.2 Senior Physics

At Year 12, Heather's unit on Atomic and Nuclear Physics touched on the environmental dimension of sustainability. As part of their internal achievement standard, students looked at the impact of nuclear fission and the development of cleaner nuclear fusion technology. Heather explained, NCEA Level Two primarily emphasised the atomic physics concepts and the environmental component provided context for further Level Three studies. While constrained by assessment, Heather realized the unit's potential for interdisciplinary learning. When discussing fusion, she identified the need to produce hydrogen, explaining,

So you'll go over to chemistry side because you'll be looking at how to generate vast amounts of hydrogen. There's going to be chemistry in that, then the reactions and the massive industrial complexes you'd need to make the hydrogen for the fusion stations to function. And then you've got the side effects there, the by-products of the chemistry side, so you have to move over to the bio side to see what it's doing to ecosystems.

The knowledge to teach each of Heather's outlined components is likely present in science departments, so the challenge lies with assessment writers and with science

departments to bring different learning components together so students can develop a broader understanding of current issues.

4.4.2.3 Senior Biology

In what he described as a “passion project”, Andrew developed a senior biology unit centred around the restoration of a local lagoon. With the help of scientists, his students collected baseline biodiversity data on mammalian pests, lizards, fish and macroinvertebrates, presenting this in a report to their local council. The data was then used as a reference from which to measure the ongoing impact of the restoration project. Andrew shared his inspiration and vision for the unit:

It’s been one of my long-held drives, students should be able to add scientifically to the science community. They should be able to collect meaningful data that actually helps to make, I guess, informed decisions.

Andrew’s unit incorporates sustainability ideas and pedagogy and seeks to develop scientific literacy. The project raises awareness of a relevant, local, environmental issue, while the collection of useful data and subsequent council report offers the opportunity for students to take meaningful action. In addition, the students worked alongside “scientists in a sustainable field, to understand if that’s a career that they may be interested in”. These experiences can help demonstrate the validity of the scientific process, inspire a future career path and, importantly, develop a sustainable mindset for those who go on to become future scientists.

Of most significance, this unit did not involve an NCEA achievement standard or offer credits. Teachers often comment that students lack motivation for learning that will not be formally assessed, yet as Andrew summed up:

I think the students have really responded to those opportunities, to engage in those types of learnings because they’ve picked biology for example, because they’re passionate about it, not just to get the credits.

To have students highly engaged in a non-assessable task is noteworthy and Andrew’s example offers initial but compelling support for the relevance of

sustainability education in the senior sciences. Its inclusion at this level is likely to target genuinely interested students with a comprehensive understanding of science concepts enabling them to deeply reflect on and understand the complexities of pressing issues.

4.4.3 Junior Science

In addition to their senior science lessons, the teachers also shared many varied and worthwhile examples of sustainability at Year Nine and Ten levels. Units which took steps to raise awareness of local issues, involved problem solving, laid foundations for action taking or incorporated sustainability into assessment were shared.

4.5.3.1 Harry: Igniting Interest in the Local Environment

Year 9s at Harry's school spend a term studying an integrated biology and chemistry unit, focused on the local river. They cover content such as food webs, biodiversity and adaptations as well as basic particle theory, mixtures, solutions and separation techniques. To bring in sustainability, the students learn of the adverse effects local industry has had on the quality of the river water and the subsequent remediation. Students visit the river and carry out their own water testing analysis.

In Harry's view, this topic and learning activity has multiple benefits for students. He believed that "students going outside and actually gaining an appreciation for the environment" sparks an interest to care for the world, aligning with Sandell and Ohman (2010) who believe exposure to the natural environment is important for students to develop an emotional attachment to it. Real time data collection was seen as powerful showing remediation is working to "encourage the kids that we actually can reverse things". Harry felt instilling in students "hope that, if we make an effort, we can actually make a change", was important and is a theme which resonates through the literature (Gardiner & Rieckmann, 2015; Hicks, 2014). Integrating chemistry and biology content was seen as a way to enhance engagement:

spark their [student] interest much more than just looking at water chemistry if they suddenly see there's bugs in there or even better, fish, it just suddenly

makes them go, oh this is important, there's things alive in here and it is worth looking after.

Assessing sustainability is often seen as a challenge (Cebrian et al., 2025) but Harry found one way to achieve this. Maintaining the local focus, he tasked students with investigating whether a proposed eco-sanctuary provided the right conditions for a potential animal inhabitant to thrive. The students wrote reports “weighing up the pros and cons and other alternatives, so trying to do some critical thinking”, providing opportunities to synthesise information and make informed decisions. Moreover, in ‘real life’, the proposed ecosanctuary faced delays due to funding and Harry hoped his science activity might raise awareness, regenerating interest in the project. Whether fully realised in this series of lessons, Harry’s unit also begins to show how the economic dimension could have been interwoven, further strengthening the teaching of sustainability.

4.5.3.2 Andrew: Sustainability across Contexts

Andrew described sustainability as using Earth’s resources sustainably, a view that influenced his Year 9 ecology units. In one unit, the students visited two local habitats, one native forest and the other exotic plantings, with the aim of “deepening their [student] understanding around what it takes to, I guess, understand ecological systems” and how different habitats can be managed and conserved. Like Harry, Andrew brought sustainability into the assessment which involved researching why a native organism was “taonga to Māori” and designing posters to be ‘displayed’ at the airport to,

remind tourists that they are in a different country that might have different values around conservation and we’ve got really special things here that we need to conserve.

Andrew’s task demonstrates how a sustainability lens may bring socio-cultural knowledge and perspectives into science lessons and, within the relevant context of tourism, highlight ways students can potentially take action.

In another unit with a sustainable resource management focus, students investigated the environmental impact of producing a meat burger patty versus a plant-based one. For assessment, students chose a real-world issue relating to food production or consumption, used scientific evidence to describe how the issue arose and discussed the impact on people. Students proposed a “social action that could be taken to facilitate change”. These tasks required students to substantiate claims with scientific evidence, a key component of scientific literacy education (OECD, 2024). Researching the cause and effect of issues was also seen as important. As Andrew said, “it is easy to blame China, these countries with big populations, for the polluting” but students need to see “where themselves, whanau and the community fit into the problem”, as it is from here “they can think about the actions that they can make, either personally or engaging with others” to bring about change.

Andrew also wove a sustainability thread into an Earth and Space unit. Using an overarching theme of “survivability”, forces, space and microbes were covered. In researching space travel, habitability and the colonisation of Mars, Andrew hoped students would “understand how difficult it’s going to be to inhabit a new planet” and this would “create that appreciation of the current planet we live in” and the need to “preserve what we’ve got here”. Andrew has demonstrated a way to use sustainability ideas to provide a different and thought-provoking context to a predominantly Physics-based unit.

In a similar approach to Coutts, York and Mower (2022) Andrew also adapted STEM activities to include a sustainability element. For activities such as ‘the tallest tower challenge’, “bonus points were awarded at the end if they [students] were able to return the materials in a reusable state”. He made changes to “decrease our plastic footprint that we have within our school, our department budget”. Andrew’s take on these challenges required explicit consideration of sustainability by the students, requiring them to make choices over the value of recyclability to their overall challenge goal.

4.5.3.3 Ben: A Systems Approach

Ben's teaching was influenced by his conception of sustainability, where he saw it as "multilayered" and consisting of many "complex systems". Using kina (sea urchin) barrens as a context, Ben explained that on the surface it was an easy way to start sustainability discussion; "there's too much kina and not enough seaweed, right, creating the kina barrens". But this local, relevant issue also allowed for students to begin "delving deeper into the complex systems" and see the cyclical nature of the processes. Ben's students harvested kina for human consumption but also learnt how this action in turn "helped support the regrowth of the reefs". To continue the process, the students then turned the kina shells into fertilisers, used to grow and supply vegetables for the school.

The kina barren lessons, in Ben's view, provided an opportunity for teachers to "connect ideas of sustainability to that cyclical process". The chosen activities demonstrated cause and effect of human behaviour and provided an opportunity for students to take action towards a local problem. There was scope to blend science content from different areas, including ecology, botany and fertiliser chemistry. Furthermore, harvesting and eating kina is a practice common in Ben's predominantly Māori school community and he felt the students "loved it because some of it is cultural knowledge for them" and they could apply their own socio-cultural-based knowledge "within their school context".

4.4.4 Section Summary

This section presented examples of how teachers integrate sustainability into their science curriculum, covering NCEA Level One, senior science, and junior science. At NCEA Level One, teachers used real-world, local issues like mining, sustainable water practices, and climate change to frame their units, meeting assessment aims while embedding sustainability through the integration of science concepts, multiple perspectives, and mātauranga Māori. Senior science examples, while more constrained, still demonstrated a sustainability focus, such as applying Green Chemistry principles, discussing the environmental impact of nuclear fission, and enabling students to take action by collecting meaningful data for a council report. At

the junior level, sustainability was incorporated through field trips, data collection, and project-based learning activities.

4.5 Benefits of Sustainability – A Science Teacher’s Perspective

The literature reports numerous benefits of Education for Sustainability (EfS) for students (see Chapter Two). These teachers were asked about both the perceived benefits of their sustainability-focused teaching and how it could enhance science education goals. While asked separately, the teachers did not differentiate, seeing these benefits as interconnected. For example, Heather described sustainability as a way to make science relevant, jumping to the enhancement of science education aspect. To provide context, this section first reports what these teachers believed to be the purpose of science education before moving to describe the benefits of EfS and its support for science education collectively.

4.5.1 The Purpose of Science Education

These teachers emphasised the development of scientific literacy, contrasting other studies which suggest teachers prioritise science content (Brommesson et al., 2025; Stouthart et al., 2025). The teachers all expressed a desire for students to use science knowledge to understand the world, participate in science-related discourse and make evidence-based decisions, aligning with the first OECD scientific literacy descriptor (see section 2.1). For informed decision-making, the teachers offered varied reasons. Sarah stressed students become critical of information, seeing this as crucial for “democratically capable citizen[s]”. Andrew also raised the idea of a democratic society, believing students should understand the decisions of others, such as politicians, as these would impact them throughout their lives. Heather focused on combatting misinformation, explaining science education can help students “read, understand and assess information that is out there”. Collectively, the teachers believed that a strong foundation in science could help students to critically evaluate information and navigate complex global challenges.

Another scientific literacy component, that of appreciating the role science and technology can play in shaping our environment, was covered by Ben. He stated:

Scientific solutions have huge impacts, they impact on daily life. It's really important that [students] understand what those impacts are going to be so that they can make the best decisions for themselves and be well equipped to be able to handle the big changes that happen through technology and innovation and science.

Ben delved deeper, explaining “science education needs to bridge the connection between the science, the scientists and everyday people to make these processes more transparent”. Not only did he mention links between science and innovation, echoing Gluckman’s (2011) vision for New Zealand science education, he emphasised the importance of understanding the process by which scientific knowledge is generated, suggesting he ascribes to a more progressive model of scientific literacy.

4.5.2 Sustainability - Benefits for Students and Science Education

Developing scientific literacy (SL) was these teachers’ overarching goal for science education, and this view provided a base to explore the ways they believed sustainability could enhance it. While increasing student engagement was the main rationale for each teacher’s sustainability-focused lessons, they had different ideas on how sustainability could enhance engagement. In addition, they described varied benefits for students, reported in further detail.

Locally relevant contexts and hands-on, experiential activities, both strategies advocated by EfS and SL frameworks, were seen as ways to increase student engagement. The teachers believed activities, such as field-trips, sparked interest and captured student attention, while the inclusion of local, community-focused topics made the learning relevant and meaningful to students. Harry noted “students really like going outside, even on skody days” echoing literature which indicates students do like learning out in nature (Ballantyne, Fien, & Packer, 2001; Gough & Sharpley, 2005). Thus, particular components of EfS are seen by teachers as tools to increase student engagement.

Andrew, Sarah and Ben went further, seeing sustainability teaching as a way to contextualise science, making it not only engaging but also relevant to students' lives. Andrew outlined,

Sustainability can enhance those branches of science, they [students] can see how those theories can be applied in the real-world context. I guess it's a meaningful context to apply so much of the science that underpins it.

Sarah agreed, believing that if science were taught through a "lens of sustainability", it could help students connect science with everyday life. For her, this went further than increasing engagement by giving students a reason "why they should use science". To provide "useful, everyday science" examples was these teachers' goal and is also a key component of SL. Together, these examples highlight how teachers believe a sustainability focus may increase student interest in science topics, both in class and in their wider lives, in turn developing SL.

While the teachers agreed that sustainability-related topics could help make science content relevant, Ben expanded on the notion of relevance. He felt that students today were;

Fully invested in the environment. They're fully invested in equity, in all aspects, and by teaching sustainability in science we're actually showing them how these things are being valued within our society.

Ben suggests that the inclusion of relevant, sustainability-focussed issues, may acknowledge student interests and give them some agency and voice within curriculum development, making the science curriculum more humanistic and accessible.

Moving beyond engagement, some teachers saw a sustainability-focus as a way to develop worthwhile skills and move students towards more sustainable behaviours. Harry felt that education outside the classroom supported connectivity with nature, which might prompt care for one's environment while Ben believed learning in a locally relevant context could prepare students to engage with future, novel experiences:

Learning connected to our local context lets the kids understand more about their backyards and I think if they are invested in their home then they can be invested in broader contexts, globally. Developing that understanding here allows them to then go and connect it in any area that they go to.

Further examples of skill development were provided. Andrew saw a sustainability focus as one which could help provide a context to address misinformation, while Harry saw it as an opportunity to delve into issues that were not clear cut. He felt students could learn to appreciate things are often complicated and there may be validity to both sides of a debate, feeling these attributes were beneficial in preparing students to engage with other information sources throughout life.

Action-taking was noted as a benefit of sustainability-focused education. Andrew believed it fostered a “how can we fix it” mindset, giving students a sense of control and encouraging personal or collective action as students hopefully saw how “social connectedness and working together would be needed to get us out of this [issues facing humankind]”. Sarah felt that “a lens of action-taking could empower students to think that maybe they can make a difference” and reflect on their choices. Harry and Andrew viewed action-taking as a way to negate “doom and gloom”, putting “a positive spin on it [sustainability issues]” so students aren’t “feeling hopeless and giving up”. Coming full circle, Sarah saw it as providing an engaging “why does it matter” dimension to learning, believing, similarly to Harry, it might make students care. These findings suggest how, in the teachers’ opinions, action-taking, especially collective action taking, may enhance science education.

While this study did not collect evidence on actual student engagement or achievement, two teachers offered anecdotal evidence. Harry, mentioned that his separate sustainability-oriented Year 11 science course had higher student engagement than the general Year 11 Science course, providing some tentative evidence to support the teachers’ belief that EfS could make science lessons more engaging. Sarah, having the benefit of having taught the new Level One standard for four years as part of the pilot study, noted that there had been no negative impact on their

Level Two achievement data, suggesting this new sustainability-focused standard prepared students for further science study.

4.5.3 Section Summary

This section examined how teachers perceive the benefits of integrating Education for Sustainability (EfS) into science education. Teachers defined the purpose of science education as fostering scientific literacy and indicated EfS may enhance this goal. They highlighted that a sustainability-focus increases student engagement by using locally relevant contexts and hands-on activities that makes science relevant to students' lives and demonstrates real-world applications. EfS is also seen as a way to develop crucial skills, such as critically evaluating information and appreciating complex issues. Finally, teachers noted that EfS promotes action-taking, which empowers students and provides a sense of control. Anecdotal evidence suggests this approach can lead to higher student engagement without compromising academic achievement.

4.6 Challenges to Incorporating Sustainability

Previous research has identified challenges to incorporating sustainability into school curricula, and this section identifies the specific challenges faced by these New Zealand teachers. Aligning with the literature, these teachers identified time, teacher-related factors, the nature of sustainability education and education policy as core challenges. Data related to these challenges are presented in the following section.

4.6.1 The Challenge of Time

It is, perhaps, inevitable that teachers will identify “lack of time” as a challenge when implementing significant curriculum changes. This study was no exception, and the teachers all spent additional time putting together new units of work. To add to existing research, I asked teachers to identify sustainability components which required the most time to teach, and Education Outside The Classroom (EOTC) and the nature of some activities used to incorporate sustainability emerged as most time-consuming.

EOTC is advocated by EfS scholars as being fundamental for learning in sustainability and teachers spent time incorporating these experiences to ensure they were worthwhile for students. Andrew's lagoon project was part of wider scientific research thus meetings with the participating scientists were required to develop the programme. Ben also described the time required to implement a bespoke course. In using an outside provider for his Year 11 course, he explained that he invested time,

Making sure that the provider I was using was one that was local to our area, so that we could have that local connect to the sustainability issues we were talking about.

He described the local provider as "really awesome. We wanted to make sure that there was that local iwi connection, so they supported us in getting that". Having envisioned an entirely local course, Ben felt that the time invested ensured an authentic learning experience for students. Together these examples highlight what is both a challenge and strength of learning in place; the organisation may be time consuming, but the result can be tailor-made, locally relevant learning experiences for students.

The teachers felt that some EfS-related teaching activities required additional time, compared to the teaching of content alone. The evaluation of multiple information sources, a requirement of the new NCEA level one standard, was identified as particularly time-consuming. Sarah noted that "definitely a lot of time was spent on getting the bigger picture, why it matters and the Te ao Māori part". Heather highlighted a disconnect between the students' current skill level and that which was required:

A lot of time was spent on training them in literacy to be honest, looking at all these different resources, many, many resources. And going through with a fine-tooth comb and picking out what they need. And so that's analytical thinking, and then synthesising it, that's very high-level stuff, and they do not have the skills.

She felt that although these skills were worthwhile developing, the time required in supporting students to reach this level warranted consideration.

Action-taking activities were also identified as requiring extra time. Ben originally envisioned his action poems would be, “presented at assembly or even a small showcase somewhere, but unfortunately because of the time restrictions that we had we weren’t able to do that.” This challenge was echoed by Andrew who said, “that is the part that we seem to struggle with because we do want the kids to take action, but the timings of trying to get there is a lot harder.” These comments indicate that if teachers are to meaningfully incorporate approaches such as action-taking, time will need to be allocated.

While teaching sustainability required additional time, the teachers agreed that trying to teach it at faster could impact the learning’s essence. Ben stated “I think it can be taught in short bits, but I don’t think it can be taught quickly. I think it’s one of those concepts that you have to tease out with the learners”. Andrew added “I guess you can always teach a fundamental, but a fundamental no matter the context, by themselves they don’t actually take meaning.” These comments reveal the teachers’ appreciation that sustainability issues are complex, taking time to explore, and that rushing may reduce the learning to isolated concepts, failing to maximise the full potential.

It was sustainability’s potential to link multiple ideas and provide deeper meaning that teachers felt would be most impacted by hasty teaching. Harry again stressed that sustainability should underpin all learning and couldn’t be rushed, stating “what I’m trying to avoid is the idea that it’s something you just learn for the test and then forget”. Andrew explained that by making links and revisiting ideas “time and time again” students gained a broader understanding. Ben also felt sufficient time was required to fully explore sustainability ideas:

If you were rushing to teach it and not having enough time to really explore the idea, it could have the opposite effect and it could serve as a point of confusion rather than as a point of deeper, meaningful understanding.

The teachers appeared unified in their beliefs that in trying to teach sustainability too quickly the true meanings may be missed, failing to achieve deeper, connected learning which EfS advocates.

4.6.2 The Challenge of Teacher Factors

Challenges relating to teachers were also identified. The teachers in this study believed teacher knowledge of sustainability and its integration, alongside teacher beliefs regarding the place of sustainability in curriculum, posed further challenges.

4.6.2.1 Teacher Knowledge

While the literature often suggests teachers have poor knowledge and understanding of sustainability (Basheer et al., 2022; Birdsall, 2014; Burmeister & Eilks, 2013a), these teachers saw lack of knowledge pertaining more to the integration of sustainability than understanding the concept itself. Heather felt teachers may lack insight into how sustainability connected to various science topics and Ben said support was needed to show teachers “what teaching sustainability across the sciences actually looked like”. Sarah also spoke of integration challenges:

There’s also a lack of really, I guess, clear ideas of how to do it as part of science as opposed to something that sits alongside science. If it was clearer how we can weave it through science, then it would be incorporated more.

Sarah compared the integration of sustainability with that of the Nature of Science, noting how change in the classroom requires effort and without a clear vision, it is easier to stick with the status quo. Thus, developing teachers’ knowledge of EfS practice rather than expanding understanding of sustainability may be required.

Alongside EfS understanding, the value of scientific knowledge, both for teachers and students, as well as local knowledge was highlighted. To effectively link sustainability with science, Andrew believed teachers required a broad baseline understanding spanning the science subjects. He felt some new teachers lacked scientific knowledge

beyond their specialty disciplines, impacting their ability to incorporate sustainability. Additionally, Andrew felt students “needed to have enough understanding of science to understand sustainability”. Harry added that teachers may need time to gain the “local knowledge” required for some units, advocated by both the New Zealand Curriculum and EfS. These observations show that these teachers are aware that effective EfS requires a broad base of knowledge and raise legitimate concerns about the challenges of achieving this.

Teachers shared what they believed to be the impact of teachers lacking sustainability or EfS knowledge. Ben thought it may lead to students misunderstanding sustainability issues and believed, that though time-consuming, background reading and upskilling was essential to make sure “that the information that’s been conveyed is really accurate, because introducing misconceptions could actually have serious ramifications”. Given sustainability issues are complex and often controversial, Ben’s comments suggest in-depth teacher understanding is necessary to prevent the spread of misinformation.

EfS spans the curriculum and the teachers noted that subject knowledge beyond science is required. Heather queried,

It’s not like when we’re trained, we’re taught how to do those interconnections, we’re not all specialists in other subjects. So how can you start to make connections when you don’t know the other context?

To probe further, she was asked about the social, cultural and economic dimensions of sustainability. Heather felt teachers may be reluctant to stray too far from their own specialist area explaining,

It’s not like we’re discouraged from looking at wider ramifications. But the teacher training hasn’t kept up with this, a lot of teachers are older and they’re very, very used to their box.

Her two comments, though subtly different, highlight the need to further explore whether it's a lack of cross-curricular knowledge or a reluctance to step outside science that presents a barrier for sustainability. Either way, the findings suggest that realising the holistic, three-pillared nature of sustainability is challenging for some teachers.

4.6.2.2 Teacher Beliefs - The Place of Sustainability in Science Education

Striking a balance between conceptual science and sustainability, especially at senior level, was a challenge but these educators felt it was not necessarily because teachers prioritised science content. The belief that there was “no time” was pervasive and, as Sarah said, “we're meant to teach the curriculum, but in reality, we're guided [at senior level] by the assessments and our students passing”. Ben added:

We teach a whole bunch of content so that kids can pass exams rather than actually spending time doing some of this meaningful learning like we can do with the juniors.

These comments suggest Sarah and Ben see value in teaching sustainability but may feel constrained by assessment requirements.

In fact, these teachers offered a range of reasons for sustainability's lack of attention in the curriculum. Andrew felt teachers have a “hierarchy of needs” and that sustainability's importance “probably yo-yos. I'd probably suggest it's not the most top for everyday teachers, but I think it's definitely pressing and in the background”. He felt it was not science content or even assessment which took precedence but factors such as classroom management. Heather agreed, but felt it was due to “a lack of preponderance of that concept in the mind, because it wasn't a thing for the older teachers when they were growing up”. The findings suggest that sustainability may not always be a priority for teachers but the reasons for this are varied.

Though not always a reflection of teachers' own views, community perspectives can impact teaching, and educators must be mindful of them. Heather noted that parental opinions influence student's receptiveness to sustainability education, especially when

dealing with controversial issues. She explained that “if a student feels aggrieved, the first place they will go will be to the parents”. At Harry’s school, a new sustainability-focused Level One science course received pushback despite offering a robust progression pathway to Level Two. Students were concerned it was an “easy option” and though it was unclear whether they saw sustainability as “not proper science” or were just nervous because it was new, these comments highlight how student or parental perception may impact teachers’ decisions on whether to include sustainability.

4.6.3 The Challenge of the Nature of Sustainability Education

Together with time and teacher factors, the nature of sustainability education posed challenges for these teachers. EfS advocates for learning with interconnected and cross-curricular approaches and encourages students to consider controversial, value-laden issues. These aspects of sustainability education were highlighted as specific challenges and are outlined in this sub-section.

4.6.3.1 Interconnectivity of Ideas

Teaching the interconnectedness of sustainability ideas was found most challenging by teachers. Ben noted, “On the surface it looks very straightforward, it’s an easy topic to talk about, but as you delve deeper, there’s actually a lot of challenges.” He believed these stemmed from trying to conceptualise such a broad and diverse concept:

until you delve deeper into all the complex systems, the kids don’t really understand the significance of the broader implications of sustainability or the big picture of sustainability. You need to break it apart and scaffold that learning.

He highlights a real challenge for EfS; that unless the multiple contributing elements within the system are covered and understood, the big picture and its ramifications may fail to emerge.

Subject-silo school structures and timetabling were seen as barriers to recognising the interconnectedness of sustainability-related issues. Harry said he'd like to see more links made across the subjects, and Ben contributed "it's how all these different silos connect that I think is a big thing for me". In both interviews, Heather noted compartmentalised subjects posed challenges, saying:

Sustainability, it's not siloed, it's across the subjects. Having these silos is most unhelpful because the students don't realize the very thing I want them to realise, which is the interconnectedness of everything.

Her comments build on those of Ben's; that when studying an issue comprising multiple systems, the elements do not fit neatly into boxes. The practicalities of how to teach a sustainability unit which spans the curriculum within current school structures is a challenge these teachers grapple with.

The teachers exemplified the challenges posed by subject silos. When asked about incorporating the economic side of growing produce, Ben noted other school departments were already exploring sustainable business practices. Similarly, Harry's school's English Department also included an environmentally based Te Awa topic, but daily teaching demands made it difficult to meet with colleagues and discuss curriculum overlap. Ben's comments reflect an adherence to subject-based boundaries, perhaps not wishing to stray into others' teaching territory, while Harry recognised the potential for collaboration but saw school structures as a challenge. These examples demonstrate why a school-wide approach to EfS, as advocated by pedagogy, can be difficult in practice.

4.6.3.2 The Teaching of Values in Science

Teachers' perceived subject boundaries not only impact the inclusion of content from outside science but also the incorporation of values and attitudes, integral components of EfS (UNESCO, 2020; Mulà & Tilbury, 2025). In concurrence with this literature, the teachers agreed that values were important in sustainability education. Ben stated "how an individual utilises science is very much based on their moral values" and Sarah felt that people should be driven by values as this was "a higher level of morality". Thus,

these findings suggest the teachers recognise the importance of cultivating values and their place in EfS.

Though some teachers saw values and attitudes as worthy inclusions, they differed in their comfort to do so. Sarah felt very comfortable bringing this component into her teaching, while Ben said, “I’m always kind of apprehensive going into it, but I think it’s an important conversation to have with the learners”. Heather again felt teachers may be reluctant to step “outside their box”, as it required subjective, personal values to be interwoven in a subject not necessarily grounded in that approach. She cautioned:

You could easily go too far and overstep the mark and then you’re moving from bringing values in to more like indoctrination. So, you’ve got to be super careful.

These teachers appreciated that sustainability issues were often controversial (Leveinson & Turner, 2010) and their responses highlighted the diversity in views regarding the place of values in science education (Stouthart et al., 2025).

4.6.4 The Challenge of Education Policy

The New Zealand Curriculum is broad, and teachers have considerable autonomy to design their curriculum (Hood, 2019). Even at senior secondary level there is flexibility to select achievement standards to best meet the needs of learners. Currently, the National Certificate of Educational Achievement (NCEA) is being refreshed, and this thesis has reported teaching examples for one new science achievement standard. Some challenges teachers faced in implementing this standard are outlined next.

Assessment requirements may influence the integration of sustainability. As Heather said:

If you look at all the new achievement standards that are coming out, they’re highly focused on social implications. Not specifically on say economic but then economic is a subset isn’t it of social implications?

Her comments highlight how assessment and policy writers can impact sustainability's incorporation – Heather felt that the new specification directs teachers towards the social component while giving less attention to the economic. She also noted that social factors are included “maybe not on the Achieved level, but certainly on the Merit and Excellence level, that it's coming in more and more.” Her comments suggest that the new standard assigns sustainability dimensions to particular levels of learning, potentially limiting access to sustainability ideas for some students.

The clarity of assessment specification was highlighted as a further concern. While Harry found the teaching of the new NCEA Level One standard ran smoothly, he described the assessment process as “shambolic”. He expressed frustration over the lack of exemplar material and felt that, to a degree, teachers were left to make a “best guess” on how to grade the papers. Harry's experience further highlights the role school Education departments may play in enabling and supporting the integration of sustainability into curricula.

Learner agency is also strongly embedded in the New Zealand Curriculum (Ministry of Education, 2007) and some teachers described units which offered students choice. To foster student agency, Andrew's science department offers a junior unit where students research a food production or consumption issue of their choice. When asked how sustainability dimensions, such as economic factors, were incorporated, Andrew explained,

Some students go down the different pathways, like economic. I guess we are more trying to focus on those social implications, but students have the ability to go down those particular pathways if they want to.

By adopting a student-led approach, only some of Andrew's students engaged with the economic dimension of sustainability. Thus, exploring ways to offer students choice while ensuring a comprehensive coverage of the sustainability issue is needed.

4.6.5 Relationship between these Challenges

Although the challenges to sustainability are presented in separate categories—time, teacher factors, the nature of sustainability and education policy—they are interwoven and interdependent. For instance, upskilling teachers is as much about time as it is about the motivation to teach in new and unfamiliar ways. Similarly, interdisciplinary teaching requires broad knowledge beyond one specialist area and also a school structure that facilitates the approach. The inclusion of action-taking, for instance, is not restricted by just one challenge; teachers note time, assessment demands, and an unfamiliarity with the approach as interconnected issues. Therefore, while these barriers are presented as distinct, they are in reality a simplified view of a myriad of interrelated issues.

4.6.6 Section Summary

New Zealand teachers identified four core challenges to incorporating sustainability: time, teacher-related factors, the nature of sustainability, and education policy. Time was a significant barrier, especially for activities like Education Outside the Classroom, evaluating information sources, and action-taking. Teachers noted that rushing this learning risked compromising its essence and failing to achieve deeper meaning. Teacher factors included a lack of knowledge on how to integrate sustainability rather than of sustainability itself and varied beliefs on its curriculum priority due to assessment pressures. The nature of sustainability presented challenges due to the need for interdisciplinary teaching and navigating value-laden issues. Education policy also posed issues through assessment design and clarity. These challenges are not isolated but are interwoven and interdependent.

4.7 Chapter Summary

This chapter presented findings from interviews with five teachers, exploring their understanding and practice of sustainability's integration into science education. Understanding of sustainability was diverse, though most teachers focused on environmental preservation and natural resource management with some recognising the temporal component of sustainability and the need to preserve resources for future generations. Some teachers moved beyond a simple definition, viewing sustainability

as a "worldview" or "lens" through which to approach science and life in general. The teacher's understanding influenced their teaching approaches, which often aligned with EfS principles. EfS understanding was characterised by interdisciplinary approaches, raising student awareness of local issues, and fostering action-taking. However, the study found that evidence of EfS may come from teaching examples rather than definitions of EfS.

Teaching units were rich and varied. Examples ranged from NCEA Level One units on local mining impacts and sustainable water practices to senior-level discussions on Green Chemistry and junior science units on river ecosystems and conservation posters. These examples demonstrated how teachers could integrate sustainability to contextualise scientific content and develop scientific literacy. Typical teaching strategies required students to consider multiple perspectives, make informed decisions, learn in locally relevant contexts, and collect and analyse real-world scientific data.

Teachers identified several benefits to incorporating sustainability, primarily that it enhances student engagement and contributes to scientific literacy development by making science relevant to students' lives. However, the chapter also reports significant challenges. Finding time to engage in EfS activities such as evaluating information sources, and action-taking, was seen as challenging. Teacher-related factors, such as a lack of knowledge on how to effectively integrate sustainability and differing beliefs on its curriculum priority, also posed barriers. The inherent nature of sustainability itself created challenges, particularly the need for interdisciplinary teaching and navigating value-laden issues. Additionally, policy constraints, such as assessment design and clarity, were mentioned as hindrances. The findings emphasise that these challenges are not isolated but are interwoven and interdependent, creating a web of issues that teachers must navigate to successfully embed sustainability in their courses.

CHAPTER 5 – DISCUSSION

5.1 Introduction

Chapter Five discusses the key themes from the findings in relation to the relevant literature. Firstly, teachers' understanding of sustainability and sustainability education are addressed. Next, examples of the teachers' practice are explored, covering junior, NCEA Level One and senior science. This is followed by a discussion of where teachers see the benefits and challenges of sustainability education to lie. The thesis then concludes, outlining limitations, implications, and further research recommendations.

5.2 Teachers' Understanding of Sustainability

The varying ways the teachers conceptualised sustainability reflects its complex, multifaceted nature and reinforces that sustainability means different things to different people (Evans et al., 2012). Notably, teachers did not always distinguish between sustainability and related pedagogy, as found in other work (Evans et al. 2023; Hobson, 2020) nor did they use the term Education for Sustainability (EfS). This section discusses teachers' conceptualisations of sustainability and their explicit descriptions of sustainability pedagogy.

5.2.1 Teachers' Conceptualisation of Sustainability as a Concept

The findings from the study indicate that teachers hold a range of conceptualisations of sustainability as a concept. These included environmental preservation, resource management, temporality, the systemic nature, sustainability as a worldview, and socio-cultural dimensions.

All participants emphasised environmental preservation and resource management as central to sustainability, consistent with previous findings (Birdsall, 2014; Brignall-Theyer et al., 2009; Burmeister & Eilks, 2013a). However, there was diversity in how strictly they believed resources should be used with views ranging from cautious use to complete avoidance of environmental harm. Research shows that teachers' beliefs about resource use and environmentally responsible behaviours impacts how they

model sustainability in the classroom, thereby shaping students' perceptions of their own resource management responsibility (Hastürk & Çol, 2024; Timm & Barth, 2021). Insights into teachers' views on resources may be valuable to Green Chemistry Education (GCE), as a core principle is sustainable resource use (Anastas & Warner, 1998). Studies like this may identify teachers who may be more open to adopting pedagogical approaches such as GCE.

The teachers also recognised the temporal dimension of sustainability, contrasting other studies (Birdsall, 2014). While my study interviewed experienced secondary school science teachers as opposed to primary trainee teachers, the results suggest a broadening of teachers' understanding of sustainability in the past decade. Although the small sample size limits generalisations, teachers' recognition that sustainability involves consideration of future generations is important as both EfS and Scientific Literacy (SL) have a strong moral component (Valladares, 2021). By highlighting the long-term impacts of present-day actions, teachers may guide students towards realising their ethical responsibilities.

Some teachers displayed an emerging awareness of the systemic nature of sustainability and conceptualised it as a worldview. This perspective is vital for both sustainability and SL as it enables students to synthesise information, make informed decisions and take action (Eilks, 2015; OECD, 2024; Taylor et al., 2003). This understanding may help teachers move beyond an overfocus on discipline-specific content (Osborne & Allchin, 2024; Westwell & Panizzon, 2012) and teach in ways that help students understand the complexity of real-world issues. Understanding sustainability as a worldview or lens, contrasts other work which often finds teachers view it as a discrete topic (Majid et al., 2023). Viewing sustainability as a worldview or a measure of what it means to be a good person—as described by some teachers—can position educators to explore the connections between science and society through a moral lens, a shift closer to Vision III of SL, which emphasises critical thinking and informed, socially responsible action (Valladares, 2021).

Embedding sustainability into science education may help it become more culturally relevant (Zidny et al., 2020) and one teacher referenced indigenous knowledge systems, using phrases such as “Mother Earth’ in her description of sustainability. The current New Zealand science curriculum refresh strengthens the integration of mātauranga Māori (indigenous knowledge) (Ministry of Education, 2023) and these findings suggest that teachers who already hold views accepting of different knowledge systems may be well-placed to adapt to these curriculum changes.

The study also identified some gaps in the teachers’ understanding of sustainability, echoing previous studies (Birdsall, 2014; Brommesson et al., 2025). EfS explicitly acknowledges the interconnectedness of social, economic, cultural, and environmental systems (Sterling, 2001; Tilbury, 1995) and while some teachers recognised human responsibility, their conceptualisation of the social dimension was less developed, and the economic dimension was absent from their sustainability definitions. These findings support Brommesson et al.’s (2025) assertion that the economic perspective remains the weakest link in realising the holistic nature of sustainability education. The imbalanced understanding of the sustainability dimensions may hinder students’ ability to fully understand the complexity of sustainability issues and addressing this may help ensure EfS achieves goals such as holism and the integrated systems thinking in the science classroom.

5.2.2 Teachers’ Conceptualisation of Sustainability Education

Education for Sustainability (EfS) encompasses teaching strategies aimed at integrating sustainability into the curriculum (Tilbury, 1995). These teachers held slightly more developed understanding than suggested in other research (Chalmers, 2011; Evans et al., 2012; Prabawa-Sear & Dow, 2018). Using the framework outlined by Evans et al. (2012), these teachers likely fell in Category 3, holding mostly ecologically focused views combined with pedagogical understanding. While teachers did not always explicitly discuss EfS approaches, or use the term ‘Education for Sustainability’, some approaches such as cross-curricular teaching, action-taking and the need to raise awareness were described by teachers.

EfS recommends cross-curricular teaching (Eilks, 2015; Sterling, 1996; Tilbury, 1995), an approach specifically noted by some teachers. One teacher developed a course to deliberately blur boundaries across the science subjects, while others offered illustrative examples of how concepts (bamboo fabric), or contexts (the local river) could span multiple subjects. Additionally, one school was using a unifying action-taking theme to implement cross-curricular teaching in their junior school. These findings suggest that some teachers, and schools, are open to interdisciplinary approaches and may be moving in this direction. Beyond supporting a core component of EfS, such approaches also enhance scientific literacy (SL) by reflecting the collaborative, multidisciplinary nature of contemporary science, which relies on diverse knowledge to address complex global challenges (Gilbert, 2017; Roth & Lee, 2002; Sammel, 2014).

Some teachers highlighted raising awareness as part of their sustainability-focused teaching, aligning with other literature (Chalmers, 2011; Chen et al., 2020; Cowie et al., 2004). However, the teachers in this study interpreted awareness more broadly than just focusing on environmental issues. Two teachers saw it as a way to connect learning to local contexts and community perspectives, a strategy supported by both SL and EfS frameworks as a way to engage students and foster critical thinking (Fien, 2001; Ministry of Education, 2007; Tilbury, 1995). That these teachers explicitly considered this suggests a more developed understanding of how awareness can be deepened through context. Another teacher viewed awareness as encouraging students to simply “notice” their surroundings—a first step, in his view, toward developing care and, ultimately action. His perspective highlights one potential way – developing in students genuine care for the world around them- to bridge the commonly identified gap between awareness and action (Shallcross & Robinson, 1999).

The need for action-taking was explicitly emphasised by several teachers, who highlighted the importance of learning experiences that lead students to seek solutions to real-world issues and foster social responsibility. Action competence, particularly socially responsible, collective action, is a well-established component of EfS and also a focus of SL Vision III (Mulà & Tilbury, 2024; Sass et al., 2020; UNESCO, 2017;

Valladares, 2021). These teachers noted that action-taking requires students to engage in critical thinking and problem-solving, suggesting an understanding of its deeper educational value. One teacher further noted that students should be encouraged to consider the types of social actions they could take to facilitate change, a view consistent with the development of action-competence outlined in literature (Birdsall, 2015; Jensen, 2000).

This study lends some support to the suggestion teachers have an intuitive understanding of sustainability that they draw on for curriculum planning (Taylor et al., 2003). One teacher in my study, despite being initially unconfident in her knowledge of sustainability, demonstrated a deeper underlying understanding through her ability to draw spontaneous cross-curriculum connections and her appreciation of indigenous knowledge systems. This finding suggests being able to formally define EfS may not always be necessary for effective integration, an idea further developed throughout Section 5.3.

Finally, the study recognises that research may not fully capture the breadth of teachers' sustainability and EfS understanding. As sustainability is an abstract concept that must be situated within a context (Birdsall, 2014; Evans et al., 2023), teachers may shape their definitions and pedagogical examples based on this research context. For example, secondary science teachers may omit economic dimensions because they may not feel relevant to their subject, whereas environmental or ecological dimensions are core to their subject and more readily discussed. This suggests that what teachers present during research may better represent where they see the boundaries of sustainability integration, rather than the limits of their understanding.

5.3 Sustainability in New Zealand Secondary Level Science Education – Practical Approaches

Literature regarding the incorporation of sustainability into secondary level science education in New Zealand is scarce (see Chapter Two). Existing examples include the development of a model for teaching socio-scientific issues (Saunders & Rennie, 2011)

and the enhancement of action competence within a senior environmental science course (Arthur, 2011). There have also been initiatives to use mātauranga Māori to introduce sustainability to science education (Callaghan et al., 2018). Research suggests teachers lack knowledge of how to integrate sustainability (Waltner et al., 2020). To contribute to this understanding, five teachers shared units of work they believed incorporated elements of sustainability.

Sustainability was primarily incorporated into junior sciences and at NCEA Level One, where it was guided by assessment requirements. The teachers used place-based contexts, interdisciplinary units, hands-on learning and systems-thinking approaches with the addition of perspective taking at NCEA Level One. In senior sciences, citizen-science projects, awareness-raising and Green Chemistry were used. These approaches are discussed further.

5.3.1 Context and Place - Sustainability in Aotearoa

These teachers used local context, both the issue and geographical location, to integrate sustainability into their science units. Place-based approaches are advocated by The New Zealand Curriculum (Ministry of Education, 2007) and can support the integration of sustainability (Bolstad, 2004) to make learning relevant and engaging (Penetito, 2004). Real-world examples such as eco-sanctuaries, native versus introduced plantings, kina barrens, and mining operations, may have enabled students to forge strong connections with their local environment, demonstrating how students may become "place-makers", empowered to actively transform their environment (Bolstad, 2004). Heather's unit exemplified this; in seeing mine-related damage, she hoped students would act to prevent similar future situations. These units contribute by demonstrating ways place-based issues can embed sustainability in a scientifically-meaningful way. Approaches which raise awareness of relevant local issues hopefully develop in students a sense of connection and care for their environment to prompt future action-taking behaviour.

Localised contexts also allowed for the integration of mātauranga Māori. Teachers' used water-related contexts - such as drinking water treatment and local river quality—

supporting Ruru's (2018) view that water is an ideal theme from which to consider mātauranga Māori due to its deep connection to cultural identity and wellbeing. Sustainable fishing practices, and the harvesting of kina further recognised mātauranga Māori's role in ecological stewardship (Ministry of Education, 2020). Interpreting local context slightly differently, one school used the arrival of their local Māori iwi as a starting point to consider the science knowledge needed for establishing a sustainable settlement. These examples add to research by Callaghan et al. (2018), illustrating how local context, Mātauranga Māori, and sustainability can be meaningfully intertwined to create rich learning opportunities, integrating socio-cultural dimensions and alternative ways of knowing.

5.3.1.2 INTERDISCIPLINARY KNOWLEDGE- SUSTAINABILITY IN AOTEAROA

To understand complex sustainability-focused issues, varied knowledge is needed making interdisciplinary approaches essential (Eilks, 2015; Wade, 2008; Zeidler et al., 2014). However, school structures and subject boundaries can make interdisciplinary teaching challenging (Eames et al., 2010, Wypych & Field, 2021). These teachers showed some ways it is possible. At NCEA Level One, one unit blended chemistry and biology, exploring the chemistry of acid-mine drainage and its biological impact on aquatic life before revisiting chemistry for limestone remediation. Lessons also extended beyond science with the building of a water sump (Technology), the writing of action poems (English), and cost calculations to source and treat water (Mathematics). The examples show how teachers may meet calls for greater linking of scientific ideas in meaningful contexts to deepen student understanding and make learning relevant (Ministry of Education, 2020, Moeed, 2020).

Interdisciplinary units were also used to introduce sustainability to junior science. Biology and chemistry combined within a local river unit while physics and biology concepts jointly supported a theme of 'survivability' to consider the colonisation of Mars. Adding to the literature (Coutts, York and Mower, 2022) one teacher introduced sustainability to a Science, Technology, Engineering and Maths (STEM) tallest tower challenge to include design recyclability. Since STEM challenges may often prioritise winning and students have struggled to justify design sustainability (Coutts, York and

Mower, 2022), this approach offers one way this could be addressed; prioritising sustainability in assessment criteria ensures students, at the least, have to consider it. One school went further, combining Mātauranga Māori and sustainability to connect learning across their junior curriculum. Each subject was seen as necessary in developing students' understanding of how their local area was settled. In integrating sustainability, these New Zealand science teachers combined disciplines to represent the multidisciplinary nature of contemporary science, steps seen as necessary by Gilbert (2017), while the sustainability themes engaged students in real-world environmental issues where diverse knowledge may lead to action and change.

5.3.1.3 HANDS-ON LEARNING - SUSTAINABILITY IN AOTEAROA

Hands-on, sustainability-focused activities were also used. While classroom experiments may be seen as contrived (Osborne & Allchin, 2024) and unrealistic (Gilbert, 2017), these teachers demonstrated how a sustainability focus may reorient practical work to be authentic and inquiry-driven, solving meaningful real-world problems. Students participated in water sampling and analysis, went on field trips, built sumps, dissected fish heads and made natural fertilisers. Hands-on activities may make science more relevant (Hodson, 2003) while learning in the environment is enjoyable (Ballantyne, Fien, & Packer, 2001) and may develop critical thinking (Tilbury, 1995) and strengthen students' relationships with nature (Hodson, 2003).

These hands-on activities also showed how science knowledge could be used to strengthen the understanding of sustainability issues (Lang & Wiek, 2021). Longbottom and Butler (1999) caution that sustainability issues may be trivialised unless accompanied with adequate science understanding and these tasks, which often included data collection and analysis components, may have contributed to enhanced student comprehension of the problems. Thus, sustainability themed practical activities provided a relevant context for the students to engage with scientific processes in a meaningful way, helping develop SL and deepen understanding of sustainability issues.

5.3.1.4 SYSTEMS-THINKING - SUSTAINABILITY IN AOTEAROA

EfS recognises the interconnectedness of socio-cultural, economic, and environmental systems (Sterling, 2001; Tilbury, 1995) and learning opportunities which interweave these pillars can broaden student understanding (Parry & Metzger, 2023). In junior science a kina harvesting and fertiliser activity demonstrated the cyclic nature of the issue. The activity was culturally relevant and offered an entry point for economic dimensions through the potential to develop produce sales. At NCEA Level One, the inclusion of matauranga Maori and local iwi perspectives provided a socio-cultural dimension, while water treatment costings and exploration of the relationship between mining and whitebait industries touched on economic dimensions. It is suggested consideration of these sustainability dimensions may also help students become more socially critical, vital and students will be future decision-makers (Ferkany & Whyte, 2013). Thus, this system's approach likely enhanced student understanding, highlighting the inherent connectivity and interdependence of ideas present within a single issue.

5.3.1.5 PERSPECTIVE TAKING - SUSTAINABILITY IN AOTEAROA

Perspective-taking is a key component of the new NCEA Level One standard and aligns with elements of teaching socio-scientific issues (SSI), EfS, and the development of SL (Eilks, 2015; Ministry of Education, 2023; Taylor et al., 2003; Valladares, 2023). By selecting sustainability-infused SSI, these teachers created opportunities to consider multiple perspectives and make informed decisions. The units all included Te ao Māori perspectives, drawn from local iwi, acknowledging their strong links to culture and knowledge systems and providing a more nuanced understanding. This approach extended learning beyond purely scientific concepts, emphasising socio-cultural dimensions, aligning with a more progressive vision of SL (Valladares, 2021). The findings demonstrate how science education can develop SL for informed decision-making, recognize New Zealand's bicultural identity, and prepare students for modern scientific environments where they will need to work alongside indigenous leaders (Tolbert, 2023).

Literature indicates that perspective-taking is challenging for students and requires explicit teaching (Birdsall, 2010). This research contributes suggestions of how

teachers may support student learning in this area. Field trips, media articles, and television documentaries were used to introduce and analyse alternative viewpoints, specifically targeting perspective-taking within SSI. Sammels (2014) asserts that expanding SL depends on understanding not just an issue's scientific components, but also underlying values, agendas, and beliefs and these units reflect a way New Zealand teachers can leverage sustainability to achieve this goal.

5.3.1.6 SUSTAINABILITY WITHIN ASSESSMENT

Sustainability is considered difficult to directly assess (Wilson & von der Heidt, 2013), and research in this area is limited (Cebrian et al., 2025). The new NCEA Level One achievement standard suggests one way to introduce sustainability into assessment, and this study provides further examples at the junior science level. Students researched the social impacts of a food production issue, created posters of native species and considered whether a local eco-sanctuary provided the right conditions for various species to thrive. Assessments required students to raise awareness and synthesise varied information to make informed decisions and propose sustainable courses of action. The examples highlight different ways that sustainability-related thinking and competencies can be incorporated into junior science

5.3.1.7 NCEA LEVEL ONE

Three different interpretations of the new Level One achievement standard, *Write an informed response to a local, scientific issue*, each with a sustainability component, were described. This standard aligns with teaching SSI by using real-world, science-related issues to develop students' critical thinking, ethical reasoning, and decision-making, while deepening their understanding of science in societal contexts (Stolz et al., 2013; Zeidler and Kahn, 2014). Data from this study suggest that sustainability, mātauranga Māori, and scientific literacy may be interwoven, to implement SSI with a uniquely New Zealand character. As described, key features of this approach included locally-relevant context and place, inclusion of diverse knowledge and consideration of alternative perspectives.

5.3.1.4 SECTION SUMMARY

These junior science and NCEA Level One units exemplify how teachers can use local scientific issues, to effectively integrate sustainability and mātauranga Māori to enhance SL. Anchoring learning in local contexts and promoting interdisciplinary approaches, these units fostered a deeper understanding of complex issues and diverse perspectives. The lessons demonstrate how sustainability not only integrates into science but also enhances it, as considering alternative perspectives and the interconnectivity of systems is crucial for strengthening SL by encouraging critical thinking about multifaceted real-world problems.

5.3.2 Senior Sciences

Echoing the literature, teachers acknowledged formal assessment requirements can make integrating of sustainability at senior level challenging. Despite these pressures, some teachers are implementing comprehensive units with strong EfS components, while others feel that, for now, raising awareness of issues is where sustainability teaching best fits within their practice. As such, these findings suggest teachers in this study are at varying stages in their incorporation of sustainability at the senior science level.

5.3.2.1 Biology

Lending support to claims that sustainability may be most easily integrated into biology (Uitto & Saloranto, 2017), Andrew was the only teacher currently teaching a full senior unit with a sustainability theme. His biology unit on the restoration of a local lagoon provides insight into sustainability teaching practice in two key areas. First, it demonstrates how sustainability can be used to enhance student engagement and interest at a time when research suggests engagement is declining (Engineering NZ, 2024; Fensham, 2009); students collected data and contributed to a report for the local council, taking action towards an issue and deepening their understanding of scientific processes. Second, the unit reflects how teachers' personal values may shape curriculum choices (Hart, 2003; Hastürk & Çol, 2024). For Andrew, this was not just an assessment task, it was an opportunity to empower students to take part in

authentic science and his strong belief in student contribution to knowledge creation drove the design of the unit.

5.3.2.2 Physics and Chemistry

Aligning with literature (Uitto & Saloranto, 2017) senior level physics and chemistry did not have the same level of sustainability-engagement as biology, however, teachers described how some senior internal achievement standards offered scope to move beyond science theory and consider environmental impacts. A Level Two physics assessment raised student awareness of nuclear fission's effects, while a Level Two chemistry unit compared ammonia production methods, to introduce sustainability themes. By raising awareness of issues and exploring some interactions between science and society, these teachers showed that while integrating sustainability at senior level is challenging, possibilities exist. Importantly, both teachers saw potential for to further strengthen sustainability via integration within their subjects.

Though they did not use the term, two teachers incorporated elements of Green Chemistry Education (GCE), an approach that fosters critical thinking, environmental awareness, and sustainable attitudes by applying twelve chemical design (Anastas & Warner, 1998; Cann, 2009; Holfelder, 2019). The ammonia production unit reflects GCE principles by contrasting traditional processes with less harmful alternatives. Both teachers addressed GCE elements in their teaching of batteries and Redox chemistry by discussing responsible waste management. Microscale experiments were described to reduce resource use and it was suggested battery topics could extend into soil systems and environmental considerations, enriching links across science topics. These findings contrast with Parker, Norhoha, and Bongers (2023), who found that university lecturers often saw GCE as competing with traditional content; these teachers viewed it as enriching and integrated offering further evidence for claims that teachers who value sustainability may be more likely to include it (Hart, 2003). These examples show how GCE can bring sustainability into senior chemistry, helping students recognise chemistry's environmental impact and consider more sustainable practices.

5.3.3 Action Taking

Research suggests that the inclusion of legitimate action-taking poses a challenge for sustainability education (Brommesson et al., 2025; Owens, 2008). While school-wide initiatives and Enviroschools programmes successfully promote direct action-taking activities such as recycling (Eames et al., 2010; Wypych & Field, 2021), there is need to explore other forms of action-taking to give students greater agency (Birdsall, 2010). This research highlighted three ways teachers integrated action-taking within a science classroom: by raising awareness, by considering possible actions, and by directly engaging in action.

With regards to action-taking, “raising awareness” had differing meanings for teachers. Some believed it may prompt future-oriented action; Harry believed raising local ecosanctuary awareness could reignite community interest in its redevelopment, while Heather thought awareness of a mine’s history could empower students to prevent similar future situations. While awareness-raising is a common EfS approach (Chalmers, 2011; Chen et al., 2020; Cowie et al., 2004), literature argues it is often insufficient to provoke meaningful action (Cutter-Mackenzie & Smith, 2003) and can position teachers rather than students as the action-takers, a disconnect from how action-taking is envisioned in literature (Jensen & Schnack, 1997; Kollmuss & Agyeman, 2002). Nonetheless, the findings contribute by showing how these New Zealand teachers may conceptualise action competence.

Other examples gave students greater involvement in the action-taking process, without including opportunities for direct action. One class studied community action taken against a mine, while another proposed a plan for more sustainable food production. These findings align with other research suggesting it is easier for teachers to provide students opportunities to learn about or plan actions than execute them (Eames et al., 2004). In what could be seen as indirect action, one class wrote action poems for a showcase, while another designed awareness posters for tourists. Though not direct action-taking opportunities, these tasks show teachers strengthening the action-taking component.

EfS ideally requires action directed at solving specific problems and decided on by those involved (Jensen, 2002). This study reported two units where students took direct action: harvesting kina for fertiliser and the collection of baseline invertebrate data for a council report. These exemplify direct problem-solving, even if students lacked full agency in selecting the issue or action. Future curriculum at one school will require students to initiate self-directed action projects and, like the REEP project in the USA, this student agency may foster critical thinking and civic engagement while safeguarding against indoctrination claims (Agyeman, 2006). Collectively, this research highlights the varied implementation of action-taking—from teachers raising awareness to executing student-selected projects - suggesting it may currently be practised along a spectrum in New Zealand science classrooms.

5.3.4 Sustainability Conceptualisation to Practice

Evans et al. (2023) found links between teachers' conceptualisation of sustainability education and their teaching approaches, and these findings add further insights into the connection between understanding and practice. This study also suggests that a developed understanding leads to broader approaches, as all teachers viewed sustainability beyond its environmental dimension, and their practice extended beyond scientific explanations. Individual views also impacted practice; Ben, who described sustainability as “complex” cultivated systems thinking via mind-mapping, Heather, describing sustainability as spiritual, demonstrated water as something to be revered and respected in her teaching and Harry, aiming for students to care, used place-based methods, to connect students to the natural world and increase their environmental awareness. These findings are notable, aligning with Corrigan et al.'s (2014) argument that teachers' promotion of ethical values can influence student outcomes in the classroom.

5.4 Benefits of Sustainability in Science Education

Literature reports the proposed benefits of Education for Sustainability (EfS) for students (Blatt, 2014; Parry & Metzger, 2023; Prabawa-Sear & Dow, 2019) and also suggests EfS may enhance science education (Feinstein, 2011; Hodson, 2003). This

research contributes by exploring the benefits New Zealand science teachers believe this approach has for science learning.

Teachers primarily saw the integration of sustainability as a way to enhance student engagement with science by making it more relevant. They believed that their sustainability-themed units, often involving local contexts and hands-on activities, made science meaningful and connected to with students' everyday lives. Teachers, such as Sarah, believed this approach provided an important 'why' for studying science, a critical factor given global concerns about declining student engagement (Fensham, 2009; Westwell & Panizzon, 2012). It has been proposed science should adopt personally meaningful approaches (Hodson, 2010), and these teachers suggest that sustainability may be one way of doing just this.

Beyond increasing engagement, the teachers believed their sustainability-related teaching cultivated the development of other essential skills. They saw sustainability as an ideal context for students to critically examine misinformation, debate complex issues and connect diverse ideas and knowledge. This focus on developing critical thinking is advocated by both SL and EfS frameworks (Osbourne & Allchin, 2024; Sass et al., 2023; UNESCO, 2017; Westwell & Panizzon, 2012). This research suggests that the teachers believe their sustainability units are targeting these very skills, thus providing benefits beyond engagement.

Action-taking, a key EfS component, was highlighted as a benefit. Teachers saw it as providing a purpose for science learning, reinforcing why issues matter and offering opportunities for collaboration. Providing opportunities for collective action is supported by literature as the development of SL is seen as collective (Roth and Lee, 2002), it better represents modern science (Sammel, 2014) and it may encourage future sustainable behaviours (Soll, 2019). Furthermore, teachers believed that even discussing potential action could give students hope and a sense of empowerment, mitigating the "doom and gloom" emotions that can accompany global problems (Gardiner & Rieckmann, 2015; Hicks, 2014; Hobson, 2020; Ojala, 2021). These New

Zealand science teachers were aware of the need to approach issues in ways which promote hopefulness and considered action-taking a beneficial method for doing so.

Another finding was the role of indigenous knowledge systems, specifically mātauranga Māori, in the sustainability-focused science units. Indigenous worldviews often align with sustainability (Parsons, Nalau & Fisher, 2017), and teachers used sustainability contexts to consider concepts like *kaitiakitanga* (guardianship) and meet new curriculum requirements. The findings support the claim that indigenous knowledge can ease the curriculum integration of sustainability (Zidny et al., 2020). One teacher described how Te ao Māori views of water as a "beloved ancestor" could instil a sense of environmental care in students, providing a strong entry point for sustainability and fostering students' awareness of different perspectives.

These teachers' views could be seen to align with those of Feinstein (2011) and Osbourne and Allchin (2024). They believed that science education should help develop SL by encouraging students to apply scientific knowledge to critically engage with the world or becoming 'competent outsiders'. These views of SL often aligned with Vision II, where scientific knowledge is not the primary goal. However, some teachers, prompted by new standards, began to align with the more holistic SL Vision III (Valladares, 2021) by teaching interdisciplinary units that required engagement with controversial issues and diverse perspectives. This suggests that a more evolved vision of SL provides an ideal platform for integrating sustainability into science education.

5.5 Challenges facing the Integration of Sustainability

Research indicates that incorporating sustainability at school-level is challenging and the teachers in this study described encountering similar barriers in their own classrooms. In particular, these teachers highlighted time, factors relating to teachers, and the nature of sustainability as their primary challenges.

5.5.1 Time

Echoing other research (Wilson, 2012), teachers in this study identified lack of time as the main challenge for incorporating sustainability. Participatory activities such as field trips, tasks requiring synthesis of multiple information sources, and action-taking opportunities were identified as most time consuming. Literature notes that teachers struggle to cover the examinable curriculum let alone engage in cross-curricular themes and action-taking activities (Owens, 2008) and these findings support these statements.

Despite the additional time required, these teachers believed these activities were among the most beneficial. One teacher noted that students found the learning “more achievable” after the field trip, while others highlighted the value of place-based learning (Penetito, 2004). All teachers believed the essence of sustainability would be lost if rushed, stressing that time was required to understand complex, interconnected ideas. This offers further support to literature findings, such as Sappaile et al. (2025), who note that skills like critical thinking require sufficient time to develop and that sustainability issues may be trivialized or cause confusion (Longbottom & Butler, 1999) if insufficient time was spent. The study indicates that teachers believe teaching sustainability requires time, specifically to establish community partnerships, ensure authentic local examples, support complex tasks, and facilitate action. If rushed, they feel the value of sustainability teaching may be compromised.

5.5.2 Teacher Factors

Factors relating to teachers were also identified as challenges to incorporating. Teachers’ knowledge of teaching sustainability and teachers’ views on sustainability’s place in education were seen by these teachers as posing significant challenges.

While research often suggests teachers lack sustainability knowledge (Basheer et al., 2022; Birdsall, 2014; Burmeister and Eilks, 2013a), these teachers disagreed. Instead, they believed teachers lacked an understanding of how to integrate sustainability into science education. They emphasised the need for professional development and practical examples of “what sustainability across science actually looked like”. That it

is sustainability's integration that is challenging aligns with literature which suggests teachers struggle with the practicalities of 'integration' (Waltner et al., 2020) and with imbedding soft skills such as competencies or values into content-based lessons (Education Review Office, 2019; Hong, 2012; Notman et al., 2012). Furthermore, the findings highlight a discrepancy between research and teacher beliefs; if teachers do not perceive a problem in teacher sustainability understanding, they may not engage from research that frames the problem in this way.

In addition to knowledge of EfS methods, some teachers identified a lack of broad scientific subject knowledge, cross-curricular knowledge and localised knowledge as further challenges. Since complex global issues have strong scientific components, teachers need a breadth of knowledge to effectively teach EfS (Alsop & Hicks, 2016; Lang & Wiek, 2021). Some observed that newer colleagues lacked scientific breadth, aligning with views of one science teacher Hobson's (2020) study and showing these teachers shared concerns that without adequate science knowledge, sustainability issues may be trivialised (Longbottom & Butler 1999). Others felt teachers may lack locally-specific knowledge while some felt teacher training did not support the development of cross-curricular understanding. As teacher training is considered integral to the progression of sustainability education (Birdsall, 2014; Eames & Peters, 2022), these findings suggest the need to review training programmes and cross-curricula approaches within schools.

Discussions also revealed a deeper challenge related to teachers' perceived professional boundaries. Some teachers believed their colleagues may lack of confidence or be reluctant to step beyond their "science box". This was particularly true when embedding soft skills like values; while some teachers were comfortable discussing values, others expressed apprehension and even fear of veering toward indoctrination. This finding aligns with international research (Levinson & Turner, 2001; Stouthart et al., 2025; Taylor et al., 2003) and offers insight as New Zealand pursues a curriculum that embraces diverse perspectives and links to mātauranga Māori, and as scientific literacy calls for a more values-oriented vision (Valladares, 2023).

Teachers' personal views on sustainability's position in the curriculum were also seen as a challenge. Research finds teachers may prioritise subject content over sustainability (Brommeson et al., 2024; Sterling, 2004) and these teachers partially agreed, noting that while content was prioritised at senior level, it was assessment requirements which dictated this, a view aligning with other research (Wilson & von der Heidt, 2013). One teacher offered a more nuanced perspective, suggesting practical classroom realities like behaviour management, rather than a preference for teaching content, may be the reason sustainability becomes less central. These findings suggest that while teachers' beliefs about sustainability place may impact sustainability's integration, their perspectives are more complex than a prioritisation of science content.

5.5.3 The Nature of Sustainability in Education

With regards to sustainability education, these teachers highlighted three main challenges. These included the teaching of interconnected ideas, the role of curriculum and assessment policy, and the community perception of sustainability and its place in education.

Teaching interconnected ideas presented a challenge, with teachers primarily attributing this to school structure and subject-silos - a concern frequently raised in literature (Eames et al., 2010; Wypych & Field, 2021). Teaching demands were cited as a barrier to interdepartmental collaboration, while other teachers held firm views on subject boundaries. While teachers in this research recognised EfS could help students connect diverse ideas (Parry & Metzger, 2023; Tilbury, 1995) they felt hindered by school structure rather than understanding.

Three teachers spoke of the impact of educational policy on the incorporation of sustainability. Curriculum change can powerfully drive EfS integration, as demonstrated by teachers who designed courses to explicitly cover alternative perspectives, decision making and mātauranga Māori. This finding offers support to other research such as Evans et al. (2023) who argue that if sustainability were covered in exams, it would be taught. However, other assessment changes may negatively

impact sustainability' incorporation. The new NCEA Level One standards deemed some competencies, such as perspective-taking, as necessary at only higher achievement levels, while assessment support was described as "shambolic". Since assessing sustainability competencies is already considered challenging (Wilson & von der Heidt, 2013), these issues may lead teachers to avoid the new standards, potentially preventing students from benefitting and undermining the goal of bringing sustainability into the curriculum.

Two teachers noted that students' and their whānau's perceptions may influence sustainability's integration. Negative views—that sustainability is not a serious academic subject or is only for non-academic students—have persisted for over two decades (Bolstad et al., 2004; Brignall-Theyer et al., 2009; Eames et al., 2010). Findings from this study, such as difficulties attracting students into sustainability-focused courses and apprehension about parental complaints regarding deviations from traditional science education, suggest such views remain common. However, these teachers challenged this perception noting how EfS activities added complexity and required "high level thinking", suggesting a shift in their view of sustainability's academic value and offering a hopeful sign for future integration.

5.6 Limitations

The five teachers in this study were purposively selected, ensuring participants were knowledgeable about teaching sustainability and could provide examples of sustainability teaching. As such, these findings reflect the beliefs, and understanding of these teachers and, though the teachers may disagree, their lessons could be viewed as current examples of best practice in the field. Therefore, the findings are not necessarily representative of the wider teaching profession nor of all sustainability-related lessons and should be viewed tentatively. However, these findings offer detailed examples of the teaching possibilities that exist, describing ways which sustainability education may be approached with New Zealand science classrooms. In addition, they provided initial evidence relating to the interpretation and teaching of the new NCEA Achievement standards.

The Interview process used to collect data may have impacted the research quality. It is possible the participants answered questions in socially desirable ways, either knowingly or unknowingly presenting their teaching practice and views on sustainability as favourably as possible (Cohen et al., 2018; van de Mortel, 2008). In addition, the lessons teachers described may have occurred up to a year before the interview, meaning their accounts were influenced by how they recalled the teaching (Fowler, 2009) and may not be entirely accurate reflections of the actual practice.

Qualitative research is interpretive, and I have strived to understand the descriptions of each participant's sustainability teaching experience (Leavy, 2017). However, the research also acknowledges that reality is subjective and complex and, as such, multiple interpretations of these findings could exist (Cohen et al., 2018). In addition, the participants were selected based on my conceptualisation of what sustainability in science education looked like. It is possible other researchers may hold a different view and thus have selected different participants, reporting on different examples to exemplify teaching practice.

5.7 Conclusion

This study examined five teachers' views and practices regarding sustainability's integration into science classes. These teachers demonstrated a broader understanding of sustainability and Education for Sustainability (EfS) than some previous literature suggests, moving beyond environmental issues. They also described numerous EfS teaching approaches, rather than teaching only the science concepts behind environmental problems. Their active participation in sustainability education may explain their wider understanding of EfS components like action-taking, systems thinking and interdisciplinary approaches. Echoing other research, broader economic dimensions were not in the foreground of their sustainability thinking, but this seemed to be linked more to perceived subject boundaries rather than a lack of awareness.

To embed sustainability, these teachers primarily used place-based learning, adapted Socio-Scientific Issue approaches, and units that integrated multiple science subjects. These offered students opportunities for real-world data analysis, hands-on learning outside the classroom, considering multiple perspectives and planning or carrying out action for change. Mātauranga Māori emerged as a further way to introduce sustainability via principles like kaitiakitanga and exploring alternative knowledge systems, also strengthening socio-cultural dimensions. At the senior level, citizen science projects and Green Chemistry principles were evident. Together, these approaches were used to develop students' scientific literacy, including informed decision-making, and to foster care and appreciation for the world. In short, the data from the participants suggest that there are specific features when science teachers integrate the idea of sustainability in their classes.

This research indicates that these teachers supported action-taking along a spectrum; at one end raising awareness in the hope it will prompt student action, through to full student engagement in direct action-taking projects. Although student-initiated action projects are seen in the literature as one way to give students agency and avoid indoctrination, these were not described by any of the teachers in this study. However, diverse approaches were being employed to foster action-taking, with progression beginning to move toward student-driven sustainability initiatives. Despite some concerns raised in wider literature that sustainability education may evoke feelings of hopelessness, these teachers stated the opposite; they believed action-oriented activities could negate the doom and gloom and empower students.

The very nature of sustainability education posed challenges for teachers. Integrating it into science was a pressing problem, with teachers citing a need for support and practical examples. Other challenges were interrelated. While interdisciplinary teaching was valued for its ability to connect ideas, subject-siloed school systems and the demand to teach outside one's specialty created barriers. Teachers felt they needed confidence, motivation, time, and a broader knowledge base to overcome these. They noted, aligning with literature, that moving beyond science boundaries was challenging, requiring navigation of values-based issues and confronting wider

community views on sustainability's place in science education. These issues were further exacerbated by the time required for upskilling and engaging in approaches like field trips, information synthesis and action-taking. Teachers believed that sustainability could not be rushed without compromising its essence, highlighting how these challenges could impact EfS integration.

Changes to assessment requirements at NCEA Level One (effective from January 2024) have eased sustainability's integration into science for these teachers. The teachers responded to the new NCEA science standards, reorienting learning to be issues-based, interdisciplinary and culturally responsive. On the other hand, sustainability integration remains challenging in the senior sciences, especially Level Two and Three Chemistry and Physics, where it remains less prominent in assessment guidelines. While NCEA Level One changes seem to support sustainability's integration, teachers highlight that marking criteria currently place sustainability competencies at higher Merit and Excellence levels, above demonstrating scientific understanding, arguably separating sustainability from science. These findings suggest that assessment policy may prove powerful in directing where and how sustainability is integrated.

Overall, the teachers saw the integration of sustainability as making science education engaging and relevant, a view widely reported in literature. Some also saw sustainability as providing an ideal context to develop skills associated with scientific literacy, such as informed decision-making. Furthermore, some teachers viewed sustainability as a mindset or philosophy that could infuse science and provide science education with a strong, ethical, future-focused purpose, ultimately empowering students to become informed decision-makers with the skills and values to take sustainability action.

5.8 Implications

Recent changes to NCEA Level One Science incorporate some Education for Sustainability (EfS) concepts, requiring students to consider local issues and diverse knowledge and perspectives to make an informed decision. Teachers have developed programmes to support the assessment but note challenges like vague marking criteria

and mātauranga Māori controversy. Therefore, the research implies that assessment change at national level can facilitate sustainability's curriculum integration, but teachers need support. This may include timely provision of exemplars, greater clarity regarding assessment criteria and further discussion around the appropriate inclusion of mātauranga Māori to ensure teachers do not avoid new assessment standards, undermining attempts to bring sustainability into the curriculum.

When teachers integrate sustainability into science using adapted socio-scientific issues education, the science content covered becomes issue-dependent. Teacher autonomy in issue selection could lead to varied student knowledge and depth of knowledge across New Zealand, potentially impacting preparedness for senior sciences. If teachers perceive students' science progress to be hindered, they may resist adopting such approaches, ultimately impacting both sustainability's integration and broader opinions of its value. Thus, curriculum and assessment guidelines need clarity on essential science content to ensure robust and equitable preparation for further science study.

Teachers in this study were experienced; their extensive knowledge of the senior science curricula ensured they integrated sustainability while maintaining coverage of science concepts currently necessary to progress. However, other teachers may not have the knowledge and skills to design units in this way further emphasising the need resourcing and teacher support.

Teachers' understanding of sustainability and its framing within science education, influences its integration. The teachers indicated a need for professional development, preferably beginning in teacher training programmes, and resourcing, specifically examples of sustainability within science education. Existing approaches, such as Green Chemistry Education (GCE), may offer guidance. GCE does not necessarily require changes to curriculum content, rather advocates a renewed 'mindset' and way to view chemical processes. GCE offers opportunities to connect to biology and physics and explore wider relationships between science, society and the environment. Furthermore, GCE may provide a stepping stone for teachers who do hold stronger

views on the value of content-driven courses, enabling them to first introduce a different angle without making major practice changes.

Research indicates declining student engagement in science. While anecdotal, two teachers in this study believed a sustainability focus increased their students' engagement. One reported higher engagement in a sustainability-oriented Level One science course compared to a more traditional programme. Another felt the new Level One standard's contextual focus strongly connected students to the learning, building prior knowledge that could be referenced in future science studies. Therefore, further research could shift to students, evaluating engagement in sustainability-focused science lessons to determine if this approach makes science content more accessible and interesting, thereby encouraging continued engagement and further science study.

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APPENDICES

APPENDIX A – Participant Information Sheet and Consent Form

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Hamilton 3240, New Zealand

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THE UNIVERSITY OF
WAIKATO
Te Whare Wānanga o Waikato

8 May, 2024

Kia ora

Sustainability in science education research opportunity

Sustainability is a core value and vision for the future in the current NZ curriculum. This emphasis is expected to grow with the upcoming curriculum refresh, which acknowledges the importance of preparing students to face future challenges.

I believe many science teachers are already finding engaging and relevant ways to integrate sustainability into their lessons. I am eager to hear more about these innovative approaches. As teachers, we understand what works best for our students, and I believe these examples should be highlighted and shared widely. I would love the opportunity to learn more about your teaching methods and share them with others to inspire and promote effective sustainability education

I would be very grateful for your contribution. Participation in this research would involve:

1) An audio recorded conversation of up to 45 minutes with me, over zoom, or in person if location allows. During this session, you would have the opportunity to share examples of work you are doing towards integrating sustainability into your junior science and senior subject curriculum.

2) A short (15-20 mins) follow up audio recorded discussion to review the initial conversation and reflect on potential scope for further integration of sustainability onto science.

The data collected would include an audio-recording and a transcribed text version of the interview sessions. All data will be kept securely in a locked office or password protected computer. Because this work involves secondary science teaching, it is possible that your identity may be guessed by those reading the research. Nevertheless, I will do my best to maintain confidentiality and you may choose to use a pseudonym in the reported research if you wish. You may also choose to receive an update and summary when the final thesis is released or when other journal articles may be published.

Participation in this project is voluntary. After you agree to participate, if you wish to withdraw from the project, you can do so by contacting me. You may withdraw from this study and withdraw your data at any point until two weeks after you receive the summary of our second discussion. At this point data analysis will have commenced.

I would like to emphasise that your participation, non-participation, or withdrawal from this study will not negatively affect our relationship in the future.

If you have any questions about the research, please contact me at

ag360@students.waikato.ac.nz

Alternatively, my supervisors can be contacted at

Assoc. Prof. Maurice Cheng - maurice.cheng@auckland.ac.nz

Assoc. Prof. Chris Eames – chris.eames@waikato.ac.nz

If you wish to participate, please fill in the attached consent form and send it to me at ag360@students.waikato.ac.nz

I would like to thank you for your consideration of this project and look forward to the opportunity to work together.

Ngā mihi,

Mandy Gundersen

MEd student

Te Kura Toi Tangata School of Education,

University of Waikato

This research has been approved by the University of Waikato Division of Education Ethics Committee on 24th June 2024 (approval number: FEDU022/24)

Consent form

I understand that by consenting to participate in this research, I am agreeing to the following:

To have one conversation with Mandy, of approximately 45 minutes and one follow up conversation up to 20 minutes.

To share some examples, if relevant, of the integration of sustainability into science lessons. This may take the form of a scheme of work *etc.*.

To spend no more than 1.5 hours on the conversations and reflecting on the conversations.

I understand that:

I can withdraw from participating in the research at any time by contacting Mandy by phone or by email. If I choose to withdraw from this study or my data, I do not have to provide any explanation.

I can withdraw from this study and withdraw my data at any point until two weeks after the second discussion.

I can choose to receive the transcript of the conversation.

The findings of this study will be reported primarily in a Masters' thesis. There is a possibility further publication i.e. journal article, conference talk may occur.

If I have any concerns during the study, I can contact Maurice Cheng, primary supervisor, at maurice.cheng@auckland.ac.nz

Please cross out any that do not apply. I would like to

Receive a link to the final thesis and short summary of the key findings.

Receive a link to any other publications which may eventuate.

Use a pseudonym when data is reported. Suggested pseudonym

Name:

Signature:

Date:

Please email a copy of this file to Mandy at ag360@students.waikato.ac.nz

This research has been approved by the University of Waikato Division of Education Ethics Committee on .24th June 2024 (approval number: FEDU022/24).

APPENDIX B – Ethics approval

Te Wānanga Toi Tangata
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**TE WĀNANGA
TOI TANGATA**
DIVISION OF EDUCATION

24/6/2024

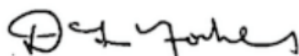
Mandy Gundersen

Division of Education Research Ethics Committee Application Approved FEDU022/24

I am pleased to advise you that your ethics application for the project entitled “Teachers' beliefs and practice regarding the integration of sustainability into science curricula.” was approved by Te Wānanga Toi Tangata Division of Education Research Ethics Committee on June 24th, 2024.

Please be aware that the Te Wānanga Toi Tangata Division of Education Research Ethics Committee must be advised (by memo) of any changes to the details recorded in your approved ethics application. This process is outlined in the application portal, under the heading ‘Amendments for an approved application’. Send your memo to fedu.ethics@waikato.ac.nz. You will receive a memo of approval once the change(s) has been considered.

Kind regards



Dr Dianne Forbes

Acting Chairperson

Te Wānanga Toi Tangata Division of Education Research Ethics Committee

APPENDIX C – Table of codes

Theme	Sub-theme	Codes
Understanding of sustainability	Environment and resources	<ul style="list-style-type: none"> • Use/management of resources • Conservation of environment • Minimising environmental harm.
	Temporal component	<ul style="list-style-type: none"> • Preservation of resources • Impact of future generations • Personal responsibility
	Systems	<ul style="list-style-type: none"> • Interconnectedness • Comprising multiple systems • Issues are complex
	Worldview	<ul style="list-style-type: none"> • Indigenous knowledge • Lens/philosophy • Way of life • Cultural knowledge
Understanding of sustainability in education - explicitly stated	Interdisciplinary	<ul style="list-style-type: none"> • Across sciences • Across subjects • Integration • School wide
	Awareness raising	<ul style="list-style-type: none"> • Issues • Different perspectives • World around them • Students role
	Action-taking	<ul style="list-style-type: none"> • Taking action • Problem solving
Sustainability in science	Scientific literacy	<ul style="list-style-type: none"> • Data collection/analysis • Everyday science • Participatory • Scientific process • Informed decision making
	Place-based	<ul style="list-style-type: none"> • Local context/issue • Community • Iwi • Field trip

	Hands-on	<ul style="list-style-type: none"> • Field trip • Practical • Collaborative
	Perspectives	<ul style="list-style-type: none"> • Iwi • Science • Stakeholders • Media
	Integrated	<ul style="list-style-type: none"> • Across science subjects • Other subjects • Sustainability pillars
	Action-taking	<ul style="list-style-type: none"> • Possible future student action • Learning about action • Students raising awareness • Direct student action
	Mātauranga Māori	<ul style="list-style-type: none"> • Knowledge systems • Environmental sustainability • Water • Controversial
	Green chemistry	<ul style="list-style-type: none"> • Reduction of waste • Chemistry and the environment • Cleaner chemical process
Purpose of science education	Scientific literacy	<ul style="list-style-type: none"> • Understand the world • Everyday science knowledge • Critical of information • Democratic society • Decision making
	Career	<ul style="list-style-type: none"> • Future scientists
Benefits of sustainability to science education	Engagement	<ul style="list-style-type: none"> • Specific activities • Contextualisation • Everyday relevance • Student agency
	Skill development	<ul style="list-style-type: none"> • Tackle misinformation • Navigate complex issues • Invested in the future
		<ul style="list-style-type: none"> • Collective action

	Action-taking	<ul style="list-style-type: none"> • “Fix-it” mindset • Empowering • Doom and gloom
Challenges in implementing sustainability	Time	<ul style="list-style-type: none"> • Planning units • Upskilling • Field trips • Synthesising information • Perspective-taking • Action-taking
	Teacher knowledge	<ul style="list-style-type: none"> • How to integrate • Broad scientific knowledge • Cross-curricular knowledge • Local knowledge • Teacher training • Professional development
	Teacher beliefs - place of sustainability	<ul style="list-style-type: none"> • Assessment demands • Other classroom demands • Sustainability awareness
	Nature of sustainability	<ul style="list-style-type: none"> • Subject silos • Values • Controversial issues
	Policy	<ul style="list-style-type: none"> • Resourcing issues • Assessment issues • Variation in student learning
Impacts	Insufficient Time	<ul style="list-style-type: none"> • Confusion • Loss of meaning
	Lack of knowledge	<ul style="list-style-type: none"> • Introduce misinformation • Unable to connect to wider areas • Simplify issue
